PROGRAMME

ECTQG 2019

21st European Colloquium on Theoretical and Quantitative Geography

Edited by
Geoffrey Caruso, Philippe Gerber, Kate Jones, Olivier Klein and Camille Perchoux

BOOK OF ABSTRACTS

5-9 September 2019
Mondorf-les-Bains, Luxembourg

PROGRAMME

ECTQG 2019

21st European Colloquium on Theoretical and Quantitative Geography

BOOK OF ABSTRACTS

LISER
LUXEMBOURG INSTITUTE OF
SOCIO-ECONOMIC RESEARCH

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Welcome to Mondorf !

We are particularly excited to welcome you in Mondorf-Les-Bains in Luxembourg and continue the great series of bi-annual ECTQG meetings. For over 40 years now, the ECTQG has gathered young and leading scientists interested in advancing quantitative methods and theories with a strong geographical dimension. Previous colloquia were held all over Europe: York, United Kingdom (2017), Bari, Italy (2015), Dourdan, France (2013), Athens, Greece (2011), Maynooth, Ireland (2009), Montreux, Switzerland (2007), Tomar, Portugal (2005), Lucca, Italy (2003), Saint-Valéry-en-Caux, France (2001), Durham, United Kingdom (1999), Rostock, Germany (1997), Spa, Belgium (1995), Budapest, Hungary (1993), Stockholm, Sweden (1991), Chantilly, France (1989), Bardonecchia, Italy (1987), Veldhoven, The Netherlands (1985), Augsburg, Germany (1982), Cambridge, United Kingdom (1980) and Strasbourg, France (1978). It is a remarkable series that demonstrates the power of self-organization (the ECTQG is not institutionalized) and the continued need for geographically aware theories and quantitative methods. We are very proud of bringing Luxembourg for the first time in this list of meetings!

The 21st European Colloquium on Theoretical and Quantitative Geography, ECTQG2019 is organised by the virtual research lab QUADTREES.LU, a joint venture of the Institute of Geography and Spatial Planning of the University of Luxembourg and the Urban Development and Mobility Department of the Luxembourg Institute of Socio-Economic Research (LISER). We are thankful to both institutions for partnering and supporting the organisation of this event and grateful to the Luxembourg National Research Fund (www.fnr.lu) for its financial support.

Following the structure of previous events, the backbone of the programme is made of a set of special sessions and standard sessions assembled by the organisers and the international scientific committee based on the abstracts received and the main recurring topics of the ECTQG. The members of the international scientific committee, the special sessions convenors and all the scientists who helped them evaluating paper proposals have made a fantastic job to provide 2 to 4 written feedback to every author, thus helping her/him progressing or situating her/his research.

This year, 8 organised special sessions have materialized on very active domains of the field, and complement general, more recurring, sessions, including networks, fractals, transportation, segregation, or spatial analysis at large. We are very glad to count a total of 121 presentations and to host about 135 participants. This is a promise of many and high quality interactions, knowing that distance is optimised within our charming venue, the Domaine Thermal of Mondorf-les-Bains.

In addition to the parallel sessions, we are thankful to Prof. Isabelle Thomas (UCLouvain, Belgium), Prof. Sara Fabrikant (University of Zurich, Switzerland), Prof. Elsa Arcaute (UCL, United Kingdom) and Prof. Luc Anselin (University of Chicago, USA) for having accepted our invitation to give us a keynote address on their specific field of expertise. With their long reflexions, they will challenge our practices and methods and help us foresighting quantitative and theoretical geography for the coming years.

The colloquium will start with an R and Python practical workshop, kindly organized by Prof. Roger Bivand and Prof. Dani Arribas-Bel. Practicals are surprisingly unusual at the ECTQG while most researchers from the community use computer tools and various languages intensively. We believe it is important that the ECTQG supports the development and sharing of experience with open source software for spatial analytics. We are certain this is the start of a long series of hands-on workshops.

Finally, we would like to express our sincere thanks to all the people involved in the organisation and to all authors and participants of the colloquium. We wish you an enjoyable and fruitful colloquium.

The Local Committee

Local Committee

- Geoffrey Caruso, Professor in Urban Analysis and Modelling (University of Luxembourg and LISER)
- Philippe Gerber, Senior Researcher, Urban Development and Mobility (LISER)
- Kate Jones, Assistant Professor in Digital Geographies (University of Luxembourg)
- Olivier Klein, Senior Researcher, Urban Development and Mobility (LISER)
- Camille Perchoux, Researcher, Urban Development and Mobility (LISER)

www.quadtrees.lu

The Local Scientific Committee is supported during the conference by Marlène Boura (UNI LU), Estelle Mennicken (LISER), Paul Kilgarriff (LISER), Justin Delloye (LISER), Kerry Schiel (UNI LU), Marcela Mader Furtado dos Santos (UNI LU) and Michaela Pamina Lange (LISER). It is particularly grateful to Carole Wiscour-Conter (LISER) for coordination of the logistics and administration of the conference, to Nadjia Ekwegbalu (UNI LU) for administrative support at the University of Luxembourg, to the Compta team at LISER for checking and cross-checking registrations, to Benjamin Boehm (LISER) for solving server and web issues, to Nicolas Stamets for social media advice and PayPal registrations, and last but not least to Benoît Lanscotte (LISER) for designs and the website and Isabelle Bouvy (LISER) for her kind and careful editing of the conference book.

International Scientific Commitee

- Mike Batty (University College London, United Kingdom)
- Itzhak Benenson (Tel-Aviv University, Israel)
- Martin Charlton (National University of Ireland, Maynooth, Ireland)
- Benjamino Murgante (University of Basilicata, Italy)
- Nuno Pinto (University of Manchester, United Kingdom)
- Denise Pumain (Université Paris I Panthéon-Sorbonne, France)
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- Richard Shearmur (University McGill, Canada)
- Petra Staufer-Steinnocher (Vienna University of Economics and Business)
- Jacques Teller (University of Liège, Belgium)
- Jean-Claude Thill (University of North Carolina, Charlotte, United States)
- Ann Verhetsel (University of Antwerp, Belgium)
- Roger White (Memorial University of Newfoundland, St John's, Netherlands)

Quantitative Urban Analytics and Spatial Data Research - Luxembourg

Quadtrees is a virtual lab that brings together quantitative geographers from the University of Luxembourg and the Luxembourg Institute of Socio-Economic Research (LISER), and associated geographers in Luxembourg. It is aimed as a place for cross-fertilization, sharing and learning among researchers.

While quantitative geography arose some 60 years ago when mathematics and computers were embraced by social scientists, many challenges remain today to understand the complexity of cities and interrelate their social, cultural, economic and environmental dimensions. Not the least is to assemble a formalised but fragmented theoretical corpus and set of methods and questions their capacity to help us understanding real world dynamics and acting toward better cities. The recent digital turn and spatial data boom may -or may not- provide us with an extraordinary boost to advance our understanding of space and cities. Quadtrees is the place where the Luxembourg researchers gather and demonstrate contributions to these debates.

Quadtrees communicates about the progress, richness and diversity of quantitative geography research in Luxembourg via a blog and social media. Posts include news about ongoing projects, recent papers, data sets, workshop, conferences, lectures, critical ideas and reflections,…

Don't hesitate to bookmark our www.quadtrees.lu blog and to follow us on Twitter **@quadtrees_lu**

Luxembourg Institute of Socio-Economic Research

Initiated in 1989 and established in 2014, the Luxembourg Institute of Socio-Economic Research (LISER) is a public research institute located in Luxembourg under the supervision of the Ministry of Higher Education and Research. Integrated into a unified legal framework (law of 3 December 2014) LISER's missions are to undertake both fundamental and applied research in social sciences that aim to advance knowledge, support public policy (both at the national and European level) and inform society.

LISER contributes to the advancement of scientific knowledge in social and economic matters. The activities of LISER's three research departments ("*Living Conditions*", "*Labour Market*" and "*Urban Development and Mobility*") are focused on the following five areas of excellence related to social fabric analysis, economic fabric and spatial development:

(1) Public policies, welfare and socio-economic inequalities

(2) Public policies and labour markets

(3) Employer-employee relationships

(4) Urban policies

(5) Spatial Mobility

In parallel, the institute aligns itself with national and european priorities and fosters the interdisciplinarity of its teams by focusing its research work on three priority research programmes: "*Crossing Borders*", "*Health and Health Systems*" and "*Digital Transformation*".

LISER hosts two complementary infrastructures key, drivers of its research development and excellence.

- The *Data Centre*, which consists of two pillars, the data collection capability (direct and indirect data collection), and the data archiving and data management capability.
- The *Behavioural and Experimental Economics* dedicated to investigating human decision-making by means of experiments performed in controlled environments. Its experimental approach contributes to improving the understanding of human behaviour in a large variety of socioeconomic contexts.

LISER aims to be an internationally recognized socio-economic research institute specializing in the analysis of societal changes. Through its inter-and-multidisciplinary research, it makes a proactive and targeted contribution to the sustainable and inclusive development of societies at the national and international levels.

Luxembourg National Research Fund (FNR)

The Luxembourg National Research Fund (FNR) is the main funder of research activities in Luxembourg. We invest public funds and private donations into research projects in various branches of science and the humanities, with an emphasis on selected core strategic areas. Furthermore, we support and coordinate activities to strengthen the link between science and society and to raise awareness for research. We also advise the Luxembourg government on research policy and strategy.

Our vision

To establish Luxembourg as a leading knowledge-based society through science, research and innovation, thereby contributing to the country's economic diversification and future prosperity.

Our mission

To set up a sustainable world-class research system in Luxembourg that will generate societal and economic impact in key strategic areas.

Our strategic priorities

The FNR aims to be a driving force for Luxembourg's innovation capabilities and focuses on the following three strategic objectives to foster research with impact:

Attaining scientific leadership in key areas
By setting the highest quality standards, we contribute to establishing international research excellence in Luxembourg. By attracting and training the most talented scientists, we help to build critical mass in key research areas, thereby supporting economic development and societal progress.

Turning public research into a competitive advantage for Luxembourg
We support the advancement of Luxembourg's knowledge-based economy by supporting industry-informed research, by reinforcing co-operation between public research and innovative industries and by facilitating the commercial exploitation of research results.

Anchoring science and research in society
We promote the active involvement of researchers and scientists in addressing current and future societal challenges. To ensure that research is established sustainably in the public consciousness as an important pillar of Luxembourg's knowledge society, we support an active exchange between scientists and the public at large.

How we work

The FNR's most highly valued criteria are excellence and quality in research. In order to identify the most promising and most excellent projects and researchers, we systematically submit funding requests to an assessment by independent international experts.

We implement the « **Principles for Scientific Merit Review** » (issued by the 2012 « Global Summit on Merit Review »), which embody the highest international standards of expert assessment, transparency, impartiality, confidentiality and integrity.

We commit to conduct our operations through a Quality Management System (QMS) certified in accordance with the ISO 9001:2015 standard.

Our CORE values

Towards researchers and research institutions:
We implement a fair and transparent process in our decision-making and nurture an open dialogue with the scientific community.

Towards the government, tax-payers and donors:
We are accountable for the usage of funds that we are entrusted with and we strive for efficiency in our operations.

Towards the general public:
We care for the long-term interest of the country and consider engagement with society as a constitutive part of science.

Towards our collaborators:
We aim to stimulate talent-development and competence building of our staff, who translate FNR's vision, mission and core values into action.

https://www.fnr.lu

Luxembourg National
Research Fund

University of Luxembourg

Founded in 2003, the University of Luxembourg is the only public university of the Grand Duchy of Luxembourg. Multilingual, international and research-oriented, it is also a modern institution with a personal atmosphere.

With nearly 6,200 students and about 1,700 employees from all over the globe, the University offers a unique mix of international excellence and national relevance, developing into the motor of economic diversification and innovation in Luxembourg. Current priorities for research are computational sciences and ICT, systems biomedicine, law and European law, international finance and educational sciences.

The University offers a range of Bachelor programmes but its focus lies on Masters and PhDs. The mandatory semester abroad for Bachelor students reflects the importance attached to international mobility.

The University of Luxembourg ranks 17 worldwide in the Young University Rankings of the Times Higher Education (THE) and 4th among the "Millenial" universities (founded since the year 2000). It is among the top 250 universities worldwide in the general THE rankings.

The **Institute of Geography and Spatial Planning** was established in April 2006. The institute is devoted to studying regional and local development and planning (amongst others in Luxembourg and in the Greater Region), European urban and spatial policy and also sustainable spatial development.

The research follows different trajectories and paradigms of human geography and spatial planning, notably institutional and actor-centred approaches, theories in the context of chains, flows and networks, and also approaches that are related to the cultural and spatial turn. Major fields of research include environmental economic geography, urban studies and metropolitan governance, spatial statistics and modelling.

The institute hosts the National Contact Point for the EU programme ESPON (European Spatial Planning Observation Network) and for the EMN (European Migration Network). It offers four study programs: the Master in Geography and Spatial Planning (www.spatial.uni.lu), the Master in Architecture, the Master in Border Studies, and a continuous education programme in spatial planning.

R & PY Spatial Analysis Workshop

A spatial analysis workshop is offered on Thursday 5th of September to the ECTQG 2019 participants (upon specific registration).

The workshop is intended to provide up to date overviews of open source software for spatial analysis in Python and R. The instructors, Daniel Arribas Bel, Roger Bivand and colleagues, hope to explore with participants shared features of software tools and data representation in both language environments. We intend to use Python 3, **Pysal 2** and associated packages, and in R the CRAN **sf** and **stars** packages and packages using their data representations for spatial analysis.

Please refer to https://github.com/rsbivand/ectqg19-workshop for detailed information.

ECTQG 2019

MONDORF
Domaine Thermal

plan

SUD
NORD

vers Burmerange
et Schengen

Impasse Emile Diderrich

Av. Dr. Feltgen
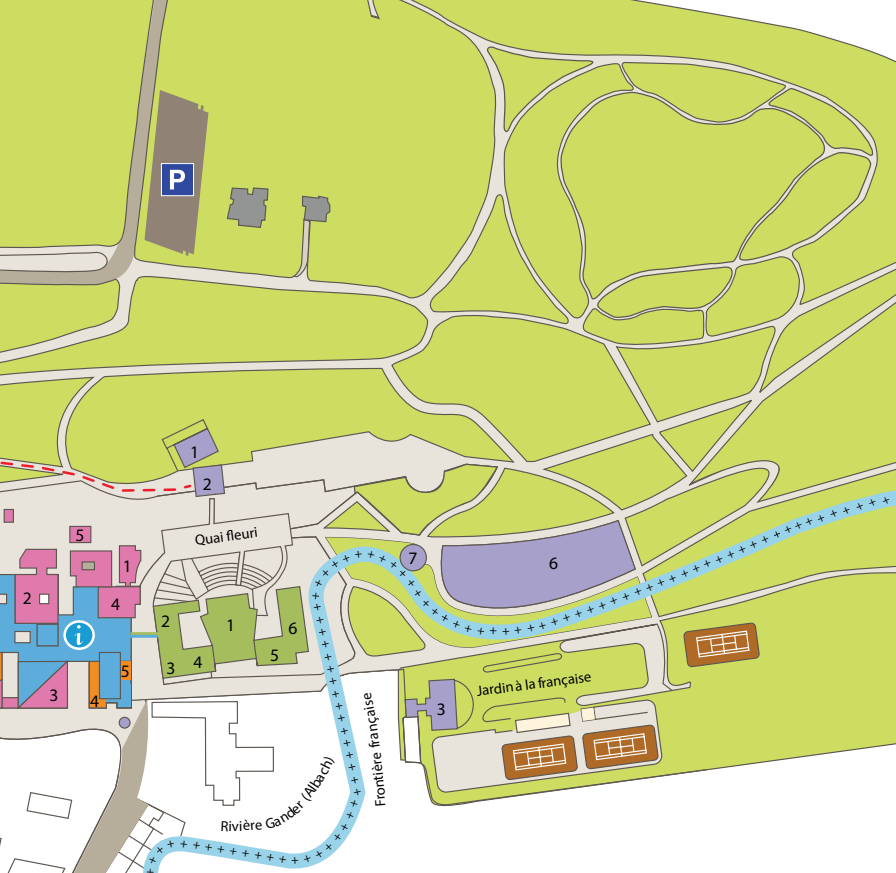
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vers A13
sortie 12

vers Remich
et l'Allemagne

vers Luxembourg, la France et la Belgique

Wifi Access Code

MONDORF_Business
MondorfThermal

Limites du Domaine Thermal

Rivière Gander (Albach)

Quai fleuri

Jardin à la française

Rivière Gander (Albach)

Frontière française

vers A13 sortie 11

Parc Hôtel
1 Entrée Hôtel
2 Réception Hôtel
3 Restaurant De Jangeli
4 Salon Janglisgare
5 Suite des Poètes
6 Salon Frantz Clément
7 Cocktail Bar De Feierwon
8 Welcome Parc Hôtel

Santé

Spa
1 Pavillon Rubis
2 Pavillon Saphir
3 Pavillon Jade
4 Institut de beauté
5 Coiffeur
6 Terraké

Wellness & Fitness
1 Piscine Thermale
2 Pavillon Saunas et piscine à 28 ˚C
3 Pavillon Fitness
4 Club Lounge
5 Sauna Sointi

Anciens Thermes
1 Salle des Fêtes « Al Thermen »
2 Bistro Maus Kätti
3 Salle Symphonie (1er étage)
4 Salon LA-SI
5 Salon Bémol
6 Direction

Autres sites
1 Waasserhaus
2 Pavillon Kind
3 Orangerie
4 Fontaine Maus Kätti
5 Chalet du Brill
6 Mondorf Easy-Golf
(Mini-Golf paysagé)
Jeu du Moulin et
Jeu d'échec géant
7 Barques et pédalos
■ Tennis
■ Routes
□ Sentiers
P Parking souterrain

i Réception Wellness & Fitness
Réception Spa
Réservation cures thermales

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Keynote speakers

LUC **ANSELIN**

Prof. Luc Anselin is a native of Belgium, where he did undergraduate work and a master's degree in economics and econometrics at the Free University of Brussels (VUB). His PhD is from Cornell University in the interdisciplinary field of Regional Science.

Anselin comes to the University of Chicago from Arizona State University where he was a Regents' Professor and held the Walter Isard Chair. He was the founding Director of the School of Geographical Sciences and Urban Planning. He also started and directed the GeoDa Center for Geospatial Analysis and Computation. Before ASU, he was a Professor at the University of Illinois, Urbana-Champaign, where he directed the Spatial Analysis Laboratory in the Department of Geography and was a Senior Research Scientist at the National Center of Supercomputing Applications (NCSA). He previously held appointments at the University of Texas at Dallas, West Virginia University, the University of California, Santa Barbara and the Ohio State University. He has held (joint) appointments in a range of disciplines, including Geography, Urban and Regional Planning, Economics, Agricultural and Consumer Economics, Political Economy and Political Science.

Anselin is the developer of the SpaceStat and GeoDa software packages for spatial data analysis. He was elected Fellow of the Regional Science Association International in 2004 and was awarded their Walter Isard Prize in 2005 and William Alonso Memorial Prize in 2006. He was elected to the National Academy of Sciences in 2008 and the American Academy of Arts and Sciences in 2011.

Anselin's publications include many hundreds of articles and several edited books in the fields of quantitative geography, regional science, geographic information science, econometrics, economics, and computer science.

ELSA **ARCAUTE**

Dr. Elsa Arvaute is an Associate Professor in Spatial Modelling and Complexity at the Centre for Advanced Spatial Analysis (CASA) at University College London. She is a physicist with a masters and a PhD in Theoretical Physics from the University of Cambridge. She has been working in the field of Complexity Sciences since 2006 when joining the Complexity and Networks group at Imperial College London. There she developed models on self-regulation for social systems, extracting fundamental behaviours from experiments on ant colonies, and working alongside social scientists towards an intervention for an Irish eco-village. In 2011, Elsa moved to UCL to join Prof Michael Batty at CASA, and since then she has been working on applying complexity sciences to urban systems. Her research focuses on understanding behaviour at different scales, and on uncovering such scales by looking at the emergent hierarchies in complex systems. In particular, she studies how urban attributes are characterised by the size of cities, scaling laws; how city boundaries can be defined in a consistent way; how inequality and resilience in urban systems can be quantified and identified; how to evaluate changes to the infrastructure; how innovation emerges, and how the spaces in which it takes place can be characterised. At present she is co-investigator of an EPSRC grant intended to look at rebalancing the economy in the UK, and she is a member of the Advisory Board for the PEAK Urban GCRF programme, UKRI, aiming at building skilled capacity for decision making on urban futures.

SARA IRINA **FABRIKANT**

Dr. Sara Irina Fabrikant is a Professor of Geography, leading the Geographic Information Visualization and Analysis (GIVA) group at the GIScience Center of the Geography Department at the University of Zurich (UZH), Switzerland. She holds a PhD in Geography from the University of Colorado at Boulder (USA). Her research and teaching interests lie in geographic information visualization and geovisual analytics, GIScience and cognition, graphical user interface design and evaluation, including dynamic cartography. She is a Co-Director of the UZH Digital Society Initiative and a member of the Swiss Science Council. She served the International Cartographic Association as a vice president, and was involved in co-chairing the program committees of AGILE 2008, GIScience 2010, and COSIT 2015.

ISABELLE **THOMAS**

Prof. Isabelle Thomas is FRS-FNRS research director at CORE, and extraordinary professor at the School of Geography, Louvain-la-Neuve (Belgium).

Most of her career is academical (National Fund for Scientific Research) at the exception of five years at the Belgian Gendarmerie Headquarters for studying crime and accidents spatial structures. Anchored in quantitative geography, her main research topics are: (1) Modelling optimal locations of human activities and more particularly the sensitivity of the location-allocation and transportation models to their geographical inputs, and (2) applied quantitative analysis for spatial data with topics such as scale, M.A.U.P., autocorrelation, statistical mapping, landscape morphometrics. Application domains are mainly socio-economic and transportation issues in Belgium. She never hesitates to collaborate with researchers of other disciplines. She was recently awarded by the American Association of Geographers (AAG) for her contribution in transport geography (2017 Edward L. Ullman Award) and by the Regional Science Association International for her contribution in regional sciences (2019 RSAI Fellows Award).

Thursday, 5th September

09:00 - 16:30	MSH, Esch/ Alzette	**R & PY - Spatial Analysis workshop**
17:00 - 19:00	Salle Foyer	**Registration**
19:00 - 21:00	Salle Foyer	**Dinner / Buffet**

Friday, 6th September

| 08:30 - 09:00 | Salle Foyer | **Registration** |
| 09:00 - 10:00 | Salle des Fêtes | **Introduction** |

10.00 - 11:30	Salle des Fêtes	**Plenary Session: Keynote 1**		
			Keynote	**Page**
		More LISA - univariate and multivariate extensions	*Luc Anselin*	*31*

| 11:30 - 12:00 | Salle Foyer | **Coffee break** |

12:00 - 13:30   **Parallel Sessions I**

	General Session: Housing Price		
	Title	**Author(s)**	**Page**
Symphonie	The valorisation of urban residential space. Questions and approaches for the quantitative geographer	*Giovanni Fusco,* ***Alessandro Venerandi***	*32*
	The dynamic impact of monetary policy on regional housing prices in the United States: Evidence based on factor-augmented vector autoregressions	*Manfred M. Fischer, Florian Huber, Michael Pfarrhofer,* ***Petra Staufer-Steinnocher***	*34*
	Why real-estate matters in spatially analyzing inequalities of wealth and assets. Interpreting Inequalities Induced by Price Inflation in France	***Renaud Le Goix****, Laure Casanova-Enault, Guilhem Boulay, Loïc Bonneval, Thibault Le Corre, Julien Migozzi, William Kutz, Ronan Ysebaert*	*36*
	Effect of urban parks on real estate prices over time: the example of Rouen (1828-1843)	***Marie Havret****, Marion Le Texier, Sophie De Ruffray*	*38*

	Special Session: Big data for Geocomputation (1/2)		
	Title	**Author(s)**	**Page**
Salle des Fêtes	Retail landscapes emerging from big data network analysis. The retail geography in Belgium through community detection	*Ann Verhetsel*, *Joris Beckers, Jeroen Cant*	*39*
	Twitter-based Public transport distributed sensors: the case of the train line between Metz and Luxembourg	*Pierre-Olivier Chasset, Arnaud Banos, Olivier Klein*	*40*
	Using real time positioning of trucks to explore logistic flows in Belgium	*Arnaud Adam, Olivier Finance, Isabelle Thomas*	*42*
	Exploring Administrative Data for use in City Specific Geodemographic Classifications in the UK	*Amanda Otley, Michelle Morris, Andy Newing, Mark Birkin*	*43*
	Unexpected Flexibility of the Israeli Public Transport Users	*Itzhak Benenson, Eran Ben Elia, Maria Marinov*	*45*

	Special Session: Mobilities and Health (1/2)		
	Title	**Author(s)**	**Page**
Salon LA-SI	Location, location, location (and health): opportunities, challenges and an introduction to mGeoHealth	*Malcolm Campbell, Lukas Marek*	*46*
	A research framework incorporating mobility in dietary behavior research and 2 Canadian dietary behavior research projects	*Michael Widener, Bochu Liu*	*47*
	Challenges in Assessing Mobility using GPS Data for Healthy Aging	*Eun-Kyeong Kim, Lindsey Conrow, Michelle Fillekes, Robert Weibel*	*49*
	Neighborhood effects on sedentary behaviors at locations and during trips: a GPS-based activity space approach	*Camille Perchoux, Ruben Brondeel, Yan Kestens, Basile Chaix, Philippe Gerber*	*50*
	Identifying activity spaces from geo-referenced Twitter data: Superstorm Sandy, mobility patterns, and emotions in New York City	*Ivor Mardesic, Martin Sykora, Sarah Lowe, Suzanne Elayan, Emiliano Albanese, Milo Puhan, Oliver Gruebner*	*51*

13:30 - 14:30	Salle Foyer	**Lunch**

14:30 - 16:00   **Parallel Sessions II**

	General Session: Spatial Analysis (1/3)		
	Title	**Author(s)**	**Page**
Symphonie	Spatial Prediction with Categorical Response Variables	*Martin Charlton, Chris Brunsdon, Paul Harris, Lex Comber*	*52*
	Enriching Exploratory Spatial Data Analysis with modern computer tools	*Robin Cura*	*54*
	Early disease diagnosis in shelter animals using Hidden Markov Models	*Katarina Mayer*	*56*
	Empty Homes: Mapping the extent and value of low-use domestic property in England and Wales	*Jonathan Bourne*	*57*
	Quantitative assessment of public sector e-mobility infrastructure development: A spatial perspective in the case of Germany	*Sujit Sikder, Magesh Nagarajan, Hendrik Herold, Meinel Gotthard*	*58*

	Special Session: Big data for Geocomputation (2/2)		
	Title	**Author(s)**	**Page**
Salle des Fêtes	Feature selection and data dependencies analysis: operative tools and case studies for geospatial data.	*Federico Amato*, Fabian Guignard, Mikhail Kanevski	59
	A data mining approach for natural hazard susceptibility assessment	*Marj Tonini*	61
	The geographies of RES impact in low density settlement area: the case of Melfi municipality	*Angela Pilogallo*, Lucia Saganeiti, Francesco Scorza, Beniamino Murgante	63
	A Tensor-based Conceptual Framework for Large Scale Multidimensional Raster Data Processing	*Sukriti Bhattacharya*, Christian Braun, Ulrich Leopold	64

	Special Session: Mobilities and Health (2/2)		
	Title	**Author(s)**	**Page**
Salon LA-SI	Using nationwide linked microdata to examine the effect of transience on the health services utilisation and long-term health conditions	*Lukas Marek*, James Greenwell, Matthew Hobbs, Melanie Tomintz, Malcolm Campbell, Simon Kingham, John McCarthy	65
	Impact of deprivation level and mobility behaviors on accessibility to breast cancer care: example in Paris region (France)	*Benoit Conti*, Audrey Bochaton, Hélène Charreire, Charlotte Ngô	66
	Designing a built environment measure of walkability: topology, greenness and connectivity as predictors of walkable streets	*Kevin Schutz*, Catherine Jones	68
	Urban air pollution and pedestrian mobility: estimating local pollution levels to identify clean pedestrian paths.	*Stefania Bertazzon*, Isabelle Couloigner, Mojgan Mirzaei, Xiaoxiao Liu	70
	The walkability score in Flanders, Belgium. Mapping density, functional diversity, connectivity and pollution as policy indicators	*Tomas Crols*, Lien Poelmans, Sara D'Haese, Peter Vervoort	72

16:00 - 16:30 | Salle Foyer | **Coffee break**

16:30 - 18:00 | **Parallel Sessions III**

	General Session: Spatial Analysis (2/3)		
	Title	**Author(s)**	**Page**
Symphonie	Estimation of regional energy consumption based on energy consumption at national level: Romanian Danube Valley case study	*Paul-Răzvan Şerban*, Monica DumitraȘcu, Bianca MitricĂ, Ines Grigorescu, Irena Mocanu	73
	Interactional Approach to Subcenter Hierarchization: the Example of Moscow and Paris	*Mikhail Topnikov*	75
	Vocational training in Greece: Evaluation at micro, meso and macro level	*Stavros Rodokanakis*	76
	Efficient population size for fire protection and its transition with intermunicipal cooperation in Japan	*Hiroki Baba*, Yasushi Asami	78

	Special Session: Geo-data science and Urban Sustainability (1/2)		
	Title	**Author(s)**	**Page**
Salon LA-SI	How does the relative spatial pattern of green within cities impact carbon uptake? A European scale analysis	*Marlène Boura*, Geoffrey Caruso	*80*
	Developing territorial Life Cycle Assessment approaches: focus on land use functions and proposition of a new operational methodology	*Antonino Marvuglia*, Eva Risch, Eleonore Loiseau, Hichem Omrani	*81*
	Geostatistical space-time prediction of air quality pollutants in Israel	Jairo Arturo Torres Matallana, *Ulrich Leopold*, Barak Fishbain	*83*
	Dynamic assessment of population exposure to air pollution using mobile phone data	*Hichem Omrani*, Bilel Omrani, Benoit Parmentier	*84*

	Special Session: Geosimulation models Exploration Methods		
	Title	**Author(s)**	**Page**
Salle des Fêtes	The changing roles of parsimony: Understanding, interpreting and explaining geosimulations via Massively Computer-Aided Modeling-Process	*Franck Varenne*	*86*
	Geostatistical simulation of space-time stochastic rainfall fields for uncertainty propagation in rainfall-runoff and urban drainage system modelling	*Jairo Arturo Torres Matallana*, Ulrich Leopold	*88*
	Fostering the use of methods for geosimulation models sensitivity analysis and validation	*Romain Reuillon*, Mathieu Leclaire, Juste Raimbault, Hélène Arduin, Paul Chapron, Guillaume Chérel, Etienne Delay, François Lavallée, Jonathan Passerat-Palmbach, Pierre Peigne, Julien Perret, Sébastien Rey-Coyrehourcq	*90*
	Coupling multi-agent system and game theory to model the emergence and the allometric growth of systems of cities	Cyrille Genre-Grandpierre, *Tania Jimenez*, Mickael Ferri	*91*
	The paradigm of a „Spatial Data Science", its methods and models for supporting the solution of some basic geographical problem types in a starting digital age	*Peter Mandl*	*93*

20:00 - 22:00	Restaurant l'Orangerie	**Dinner / Barbecue**

Saturday, 7th September

09:00 - 10:30	Salle des Fêtes	**Plenary Session: Keynote 2**		

		Title	**Keynote**	**Page**
		Uncovering hierarchies for multi-scalar analysis	*Elsa Arcaute*	*94*

10:30 - 11:00	Salle Foyer	**Coffee break**

11:00 - 12:30	**Parallel Sessions IV**		

	General Session: Segregation		
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Symphonie	Unpacking racial segregation in Brazilian cities: a case study of São Paulo and Rio de Janeiro	*Priscila dos Santos, Flavia Feitosa,* **Joana Barros***, Flavia Lisboa*	*95*
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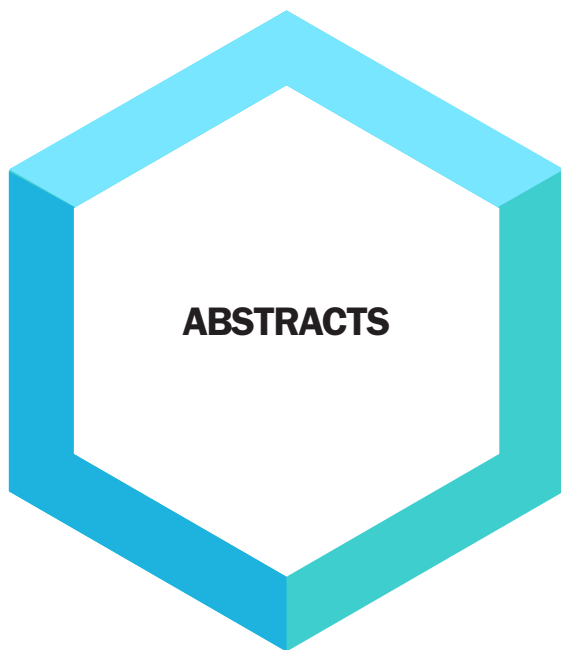
KEYNOTE 1

More LISA - univariate and multivariate extensions

Prof. Luc Anselin[1]
[1] University of Chicago

The concept of a Local Indicator of Spatial Association (LISA) has been around for more than 20 years and has seen many refinements since then. In this paper, three recent extensions are discussed that are focused on gaining insights into local clusters in a multivariate context. First is the generalization of the univariate local Geary statistic to multiple variables. Next is the operationalization of the concept of a local join count statistics, which readily lends itself to assessing bivariate and multivariate co-location patterns. Finally, the idea of a quantile LISA (QLISA) is suggested, as a special case of the local join count statistics. The quantile approach allows a sharper focus on co-location patterns of extreme observations, both univariate and multivariate. The methods are illustrated through their implementation in the GeoDa software, with examples from a study of socio-economic determinants of health in Chicago census tracts.

| I | # General Session: Housing Prices |

The valorisation of urban residential space. Questions and approaches for the quantitative geographer.

*Giovanni Fusco[1], **Alessandro Venerandi**[1]*
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Differences in the valorisation of urban residential space are an important component of urban micro-geography, imposing constraints on the kind of populations that can dwell in each area. This paper focuses on the valorisation of residential space as it emerges from market housing transactions.

Housing transactions prices are traditionally the target variable of hedonic models in urban economics. Prices are considered as data points explained by intrinsic (i.e. directly linked to the dwelling, independently of location) and extrinsic features (i.e. linked to the dwelling through its location). The main assumptions are the independence of regressors and the linearity of the relations. If linearity can be by-passed through non-linear transformations of regressors, these models still assume monotonicity between regressors and the target variable and substitutability among regressors. Hedonic regressions are specifically conceived to model the price formation of dwellings seen as commodities, whose ingredients are the regressors (whether intrinsic or extrinsic) adding up in the price.

This paper takes a different stance, linked to the way urban geographers approach the problem. We are interested in the valorisation of urban space and we use housing transaction prices to obtain a statistical description of the valorisation of spatial units. When observed statistically over space, dwelling standards, types, amenities and levels of upkeep are not intrinsic qualities of the commodity on the market. Rather, they become part of the social valorisation of space, which is the phenomenon to be explained. The paper proposes a new analytical approach and develops models of residential valorisation using only variables considered as extrinsic in hedonic models.

We selected the street segment as the natural unit of analysis of the valorisation of urban space. In studying the relationship between poverty and accessibility in Atlanta, Carpenter and Peponis (2010) already highlighted the interest of the street segment. The latter is also an essential morphological component of the physical city (Conzen 1960, Caniggia 2001) and is at the basis of the functioning of the city as a social system (Jacobs 1960; Hillier 1996; Porta 2006). Recent widespread diffusion of data has finally allowed analyses at this fine level of spatial granularity.

The street segment, with all the properties linked to its location in urban space, is seen as an ecosystem of residential functioning, for which the housing transactions are only practical sample measures. More specifically, we control for the heterogeneity of housing sizes and types in street segments and use the median of conveniently normalized transaction values as the target variable of our models.

Median valorisations of street segments are seen as a function of many locational properties in urban space. But the domain we want to model has no established theory like real-estate price formation in economic theory. Machine Learning (ML) offers undeniable advantages in modelling the relationship between street segment valorisation and locational properties. The greater freedom

in research hypotheses to be tested, the ability to deal with highly dimensional problems and the emphasis given to predictive power in the absence of a well-established theory seem particularly appropriate (Hofman 2017). At the same time, our modelling problem presents some specificities: we want to account for all possible spatial structure of valorisation in the city (significant spatial autocorrelations of model deviates must be avoided) and preserve the intelligibility of the model, which was straightforward in the hedonic approach and is often neglected in ML.

To satisfy these contradictory requirements, we propose a ML ensemble method based on Gradient Boosting, a topological version of Moran's test applied to model residuals, and SHAP, a recently developed algorithm that renders the outcomes of ML techniques human-interpretable (Lundberg 2017). To test such novel method, we implement it to study the relationship between street-level property values, obtained from 110.000 housing transactions on the French Riviera for the period 2008-2017, and more than 100 metrics quantifying aspects of urban form, functions, and landscape. Outcomes of such analysis not only show a moderately high predictive capacity (adjusted R-squared = 0.75), but also provide insightful explanations of the relationship between the metrics used and the street-based measure of property values on the French Riviera.

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KEYWORDS

Housing Market / Residential Space / Urban Morphometrics / Machine Learning / French Riviera

The dynamic impact of monetary policy on regional housing prices in the United States: Evidence based on factor-augmented vector autoregressions

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[1] WU Vienna University of Economics and Business, Austria / [2] Paris Lodron University of Salzburg, Austria

In this research, interest centers on regional differences in the response of housing prices to monetary policy shocks in the United States. The literature on this relationship is fairly limited. Previous studies generally rely on two competing approaches. The first uses structural models to analyze the relationship between monetary policy and housing prices (see, for example, Iacoviello and Minetti, 2003; Ungerer, 2015). Such models impose a priori restrictions on the coefficients. The major strength of this model-based approach is to provide a theoretically grounded answer to the question of interest. Its potential shortcoming, however, is that the answer is only as good as the model is adequately representing the relationships in the real world.

The second approach – labeled evidence-based – focuses more on the empirical evidence and relies less directly on economic theory. Researchers have commonly used vector autoregressive (VAR) models to measure the impact of monetary policy (see Baffoe-Bonnie, 1998; Fratantoni and Schuh, 2003; del Negro and Otrok, 2007; Jarocinski and Smets, 2008; Vargas-Silva, 2008; Beltratti and Morana, 2010; Moench and Ng, 2011). Such models allow the data rather than the researcher to specify the dynamic structure of the model, and provide a plausible assessment of the response of macroeconomic variables to monetary policy shocks without the need of a complete structural model of the economy.

In the tradition of the latter approach, this paper differs from previous literature in terms of both focus and methodology. With Fratantoni and Schuh (2003), we share the focus on regional differences in the response of housing prices, using metro- and micropolitan-level rather than state-level data. In terms of methodology, similar to Vargas-Silva (2008) and in contrast to Fratantoni and Schuh (2003) we use a factor-augmented vector autoregressive (FAVAR) model to explore regional housing price responses to a national monetary policy shock. The effects are measured by considering impulse responses of regions to the shock that is normalized to yield a 25 basis-points decline in the one-year government bond rate.

Differently from Vargas-Silva (2008) and Moench and Ng (2011), we employ a full Bayesian approach that is based on shrinkage priors for several parts of the parameter space. In particular, we make use of Markov Chain Monte Carlo (MCMC) methods to estimate the model parameters and the latent factors simultaneously. A full Bayesian approach has the advantage of directly controlling for uncertainty surrounding the latent factors and the model parameters. We follow Gertler and Karadi (2015) to identify monetary policy shocks by using high-frequency surprises around policy announcements as external instruments.

The paper provides a rich picture on how an expansionary monetary policy shock affects housing prices in 417 US metropolitan and micropolitan regions over a time horizon of 72 months after impact. The findings reveal regional housing price effects to vary substantially over space, with size and modest sign differences among the regions. Some few regions in Utah, New Mexico, Kansas, Oklahoma, Mississippi and West Virginia show no significant impact or even slightly negative cumulative responses. In most regions, however, the cumulative responses of housing prices are positive, in line with theory. This regional heterogeneity may have different reasons, with heterogeneous regional housing markets playing a major role. The largest positive effects are

observed in states on both the East and West Coasts, notably in Miami-Fort Lauderdale in Florida and Riverside-Sun Bernardino-Ontario in California, but also in Las Vegas in Nevada. In general, housing impulse responses tend to be similar within states and adjacent regions in neighboring states, evidenced by a high degree of spatial autocorrelation.

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KEYWORDS

Regional housing prices / macroeconomic aggregates / factor-augmented VAR / Bayesian estimation / high frequency identification

Why real-estate matters in spatially analyzing inequalities of wealth and assets. Interpreting Inequalities Induced by Price Inflation in France

Renaud Le Goix[1], *Laure Casanova-Enault[2], Guilhem Boulay[2], Loïc Bonneval[3], Thibault Le Corre[1], Julien Migozzi[4], William Kutz[5], Ronan Ysebaert[6]*
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The paper investigates socio-spatial inequalities induced by home price inflation. The novelty of the research is to provide an empirically-grounded theorization of socio-spatial inequalities derived through housing-finance regimes, while bridging political economy of markets, and spatial data analysis of inequalities. Since the mid-1990s, housing prices have increased faster than the income of buyers, thus an important driver of inequalities and vulnerability of indebted households. The article aims to demonstrate how the flow of investments and residential housing production are spatially predicated upon intensifying the financial stratification of residential markets from the national to neighborhood scale, and presents results of a research conducted on French housing markets. We do this by linking the wealth and indebtedness of households to the broader structuration of local housing markets.

Some salient dynamics have been a continuous increase in property prices and an increase of homeownership, analyzed as resilient markets. We assume this situation derives from a shift towards an asset-based welfare model, yielding a regime linking ownership, credit affordability and house price, subsidized by the State and local governments. Indeed since the financial crisis, such considerations have been increasingly couched within broader political economic, institutional, and regulatory approaches to housing studies in an endeavor to better decipher and explain the crisis and its aftermath. Behavioral considerations regarding homeownership and its effects, as a result, have been less pronounced in the debate. Our objective therefore is to integrate these more localized considerations of housing affordability and ownership back into the broader debate as a means to synthesize diverse perspectives and mechanisms through which the housing market shapes inequality in cities.

Specifically, we analyze the evolution of social inequality in the context of housing financialization tendencies. We interpret this relationship as a feedback loop : Prospective homeowners employ diverse forms of purchasing power defined by their income level, credit score, current assets and embedded knowledge of market opportunities (1). Buyers and sellers operate on a market that spatially structures their differential inclusion in the market (2). Housing prices are therefore unstable and contingent upon the market's continuous restratification within and across neighborhoods. This stems not only from the effects of urban development cycles, but also from different policy decisions taken in regard to housing supply (public incentives and restrictions) (3), which influence the local conditions through which household wealth is accumulated or lost (4). This, in turn, shapes the structure the property's value in the market, where supply and demand interface (5) through the purchasing power of households (1).

Our theoretical framework advances this concern by bridging datasets that have yet been analyzed and visualized together at the local scale in France. Specifically, we examine conventional data s.a. census and fiscal datafiles for income on the one hand and unconventional datasets s.a. transaction records on the other. Transaction data are often used for econometrics and in the geo-visualization

of residential markets structures. To do so, we address challenges to harmonizing the temporal and spatial variability across the datasets that are necessary to accurately depict changes in local residential markets.

Elaborating on research conducted in Paris, Lyon and Avignon in the WIsDHoM ANR project, we conduct a multi-scalar approach, bridging State policies, local governments' policies and transactions by households. We also rely on spatial data describing 20 years of geotagged transactions (Chamber of the notaries), in a spatially integrated approach to measure spatial inequalities (price, income, unequal market access). Our main results show increased inequalities on property markets, and articulates neighborhood price dynamics, price-to-income ratios, financial and real-estate assets, rate of poverty of homeowners, for instance, i.e. variables that inform the feedback loop.

KEYWORDS

inequalities / housing markets / housing prices / financialization / wealth inequality / ownership / asset-based welfare / geospatial data / spatial analysis

Effect of urban parks on real estate prices over time: the example of Rouen (1828-1843)

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Urban amenities, including green spaces, impact real estate prices and induce socio-spatial inequalities (Brueckner et al., 1999). In addition, urban green spaces are increasingly under pressure by urban infill and compaction policies (Haaland and Konijnendijk , 2015), reducing the opportunity to live close by. Greening policies tend to tackle these issues, by allocating green infrastructures where they lack the most, but these policies often lead to green gentrification (Wolch et al., 2014). Considering the social benefits and injustice of urban green space requires understanding the interaction between UGS accessibility and households' sorting in cities, which are by their very nature spatial and dynamic. However, knowledge gaps exist about the spatial distribution of UGS and its interaction with household's residential location in long-term. This presentation aims at studying the effect of UGS proximity on real estate prices(1828-1843) in Rouen(France).

We use the land charge register, which have been introduced systematically in France since 1807. Established by Napoleon I, the land register is composed of a parcel map and a register, collecting information on the parcels (surface area, building area, taxable income, number of taxable openings, private garden ownership) and on their successive owners (occupation, address) for the entire French territory (Schoonbaert, 2010). Land charge registers are the only historical sources that allow studying the real estate prices distribution within cities through the 19th century in France. However, their manipulation is quite difficult, especially regarding the geolocalisation of data. Indeed, the parcel map originally associated with the land charge register has not been updated in Rouen before 1972. To locate the housing parcels, one needs to use city maps and in consequences one cannot retrieve the precise location of house numbers as only street names are reported. Information about the city morphology and main amenities may also derived from these maps.

Building on this historical dataset, we propose a series of hedonic models to assess the effect of the proximity of UGS on housing values at two dates (1828, 1843) and compare its evolution. We control for the spatial autocorrelation of the variables and the non-stationarity of the relation through space by using a geographically weighted regression model (Brundson et al., 1996).

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KEYWORDS

hedonic price model / urban parks / GWR / historical perspective

I Special Session: Big data for Geocomputation (1/2)

Retail landscapes emerging from big data network analysis. The retail geography in Belgium through community detection

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In the tradition of Christaller's central place theory, a share of studies conducted over the past decades determine catchment areas around predefined central places. These studies start with building a hierarchy of retail centers based on supply indicators, and consequently delineate catchment areas around the identified urban centers based on robust consumer flows. Nowadays consumer patterns are far more complex and fragmented than they used to be in the 20th century: instead of constant flows to the nearby center, consumers shop around in nearby and further located (sub)centers.

We use network analysis in order to delineate catchment areas without predefining central places. In a first step, a community detection algorithm is applied on data gathered by a comprehensive questionnaire about actual consumer flows for periodical goods in Belgium (Flanders). Via this technique we are able to present a new geography of retail in Belgium. In a second step, we check the correlation between these results and previous network analyses in the same study area, to test the variance of this pattern over different types of flows (Beckers et al., 2017, Verhetsel et al., 2018).

The results prove the usefulness of community detection techniques for delineating catchment areas. Although the traditional central places emerge from the data, showing the inertia of retail activities, interesting new phenomena in the retail landscape appear.

KEYWORDS

retail geography / community detection / Belgium

Twitter-based Public transport distributed sensors: the case of the train line between Metz and Luxembourg

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Introduction

In 1985, Schengen Agreement has abolished border control in Europe and particularly in border countries of Luxembourg. Since then, no single investor, organizing authority or cross-border operator has emerged on this area, especially on the French-Luxembourg border area. Although cross-border transportation services have been developed, many components of public transport remain linked to each country; i.e. ticketing and pricing are still different in each neighboring country. In addition, infrastructures on both sides of the border are regularly facing problems with strong implications for cross-border commuters. Border services are not synchronized with the rest of the network and in case of delays, waiting times and the duration of the trips are lengthened.

Objectively reporting this situation is a complex task. Public transport disruptions data are published in different formats in which cross-border lines are poorly identified and schematized, messages describe the situation in only a few words, and some transport operators even stop the publications for long delays. Daily mobility surveys administrated by different authorities do not reflect this situation. They mainly focus on trips made by individuals on a typical day, usually a day without disruption.

The main idea of this communication is that social networks can fill this lack of information. Twitter was selected for this experiment and is considered here as borderless communication service that allows people to express their opinions and moods in short texts. Therefore, our purpose is to use tweets as measures to objectify the limitations that cross-border public transport users face. So, we would like to test if Twitter spread public transport information, on a regular basis and if it constitutes a source with enough diversity of information.

Methods

A protocol was set up to capture Twitter data, build a consistent corpus and provide a framework for analyzing exchanged messages.

Since February 2014, the Twitter account @TER_Metz_Lux tells the daily life of users of the Metz-Luxembourg line through comments, opinions and moods. This account (with 4,322 followers) is a reference for the other Twitter users sharing and looking for information on this line. We use this account as a filter to collect users' tweets. Thus, from 1st January 2017 through 31st December 2018, 27,840 tweets are collected. This dataset has been cleaned up to remove duplicates, and all the retweets have been replaced by the original tweets that caused the interaction. For each tweet, the dataset consists of the tweet ID, its date of publication, the user's ID and the associated text. This text has been cleaned up by removing symbols, emoticons, URLs and other special characters. A semantic analysis made it possible then to extract a list of terms in order to obtain a table describing the number of times each term appears in each tweet.

We estimate successively two models in order to test our hypothesis. A Latent Dirichlet Allocation (Blei et alii, 2003) model intend to classify each tweet in several topics. This allows us to build a statistic of the size and the dynamic for each topic. A chronogram shows topics evolution over 2

years. Then, a population model (Otis et alii, 1978) identifies the population of users. Again, we define an indicator of the population size and its evolution over 2 years.

Results

A population of about 500 users shares it opinions and moods about public transport on Twitter. It constitutes a distributed network of sensors feeding on a regular basis a single Twitter account. The most discussed themes are essentially related to disruptions. They discuss mainly about the causes (flooding, transhumance), the consequences (delays, cancellations, bus replacements), as well as possibilities of reorganizing their trips (carpooling). These tweets describe in real time the experiences of cross-border workers and their uses of public transport. They help better understanding the disruptions of the public transport system. Beyond these comments, a local culture centered on cross-border mobility emerges from these interactions.

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KEYWORDS

Cross-border / Public transport / Daily mobility / Twitter / Sensor network

Using real time positioning of trucks to explore logistic flows in Belgium

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With the advent of big-data and the multiplication of sensors, new huge non-conventional datasets are now available, questioning our transport geography knowledge. Paired up with new algorithms, these data renew the way we delineate interaction patterns embedded in space.

Since April 1st 2016, a GPS tracker is mandatory within each truck circulating in Belgium, for kilometer taxes. Every 30 seconds, this tracker collects the position of the truck as well as some other information such as speed or direction. This contribution uses a one week exhaustive database containing the totality of trucks circulating in Belgium, in order to understand logistic transport fluxes within the country. First, the origin and the destination of each truck trip are determined within almost 270 million of GPS points, dealing with the construction of an O-D matrix. Simultaneously high care is put on the cleaning of the data, leading to the creation of a useful framework to accurately correct, manage and analyze GPS traces revealed by the circulation of trucks. Furthermore, several criteria (nationality and weight of the truck, or border crossing) are collected/computed in order to categorize trucks and hence create different OD matrices that help us to simplify the complexity of the movements in space and time. Second, a community detection algorithm (the Louvain Method) is applied on the OD matrices in order to detect communities of places that are highly connected in terms of trips. Each partition in communities (international/national, by weight category or by nationality of the trailer) are described in order to evaluate how the characteristics of the trucks influence the trip. Do the various communities correspond to Belgian urban realities and how far do truck trips hinder the urban environment?

The robustness of the results in terms of data and methods are in-depth discussed. Cleaning a raw dataset is an important step that cannot be avoided (and Big-Data do not escape to this important rule): more than 20% of the initial information was erased during this process, hence corresponding to sporadic events or issues linked with the material, the sample or wrong human actions. Results show different spatial realities embedded into a complex network organization. Economical activities and urban areas do not have the same influence on the attractiveness on the different categories of trucks within the country, and tracking the trucks add an interesting viewpoint to more classical urban and transportation models. This contribution illustrates the usefulness but also the limits of this Big-dataset to model flows between places and to depict the urban/transport complexity, leading to open new avenues for further research.

KEYWORDS

Big-Data / GPS tracking / Community detection / logistics

FRIDAY | 12:00 | Salle des Fêtes

Exploring Administrative Data for use in City Specific Geodemographic Classifications in the UK

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Recent decades have seen a dramatic increase in the availability, consumption and application of data of all kinds, including spatial data. Enabled by improvements in infrastructure and management tools, it is now easier than ever before to collect, store and manipulate data and to translate it into crucial knowledge and insight in a variety of contexts. This has given rise to a range of new opportunities for developing geocomputational processes, including paving the way for a new phase in the development of geodemographic classification systems.

Offering a framework for conveniently summarising small-area populations, geodemographic classifications have been popular in both the public and private sectors to enable increased understanding of consumers and local residents and for informing policy development. As the UK government and local administrations seek a general shift in decision making processes towards data-led techniques to reflect trends which have been seen in the private sector, the interest in the application of geodemographics for developing better public policy has in turn increased, which has resulted in a renewed focus on the development of the classification systems being employed.

Though traditionally generated from census data, the commercial sector has been quick to respond to the recent data-rich landscape by including new datasets into the build of their classifications, incorporating a broader range of key population features and leading to timelier and increasingly granular results. Conversely, though the public sector generates and stores vast amounts of varied data of its own which could hold similar potential, these have not yet been taken advantage of and translated into improvements for public geodemographic classifications.

However, there is increasing apprehension relating to the reliance on developments in commercial products in this context. The black-box nature of these classification systems and the unknown provenance of the data used in their build are among the concerns most frequently cited. Additionally, caution is advised when employing products primarily built to assist in commercial settings, such as informing consumer marketing campaigns where the intentions and thus accepted expectations of the results might differ to those required in supporting public policy developments. Moreover, broader extensions to the traditional national level methodologies currently used in the development of existing classifications has been widely recommended. Suggestions are made throughout the recent literature endorsing a more locally focused approach, developing place-specific classifications, is required due to the apparent masking of local heterogeneity occurring in the results derived at the current extent.

This research explores the potential scope for harnessing and employing available administrative data for generating an updated public classification, whilst considering the reasons which may have obstructed such progress in the past. Forming part of a wider research project to develop a place-specific classification, this study will focus on the UK city of Leeds as a case study, following earlier analysis identifying the city as a potential benefiter of such a methodological shift. Employing the openly available Output Area Classification (OAC) as a foundation, which is derived from the decennial census, this study will identify local administrative data which might serve to replace or extend some of these census variables currently employed. Then initial focus will be on housing

indicators (one of five domains in the OAC classification). Working in collaboration with Leeds City Council, data available from council tax information, housing licences and tenancy information for council properties has been gathered and will be considered with view to improving utility of an open source geodemographic classification for city specific purpose.

KEYWORDS

Geodemographic classifications / Administrative data / Public policy development

Unexpected Flexibility of the Israeli Public Transport Users

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Public Transit (PT) networks do not change for years while travelers' behavior changes over space, following dynamics of the urban land-uses and in time, following the changes in travelers' habits and introduction of new modes. The discrepancy between PT network's supply and travelers demand can result in the bifurcation of travelers' mode choice. Travelers with no access to private cars become captives of PT, regardless of the PT's level-of-service, while the rest use the car almost exclusively. This is the essence of the "PT is for commuters" hypothesis.

To verify this hypothesis, we analyze Israeli PT smartcard transactions of boarding records collected October - November 2017, 4 sequential weeks and November 2018, 4 additional sequential weeks that served as a control. There were no holidays in both periods. The weekly number of boardings in 2017 recorded by smartcard transactions was 14M and 15.5M in 2018, 83% and 87% of all paid trips, respectively.

Our analysis manifests that Israeli travelers' behavior does not comply with the "PT is for commuters" hypothesis. The opposite is true. Israeli PT users are quite flexible in their mode choice:
- 26-27% of smartcard owners board once a day only. This high share cannot be explained by possible errors in data or irregularities of the users' behavior, as occasional purchasing of a paper ticket, walking on one of the travel legs, or erroneous work of the smartcard registering device.
- The share of users who use PT 1 day is 27% and of those who use PT 2 days per week is 17%, 44% altogether. The share of users who would comply with the "PT is for commuters" hypothesis and use PT 3 - 5 days is lower, only 41%.
- Half of the PT users board, depending on their profile - standard, senior, student, pupil, less than 14-15 times during 20 working days.
- Travelers repeatedly use stops that do not belong to their activity centers. While 50% of boardings are done by the majority of travelers at 2-3 regular stops and 75% of the boarding are done at 4 -5 stops, the residual 25% of boardings are done from stops that comprise at least 50% of all stops used during 20 working days of a month.

The above estimates are characteristic for the Israeli data as a whole and repeat, with some variation, for four metropolitan areas (Tel Aviv, Beer Sheba, Haifa, Jerusalem), groups of the PT users (Adult, Senior, Pupils, Student, etc.) and for different PT operators. We assert that the explanation of this flexible behavior of the PT users lays in the low Level of Service (LOS) of Israeli PT that is essentially below the European standards. The average velocity in major metropolitan areas in Israel is ~15kph, twice lower than in the EU and the priority bus lane length per capita is only 14m that is, about 20 times lower! These constrained conditions may be a reason of the highly adaptive behavior of the Israeli PT users that plan each trip anew. The ability to adapt to the changing transportation circumstances can enforce the adoption of the PT network in case the LOS will be improved and attract the users for whom PT is a marginal mode (25% of the users at least). Israeli public transport planners must activate this positive feedback by extending priority bus lanes.

KEYWORDS

Urban networks / Big Data / Public transport / Smartcard / Travelers behavior

I

Special Session: Mobilities and Health (1/2)

Location, location, location (and health): opportunities, challenges and an introduction to mGeoHealth

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Health and medical geography approaches have normally focused on residence-based conceptualisations as an approximation for multiple types of exposure. This is a 'static' place or point in time, usually a home address or a fixed administrative boundary, perhaps measured once every several years. However, we now are able to more accurately measure, the 'true' exposure, which can be captured 'dynamically'; people moving between many places, places with differing environments and characteristics. This changes the quantum of data involved, the processing required and complexity of the challenges when using established statistical and geographical methods. From the literature, it is well recognised that place can be an important influence on health, either positive or negative; where we live matters for our health.

New methods and technologies, such as real-time personal mobile location data, afford an opportunity for new(er) approaches, with richer, large, fine-grained spatial data sources. However, these new data sources and accompanying methods bring with them a variety of new challenges, biases and opportunities. We propose an mGeoHealth, that is, the use of location-based applications for smart devices (e.g. smartphones and smart watches) in health. This means that mGeoHealth does not necessarily focus on adopting completely new technologies, but it aims to utilise readily available of smart devices, that are subsequently enhanced by suitable software or applications.

We present an mGeoHealth that sits at the intersection of the fields of mHealth (mobile health) and Health and Medical Geography (GeoHealth). As such it is a combination of two distinct, yet relatively unconnected domains. A focus on mGeoHealth is timely as it is a burgeoning area of specialised endeavour which is often missed broad(er) fields of mHealth or Health and Medical Geography. This new sub-discpline can draw on a rich heritage of geographical endeavour, whilst adapting to new(er) methods of data collection and associated methods. To demonstrate our approach, we use a series of real-life examples of data collections and associated analytics for discussion. We are particularly focused on mobility and movement as a source of exposure to environments (e.g. physical, social and so on) and also how mobility could exacerbate or ameliorate existing inequalities in health. This could be as diverse as exposure to air pollution or social connections. We conclude by adding a note of caution about the possibility of approaches based on technology itself, to further alter health inequality. We further demonstrate some of the challenges associated with research in the field of mGeoHealth, on a set of local and international studies in different settings and with various focus groups – from young adults that are familiar and component with technology to the elderly population with more limited technological skills.

KEYWORDS

health / mobility / mGeoHealth / inequalities / Smartphone / GPS

A research framework incorporating mobility in dietary behavior research and 2 Canadian dietary behavior research projects

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Maintaining a healthy diet is one of the most crucial factors contributing to the health of an individual [1]. It involves a series of everyday activities such as purchasing, preparing, cooking, and eating, and researchers across many disciplines have pursued work that seeks to better understand these various components. In the realm of geography and urban planning, researchers have primarily focused on spatial accessibility to various types of food retailers and the associations between accessibility measures and relevant food purchasing behaviors. While this body of work has helped clarify the role of food accessibility in consumption, the nutritional quality of diets, and downstream health effects, few studies have addressed when, where, with whom, and how dietary behaviors are weaved into the fabrics of everyday life using the theoretical framework of time geography. Accounting for movement allows for the inclusion of exposures beyond the residence and accounting for the temporal dimension facilitates the measurement of the length of exposure duration in places, which may alleviate the Uncertain Geographic Context Problem (UGCoP) [2]. Additionally, time geographic theory provides a framework for accounting temporal constraints and the complementary space-time trajectories of organized groups of people. Insufficient time budgets may limit people's access to food-related amenities and participation in healthy dietary activities. To this point, only a few studies unravel occurrences of dietary behaviors from the scope of household given the rich dynamics of chore allocation.

To address these gaps, we present two research projects – the Canada Food Study (CFS) and the Food Activities, Socioeconomics, Time-use, and Transportation (FASTT) Study – that use a novel research framework in which human mobility and time use play critical roles in dietary behaviours. The time use of individuals is emphasized because it provides an opportunity for:
·   measuring the length of exposure to food retail opportunities,
·   deriving a time budget allocated to food-related activities and trips and,
·   accounting for how activities unrelated to food may impact time spent on food-related behaviours.

Beyond the spatial and temporal dimensions, socioeconomic characteristics, demographics, and family environment are included to provide further context.

The first case we will present comes from the CFS, a multi-year study led by Dr. David Hammond from the University of Waterloo and it involves a large number of investigators across Canadian institutions. The CFS surveyed the dietary behaviors and health conditions of thousands of young adults (16-30 years old) from 5 Canadian cities: Toronto, Montreal, Halifax, Edmonton, and Vancouver. A subsample of the study population took part in a supplementary GPS data collection for 7 consecutive days. We will present results that show that the "dosage" (as a function of time) of spatial exposure can be used to provide more convincing evidence of the associations between exposure and food purchasing behaviors.

The second case to be presented includes preliminary results from the FASTT Study, which was conducted in March of 2019, in three neighborhoods with various levels of access to food retail outlets and public transit in Toronto. Data from this study includes dietary, health, and socioeconomic variables, 7 days of GPS trajectories, and time use diaries. Additionally, the FASTT Study sample focused on parents with children in the household, and sought to include all adults in a household.

The linkage of time use diaries and GPS trajectories will provide rich information about when, where, with whom, and how dietary behaviors occurred. Additionally, new perspectives will be discussed on how coupled adults coordinate food purchasing and consumption, given other spatial and temporal constraints.

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KEYWORDS

Mobility / Dietary behaviors / Canada Food Study (CFS) / Food Activities Socioeconomics Time and Transportation (FASTT) Study

Challenges in Assessing Mobility using GPS Data for Healthy Aging

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Mobility and activity levels are important predictors for healthy aging and continued research is needed to determine how older adult health can be maintained in urban settings. Individual sensors such as global positioning systems (GPS), accelerometers, and voice recorders, available in lightweight devices and smartphones, are being used with increasing spatial and temporal resolution of data to assess human mobility and activity. The data collected from these devices allow for objective and unobtrusive mobility studies with high external validity over longer time periods than are possible with conventional methods. Initial findings demonstrate that some sensor-derived mobility indicators (e.g., life space) have good correspondence with self-reports, though others (e.g., active vs. passive modes of transport) display inconsistencies. Further, various sensor-derived mobility indicators can be used to characterize the multidimensional nature of individuals' (daily) mobility, and our conceptual framework for classifying mobility indicators can potentially guide how to select mobility indicators depending on what aspect of individual mobility a researcher focuses on.

As these new devices become more prevalent, the associated data present a number of challenges and opportunities for ongoing mobility research. There are well-known problems associated with GPS signal outage, and sparse data must be imputed to improve data quality and consistency when routine activities and geographic contexts are a specific focus. Further, the influence of place on mobility must be considered in holistic examinations of the associations between mobility, health, and well-being. With aging populations in particular, we must consider that reduced activity outside the home influences sensor data quality, that meaningful physical activity might take place indoors without associated GPS signal quality, and that visited places, associated activities, and social interactions may impact healthy aging through factors not measured by sensors (e.g., cognition).

In consideration of these challenges and opportunities, we present a framework that outlines how particular challenges associated with individual sensor data might be overcome, in the interest of exploiting the informational opportunities associated with them. In particular, we highlight data fusion capabilities and mining methods to inform GPS data imputation, automated place detection, and context-aware spatiotemporal trajectories. While aimed at reducing uncertainty, methodological approaches for imputing missing or distorted GPS data can introduce error based on differences in real-life movement. Any error at the data processing phase may be propagated when subsequent measures, such as life space or spatiotemporal exposure, are computed and such error may be especially prevalent among populations where high rates of signal loss are expected. In terms of geographic context, sensors provide rich data on movement and activity, but are sparse in terms of situational attributes and place. Longitudinal GPS data and rich attributes collected from momentary survey via mobile phone may help infer missing places and reconstruct context-aware spatiotemporal trajectories. Finally, factors related to health and well-being, but not directly measured by sensors, must be accounted for by comprehensive examinations that account for additional influences such as personality and cognition.

KEYWORDS

human mobility / physical activity / healthy aging / health and well-being / sensor data analytics / mobility indicator / data fusion and imputation / automated place detection / context-aware spatiotemporal trajectories / real-life assessment / multi-source data

Neighborhood effects on sedentary behaviors at locations and during trips: a GPS-based activity space approach

Camille Perchoux[1], Ruben Brondeel[2], Yan Kestens[3], Basile Chaix[4], Philippe Gerber[1]
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Objective

Sedentary behavior (i.e. spending too much time sitting) has emerged as one of the leading cause of premature death, cardio-metabolic diseases and some cancers. Evidence on the influence of the built environment characteristics on sedentary behaviors remains unclear, due to the limited number of studies and the often-contradictory results. Multiple studies have pointed out the major limitation in the investigation of sedentary behaviors correlates: the use of self-reported proxies of sedentary time (e.g. TV viewing), the scarce consideration of the plurality of sedentary behaviors (i.e. transport, leisure, work and domestic), and the inaccurate modeling of people-place interactions and related environmental exposure. This study investigates the relationships between residential and GPS-based activity space measures of environmental exposure with accelerometer-based sedentary behaviors measured in total sedentary time, sedentary time at the residence, at locations and during trips. One underlying hypothesis is that the environmental correlates of sedentary behaviors vary depending on whether sedentary time is spend at location (including the place of residence) or on the move (during trips); and whether it is measured in bouts or not.

Methods

This study is part of the international CURHA (Contrasted Urban contexts and Healthy Ageing) project, and encompasses a cohort of 470 older adults residing in Luxembourg. Information related to demographics and health status were collected using standard questionnaires. Participants worn a GPS and a tri-axial accelerometer for 7 days. Multiple outcomes were considered to characterize sedentary behaviors: total sedentary time, sedentary time at the residence, at locations and during trips; each computed as the sum of minutes spent sedentary per day and prolonged sedentary time (bouts of 20 minutes and up). Environmental exposure was measured in the participants' residential neighborhood and in their activity space assessed from GPS data based on a previously validated algorithm. Measures include exposure to green and blue spaces, motorized transport infrastructure, density and diversity of amenities, and indicators of walkability and bikability. Associations between environment and sedentary outcomes were examined using linear and negative binomial multilevel models, accounting for demographics and confounders.

Results

Participants spent a mean time of 8h 13 min sedentary per day, 83% of that sedentary time occurred at locations including 72% at home, and 13 % during trips. Accessibility to car parking, outdoors recreational amenities and the length of public stairs in the neighborhood were associated with total sedentary time per day, during trips, and at the residence. Associations between sedentary time and environmental characteristics varied whether considering total minutes or prolonged bouts of sedentary behaviors.

KEYWORDS

sedentary behaviors / activity space / neighborhood effects / daily mobility

Identifying activity spaces from geo-referenced Twitter data: Superstorm Sandy, mobility patterns, and emotions in New York City

Ivor Mardesic[1], Martin Sykora[2], Sarah Lowe[3], Suzanne Elayan[2], Emiliano Albanese[4], Milo Puhan[1], Oliver Gruebner[1]
[1]University of Zurich, Switzerland / [2]Loughborough University, United Kingdom / [3]Montclair State University, United States / [4]Università della Svizzera italiana, Switzerland

Background

Disasters have substantial consequences for population mental health depending on local socio-ecological factors. However, we do not know much about population mental health outcomes at place of residence and how these compare to outcomes at other locations such as work or study places in the context of disaster. Furthermore, little is known about how outcomes differ across time, that is, before, during, or after disaster. The wealth of georeferenced social media data represents a new and exciting potential source of data for mental health research in this context. Smartphone use and online presence are becoming more and more ubiquitous and new insights into human spatial behavior and respective mental health outcomes can be gained from these data. With social media data such as from Twitter, it is the active Twitter user who generates the information that can be used in an ecological momentary assessment of emotions over time. This study aims to 1) identify activity spaces of Twitter users, to 2) extract basic emotions for activity spaces before, during, and after disaster, and to 3) detect differences in emotions across activity spaces and disaster periods.

Data and methods

Georeferenced and archived data from Twitter users have been obtained for N=80,987 individual users over the time frame of approximately six weeks (10 October to 18 November 2012) during Superstorm Sandy in New York City. We applied 'Density-based spatial clustering of applications with noise' (DBSCAN) to identify activity spaces of users over time. We then analyzed the data with 'Extracting the Meaning of Terse Information in a Geo-Visualisation of Emotion' (EMOTIVE) to identify specific emotions in single tweets for these users and across activity spaces and time frames. Finally, we used chi-square tests to identify differences in specific emotions across individual Twitter users' activity spaces and disaster periods.

Results and discussions

Activity spaces could be found for 1,504 Twitter users that had at least 100 tweets in the given time period. For these users, we identified at least two places of significance, that is, place of residence and place of work or study. Furthermore, we identified eight basic emotions, that is, anger, confusion, disgust, fear, happiness, sadness, surprise, and shame from these data across activity spaces before, during, and after Superstorm Sandy. In addition, we identified significant differences in specific emotions at resident locations as compared to other locations across disaster periods.

Conclusions

We could show that activity spaces and emotions can be identified from geo-referenced Twitter data. Furthermore, individual users' emotions were significantly different from each other depending on the place of significance to individual users and disaster periods. The approach used here can be applied also to other cities and countries with comparable settings worldwide to potentially identify mental health needs in the context of disaster.

KEYWORDS

II General Session: Spatial Analysis (1/3)

FRIDAY | 14:30 | Symphonie

Spatial Predicition with Categorical Response Variables

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There are occasions when it is desired to predict an object's membership of a particular discrete group. When the response variable takes on only two values, say 0 and 1, the analyst may choose logistic regression. Logistic regression may also be used with a multinomial response variable.

In discriminant function analysis the extraction of discriminant functions from the independent variables are used to generate probabilities of membership of the groups in question for each observation. If there are k groups in the dataset, indexed by the dependent variable, the goal of the technique is to extract k discriminant functions. Linear and quadratic functions exist. An observation is assigned to group j if the value for the discriminant function for the group is the smallest.

The reliability of the classification can be explored in a number of ways. If a correspondence or confusion matrix is generated by crosstabulating the observed classes (rows) with the predicted classes (columns) the proportion of correctly classified observations is the ratio of the trace of the matrix to the total number of observations. This ratio is also known as the portmanteau accuracy or user's accuracy. A slightly different measure of the reliability is provided by the producer's accuracy – the ratio of the number of correctly classified objects in each class to the total number of objects in that predicted class. This is sometimes known as kappa.

The output from a geographically weighted version of discriminant analysis (GWDA) includes a vector of the assignments after the corresponding rule has been applied. The values of the discriminant functions for each group in the observed data are also reported for each observation. These can be converted to the posterior probabilities. With the posterior probabilities we can then compute the relative entropy of the probabilities.

There are a series of mapping choices – we can map the assigned group, perhaps with a symbol to indicate whether the assignment has been correct or not. Mapping the probability associated with the assignment shows us where we can be more, or less, sure of the prediction. An observation which is misclassified, but has a high probability, might be regarded as an outlier, and worthy of further investigation. Mapping the spatial variation in the entropies of the posterior probabilities can reveal where there is ambiguity in the choice of the predicted class. If the entropy is low, then there is less ambiguity in the assignment than if the entropy is high (the entropy will be highest is the posterior probabilities are equal). Again, areas of high entropy might be worthy of further investigation. We use these methods outlined above to predict land cover classes in the FAO 2013 global land cover (GLC) map.

Following the practice with other geographically weighted approaches, analysis begins with suitable data exploration. Following this we proceed by fitting global models, and examining the various accuracy measures. As with the local models, mapping the spatial variation in the posterior probability of the winning class, and the entropy of the posteriors can be revealing.

In each case the models are fitted to the training dataset, and the accuracy and mapping applied to the data from the validation set. The GWDA analysis proceeds along similar lines. The bandwidth is calibrated to maximise the portmanteau accuracy using the training data, and then the predictions of the posterior probabilities are carried out using the validation data.

Whilst the global predictive behaviour is satisfying, the local predictive capability is slightly higher. Part of the improvement might be due the inclusion of the spatial effects in the model. Not all groups well predicted. We may also map the variation in uncertainty by comparing the global and local patterns of classification success through the geographically weighted portmanteau accuracy and kappa.

GWDA does provide some interesting challenges in visualisation, but there are plenty of possibilities and challenges. Examination of the discriminant function loadings, a future development, might allow us to understand which variables are locally influencing misclassification.

KEYWORDS

geographically weighted discriminant analysis / spatial prediction / land classes

Enriching Exploratory Spatial Data Analysis with modern computer tools

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After decades of an overwhelming GIS methodological approach to geographical data, recent data deluge led the way toward a new direction in geographical data analysis. It's true for "big data" as well as for the massive and heterogeneous datasets published as part of the open data movement. This renewal of geodata analysis can be referred as "Geographic Data Science" (Arribas-Bel and Reades, 2018 ; Singleton and Arribas-Bel, 2019), while others prefer to use an older term like "GeoComputation" (originally forged by Openshaw et See, 2003 and redefined by Lovelace et al., 2019). In those recent publications, authors point out that these new approaches could be relevant to "infuse new developments in the area of infrastructure to support Exploratory Spatial Data Analysis (ESDA)" (Singleton and Arribas-Bel, op. cit., p. 8).

Simultaneously, the technical tools dedicated to data (spatial or not)analysis and visualisation keep developing and become more and more user-friendly, requiring less and less technical and computer science background.
This makes it easier nowadays to grasp for human geographers. Such tools can be stand-alone software promoting new ways of representing and analysing data, such as CARTO or Deck.gl. It can also rely on new "software ecosystems" built around computer programming languages such as javascript, Python or R. Such ecosystems together enable the pre-processing, the statistical and spatial analysis and the (geo)visualisation of large spatial data by relying on a galaxy of libraries, packages and external software bindings.
This vastly used ecosystem of data analysis tools builds upon classical methods that can be translated into these software. The example of PySal (Rey and Anselin, 2010) Python library that ported a part of the methods of GeoDa (Anselin et al., 2006) illustrates this aspect

These software ecosystems are mostly agnostic to the data source: they are able to connect to most of the modern sources of data, from basic text files to distributed High Performance Computing nodes, passing through traditional relational DBMS.
While new tools dedicated to data analysis emerge, more and more data storage and organisation solutions appears frequently. The recent "column-oriented DBMS" , especially, allow the querying of large quantities of data in an extremely fast way, and are now usable even on standard computers, without requiring hours of pre-processing.

We defend that the current resurgence of geographic data analysis – based on data that are together more massive, more heterogeneous but also more accessible – can be greatly eased by the use of renewed ESDA Such ESDA could rely on data stored on modern DBMS that would be queried from data analysis computer languages and libraries.

The presentation will focus on diverse ways to leverage the use of such new technologies, enabling a renewed vision of ESDA applied to larger sources of data. This communication is strongly rooted in the intersection of technics and methodology. The demonstration will be based on a case study, focusing on a new dataset opened by french government.
This dataset gathers all the real-estate transactions in France for the past 5 years We intend to show a way of process ing the dataset analysis in an integrated R workflow, from traditional gui-based analysis to an ad-hoc exploration web-application.

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KEYWORDS

ESDA / Geographic Data Analysis / Large data / Geovisual Analytics / Columnar DBMS

Early disease diagnosis in shelter animals using Hidden Markov Models

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Early disease diagnosis and subsequent isolation of potentially infected individuals is crucial in contagious disease prevention. Disease progression modeling can help not only understand the evolution of diseases over time but also identify various disease progression trajectories. This is especially valuable when we need to differentiate between life-threatening and highly contagious diseases that share symptoms—we need to be able to differentiate between them as early as possible.

This is particularly important in overcrowded animal shelters where unvaccinated large populations of young animals are prevalent. In this paper, I use hidden Markov models (HMM) with multidimensional state structures to study the progression trajectories of major contagious diseases in cats and dogs: canine parvovirus, canine distemper, influenza, and corona virus. Because these diseases share symptoms with each other as well as other conditions, they can be challenging to identify and diagnose early. This makes it difficult to isolate infected animals before they spread the virus and causes outbreaks in animal shelters and high mortality rates. Another complication is that some animals brought to shelter are already infected; therefore we cannot observe all the stages of progression of their disease. Furthermore, multidimensional state structures of HMM models allow us to investigate dynamics of disease progression and interaction between states over time. This in turn improves model's mapping of the disease progression to the clinical stages of each disease. Multidimensional structure of models allows me to model diseases as the co-evolution of multiple factors—not only progression of symptoms present in animals—but also incorporate spatial information available for each animal. I can account for other factors affecting the animal's health such as location where it was collected, presence of infected animals collected around that time in near by areas, presence of infected animals in shelter during incubation period, and days in shelter without any symptoms. This allows me to better map disease progression stages to HMM states, and to provide probability estimates of the likelihood well before the animal tests positive for a given disease.

This paper analyses geocoded data collected by the city pound in the city of Daejeon, South Korea to track local hotspots for contagious animal diseases. Because the symptoms of each collected animal are closely monitored and recorded by the shelter staff, it is possible to identify probabilistically where each animal was infected. As a result, I'm able to classify each animal as infected before arrival. Such identification can help in prevention of outbreaks of these diseases in future—both through recognizing increased likelihood of contagious animals collected in incriminated areas (and their subsequent isolation after arrival to city pound) and by targeted vaccination programs.

KEYWORDS

disease trajectories / hidden Markov model / contagious diseases

Empty Homes: Mapping the extent and value of low-use domestic property in England and Wales

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We combine economics, housing theory, data science and geography to gain a greater understanding of low-use properties in England and Wales. We collect a unique dataset of domestic properties unoccupied by a permanent resident from 112 local authorities via freedom of information requests. The dataset covers 23 million residents and 340,000 low-use properties (3.4% of all properties). We find that the distribution is very skewed, with 5% of the lower super output areas (our smallest geographic unit) containing 29% of all low-use properties. Using a simple graphical model ad leveraging the different geospatial units used by the UK government, we estimate the value of low-use properties in the dataset to be £123 billion and that an empty homes tax of 1% would generate the equivalent to 11% of the current council tax (local government tax).

We use logistic regression to identify local authorities with high numbers of low-use properties (72% accuracy), local authorities where low-use properties are more expensive than ordinary homes (77% accuracy), and local authorities where both those conditions are true (79% accuracy). The coefficients of the models indicate that low-use property tends to be found in the most and least affordable areas and that the probability of low-use property being more expensive than a regular home increases as affordability decreases and tourism increases.

We estimate that 39%-47% of the population in England and Wales live in an area where low-use property is more expensive than property occupied by a full-time resident.

We conclude that as the areas with the least affordable housing also tend to have the highest demand for low-use property, it may be appropriate to reduce demand via measures such as an empty homes tax rather than increasing housing supply.

KEYWORDS

housing / economics / inequality / social policy / built environment

Quantitative assessment of public sector e-mobility infrastructure development: A spatial perspective in the case of Germany

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Spatial data-driven approaches are promising for evidence-based public policy making (e.g. spatial planning) by combining multi-dimensional open data and emerging technologies besides traditional data sources. In this background, this study aims to conduct an assessment on spatial diffusion pattern and its potential determinants of Electric Vehicle (EV) public charging infrastructure development in Germany. The assessment approach will be depicted beyond the administrative boundary so that can support to the efficient local infrastructure development. In fact, the earlier investigations have reported some initial findings on physical aspects of spatial variability of EV-infrastructure in Germany. The explorative approach analyzed the intensity of EV-charging points (geolocations) at multiple administrative levels (Bundesland, Raumordnungregion and Kreis). The degree of variability in both visual analytics and statistical facts were presented in relation to transportation-related land use indicators. For charging point development it is essential to combine administrative data sets with dynamic supply (e.g. charging point data) and demand side parameters. This contribution will be taken a more comprehensive look by involving both people-and placed based indicators (e.g. population density, settlement density, income level, land use mix, road density) at a raster level. The required datasets will be harvested from Open source-API (OpenChargerMap - a community lead volunteered geoinformation platform for EV charging point) and open-access geospatial data services (IOER-Monitor API that is providing by scientific data infrastructure in the combination of multi-source basic geospatial and statistical information for whole Germany). In consideration of open science principle, the open/freely available software/analytical tools will be used for preparation, data management, analysis and visualization. The spatial association will be studied after extracting spatial statistics: Moran's I (Global and local) and the Gini Index by considering the variability of intensity of EV charging infrastructure. The results should give an understanding on spatial clusters of EV infrastructure development. The issue of sensitivity will be addressed by studying multiple resolutions of rater size, issue of data quality related uncertainties. For promoting equitable regional development, there is a need for policymakers to quantitatively evaluate spatial distributiveness of charging infrastructure. The policy implication will be to investigate what extent the spatial inequality of EV could be quantified to inform future mobility infrastructure development? Moreover, the results have a potential to develop robust indicators for supporting data-driven predictions/analytics of smart city infrastructure planning.

KEYWORDS

Spatial analysis / Open data / Monitoring / EV Charging / Future mobility

II   # Special Session: Big data for Geocomputation (2/2)

<div align="right">FRIDAY | 14:30 | Salle des Fêtes</div>

Feature selection and data dependencies analysis: operative tools and case studies for geospatial data

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Statistical learning methods have become widespread tools to extract knowledge from data and understand complex non-linear phenomena. At the same time, over the last decades, geospatial data have faced a previously unseen growth of data collection and storage. Hence, recognizing the few important predictors associated with a response variable among a large set of features has turn out to be an extremely complex and important task. The presence of non-relevant features in a dataset will spread the data so that they will look equally far in a very high dimensional space. This may reduce the accuracy of prediction obtained by machine learning algorithms. Moreover, despite the recent computational advances, automatic processing of massive and high dimensional data is still extensively resource-consuming. Within this context, feature selection for the recognition of irrelevant and redundant features to be removed from the original input space is always an extremely relevant and fundamental topic in data-driven analysis and modelling.

In this research, a feature selection method based on a General Regression Neural Network (GRNN) has been developed. GRNN is an adaptation in terms of a neural network of the Nadaraya-Watson estimator, with which the general regression of a scalar on a vector independent variable is computed as a locally weighted average with a kernel as a weighting function [1]. The main advantage of this algorithm is that its calibration only requires the definition of a proper bandwidth for the kernel estimation. Hence, GRNN is faster than other feedforward artificial neural network algorithms.

The traditional GRNN architecture is based on the use of one unique value of the bandwidth for all the features. This Isotropic structure of the network (IGRNN) can be used as a wrapper for feature selection. This approach permits a complete description of the input space, identifying relevant, irrelevant and redundant features. Specifically, redundancy and irrelevancy are associated with the identification of relatedness, i.e. the non-linear predictability of an input variable using the other features of the input space.

Anisotropic (or Adaptive) GRNN (AGRNN) are an evolution of GRNN in which different values are given to the bandwidth corresponding to each feature. Proper calibration of the bandwidths will scale the input features depending on their explanatory power. Specifically, a large smoothing parameter will give rise to a lower discriminative power of the associated feature, and vice versa [2]. Hence, AGRNN can be considered as an embedded feature selection method in which the bandwidth values of the kernel express a measure of the relevancy of the features.

The two feature selection approaches, based on IGRNN and AGRNN, have been tested on several geospatial and environmental case studies including regression tasks, such as spatial wind speed prediction, and risk assessment, such as susceptibility mapping of forest fires and landslides or probability mapping of permafrost presence in alpine regions. Both approaches have been found to be able to recognize dependency in data. However, the wrapper approach is not advisable in

extremely high dimensional spaces, where AGRNN can instead be extremely useful. Further studies are foreseen to improve the interpretability of the bandwidth values of the AGRNN kernel as a measure of the relevancy of the features, which will help to understand the behaviour of the algorithm in high dimensional spaces and to scale it for the applications on big data sets.

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KEYWORDS

Machine learning / Feature selection / Geospatial data / Data dependencies / Geocomputation

FRIDAY | 14:30 | Salle des Fêtes

A data mining approach for natural hazard susceptibility assessment

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The recent development of methods allowing to perform intelligent data reduction is a central issue in environmental science. The availability of massive digital geo-referenced databases led GISscientists to search for new tools able to deal with such complexity. In this context, innovative techniques based on pattern recognition and data mining can be employed to find a structure in the data, to map susceptibility areas for a given environmental natural hazard and to address towards prevention and forecasting measures.

A map of susceptibility indicates areas with a potential to experience a particular hazard in the future based solely on the intrinsic local properties of a site and express in terms of relative spatial likelihood.

According to the basic assumption that "the past is the key to the future", new events are expected to occur under similar conditions as the observed ones. This allows to elaborate susceptibility maps derived from the modelled relationships between the observed events and the predisposing factors. The present study focuses on the investigation of two natural phenomena, notorious for having a negative effect on humans and the environment: wildfires in Mediterranean regions and landslides in Switzerland. We will explore the ability of Machine Learning (ML) approach for the spatial assessment and modeling of landslides and wildfires susceptibility. In a broad sense, ML includes a class of algorithms for the analysis, modelling and visualization of data, and perform particularly well to model environmental and anthropogenic hazards, which naturally show a complex and non-linear behavior.

The present analyses were performed using Random Forest (RF), an ensemble supervised ML algorithm based on decision trees, capable of modelling the hidden relationships between a set of observations (the burned areas for wildfires and the mapped landslides) and the environmental predictors (e.g. DEM and derivatives, distance to roads/rivers, land cover, etc.). From a computational point of view, a subset of the training dataset is generated by bootstrapping (i.e. random sampling with replacement) and about one-third of the cases, called out-of-bag, are left out. Thus, the algorithm creates a decision tree for each training subset and a number of variables are randomly sampled as candidates at each split by measuring the node impurity using the Gini index. This lets the trees growing up and stopping when each terminal node contains less than a certain amount of data points. Finally, for classification problems, the prediction of new data is computed taking the majority or the soft voting. The prediction error is evaluated by computing the predictions on the out-of-bag, while the testing dataset is used to evaluate the generalisation performance of the model, which is the ability of a ML algorithm, trained on a given dataset, to make good prediction on unused observations. Our model involves the generation of the pseudo-absences, which identify the areas where the hazardous event did not take place. Indeed, to assure a good generalisation of the model and to avoid the overestimation of the low classes, pseudo-absences need to be generated in all cases where they are not explicitly expressed.

The ML approach proposed in this study differs from the heuristic-based models for susceptibility assessment because it is "data driven", meaning that it is able to extract knowledge and insights

directly from data rather than by intuition or by personal experience. Therefore, ML algorithms may successfully pinpoint a relationship among observed events and surrounding factors, identifying patterns and trends that might not be apparent to a human. The implemented RF models successfully allowed to elaborate susceptibility maps of wildfires in Liguria Region (Italy) and of landslides in Canton Valais (Switzerland). Additionally, they provided the measurement of the importance of each environmental predictor, allowing to rank them on the basis of their relative contribution to the model. In summary, RF seems to be a promising alternative to deterministic or statistical expert-based method for the susceptibility assessment of environmental hazardous events.

KEYWORDS

Data mining / Random Forest / Natural hazards / Susceptibility mapping

The geographies of RES impact in low density settlement area: the case of Melfi municipality

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Territorial transformations are currently influenced by the combinations of multi-scale processes generating a complex dynamics of change. Current trends highlight the need to formulate new development models capable of overcoming the limitations of traditional urban growth models. We focus on emerging conflicts between CO_2 reduction policies and preservation of natural and ecosystem values at local scale. Global policies, since Kyoto protocol, promoted a generalized effort in promoting the transition toward low carbon economy and a relevant component of such development process is connected with the installation of Renewable Energy Sources (RES) plants (especially wind turbines and photovoltaic fields). Such technological settlement processes in low density settlement areas generate territorial impacts comparable and even more prominent than residential settlement growth according with current trends.

This paper discusses a territorial impact assessment methodology as a Decision Support System (DSS), based on an ex-post evaluation of ecosystem services loss deriving from RES plants in a specific case study area: Melfi municipality in the Basilicata region (Italy).

In such context the effects of rapid advent of renewable energy plants reduced territorial potential related with the strong agricultural and natural vocation.

The proposed methodology, starting from the territorialisation of RES plants according with temporal evolution (deriving from specific sectoral planning tool managed at regional level from 2010 to 2017), consider the ecosystem services estimation based on InVEST tools (carbon stock and storage, crop production, crop pollination and habitat quality) in order to achieve spatial multi-criteria maps of resulting territorial impacts. The results allowed to clarify the limits of local sectorial planning approach and to highlight the opportunities offered by a performance-based planning in assessing alternative transformation scenarios.

Conclusions regards policy implications of such analytical model toward a multidimensional performance based planning system where alternative low carbon transition scenarios may be compared. In order to take into account territorial specializations and identity assets as a tool to drive decision making in a sustainable planning perspective, a new development model is worth of deeper investigation.

KEYWORDS
Performance-based planning / RES / Ecosystem services

A Tensor-based Conceptual Framework for Large Scale Multidimensional Raster Data Processing

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Over the decades, the earth science community has been working hard towards a unifying model that deals with the ``curse of dimensionality''. Moreover, a framework that underpins a scalable and extensible approach to drive distributed processing for solving the problem of efficiently managing and disseminating vast volumes of multidimensional raster data. We proposed a sophisticated way of handling large-scale multidimensional data, adopted for raster-based geographic information systems (GIS). We formulate the problem into a tensor learning framework which explores the scalable tensor data structure and inherent parallelism offered by data-flow based implementation to define the geospatial grid used to construct and process the data tensor. The framework can be considered as an extension of cubic map algebra to multi-dimensions for spatio-temporal data handling. TensorFlow is used to define and run computations involving tensors. TensorFlow is an open source software library, developed by Google. It combines the computational algebra of compilation optimization techniques, making accessible the calculation of many mathematical expressions where the problem is substantial and the time required to perform the computation is long. Tensors are the primary and central data structure that TensorFlow uses to operate on the computational graph. Tensors are mathematical objects which represent generalizations of vectors and matrices to potentially higher dimensions. A tensor is described by the order, a unit of dimensionality; shape, the size of each dimension and a static type assigned to the tensor's elements. In this approach, spatio-temporal data is represented as non-overlapping, regular tiles of 2-D raster data, stacked according to the time of data captured. We applied our framework to quantify the spatio-temporal dynamics of solar irradiation calculations and 2.5-D shadow calculations for cities at very high space-time resolution using the proposed framework. The models are fast and accurate with theoretical guarantees for its convergence. We validated the correctness and efficiency of the models on real application datasets. Results show noticeable and significant improvements in overall performance keeping accuracy at negligible differences. The proposed framework provides some significant improvements over other approaches, transparent use of GPU computing, implicit parallelism and distributed execution and high scalability of computation across machines with big data; are few of them. The tensor-based conceptual framework also enables agile analytics on large scale spatio-temporal datacubes, including simulation, sensor, time-series analysis, and statistical data. Future work concerns deeper analysis on formalizing the multidimensional versions of the primitive operations defined in map algebra; namely, local, focal and zonal operations using the proposed tensor-based framework.

KEYWORDS

2.5D shadow calculation / Tensorflow / Tensor

II

Special Session: Mobilities and Health (2/2)

Using nationwide linked microdata to examine the effect of transience on the health services utilisation and long-term health conditions

Lukas Marek[1], James Greenwell[2], Matthew Hobbs[1], Melanie Tomintz[1], Malcolm Campbell[1], Simon Kingham[1], John McCarthy[2]
[1]University of Canterbury, New Zealand / [2]Ministry of Health, New Zealand

The New Zealand government manages a unique research database of linked microdata about people and households called the Integrated Data Infrastructure (IDI). It consists of data from government agencies, Statistics New Zealand, and non-government organisations. The IDI has become an integral part of the evidence-based policy lead research in New Zealand as it allows researchers to utilise real-world data ensuring the results are closely knit to current reality and widely applicable. The de-identified records in the IDI also enable researchers to study human and social interactions on both an aggregated and individual levels.

This research was carried out in collaboration with the New Zealand Ministry of Health and Lakes DHB. It describes how we used the IDI in order to determine how home address and the frequency of address changes (transience) may affect long-term health outcomes and health service utilisation. We assigned the level of transience to each individual living in New Zealand (4.43 mil) during the reference period (2013–2018) by combining the address change table, death records, birth records, immigration records, overseas spell records, and socioeconomic deprivation of home address. We identified that up to 5.6% of the New Zealand population is classified as vulnerable transient or transient meaning that approximately 250,000 people were changing their home address very often while living mostly in the socioeconomically deprived areas. Often, these same people experience inequities in the provision of health services.

In the second part of the study, we focused on the situation in one of the New Zealand's District Health Boards (Lakes DHB) that are responsible for providing or funding the provision of health services in regions of New Zealand. The transience of the population in this region (8.3%) is generally higher than the New Zealand average. Lakes DHB also has a higher proportion of Maori (NZ indigenous) population, fewer people in the 20–39 age group than the national average, and a relatively high proportion of people living in the most deprived areas. All these factors combined affect how people reach out the health-related services and interact with them. We analysed this interaction, and we also researched how the level of interaction relates to the transience of the population and its demographic structure. In the analysis, we focused mainly on the characteristics of the transient and vulnerable transient population of Lakes DHB and children and youth population.

Understanding the characteristics of the affected population together with insights about primary health service utilisation can improve the design of integrated health services and their accessibility for vulnerable populations.

KEYWORDS
Transience / Population / Health Services / Microdata / New Zealand

FRIDAY | 14:30 | Salon LA-SI

Impact of deprivation level and mobility behaviors on accessibility to breast cancer care: example in Paris region (France)

Benoît Conti[1,2], Audrey Bochaton[1], Hélène Charreire[2], Charlotte Ngô[3],
[1]Paris Nanterre University, France / [2]Paris-Est Créteil University, France / [3]Paris-Descartes University, France

Background information

Breast cancer is the most common cancer among women with about 50,000 new cases per year in France. However, since the 2000s, the situation regarding inequalities between women has worsened. The relatively higher incidence (number of new cases) among female graduates tends to disappear, contributing to increased inequalities between social groups: women with modest incomes who are diagnosed later than others have a lower survival rate. Indeed, precarious women have less access to screening: geographical location is an important determinant. The distance from specialized centres and the fact of living in territories where economic and social inequalities is greater, considerably reduce patients' chances of having access to the best quality of care.

Proposition for background

Breast cancer is the most common cancer among women with about 50,000 new cases per year in France. In addition, since the 2000s, the situation regarding social inequalities in cancer mortality among women has worsened (Menvielle G, Chastang JF, Luce D, Leclerc A, 2006). On one side, the relatively higher incidence (number of new cases) among female with high educational level tends to disappear and, on the other side, women with lower incomes have more risk to be diagnosed later than others with consequences on survival rate (Bouchardy C, Verkooijen H M, Fioretta G, 2006). One hypothese is that the distance from specialized centers and social deprivation (at individual and contextual level), reduce patients' chances of having access to relevant health screening and care. In addition, precariousness can be a barrier to patient mobility and have an impact on the therapeutic itinerary.

Objective

The objective of this communication is to assess the impact of patient mobility behaviors on breast cancer accessibility according to their deprivation level, particularly during the diagnosis and medical treatment. We suggest that deprivation level is a determinant of social and spatial inequalities and influences mobility practices.

Methodology

Our research is based on a clinical study of breast cancer patients and data was collected by questionnaire regarding their social and demographic characteristics, transport conditions and choices to the health care facility and their "health activity space" (home, work, hospital, general practitioners). This study will allow a better comprehensive assessment of social and spatial accessibility at the different step of care (screening, diagnosis and treatment) and not only on a measure of theoretical (social and spatial) accessibility. The study of precariousness makes it possible to propose a critical look at the theoretical conditions of accessibility to hospitals, supposedly equivalent for people living in the same place.

This research is based on a cohort of approximately 750 women patients (recruitment is ongoing) from 15 hospitals in the Île-de-France region. The study will include any patient residing in Ile-de-France who comes for breast cancer treatment, at any stage of the diagnosis. The 36-month study consists of an inclusion phase and a 12-month follow-up phase to include all treatment implementation data. Three scores are used to assess individual deprivation: the EPICES score, Pascal's score and the basic needs associated with poverty in the French version of the EDI score (European deprivation

Index). "Deprived" patients will be those who have been identified as such by at least one of the three score. Statistical analyses will be used to assess relation between accessibility, mobility and deprivation levels and breast cancer outcomes such as stage of breast cancer, participation of screening, type of treatment.

Results
The results of the treatment of the inclusion questionnaires are currently being analyzed.

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KEYWORDS

Accessibility / Mobility / Deprivation / Breast cancer / Île-de-France

Designing a built environment measure of walkability: topology, greenness and connectivity as predictors of walkable streets

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Luxembourg has one of the highest rates of car ownership in the Europe with 662 cars per 1000 inhabitants (Eurostat 2016). The dependence on the car together with the urban planning decisions that put the car before other sustainable transport modes, such as bike and foot, means people walk less. The volume of cross-border workers commuting from the greater region of France, Belgium and Germany exacerbates problems associated with car dependency. As towns and cities across Luxembourg and into the greater regions, face environmental and public health challenges there is an ever-increasing need for policy makers to prioritise sustainable transport.

At the same time, internationally, over the last 20 years there has been considerable interest in the notion of walkability, with many studies carried out across the globe. It is one solution to the challenges presented, as it is an environmentally friendly and cheap transport solution fostering physical activity. The benefits of walkable environments indicate that for adults living in walkable neighbourhoods they are more likely to do more exercise than those living in less walkable neighborhoods (Sallis et al. 2016). With this policy background in mind, this paper explores the development of a built environment measure of walkability. We use one city in Luxembourg as a case study area to evaluate the feasibility of building such a measure of walkability, using the street segment as the scale of measurement. This scale of measurement is justifiable because it is the means in which we move around on foot through our cities, towns and villages.

The notion of walkability often manifests in research as weighted or unweighted walk scores that indicate how walkable a neighborhood is. Such composite indicators are often developed using indicators of residential and commercial density, destination accessibility/proximity and street connectivity. Thus, there is a plethora of literature that develop walkability scores but many of them do fail to take into account of the topography of streets, which of course for many towns and cities is an obvious factor that influences how walkable neighbourhoods are particularly from the perspective of an aging population and those with reduced-mobility such as wheelchair users. So whilst an obvious factor it is one that is overlooked in the literature probably due to its perceived triviality.

Therefore, the objective of this research paper is to develop a weighted walkability score that focuses on the calculation of built environment measures of walkabilily derived only from Open Data available from data.public.lu. We explore the usefulness of a score that that integrates the (1) variability of topography calculated from a high resolution DEM (2) evaluation of greenness measured using NDVI calculated from ortho-imagery and (3) connectivity and integration calculated using measures of Space Syntax. These measures have been selected as they indicative of street level qualities that influence perception of walkability.

The results are initially calculated for one town in the north of Luxembourg, Diekirch. Chosen because of its historical core, dispersed residential neighbourhoods and undulating environment. So whilst a small case study to start, the algorithm once tried and tested will then be applied to a larger scale.

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KEYWORDS

Walkability / DEM / NDVI / Streets

Urban air pollution and pedestrian mobility: estimating local pollution levels to identify clean pedestrian paths

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Introduction and problem statement

Every winter, in recent years, harmful levels of air pollution, especially particulate matter (PM2.5) are recorded for several consecutive days in numerous European cities. In those situations, private vehicle circulation is banned in certain areas, and the population is encouraged to walk, bike, or use public transit. These alternative modes of transportation may be effective in reducing noxious emissions, yet they are likely to increase the population's exposure to air pollution, particularly at times when it is more severe.

However, air pollution exhibits spatial variability at the intra-urban scale, that can result in significant differences across a single city, depending on several factors, such as morphology and wind, land use, and transportation networks. Understanding the spatial pattern of air pollution can lead to smart route choices, decreasing people's exposure to noxious pollutants. Understanding the air pollution pattern in each city requires in-depth spatial analyses and reliable estimation models based on pollution records.

Urban air quality is measured frequently and regularly over time, but spatial measurements remain sparse and sporadic. This poor knowledge of spatial pollution patterns leads not only to poor behavioral choices, e.g., walking along high-traffic roads, but also to poor understanding of pollution-related health risks, as spatial error is propagated through exposure and disease models, reducing their reliability.

Objectives and Methods

This paper builds on the spatial land use regression analysis conducted by the research group in a major Canadian city, Calgary. Using a large network of air quality monitors, that analysis estimated air pollution at fine scale for this city, which exhibits a large urban area with relatively low pollution and population density. In this paper we use those results to identify smart paths, where people can walk or bike away from the most polluted areas.

Land use regression (LUR) models analyze pollution concentration as a function of land use variables (e.g., traffic volumes, industrial emissions, and population density), and estimate coefficients that link each land use variable to the recorded pollution concentration. These regression coefficients, combined with land use variables all over a city, can yield fine scale estimates of intra-urban pollution concentration. Our group has develop various spatial specifications of LUR models, including spatially auto-regressive and geographically weighted models, to improve our understanding of the spatial pattern of air pollution and yield more reliable regression coefficients, ultimately reducing the spatial error associated with pollution estimates.

This study extends this method to the Italian region of Tuscany and its capital city, Florence, along with its metropolitan area. Compared to Calgary, Florence exhibits a small and densely populated urban area. Further, it is a major tourist destination, where large numbers of people get around using different mans of transportation. Using pollution data publicly available from the regional regulatory network (ARPAT), the study analyzes the pattern of air pollution over the region and within the metropolitan and urban area of Florence.

Expected results

For both regions, the study yields maps of intra-urban air pollution and transportation corridors. Each map yields a network of secondary roads which are recommended for pedestrian and bicycle use in areas where pollution is lower. These 'clean' paths are also 'safer' than traditional major roads, in

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that they achieve a greater separation between motorized vehicles vs. pedestrian and bicycle traffic. For this reason, these paths are considered 'smart'.

The Calgary study relied on a large sample of air quality records. Conversely, the Tuscan study suffers from the limitations of a relatively sparse monitoring network, which fulfills the mandate of a regulatory network, yet was not designed for the requirements of land use regression analysis. For this reason, the Tuscan study constitutes a preliminary, exploratory analysis. Further work will extend the analysis, to yield more robust and reliable land use coefficients. For this further work we envisage the deployment of low-cost air quality sensors that will provide a larger spatial sample of air pollution, as a basis to a detailed land use regression analysis.

KEYWORDS

air pollution / land use regression / clean pedestrian path / urban pedestrian mobility / population health

The walkability score in Flanders, Belgium. Mapping density, functional diversity, connectivity and pollution as policy indicators

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The population in Flanders, Belgium, is not sufficiently physically active, which leads to obesity and a higher risk of diseases. Too many people use their car for all their displacements, and 20% of the population even for distances shorter than 1 km according to the Flemish Trip Behaviour Survey (OVG). The spatial structure of the built-up environment in Flanders is one of the main factors causing this behaviour as it is characterised by vast areas of urban sprawl and ribbon development. It has been shown worldwide that people living in more dense, connected and diverse neighbourhoods walk and cycle more, independent of the micro-environmental characteristics. A walkability score was proposed in different international studies as an objective quantity of how walkable an environment is from a functional view.

The walkability score is computed as a sum of z-scores of three components: (1) street connectivity, (2) population density, and (3) function diversity. All components are calculated within a buffer distance from each location. In our application, the buffer distance is 1 km along the road network around a raster cell (resolution: 10 m). Street connectivity, which gets a higher weight and accounts for half of the total score, is modelled as the number of street intersections within the buffer. The function diversity is an entropy index of the difference in area between different types of functions. In Flanders we used 4 types: (1) employment (area of buildings with at least 20 employees), (2) entertainment buildings and green land use close to a road, (3) institutional buildings, and (4) retail buildings. Finally, the walkability score was aggregated to a resolution of 100 m.

The results show a high walkability index in city centres, but also in some social housing areas if they're not too far away from retail and services. These social housing areas have a high population density as well as more paths in between the buildings than many other residential neighbourhoods, and as such they have a higher walkability score. We also compared the results with daily travel surveys to find the link between the Flemish transportation habits and the score. Nevertheless, neighbourhoods with a high walkability score are not always the most healthy neighbourhoods as the exposure to bad air quality, heat stress and noise tend to be worse in city centres, which are characterised by a higher walkability score. Moreover, not all neighbourhoods with a high potential for active travel have safe road infrastructure for pedestrians and cyclists. The walkability score can be used to inform policy makers about the potential of neighbourhoods to be healthy and walkable environments. The government should invest money in an improved quality of the infrastructure for pedestrians (pavements, crossings, …) in high-scoring areas, and think about reducing the capacity for other modes causing pollution and noise. For low-scoring areas the advice can be either to increase the number of functions or path connections for pedestrians and cyclists if some of these specifically have a negative impact on the score, or to select these areas as less suitable locations for urban densification in the future.

KEYWORDS

Health geography / Travel behaviour / Connectivity / Urban sprawl / Land-use and transport policy

General Session: Spatial Analysis (2/3)

Estimation of regional energy consumption based on energy consumption at national level: Romanian Danube Valley case study

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Energy consumption has been increasing remarkably during the past quarter century. Economic development that includes improvements in the standard of living and the evolution of scientific technology are thought to be the main reasons for this explosive increase in energy consumption. However, economic development has different effects on energy consumption. This is because these processes differ in each region (Kadoshin, Nishiyama, Ito, 2000).

Starting from national data on energy consumption disaggregated into end-use sectors: residential and agricultural, industrial, and transportation, we propose here to estimate energy consumption at county level. Therefore, the total energy consumed by the nation in a year is decomposed into a "population component" and a "nonpopulation component". Changes in population and nonpopulation components were calculated for each year. The variables used were grouped into demographic indicators (population size, share of urban population, economically active population by activity of national economy: agriculture, industry, transport) respectively economic indicators (energy consumption by activity of national economy: agriculture, industry, transport, residential energy consumption, GDP per capita).

Annual data are available for twelve counties in Romania along the Danube Valley covering the period 1990–2017.

In the first stage, based on the share of indicators at county level in the national value, we shall determine the energy consumption at county level, knowing the consumption at the national level, for each year and each county, using the equation:

$$IN/IC=EcN/EcC$$

where
IN is the indicator (demographic or economic) at national level,
IC is the indicator at county level,
EcN is energy consumption at national level and
EcC is energy consumption at county level.

When population size is used, energy consumption refers to residential energy consumption, when economically active population by activity of national economy is used energy consumption by activity of national economy is taken into account.

In the second step, the results obtained will be corrected using two variables: share of urban population (the efficiency of energy consumption increase when the population density in a city is higher) and GDP per capita. Economic development contributes substantially to changes in energy consumption. Many researchers have focused on the nexus between energy consumption and economic growth. This nexus suggests that higher economic growth requires more energy consumption and more efficient energy use needs a higher level of economic growth. Since the pioneer work of Kraft and Kraft (1978), Granger causality test approach has become a popular tool for studying the relationship between economic growth and energy consumption in different countries, e.g. Stern (1993), Belloumi

(2009), Pao (2009) and Ghosh (2010). Urbanization has a positive effect on energy consumption, further countering the claims of modernization theorists. However, the expected decline of population growth in Romania will help curtail expansion in energy consumption.

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KEYWORDS

Energy consumption / Demographic and economic indicators / Danube Valley / Romania

Interactional Approach to Subcenter Hierarchization: the Example of Moscow and Paris

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Subcenters or centralities hierarchy is one of the main characteristics of urban systems. According to central place theory, higher order subcenters provide population with more rarely incident services than the lower order ones. This theory helps to optimize the grid of tertiary facilities for functional stability of urban systems and for the further specialization of facilities. However, it reality, the incidence of secrives does not show the exact limits between lower and higher order subcenters. This approach may lead to management problems. For example, we may mix up the subcenter order and try to develop some services, wich won't be working in this particular place the way we'd like them to. The reason is the type of probability distribution. It's close to a normal one, when a heavy-taled one is required for a proper hierarchization. The cases of Paris and Moscow urban regions are exactly like that. It this paper, we propose the hierarchization approach based on central flow theory and the interaction intetsity between the recognized subcenters.

The main data sources for this study are OpenStreetMap POI and road network graph, based on OSM data. Firstly, we extract subcenters from OSM POI using hierarchical density-based clusterizetion (HDBSCAN, which is the most flexible way to find spatial clusters of different geometric shapes and densities. These are the nodes of the hierarchical subcenters grid. Secondly, we assume, that the flow between the two nodes is the measure of interaction between the nodes or the traffic volume through this particuar edge of the graph. Space Syntax integration measurement is the easiest and most effective way to evaluate the traffic volume.

Based on average integration in the neighbourhood of the subcenter, we apply the soft HDBCAN clusterization of subcenters to get the hierarchical regions grid. It can be used for multiple purposes from research to planning.

Comparison of services incidence in subcenters and interactional characteristics of Moscow and Paris urban regions leads to conclusion that the interactional approach hierarchy can be interpreted univocially. It's more refferent to social logic of space in these regions.

KEYWORDS

Space Sytax / Central Place Theory / Central Flow Theory / Urban Regions / Moscow / Paris

Vocational training in Greece: Evaluation at micro, meso and macro level

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The basic aim of this paper is to study the impact that educational level (from those never in school to PhDs) and vocational training programmes had on the labour market of semi-peripheral EU countries, using Greece as a case study. In particular, the paper focuses on the Greek NUTS-2 regions of Attica and Central Macedonia, as well as Greece as a whole, during the period 1988-2000. It investigates econometrically whether the training courses in these two regions were compatible with the skill needs and thus, helped the trainees to increase their chances of finding a job, as well as to what extent there were skill mismatches between education-training programmes and the labour market. The analysis investigates half of the Greek population (the two NUTS-2 regions) and compares it econometrically with the rest of Greece. This investigation was undertaken using Labour Force Survey micro-level data. I test the human capital theory and the matching theory. As almost all training actions in the country are co-financed by EU funds, the research also probes the outcomes of these funds during the period of the Community Support Framework - CSF-1 (1989-93) and CSF-2 (1994-99) in the domain of training. Also, I research what are the social and demographic characteristics that increased the chances of someone in the examined population finding a job.

I discuss the EU Involvement with the vocational education and training (VET) systems of the member states, the three levels (micro-meso-macro) of analysis and how they are related, and the challenges with data collection and limitations. I also analyse the comparative political economy, skills formation and Southern Europe, the Greek political economy, the European Employment Strategy (EES) and reform capacity in Greece. I follow a critique of the EU's model for financing vocational training in the Greek context and link this research to the present economic situation in Greece.

I use a logit model for studying differences between those that did participate in training programmes and those that did not. Moreover, regression models allow for group comparisons by adjusting for demographic and socioeconomic variables. I merged all three years together in order to take advantage of the time-series features of the data (three time-sets of observations in 1992, 1994 and 2000) and used dummies for the years instead. I have generated one model with all the main effects, all variables of interest, plus all the control variables and have run it in a pooled format. Namely, I have pooled together all the available data into one database. Also, I have aggregated some of the categorical variables with few observations in order to increase the observations within each cell, so as to avoid exceptionally large coefficients and confidence intervals.

In the main, my econometric results for Greece confirm the human capital theory concerning education, namely, university graduates had higher probabilities of finding a job than people from lower educational categories. However, this was not the case in the field of training, since this variable was found to be statistically non-significant. Thus, it would appear that matching theory has better explanatory power than human capital theory in the Greek context. This is because the former perspective holds that those with more education need less training and in Greece there are many over-educated people.

My analysis at the micro-level indicates that this training "revolution" was not accompanied by any real improvement in matching supply with demand or increasing people's chances of finding a job. The study moves beyond the micro-level and embeds the empirical findings within the institutional/organizational environment of Greek vocational training (meso-level) and the broader

political economy of Greece and its position in the EU political economy (macro-level) to provide a comprehensive explanation of what empirically is identified as the minimal impact of these policies. To this end, a comprehensive analysis is undertaken in an attempt to link all three levels (micro, meso, macro). The findings are of relevance beyond the Greek case as they are also useful for comparative research pertaining to European regions or countries. Moreover, the study outcomes will be valuable to those who are interested in designing and implementing training programmes for structural change, as a number of key failings that have occurred in the Greek case are identified. The results of this research challenge the usefulness of the active labour market policies (ALMPs) alone. Training mechanisms, concrete political economy, inadequate public administration and the clientelistic system were the main obstacles to the matching process. This does not mean that training and ALMPs are not needed in Greece, but they can only function effectively in the presence of a suitable institutional framework, which has yet to become a reality.

Efficient population size for fire protection and its transition with intermunicipal cooperation in Japan

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Background

With the advent of population decline in Japan, municipalities suffer from the increase in per capita expenditure. Therefore, municipalities try to become more cost-efficient by exploiting economies of scale. Some municipalities have conducted municipal consolidations, which were subsidised by the national government, and sought to reduce per capita expenditure. Yet, as small-sized municipalities are not able to fully utilise the opportunity, the possibility for them to be more cost-efficient is intermunicipal cooperation (IMC), in which several public services are shared by participating municipalities. While such municipalities can exploit economies of scale by taking advantage of IMC, transaction costs are added simultaneously (Brown & Potoski, 2005). Transaction costs can be divided into multiple categories, including information, negotiation, and monitoring costs, and sometimes negate economies of scale.

In this study, we explore the efficient population size, which minimises the per capita service provision cost, balancing both economies of scale and transaction costs. Moreover, we consider the transition of the cost structure with IMC, which articulates the advantage/disadvantage of IMC in achieving the efficient population size. Consequently, we estimate the extent to which the actual population size differs from the efficient population size.

Method and data

We employ the Cobb–Douglas form as a cost function and consider local environment variables. It seems to be true that fire protection service is non-excludable, but it is not necessarily non-rivalrous for the beneficiaries. We thus consider a congestion effect, in which the actual service level is considered with rivalry among municipalities. Then, the cost function is non-linear to the population term, and the first-order condition indicates the efficient population size.

In this study, the local environment variables are added in terms of composition of land use, fiscal constraints, and socio-economic conditions of local residents. As an analysis unit, we focus on the fire protection service area, but the data obtained are basically per municipality. Therefore, we modify the municipality data so that the local environment characteristics are averaged in each fire protection service area. In consequence, 744 fire protection service units are obtained.

Results

First, economies of scale were proved to exist for fire protection, and the cost function is non-linear. The average efficient population sizes are 529,172 for a fire protection unit engaged in IMC and 342,581 for municipalities conducting fire protection independently. These results imply that more than 90% of the fire protection units are below the efficient population size, indicating that most have an opportunity to take advantage of economies of scale. Nevertheless, the municipalities located in the interior regions of Japan make it difficult to enlarge the area by participating in IMC, partly due to geographic constraints.

Second, IMC changes the cost structure, possibly through transaction costs and multiplied economies of scale. This study demonstrates that municipalities participating in IMC require additional transaction costs, and the costs are discounted by population size. Therefore, the results seem to contradict those of previous studies finding that small municipalities take advantage of IMC (e.g., Soukopová & Vaceková, 2018). However, municipalities with more than approximately 340,000 inhabitants might not be able to take advantage of economies of scale independently, while they

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do have the opportunity to multiply economies of scale when participating in IMC. Furthermore, once municipalities participate in IMC, local environment factors change, which provides them the possibility to achieve more efficient public service provision.

Concluding remarks

The findings obtained in this study provide valuable information regarding how the population size of municipalities impacts the potential benefits of IMC. As Feiock (2007) has argued, IMC is an important urban policy. The results obtained in this study have implications for policy makers.

Essentially, the estimation results in this study enable municipalities to delineate boundaries for new IMC, simulating the efficient population size for municipalities to consider new service provision areas. However, geographical constraints render the optimal IMC grouping more difficult, and municipalities also should care about transaction costs like additional agents, negotiation, and monitoring. Furthermore, the results obtained in this study provide municipalities with basic information about who potentially gains or loses the benefit in the current situation. Actually, affiliation with IMC authorities is expressed as a result of complex political interactions between local municipalities. The topic can be extended into a game-theoretical setting between the players of local municipalities dealing with a fair division problem, which needs to be addressed in further research.

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KEYWORDS

Intermunicipal cooperation / Public service / Economies of scale / Transaction costs / Fire protection

III   Special Session: Geo-data science and Urban Sustainability (1/2)

FRIDAY | 16:30 | Salon LA-SI

How does the relative spatial pattern of green within cities impact carbon uptake? A European scale analysis

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Cities constitute the main source of CO_2 emissions into the atmosphere. Urban areas exhibit a variety of land use profiles and carbon metabolisms. Yet it is important to assess to what extent they can cope with their own emissions. We address this issue by examining how the internal spatial organization of cities can impact the flow of anthropogenic CO_2 between their major sources - human activities - ; and their main storage infrastructures, with a focus here on urban green spaces and forests. Is it better to have a dense core with a peripheric green belt? Large green patches within the core centre? Or small and fragmented green spaces?

The objective of the present work is to tests whether the internal spatial organization of urban areas - in terms of green infrastructure characteristics and land use types - matters for evaluating carbon sequestration potentials within urban areas. Or whether they can simply be considered as single objects with a quantity of carbon emissions and a carbon sink capacity derived directly from aggregated land use data.

We present a spatially explicit urban carbon flow model. Using land use data, an emission inventory and sequestration potentials from the vegetation we allocate a carbon budget to each spatial unit within the urban systems. Anthropogenic CO_2 emissions are accounted from different land use categories using the TNO CAMS dataset. The potential of carbon sequestration by the urban forest is set using estimates from the literature. Urban carbon flows are then simulated for all Functional Urban Areas (FUAs) of European cities using the Urban Atlas 2012 database.
Most studies on carbon dioxide uptake into vegetation at city or metropolitan scales estimate carbon stocks or aggregated carbon flows, while spatially explicit urban carbon flow analyses are made on spatially limited areas - i.e. neighbourhood level. Also, the homogenous land use data and emissions inventory at the continental level allows for a comparison of the different urban areas. We then compare the aggregated budget of the areas of study – commonly done in budget approaches from micro to global scale – to the spatially explicit budget. It allows us to estimate the real contribution of the urban forest to the uptake of anthropogenic emissions within the same urban ecosystem. The analysis then investigates the level of efficiency of CO_2 uptake for different typology of urban areas for different carbon profiles. The efficiency is defined as the share of local emissions captured within the urban boundaries.

In the future, the model will be validated using eddy covariance empirical data.

KEYWORDS
urban vegetation / carbon dioxide / Europe / carbon flows / carbon uptake

Developing territorial Life Cycle Assessment approaches: focus on land use functions and proposition of a new operational methodology

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Life Cycle Assessment (LCA) is a well-known and established methodology used to assess the environmental impacts of a product, a process or a service during its entire life cycle. Although LCA was originally intended as a product-oriented approach, its scope has now been extended to include mesoscale and macroscale assessments. For this reason, LCA may nowadays play a significant role in investigating the implications of current spatial planning policies, and particularly in assessing at sub-national scales their associated environmental impacts and the corresponding functions provided. In order to answer this need, the extension of LCA called Territorial LCA (TLCA) has been recently introduced as a new frontier of LCA (Loiseau et al. 2018). However, this leap from the product (micro) scale to the system (meso-macro) assessment scale, brings about several challenges and requires considerable improvements and adaptations to the traditional LCA methodological framework.

The first challenge is the definition of the multi-dimensional concept of territory within the LCA framework, which includes: i) the material dimension of a geographical area (the space), ii) the organizational dimension, and iii) the identity dimension (Loiseau et al. 2018). The first concept is defined by the physical properties of the space and their relationships with the development of human systems. The second is defined by the social and institutional stakeholders that conceive the strategies to promote territorial development. The third concept expresses the history, the vocation and the needs of the territory and should influence the conception and implementation of any project related to that territory, by social and institutional stakeholders.

The second challenge identified is the characterization of the territory studied in a TLCA based on defined territorial functions. The definition and quantification of territorial functions allows the consequent description of the activities that support them, and thereby the assessment of the associated environmental burdens.

The aim of our research is two-fold: i) proposing a methodology to allocate activity-related burdens to territorial units that directly or indirectly support them, and (ii) harnessing urban data analytics to use descriptors from a set of domains (namely housing, employment, quality of life, etc.) to compute an eco-efficiency index of the studied territory. Eco-efficiency is defined as the ratio between the services provided by the territory (quantified using specific indicators) and the corresponding environmental impacts generated (Seppäläa et al. 2005).

The indicators used to quantify the services provided are multiple and can be classified in three main domains: social land use (e.g. number and location of jobs, number of community-based facilities, access to health and recreational services); environmental land use (e.g. the number of Natura 2000 areas, bird species, amount of waste locally treated); economic land use (e.g. GDP, provision of transport services).

To test the validity of our approach, we collected data about two different locations: the city of Esch-sur-Alzette, in the Southwest of Luxembourg, and the urban area of Sète, within the Thau territory

located in the South of France. These two locations share similar characteristics in terms of size and population. Moreover, both areas are well connected to larger cities, and exchange with them numerous flows (inhabitants, workers,...), while providing their own economic activities.

The data for this test application come mainly from national statistical surveys and from processing of remote sensed information. The two case studies will explore what makes a city or territory attractive given its territorial functions. Esch-sur-Alzette is a post-industrial city with a mixed workforce (half in the construction industry and the other half in tertiary activities including research and education). The Sète urban area is located in a coastal territory with major economic activities including the shellfish industry, viticulture, tourism, services, and commercial port operations.

Once the methodology will be set up and its effectiveness validated, it will be possible to explore its application to other territorial contexts for which data will become available.

Using spatial data mining techniques we identify homogeneous territorial units in terms of services provided and then assess and compare their eco-efficiency index values. In the medium-term, the aim of this research is to compute the evolution of the eco-efficiency index of the spatial units over time and identify hotspots in order to suggest strategies to improve the environmental performances of territorial units that provide the same services.

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KEYWORDS

urban areas / eco-efficiency / urban functions / environmental impacts / sustainable urban planning / spatial territorial life cycle assessment

Geostatistical space-time prediction of air quality pollutants in Israel

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Spatio-temporal maps of air quality are required to e.g. monitor how ambient pollutants are transported over space and time. Air pollutants in the ambient occurring as nitrogen dioxide (NO2), nitrogen oxide (NOx), ozone (O3), and particulate matter (PM) can pose immediate threats to human health. This paper presents a space-time geostatistical approach to predict ambient pollutant maps for Israel based on 30 min observations of NO2. To understand spatio-temporal correlations of pollutants in the ambient air is a key step to model adequately the transport fields in the spatio-temporal domain while accounting for space-time uncertainties.

We developed a space-time model to predict precipitation fields. We used a geostatistical technique for prediction of the mean value and variance of precipitation over the territory of Israel. An empirical variogram and the sum-metric model were fitted. Also the difference between the empirical and fitted variograms were computed to check the goodness-of-fit. Given the duration of the event selected for calibrating the sum-metric model, we defined the temporal range of the fitted model. The empirical space-time semivariogram for NO2 was computed based on observations recorded in 2015. We fitted the sum-metric semivariogram model to the observations and use spatio-temporal kriging to predict ambient NO2 concentrations for Israel for 1 day in January 2015 at a temporal resolution of two hours and a spatial resolution of 2 x 2 km. The experimental variogram showed that all variogram parameters were visually identifiable spatial, temporal and spatio-temporal nugget, range and sill.

We compared the spatio-temporal predictions with a pure spatial geostatistical prediction using ordinary kriging using a dedicated semivariogram for each time step. . Standard deviation maps were produced for the spatio-temporal model. To incorporate the temporal domain in the geostatistical model accounting jointly with the spatial correlation, reduces the uncertainty in the predictions of NO2 and provides also more realistic patterns in space and time to allow for improved mapping of air pollutants. To produce even more accurate images of air pollutants a next step will be to use geostatistical space-time simulation to produce the entire probability space for air pollutants across Israel.

The proposed methodology opens possibilities to implement workflows for real-time prediction of air quality pollutants over the territory of Israel based on ground sensors, allowing to make use of the stochastic geostatistical space-time framework to predict air quality pollution over sensitive areas or regions of special interest. The methodology is also generic enough to constitute a key reference for further implementations for different case studies, which constitutes an important contribution in the state of art and paramount given the nature of air pollutants in the ambient as NO2, NOx, O3, and PM and their harmful potential over the human health.

FRIDAY | 16:30 | Salon LA-SI

Dynamic assessment of population exposure to air pollution using mobile phone data

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Context and topic

The effect of air pollution on the environment and human health has attracted increasing attention from researchers, policymakers and citizens. To reduce health-related risk, it is crucial to estimate variations in air pollution exposure with low uncertainty in time and space. Traditionally, air pollution levels have been monitored using ground stations at fixed locations that are managed by environmental or governmental authorities. However, these networks of stations are often sparsely densely distributed over large areas leading to inaccurate measurements and high spatial uncertainty. Another critical issue is that most of existing exposure assessments regard population as static, without considering the temporal movement of the population in space. This leads to a temporal uncertainty in air pollution exposure because this static assumption does not account for an increase or decrease in pollution exposure arising from population mobility (e.g., daily commute to working place). Therefore, any decision-making based on the static population may become unrealistic.

Tracking people's movement by using mobile-phone data provides a more precise way to estimate the levels of exposure to pollution. In this study, two scenarios of exposures are compared, the first one, referred to as "dynamic" air pollution exposure is weighted by population activity counts extracted using mobile data records. The second scenario referred to as "static" air pollution exposure considers air pollution exposure weighted by the population at residence (in which the population was stationary over time) using a Census-spatial population data.

Data

To do so, we used a case study from Orlando Metropolitan County in Florida State U.S.A. with its 1267 zones. The mobile phone data (also called by Call data records-CDR) comes from the University of Florida and AirSage Company in the USA. This dataset contains 30 days of individual movement between zones, hour by hour. Then, the population count, at residence, comes from the United State Census Bureau (open data). Last, the hourly air pollution (PM2.5) concentration values come from monitoring stations of the United States Environmental Protection Agency (EPA). To match air pollution with individual movement across space (i.e., zone) and over time (i.e., hour), we apply spatial kriging (interpolation technique).

Expected results

Results reveal large differences in exposure between the two approaches and suggest that the dynamic approach can improve substantially the quantification of risk to air pollution exposure by taking into account the spatial and temporal variations. Reducing uncertainty in air pollution exposure is a first step in reducing health risk and providing decision-making tools, data and model for policymakers.

Future work

The different kind of datasets are always available in open-data, except for mobile phone data, which makes our research, to some extent, reproducible to other cities across the world. Future studies

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should expand on the framework by exploring other pollutants (e.g., NO2, O3, and PM10), study areas, interpolation methods/algorithms and more explore new data source like the newly sentinel 5P to study exposure to air-pollution at a global scale (e.g., country or continental scales).

KEYWORDS

Air pollution / spatial-temporal uncertainty / human mobility / particulate matter / dynamic assessment / exposure / mobile phone data

III Special Session: Geosimulation models Exploration Methods

The changing roles of parsimony: Understanding, interpreting and explaining geosimulations via Massively Computer-Aided Modeling-Process

Franck Varenne[1]
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Recent works dedicated to tackling the difficulties of agent-based models (ABM) calibration and assessment have more and more engaged in what could be called a Massively Computer-Aided Modeling-Process (MaCAMP): (Schmitt et al., 2015), (Reuillon et al., 2015), (Cottineau et al., 2015). This is a computer-aided modeling process which - thanks to platforms like OPENMole - massively uses computations operated via grids to "allow a global exploration of the capabilities" of a given ABM in geosimulation (Schmitt et al., 2015). Thanks to this process, almost every free parameters combination of values in the different mechanisms hypothesized in the model is tested in its outcome against the intended output. The result is that this massive, computer controlled and systematic calibration process is no more exposed to the risk of not being a real optimum by being a local one only. Indeed, this risk is high when free parameters are numerous, not easily interpretable and when their estimation relies on incomplete because partially human controlled trial-and-error processes (Schmitt et al., 2015).

In front of this trend towards calibration through massive computations, a question arises: what's the epistemic role of the models' parsimony if there remains any? Why not get rid of this apparently out-of-age limitation? The surprising fact is that the research works developing this approach still invoke the extreme importance of simplicity, parsimony and controlled complexification for their model building, even if their models finally are complex. Surprisingly enough, parsimony still has an epistemic value in the context of MaCAMP. But what is it? In this talk, I will defend three claims: 1. The use of parsimony is still there but it is not exactly the same as it was in non massively computer aided modeling processes. As a consequence, it appears that the epistemic values of parsimony in geosimulation are diverse and changing; 2. These different values of parsimony can be related to its different use at different levels - or for different aspects - of each of the different mechanisms represented in the model. Sometimes parsimony is sought for assuring genericity, sometimes for improving understanding, sometimes for assuring the strict incremental nature of model complexification, sometimes for enabling interpretation and sometimes for establishing the explaining power of some mechanism of the model. 3. Nevertheless, one can discern a general trend: in the case of MaCAMP, parsimony is less sought for global understanding of the model or via the model that it is for the interpretation of mechanisms or for the establishing of some partial explanation of the target system's behavior via mechanisms.

In a first section dedicated to some definitions, I will assume the distinctive meanings of "understanding" and "explanation" that are most frequently used: "By 'explanation', I mean the intelligible representation (i.e. by concepts) of a system of interactions or a mechanism (elements + actions) that are assumed to be the cause of a phenomenon […] By 'comprehension' or 'understanding', I mean a unifying conceptual representation that can be mobilized by an unassisted human mind. We understand a phenomenon that is composed of a variety of sub-phenomena when we can, by means of a single mental (mathematical or logical) operation, reconstruct the gist of the structure of that variety" (Varenne, 2018, p. 165). By "interpretation" of a model or of some part

of it, I mean the opinion of what it means or of what it refers to. Interpretation seems necessary for explanation and understanding. But the reverse does not hold. In the second section, relying on an analysis of some seminal passages of the System of Logic by Stuart Mill, I will recall the traditional reasons why parsimony is authorized and sought for not only in natural sciences but also in theoretical and quantitative social sciences. From this viewpoint, the relevance of a parsimonious theory was related to our desire to both understand and explain. In the third section, taking the examples of Hägerstrand's theory and models of diffusion (Hägerstrand, 1967) and of Pumain's evolutionary theory of cities (Pumain, 1997), I will emphasize the difference between theories conceived as sets of principles and theories conceived as sets of hypotheses and mechanisms such as the ones implemented by geosimulation. The latter may gather different mechanisms that affect different entities as much as different aspects of the same entities. When tackling these theories via MaCAMP, the search for parsimony could be reduced to the search for a "minimal set of mechanisms". But, in fact, as the last section will show through an analysis of the quoted papers, many trade-offs between different - and sometimes contradictory - needs of parsimony appear to be necessary if one wants to assure interpretability and/or explainability at different levels of the models and during its conception. Most of the time, an overall understanding has to be sacrificed but to the benefit of a distributed explanation.

KEYWORDS

geosimulation / agent-based models / massive computation / computer-aided modeling process / evolutionary theory of cities / OPENMole / parsimony / epistemology

Geostatistical simulation of space-time stochastic rainfall fields for uncertainty propagation in rainfall-runoff and urban drainage system modelling

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Recent practice in Urban Drainage Modelling (UDM) incorporates characterisation of model input uncertainty in the temporal domain. In previous studies of the Haute-Sûre urban drainage system (northwestern Grand-Duchy of Luxembourg) we used a fairly simple characterisation of input uncertainty in the temporal domain for a simplified urban drainage model [1]. We learned that rainfall is the main source of uncertainty when uncertainty propagation is performed in the simulation of water volume in the Combined Sewer Overflow (CSO) tank, and the emission of pollutants as ammonium (NH4) and Chemical Oxygen Demand (COD) to the downstream river or lake. We basically ignored the spatial dimension, we treated rainfall as a non-spatially distributed time series, that had the same characteristics as time series of rainfall measured at a point station, nevertheless in fact the rainfall that enters the system is the accumulation of rainfall over the catchment, so it is an aggregate over space and also over time because water that hits the surface needs time to flow to the inlet of the sewer system. Neglecting spatial and space-time distribution of rainfall entering into the urban drainage system may result in inaccurate quantification of rainfall and, hence, in substantial uncertainties associated to water quantity and quality predictions. This paper proposes a more realistic characterisation of rainfall as an input for UDM in order to better evaluate its impacts on these predictions.

Rainfall-runoff model
Simulated rainfall maps were fed into a precipitation-runoff model, itzi. The roughness coefficient and infiltration maps were also considered. We have chosen the Goesdorf sub-catchment to illustrate the results of the rainfall-runoff model, which corresponded to runoff depth over the land. Then the routing flow through the CSOC outlet was computed.

Sewer system model
The sewer system model is used to compute in deterministic mode the water quantity variables (combined sewer overflow chamber, CSOC, water volume, and combined sewer overflow, CSO, spill water volume), and the water quality variables (loads and concentrations of chemical, COD, and ammonium, NH4) based on the point precipitation measured at Dahl station (the closer rain gauge station to the Goesdorf sub-catchment). Also, given the input uncertainty characterisation in the temporal domain, a stochastic computation of the water quantity and water quality variables is performed. In the spatio-temporal domain, we characterised the model input uncertainty as stochastic rainfall maps. These maps are used to compute the rain volume from the precipitation-runoff model for later feed the EmiStatR model and compute the water quantity and water quality variables.

Stochastic rainfall fields space-time geostatistical simulation
We developed a space-time geostatistical simulation model for rainfall fields, using high resolution (1 min time step) point rainfall measurements as the primary variable for deriving the space-time variogram model at point scale, and radar rainfall imagery as the spatial variable at a coarser scale (about 1 km x 1 km grid cell). This radar imagery is downscaled to the point support in order to merge with the point measurements of the rain gauge stations and define the space-time variogram model. We then simulated rainfall over space and time using a Monte Carlo technique. The resulting space-time rainfall simulations are fed into a rainfall-runoff model simulating the routing of the runoff

across the catchment to finally enter the urban drainage system model to predict water quantity variables. We foresee that the simulated stochastic space-time rainfall fields and the Monte Carlo based uncertainty propagation demonstrate that we can achieve a better representation of the physical processes for runoff generation and urban drainage hydraulics as a contribution in the state-of-art in UDM.

KEYWORDS

space-time uncertainty propagation / space-time stochastic simulation / conditional simulation of rainfall / change of support

Fostering the use of methods for geosimulation models sensitivity analysis and validation

Romain Reuillon[1], Mathieu Leclaire[1], Juste Raimbault[1], Hélène Arduin[2], Paul Chapron[3], Guillaume Chérel[1], Etienne Delay[4], François Lavallée[5], Jonathan Passerat-Palmbach[6], Pierre Peigne[7], Julien Perret[3], Sébastien Rey-Coyrehourcq[8],
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In recent years, there has been a significant increase in the development of methods to explore, validate, calibrate and optimize geosimulation models. These methods and tools remain, however, underused by simulation communities, despite an ever improved and easier access to high performance computation facilities. The OpenMOLE model exploration software (Reuillon et al., 2013) is one of the reliable approaches fully dedicated to promote these techniques. This presentation offers some feedback on the recent initiative of a researcher school in model validation, focused around models and practices linked to the OpenMOLE platform. We present the iterative exploration and validation protocol developed during the school, with methods of increasing refinement deployed on a toy geosimulation model (spatialized prey-predator agent-based model of a zombie infection, with multi-modeling paradigms to include diverse processes for agent behavior). First, we illustrate classical sensitivity analysis methods (stochasticity, design of experiments, global sensitivity indices), and then specific methods to study spatial configuration sensitivity, evolutionary computation methods for calibration and diversity search, and Bayesian calibration methods. They are applied on diverse specific submodels, highlighting specific mechanisms of the model, in order to answer associated thematic questions. We also illustrate the comparison with competing model ontologies by calibrating an ODE-based model on data generated by the simulation model. We finally synthesize lessons learned in the final challenge part of the school, consisting of the autonomous exploration of a new model instance by participants, including defining a thematic question and applying appropriate validation methods. This experiment both introduces a broad overview of new geosimulation model methods, and suggests ways to disseminate these into the modeling communities through similar pedagogical implementations.

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KEYWORDS

Validation of simulation models / Multi-modeling / Model calibration / Sensitivity analysis / Incremental modeling / Pedagogy of simulation models

Coupling multi-agent system and game theory to model the emergence and the allometric growth of systems of cities

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Systems of cities are complex systems because cities are not isolated. They interact with others through material or virtual exchanges, and their growth partly depend of these interactions. City systems have been widely studied by Complex Theory and Geography (Batty, 2013, Pumain, Reuillon, 2017) because understanding these systems appears to be crucial when the majority of the world's population lives in cities.

Work on city systems has mainly allowed:

- to discover regularities in the distribution of the size of cities: the rank size law (Batty, 2006, Arcaute et al., 2015,), which is a power law relating the rank and the size of cities that can be observed in many countries
- to point out the role of innovation and its diffusion in the urban hierarchy to explain the differential growth of cities (Pumain,2017)

However, the question " where do cities emerge and how new cities contribute to the hierarchy of the city system" remains partially open. Most of the time, simulation of the allometric growth of cities start indeed from an existing hierarchy, and current models which try to understand emergence of cities are very complex and based on a lot of assumptions, regarding in particular the economic interaction (Pumain, Sanders, 2013, Pumain, Reuillon, 2017.

Trying to understand the emergence and the growth of city systems and following a principle of parsimony, we propose a model coupling Multi-Agent System (MAS) simulations and game theory (Leyton-Brown, Shoham, 2008).

The model is based on the simulation of interactions between cities at an individual level. The aim is to show how, starting from a scatter of cities of the same size, it is possible to obtain a hierarchical system, including emerging cities, by acting only on the rules governing the exchange of people between cities.

Our model is composed of three main objects:

i. The city modeled by a node on a graph. It have a starting population, a rate of demographic growth and an attractiveness (i.e. a capacity to attract people from other cities), which is a function of the number of exchanges it has been had till the start of the simulation.

ii. The transport network, which is modeled by the arcs of the graph connecting cities. Arcs are characterized by a length and a speed. The graph changes during the simulation when new cities emerge and are connected to an attractive city. This connection is not mandatory. The connection occurs in 50% of the cases.

iii. The individuals (inhabitants of the cities): some of them (same rate of the population for all the cities) go outside their city i to reach another city j. The destination j is chosen regarding the respective attractiveness of the cities and their network distance from i. The attractiveness of a city i at a step t of the simulation is a function of its contribution to the exchange till the start of the simulation :

Attractiveness i = [(nb. individuals which have left i to exchange before t + nb. individuals who have chosen i as a destination) / total of the exchange between all the city before t]

Other types of attractiveness function (not linear with exchange) can be tested

When individuals met along the network, they "exchange" at this exchange location and get profit of these exchange. In order to maximize their gains, individuals have to meet a lot of individuals the closer as possible from their city of origin. Based on their "experience" agents calibrate the minimum and maximum distances they accept to travel in order to exchange. After a period of time, when a threshold of number of exchanges is reached at an exchange place k, individuals which have previously exchange in k in the most profitable way move to k and a new city will emerge.

To explore the model, we test different starting population, rate of moving people, attractiveness function, network configurations and threshold of emergence.

At last we seek to validate the model by using empirical data.

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KEYWORDS

System of cities / Multi-agent system / Game Theory / Emergence and growth of cities / Interactions

The paradigm of a „Spatial Data Science", its methods and models for supporting the solution of some basic geographical problem types in a starting digital age

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Today we are living in a starting digital age. There are many new techniques and automated work flows supporting our daily life, decision making, industrial production etc. Data is produced anywhere and anytime and used for solving many problems which are primarily due to this young more and more machine supported human life. So geographical data is also used for solving geographical problems like orientation, location, regionalisation, assessment, spatial prediction etc. How a new geographical paradigm "Spatial Data Science" is supporting the solution of such problems is discussed in this paper.

During the last decades different terms like Locational Analysis, Quantitative Geography, Computational Geography or Spatial Analytics were used to name the scientific work based on data in geography. The background for these approaches always were current "methodical paradigms" like Multivariate Methods, System Dynamics, Fractals, Cellular Automata, Fuzzy Sets, Agent-based Modelling etc. Though these paradigms consisted of very different methods, the basic abstract problems, which could be solved by geographical data processing, always were the same. These ageless basic problem types in geography are Data Description, Data Reduction, Classification, Location/Allocation, Assessment, Interaction Modelling, Process Modelling, Prediction and Prescription. Because of the different methods being developed in the changing paradigms the solving methods for the various basic problem types in geography were adopted to them and changed too. In the first part of this paper three basic problem types, namely classification, location/allocation and process modelling are described and the different solving methods are listed and discussed.

The newest methodical paradigm, which has been used for data processing and modelling in geography since half a decade is "Spatial Data Science". Using this paradigm most of the basic problem types can be solved in a proper way. Usually the problem solving or the modelling process follows the "Cross Industry Standard Process for Data Mining (CRISP-DM)", which is the basic procedure in most modern data science software. For solving problems using geographical data some special geographical problems, like Spatial Autocorrelation, the Modifiable Areal Unit Problem or Ecological Fallacy have to be considered. In combining geographical data, software for solving the special geographical problems and a data science procedure very good applicable problem solving procedures of spatial data science can be generated. In the second part of this paper spatial data science approaches were described which can be used for solving the three addressed basic geographical problem types.

As a final best practice example a model from the context of energy potential spatial analysis, prediction and prescription using spatial data scientific methods are is presented.

There are still many methodical, software and interpretational problems in applying spatial data science methods. Finally they are shortly discussed. The paper intends to show that nevertheless a spatial data science approach can provide useful solutions for the most data based geographical problems already.

KEYWORDS

Spatial Data Science / basic geographical problems / special geographical problems / energy potential spatial analysis / starting digital age

KEYNOTE 2

Uncovering hierarchies for multi-scalar analysis

Dr. Elsa Arcaute[1]
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Urban systems can be studied at different spatial resolutions, which feedback into one another. In this talk, we use clustering techniques of networks embedded in space in order to uncover the emergent hierarchies and the relevant resolutions. In particular, we look at infrastructural networks giving rise to geographical divisions, and at the evolution of clusters of economic activity in London.

General Session: Segregation

SATURDAY | 11:00 | Symphonie

Unpacking racial segregation in Brazilian cities: a case study of São Paulo and Rio de Janeiro

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Brazilian cities are known by their stark inequalities, which reflected in the spatial pattern of cities following decades of intense migration and unmanaged fast urbanization. The result is a clear core-periphery segregation pattern, where high-income groups are located in central and well-serviced areas while lower-income groups tend to live in peripheral and under service areas. Although this pattern has recently become more fragmented, as a consequence of the emergence of gated communities and increase heterogeneity in peripheral areas, there is evidence that processes of segregation continue to reinforce this pattern. As such, the core-periphery segregation pattern of Brazilian cities has been resilient to long periods of fast urban growth and societal changes and remains so despite recent societal changes.

While residential segregation has been known as one of the most prevalent problems of Latin American cities and Brazilian cities, directly linked with poverty and housing precarity, it has been predominantly studied as a socio-economic rather than racial issue. Yet, recent studies have pointed out that racial segregation is not a mere consequence of socio-economic inequalities. Although there is a strong correlation between race and income in Brazil, a heritage from colonial times and slavery in the country, there is evidence that racial differences might be an active driver of segregation in Brazil.

The present study produced a combined analysis of income and racial segregation in two major Brazilian metropolises: São Paulo and Rio de Janeiro. The pattern of residential segregation for those cities is unpacked using a combination of global and spatial segregation indices applied to microdata from the Census 2010. By applying exposure/isolation segregation indices, the analysis reveals the effect of race in the spatial segregation of those cities and explores spatial relationships between racial-income groups.

Results indicate that although income plays an important role in the definition of the spatial patterns, the role of race has been underestimated. Once income groups are combined with race, it is clear residential clustering is not based on income alone. Rather, the study has produced evidence there is strong racial segregation between same income groups, with a clear distinction of patterns between high-income white and black/mixed groups. In addition, by exploring the spatial relationship between racial-income groups, the study produced evidence that integration between groups is strongly mediated by race. The study also contributes to the understanding of the role race plays in the spatial distribution of population in Brazilian cities, beyond their traditional core-periphery socio-economic segregation pattern.

KEYWORDS

residential segregation / race / socio-economic / spatial patterns / segregation indices / metrics

Segregation beyond scale: assessing the individual perceptions of migrant residential segregation

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With more and more fine-grained "big" data becoming publicly available, researchers are being challenged to develop reliable individual-based indices to assess the complexity and the multiple facets of urban segregation. In the extensive literature on segregation, common measures usually quantify the differences between local concentrations of different groups. The existing indices aim at emphasizing the uneven spatial distribution of groups, their concentration, clustering, centralization or exposure to each other. Upon closer examination, most of these indices have two limitations: they depend on the arbitrary definition of local neighbourhoods or spatial units, and they are scalar quantities, meaning that one single number is used to summarize the entire information in the data.

During the last ten years, new segregation measures aimed at taking into account the multiscalar dimension have been introduced. Most of them are however limited to selecting an arbitrary number of scales, either by aggregating arbitrary numbers of spatial units, or by building circular neighbourhoods of arbitrary radii around a starting point. Nonetheless, the major breakthrough of most of these approaches is the idea of computing egocentric profiles or egocentric signatures, that is individual experiences of the city. We build upon the latter concept to develop a new mathematical object, which encompasses all individual experiences, at all possible scales (modulo the initial scale at which the data is available). This object, which may be seen as a multiscalar fingerprint of the city, consists of the set of all individual perceptions of how different one's neighbourhood is from the city as a whole, when what we call neighbourhood enlarges gradually from a given location to the entire city. Each trajectory is associated to a starting point, and at each of its instants, one evaluates the divergence between the composition of the population in an increasingly larger area around the starting point and that of the entire city. Hence, individual trajectories encode the perception of an individual who starts by visiting their direct neighbourhood, then the next closest one, and so on, gradually, until having visited the entire city.

At this point, one may easily see that the set of trajectories contains all the information about the spatial patterns of segregation, at all scales and from the finest available point of view. However, the size and the complexity of such an object make it difficult to analyse as such. We introduce two concepts for summarizing the trajectories, focal distances and distortion coefficients. First, let us remark that the common point of the trajectories is that eventually they all converge to zero. But, depending on the spatial structure of the city, the speed of convergence will differ from one starting point to another. The areas where the inhabitants feel the most cut-off from the city – at all scales –, will have a slower convergence, whereas the well mixed areas – at all scales –, will converge very rapidly. With this in mind, we define focal distances as the instant – in terms of aggregated population – where a trajectory drops (and remains) below an arbitrary convergence threshold. Focal distances indicate, for a starting point, how far one needs to go to see, with a given precision, the city's population, or, in other words, the "distance" one needs to cover in order to get a relatively clear perception of the city. When averaging all focal distances of a trajectory over all possible convergence thresholds, one gets what we term a distortion coefficient. Hence, for each location in the city, one may compute how distorted the city is perceived from that point, at all possible scales. One is thus able to see and therefore monitor how segregation, taking into account its multiscalar nature, changes across space.

To illustrate these new concepts, we use a a very large dataset provided by the Joint Research Centre of the European Commission (https://bluehub.jrc.ec.europa.eu/datachallenge/), and related to the integration of migrants in the European countries. The data is available in high-resolution (100x100m cells on regular grids), and contains the counts of foreign-born inhabitants per country and continent. Distortion coefficients maps are computed for four European capitals (Berlin, Madrid, Paris and Rome) and for various categories of migrants. Our method proves to be a powerful tool for visualizing segregation across space, and at all scales. We are thus able to compare cities and assess not only which are the most segregated, but also where segregation takes place, which communities are the most segregated and to which extent. Additionally, we discuss the dimensionality and the algorithmic complexity issues related to computing the trajectories and the distortion coefficients, and provide some first solutions based on sparse representations of the data.

KEYWORDS

Segregation / Multi-scale / Migration / Spatial statistics

Immigrants and refugees urban residential segregation: Recent evidence from two small/medium cities in Greece

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Understanding the complex urban spatial relations between natives, immigrants, and Refugees and Asylum Seekers (RAS) is certainly a challenge of high importance and priority for both policy makers and the research community. As such, a number of recent research projects, such as the "Data Challenge on Integration of Migrants in Cities" (D4I) implemented by the Joint Research Centre (JRC), made clear the need for developing new tools to measure immigrant integration/segregation and to visualize these patterns and relations. The current paper aims to contribute to this literature. In particular, it employs both classic measures (the Dissimilarity D, and the Isolation I indices) and the SKATER (Spatial "K"luster Analysis by Tree Edge Removal) methodology to depict the pattern of immigrants' and RAS's residential segregation in two small/medium Greek cities, Larisa and Katerini.

Greece, in contrast to most other European countries, was an ethnically homogeneous country until three decades ago when it started receiving a substantial number of immigrants from countries with few, if any, historic or cultural links. According to various estimates, immigrants (including unregistered and Greek ethnic ones) made up more than two million (about 18.8% of the native population) in 2011, compared to about one million in 2001 and to fifty thousand in 1991. Most of them, as scholars find, move into urban areas showing a tendency to concentrate in specific districts (mainly in central or poor urban areas where house prices/rents are low and there is housing stock available), a pattern that was enhanced by the xenophobic intolerance of the natives, and newcomers use to settle where co-ethnics reside in order to take advantage of the social/community networks. More recently, Greece has also received a substantial influx of RAS, coming mainly from Syria, Afghanistan and Iraq. These inflows peaked in 2015 (comprising more than a million people) and reduced over the next years due to the EU-Turkey Agreement and the deployment of stricter border controls by both the Greek state and the neighbouring countries. However, tight EU restrictions in RAS movement led to the "entrapment" of a substantial number of such people in Greece for an indefinite period. In response, the Greek state, with the aid of the EU, has deployed policies (e.g. the ESTIA programme) for the spatial allocation, settlement and accommodation of these people aiming to ensure the quality of life for both newcomers and the existing population and to facilitate integration.

Although this phenomenon has attracted the attention of the scholars, a very few studies have up to now examined the inter-urban allocation pattern of immigrants and none have explored the dynamics of the RAS distribution in Greece. In addition, the majority of studies used simple measures of segregation, their analysis is mainly descriptive and the areas examined concern the capital (Athens) and big cities, rather than smaller urban areas. The current paper comes to fill in this gap. Aiming to explore the segregation patterns and dynamics of immigrants in two medium/small size cities in Greece, it starts by calculating typical segregation measures (D and I) and compares these to the results acquired using the SKATER algorithms. This spatially constrained multivariate clustering approach utilizes unsupervised machine learning methods to determine natural clustering in the data. Primary data came from the Hellenic Statistical Authority, the Ministry of Education, the local authorities (municipalities), and the UNHCR. All data, were aggregated to the spatial analysis units used by the Census. These official census tracts are used since 2001 and all data were integrated in a geodatabase so that the results are comparable over time. These spatial units concern up to 1500 individuals since more detailed data are not available due to data privacy policy by the authorities. Data/variables and exploratory analysis maps were produced to support early research results.

KEYWORDS

urban residential segregation / small cities / refugees and asylum seekers(RAS) / immigrants / Spatially Constrained Multivariate Clustering / SKATER algorithm / Greece

How far do people travel to use urban green space - a view from three European cities

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Access to Urban green space (UGS) is vital to urban sustainability. They provide benefits such as air filtration, heat islands mitigation, and improve citizens quality of life and health. UGS is also an extensive occupation of land that competes against other sustainability strategies, such as compactness and infill urban development. Planning UGS strategically is therefore crucial for sustainability but also in terms of environmental and health justice since UGS may be easier to provide in the city outskirts and reinforce (or compensate for) the center-periphery sorting of households due to housing markets.

Per capita urban green space (UGS) measures are often used to compare UGS provision across urban areas. Such average indicators, though, say little about the actual UGS use by inhabitants and potential differences in use by different socio-economic groups and different locations within a city. The spatial distribution of UGS in relation to where people live and who these people are can tell more about the use of UGS and to whom their benefits accrue.

We compare the spatial distribution of UGS in three European cities and analyse how it affects the distance travelled to UGS, while controlling for the socio-economic characteristics and the residential environment of respondents and the inner characteristics of UGS. We apply a multi-level model and find that the socio-economic characteristics (e.g. household size, nationality, occupational status, car ownership), the residential environment (e.g. satisfaction with local UGS quality) and the size of UGS explain the distance travelled. We show how these effects vary across our case study cities: Luxembourg, Rouen and Brussels.

KEYWORDS

urban green space / multi-level model / comparative analysis

IV

Special Session: Geo-data science and Urban Sustainability (2/2)

SATURDAY | 11:00 | Salon LA-SI

From forecasting to backcasting: The potential of simulation methods for policy design in strategic planning

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Computational technologies have facilitated the analysis and understanding of complex urban environments. They have been mostly used for forecasting to support urban decision-making. For example, planners can simulate the future impacts of their decisions for evaluation purposes. They can also extrapolate current trends into the future to predict possible threats and opportunities, hence take preactive decisions. It is true that this forecasting approach can give better insights in decision-making; however, it has been subjected to some criticism. First, predicting the future in light of complexities is fraught with uncertainty. Second, forecasting confines planning within the boundaries of future predictions turning it to a reactive practice, whereas its ultimate purpose is to be creative. Instead of predicting the future and reacting to it, planning needs to determine the steps for achieving a certain desirable future. This has called for another approach to planning in the 1980s known as backcasting, the opposite of forecasting. Although it was not developed in the urban field at first, its concept has been observed to resemble an approach for urban planning which was popularized nearly at the same time. That is strategic spatial planning.

Like the backcasting concept, strategic planning is concerned with designing the policies and actions, called strategies, that can drive urban change towards a desirable target in the future. However, in strategic planning, determining the policies that can achieve the desirable future is a major challenge. This is because the current process takes place by engaging stakeholders of the city. These stakeholders always have different agendas, preferences and utilities. Thus, conflicts arise when selecting and designing strategies, as each stakeholder is in favour of strategies which maximises his own utilities. To reach an agreement, negotiation takes place. The problem is that in negotiation, some undesirable patterns of behaviour, like domination of powerful stakeholders or lack of interaction of others, have been observed. Moreover, the reached outcomes are limited to stakeholders' proposals which might not cover a wide range of possible strategies. Some current studies have simulated the process of negotiation to help determine policies (Pooyandeh and Marceau, 2014; Paritosh, Kalita and Sharma, 2018). However, the aim was to determine policies that can consider the utilities of stakeholders without being obliged to achieve a certain common goal as well. Also, negotiation in these studies has been limited to a single issue, e.g. land use, or between the same type of stakeholders, e.g. policy-makers. They have not been applied in strategic planning which involves higher complexities.

In this respect, the aim of this paper is to discuss the potential of simulation methods in backcasting to design strategies that can achieve the common goal of the city while satisfying the interests of different stakeholders. The paper is structured in four main parts. First, the complexity of strategic planning is understood by analysing the generic urban system and the different types of stakeholders. Second, the paper reviews the theories of stakeholder utilities and interaction and how they relate to the different categories of stakeholders. Third, a methodological review is presented for the modelling tools used to simulate stakeholder behaviour and decisions and their potentials

and constraints are discussed. Fourth, the paper conceptualizes two proposals for integrating these theories with simulation methods to design the strategies towards the desirable future.

The discussion presented in this paper shows the opportunities for deploying simulation methods for a backcasting approach in urban planning instead of forecasting, hence provides better support for urban decision-making.

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KEYWORDS

Strategic spatial planning / Urban decision-making / Urban simulation / Stakeholders / Negotiation / Backcasting

Quantifying the ambient population: A critical review

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Traditionally, populations have been quantified through the use of censuses and household surveys, which capture the place of residence of individuals. These data fail to capture the fluctuations in populations which occur temporally, especially in urban areas which often experience an influx of workers, shoppers and visitors. For the purpose of this project, the ambient population is defined as the number of persons within a defined outdoor geographical area, at a given point in time, excluding those located on modes of transport or at their place of residence.

Estimates of the ambient population are a key development in understanding the structure of cities and urban dynamics. Urban dynamics are the changing movements of people, objects and information in a city and an understanding of their components is an integral element of city management and planning. The United Nations (2014) estimate that two thirds of the global population will be living in cities or other urban centres by 2050. The predicted increase of the number of individuals living in cities magnifies the urgency of developing approaches to quantify the ambient population. Estimates of the ambient population are essential to the sectors of retail, housing, transportation and emergency management. As highlighted by Ahola et al (2007), current risk management models do not take into account the temporal fluctuations in the location of the population during different times of the day. The inclusion of estimates of the ambient population in risk management models would improve the reliability of evacuation plans and resource allocation. Estimates of the ambient population can be a valuable asset for local government from an economic perspective, including aiding in the assessment of whether locations are performing well in terms of visitor numbers and retail spend. Socio-economic proposals by local governments for the staging of events and financial support can be fortified by estimates of population and can provide indications of the success of events held in an area.

Previous endeavours to quantify the ambient population have been bound by the absence of complete appropriate datasets at fine temporal scales. The 2011 UK Census captured information regarding the workday population, which provided estimates of people in an area during working hours when people who work outside of a geographical area were omitted from the counts. While this information is able to supply a general indication of the proportion of people that work in area, it does not capture fine fluctuations or non-work activities such as shopping or leisure activities. There is no single dataset which provides information regarding the location of people when they are not in the home on a daily or hourly basis, but there are a number of new datasets produced by recent technologies which could be utilised in conjunction with one another in order to provide estimates of the ambient population. These datasets include; Wi-Fi sensors, footfall cameras, mobile phone activity data, remote sensing and geo-located social media posts. There are many challenges associated with these new sources of data; such as, geo-privacy, validation, geographical coverage and the unknown accuracy of devices. The novelty of the data means that there has been very little exploration of the issues posed by these datasets, providing an opportunity to explore the data in detail and assess the applicability of utilising the data for attempting to quantify the ambient population.

This project will provide a critical review of the aforementioned data sources which could be employed for spatio-temporal investigations of populations. Additionally, the work will explore spatio-temporal trends within footfall counts from Wi-Fi sensors located in the city of Leeds, West Yorkshire, England in order to provide an example of the potential of new data sources for understanding dynamic

populations. The work goes onto compare the temporal fluctuations in the ambient population of Leeds which are captured by Wi-Fi sensors and footfall cameras to determine whether the two data sources capture similar trends throughout a 24-hour period.

KEYWORDS

ambient population / urban dynamics / spatio-temporal / population dynamics

Urban Perforation and Regeneration in Japan: The relationship between Urbanization Characteristics, Network Centrality and Population Distribution

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Japan experienced spectacular urbanization and population growths over the course of the last hundred years. With a population of 57,963 million of inhabitants in 1920, its count more than doubled when the population reached its highest level in 2010 with 128,057 million of inhabitants. These trends have been accompanied by a massive urbanization dynamic, massive to such extent that with an urbanization rate now reaching 93.0% (UN, 2014), the distinction between urban and rural spaces is becoming pointless. The Japanese system of cities is mostly made of a rather limited number of overlapping megapolises characterized by a hyper-dense population distribution. Japan is meanwhile also referred to as a post-growth society, being ahead of other developed countries in some sociodemographic and economic trajectories. Increased longevity combined with a very low fertility rate show that the population is expected to shrink by one-third by 2060, with a remaining count composed of a proportion of population aged 65 (or older) of at least 40% (IPSS, 2012). The interesting phenomenon is that the Japanese society is expected to keep urbanizing despites the population decrease (97.7% urban by 2050; UN, 2014). It thus presents new challenges, never seen before on such a large scale, regarding the spatial distribution and evolution of intra-urban population densities that are already in place. Dedensification leads to urban perforation, a process characterized by the concentration within metropolitan areas of vacant plots and buildings, store closures, etc. Conversely, perforations are accompanied by a density increase in others locations. Anticipating and planning a sustainable shrinkage, a successful regeneration and/or maintaining an equilibrium in some spaces has become a priority for the government.

Researchers are increasingly trying to understand the spatial logic behind these perforations and regenerations (Fujii, 2008; Sorensen, 2019). Yet, in the absence of strong theories on the spatial dimension of metropolitan shrinkage, we decided to go for an inductive search of relation using a dataset made of indicators related to three categories: urbanization characteristics, network centrality and population distribution. Urbanization characteristics concern mainly the form of the urban fabrics (Araldi and Fusco, 2017), which includes indicators like the average and variability of setbacks, height, convexity and elongation of buildings, etc. while centrality indicators (Porta et al., 2010) are related to network connectivity characteristics such as the number of destinations reachable in a given radius. Finally, for population distribution, the 2005 and 2015 official censuses have been used. The scales of the calculated and gathered indicators are categories related i.e. a 250-meter grid for the censuses, the building level for centralities and the street proximity bands for urban characteristics.

The case study for this research is the metropolitan region of Osaka, which stabilized (2010-2015 population growth rate of -0.01%). As compared to Greater Tokyo (which is still slowly growing), a stabilization means an enhanced logic of hot- and cold-spots of metropolitan life, hence the selection of this case study. More specifically, a hyper-urbanized sub-space of 2,500 km2 including Osaka and Kobe and accounting for around 10 million inhabitants has been selected. All indicators have subsequently been gathered to a homogeneous scale following a tessellation-based assignment to links (Okabe and Sugihara, 2012). The assignment has been made using a Voronoi diagram based on the road network (excluding highways). Gathering the data to a homogeneous scale ultimately allowed running several models in order to analyze the relationships among these categories. Geographically Weighted Regression (GWR) provide for example insights into the local

relationships between population dynamic and some of the variables belonging to this study. New hypotheses regarding the link between the locations of hot- and cold-spots and their inner features (morphological, demographic and configurational) will be presented. Understanding this link can help anticipating, tackling and/or planning urban perforation and regeneration in the long run.

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KEYWORDS

Urban perforation / Urban regeneration / Urbanization / Japan / Osaka

Quantification of Photovoltaic Potential for Building Façades using PostGIS in Luxembourg

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The assessment of renewable energy potentials in urban environments gained a lot of interest in the recent decades due to CO2 reduction goals by cities, national policies as well as directives by the EU. In combination with advances in data creation and processing as well as the definition of standards like CityGML, new ways of modeling urban potentials have been developed. This lead to numerous approaches estimating roof-top solar photovoltaic (PV) production. However, in recent years due to research in building materials, the façades became more attractive and feasible for PV electricity production.

This paper describes results on the development of an completely FOSS-based approach to assess the electricity production potential by building façade PV. To estimate solar irradiation we followed the hemispherical viewshed approach described by Fu, 1999. Combining it with an approach to dissect walls into regular 3D point grids (1 meter spacing) we calculate the sun visibility (each hour) and the sky viewshed throughout the year. This results in direct and diffuse irradiation for every wall point. To generate the electricity potential, the irradiation values are summed up for the wall points and are fed into an economic model. This is driven by technical parameters of the installation, such as module efficiency, installation and maintenance costs, figures about payback tariffs and envisaged module lifetime.

The overall result is a city-wide PV suitability and electricity production potential map of every building façade.
The processing is based on a city model in the CityGML format using the 3DCityDB database and the spatial processing functionalities of PostGIS. A set of Python scripts has been developed as a central control instance. The scripts control the processing of direct and diffuse irradiation as well as clear sky irradiation relying on the external "pvlib" Python library. Furthermore, we use the scripts to manage parallel processing of queries against the database to achieve scalability and improved performance. The parallelisation is done by processing single building walls. We run a case study with approximately 8000 single wall elements to process. We identified so far one of the major bottlenecks of the approach. This are the calculations of sun visibility for every wall point per timestamp (intersection with surrounding buildings) which takes per wall several minutes to process depending on the number of points per wall.

Since we implemented a parallel processing of the walls running on a 80-core dedicated server machine, the completion for an entire city of ~3 million wall points uses a decent amount of time for the given size of data set. Here we describe a scalable and highly parallelised approach which can be easily implemented through standard tools and libraries. This open up now for distributed approaches using multiple database servers for even better scalability.

KEYWORDS

Renewable Energies / Smart Cities / Free and Open Source Software (FOSS) / OpenGeoSpatial Consortium (OGC) / PostGIS

IV # Special Session: Co-evolution of Networks and Cities

An evolutionary theory for the spatial dynamics of urban systems worldwide

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Analyzing the spatial dynamics of complex urban systems clearly deserves an evolutionary frame. Following the methodology and results already obtained in the GeoDiverCity project (Pumain et al. 2015, Cura et al. 2015, Pumain, Reuillon 2017), including USA, Europe and BRICS countries, we complete them with new datasets at world scale and other types of models. These models conceived for explaining city size and urban growth distributions establish a correspondence between urban trajectories when observed at the level of cities and systems of cities. We test the validity and representativeness of several models of complex urban systems and their variations across regions of the world at different spatial scales (Raimbault 2018a, 2018b). The originality of the approach is in considering spatial interaction and evolutionary path dependence as major features in the general behavior of urban entities. We investigate models of urban growth at different scales and on different urban systems: a model of urban morphogenesis at the metropolitan scale, which we calibrate dynamically, using the diachronic population grid on largest urban clusters, and interaction models for systems of cities at the macroscopic scale on main systems of cities across the world. We also suggest research directions towards the coupling of these models into a multi-scale model of urban growth.

Complex systems' dynamics is in principle unpredictable, but contextualizing it regarding demographic, income and resource components may help in minimizing the forecasting errors. We use among others a new unique source correlating population and build-up footprint at world scale: the Global Human Settlement built-up areas (GHS-BU). Already explored statistically for comparing urban sprawl trends in the countries of the world by Eric Denis (2019), the dataset is available at different dates between 1975 and 2015. In 2015 the source delineates precisely some 13 000 urban agglomerations between 50000 and tens million inhabitants in the world. These data help in further empirical testing to the hypotheses of the evolutionary theory of urban systems and partially revising them.

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KEYWORDS

urban systems / dynamic models / evolutionary theory / world

A meta-analysis of models for interactions between transportation networks and territories

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The dynamics of territorial systems have extensively been studied in their interaction with transportation networks which are assumed to play a significant role in their trajectories. Therefore, several modeling approaches focusing on the interactions between transportation networks and territories have been introduced by various disciplines, including for example land-use transport interaction models from planning and transportation science, spatial interaction models or co-evolution models from geography, network growth models from physics. This contribution introduces a systematic review and meta-analysis to understand the nature and properties of these models in relation to their disciplinary context. We construct a corpus of models through a systematic review. The raw corpus after initial keyword requests is composed by around 3800 papers, which were screened for inclusion first on their titles (297 papers kept), then on their full-text content resulting in a study corpus of 145 papers. For each model, properties are extracted including the type of coupling (weak or strong and the direction) between network and territory, spatial and temporal scales, the methodology used, and the discipline, in order to proceed to a meta-analysis of these. Exploratory analysis confirms the diversity of approaches existing, whereas statistical analysis links type of models and disciplines with properties, showing for example the strong influence of the type of coupling with time scale, or of the discipline on the spatial scale. We finally use random forest regression to compare the relative importance of variables to explain model type, and show that among different way to define disciplinary belonging, position in the citation network has the largest influence. This work thus provide a systematic and broad overview on the diversity of approaches to model interaction between networks and territories, and foster the possibilities of a reflexive positioning in the context of building new models.

KEYWORDS

Network-territories interaction models / Systematic review / Meta-analysis

How important was path dependency for European railway network expansion? An investigation with Transport Link Scanner

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Improvements that reduce transport costs are generally expected to locally increase productivity and, in cascade, foster economic and urban growth; while investments into transport cost reduction are typically driven by demand, and thus follow economic growth. The consequence is a process of co-evolution of cities and transport networks. In debates surrounding transport network investments, it is often repeated that the logic of transport network evolution and the co-dependency of transport networks and cities makes that any local investment choice has considerable impact on later outcomes of the processes of transport network expansion and urban growth. This leads to path dependency, linked with the more profound assumption that spatial patterns of economy may have multiple outcomes.

Jedwab et al. (2015) have shown that early railway network investments in Kenya had a substantial impact on the equilibrium population distribution; which had long-lasting impacts on Kenya's economic geography because of the sunk costs associated with earlier population growth. In Kenya, railway construction coincided with mass immigration from Europe and Asia, and the settlement of many new cities. Besides railway connectivity, other geographic endowments seemed mostly irrelevant for settlement; and there were no prior investments or sunk costs that could have affected urban growth or network development. In Europe such a clear starting situation did not exist when railways were introduced, as most European cities by far outdate railways and had already accumulated substantial human, cultural and political capital before any railway was constructed. This begs the question how relevant path dependencies are in already urbanized geographies?

This study uses an extended version of the Transport Link Scanner model (Jacobs-Crisioni and Koopmans, 2016) to explore the role of path dependencies in network development and urban growth. Transport Link Scanner is an agent-based model that iteratively 'offers' a limited number of plausible network investment options to investors. Those investors may have different preferences with regard to operational profits and societal benefits. The investment-investor pair with the highest selection probability is selected and added to the modelled expanding network. Thus growing a network in a multi-agent setting invariably leads to a final network representing a Nash equilibrium. For this study, a number of changes have been made to the original Jacobs-Crisioni and Koopmans model. Most importantly, selection of alternative origin-destination pairs for any new link is now based on a multivariate logit model; the final selection of an investment is now only based on the perceived operational and societal cost-benefit rates of that investment; and optionally the population distributions driving network investment are not based on historical municipal population changes but on a panel data model that distributes population growth based on a number of factors including accessibility change (see Koopmans et al. 2012).

The Transport Link Scanner model is used to quantify to what degree prior investments changed final network outcomes and to what degree prior investments affected spatial distribution of urban growth. To do so, a reference model of network change and population growth has been established. Subsequently, alternative network and population growth scenarios were modelled by ingesting exogenous network investments in the modelling approach in different stages of network development. This presentation will discuss Transport Link Scanner, the new elements outlined above, and tentative first results of this attempt to quantify path dependencies.

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KEYWORDS

Network development / Co-evolution / Railways

Serving territories by rail lines : opportunities for a new approach

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In the European context of opening to competition (Cantos et al., 2012), French rail network is engaged in profound structural changes (Rimbaud et al., 2017). This leads public authorities and local actors to question the future of the important secondary network, or what we name in France "small lines" and recently requalified "fine service lines of the territories". These "small lines", which is about 40% of French railway network (more than 12 000 km) and transport passenger as well as freight, are lines classified 7 to 9 in the nomenclature of the infrastructure manager, SNCF Réseau, nomenclature that is based on the one of the International Union of Railways (UIC). Their future is then the subject of many discussions and various reports suggest that SNCF will have to make financial decisions to the detriment of lines with low passenger and / or freight traffic (Spinetta, 2018). While many "small lines" are threatened by the aging of their infrastructure without prospect of renewal, the signing of the « Performance Contract 2017-2026 » between the State and SNCF prohibits the latter from investing in low-traffic lines. This implies that local authorities have now to participate financially in the rehabilitation of these lines whereas the allocation of their resources do not increase.

This research is the first part of a partnership with the Normandy region which aims at establishing a new economic model of the Normandy's fine service lines. Its objective is to go beyond the UIC classification, which is of little relevance in terms of public decision-making, by developing a new evaluation methodology of the current characteristics and uses of rail network lines. It draws on two previous works: first, the work of Meignien and Vernier (2016) on the economic model of small lines; second, it is based on the first attempt to develop such an evaluation methodology by the LVMT on the New Aquitaine Region (Deraëve et al, 2018). This methodology consists of evaluating the current condition of rail lines using five characteristics specific to a rail service: (1) infrastructure, (2) service offer, (3) traffic, (4) the cost for the region, (5) the importance of service to the areas served by the line. Based on several indicators specific to each of these characteristics, it is assigned to each of them a score to evaluate whether this criterion is good or bad on the line studied, in order to identify the strengths and weaknesses of this one. This evaluation methodology is thus a tool that can be transposed to different types of territories, taking into account their specificities and their potentialities.

We therefore propose to present here the first results obtained on the Normandy region. The main result of this research is to establish the bases of an alternative classification to the UIC nomenclature likely to guide the Regions in their enterprise of prioritization of needs and ranking of their actions. Our work shows that some axes have potentially higher performance than what suggests their UIC rating. However, others are conform to the latter. This alternative classification may thus lead the public authorities to reconsider their choices regarding the necessary investments in rail infrastructure. It can redefine a spatial planning strategy in view of the potential offered by its railway lines. So, in the heated debate over the possible end of the "small lines", our work makes it possible to envisage the production of a decision-making tool aimed at reconsidering the question of the fine-tuning of the territory through analysis and the potential of the latter, particularly from the study of its socio-economic characteristics and its mobility policies (Thevenin et al., 2016; Li et al., 2016) .

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KEYWORDS

Territories / Network planning / Rail transports / Fine service line of the territories Regional Transports policies.

Trajectories of links between transport infrastructure and functional polycentricity at Local Urban Systems scale

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How does polycentricity shapes the emergence of transportation networks ? How in return improved speeds can influence intercity commuting (Conti, 2015) and therefore the level of functional polycentricity ? In general terms, the ways spatial organisation of settlements within territories (Le Néchet, 2015a), spatial organisation of flows (Klapka, 2016), and spatial organisation of transportation networks (De Goei et al., 2010) jointly evolves are seldom studied with a medium to long term perspective (Mimeur et al., 2015). In this contribution, we wish to combine an empirical approach, over 40 years evolution, and a modelling approach to establish a typology a sequences of evolution of densities, flows and transportation links between cities.

This submission follows contributions by Le Néchet (2010, 2011, 2017, 2019a, 2019b) ; Le Néchet & Raimbaut (2015) ; Raimbault (2018) on a model called LUTECIA (Land Use, Transport, Evaluation of Cooperation, Infrastructure provision and Agglomeration effects).

On the empirical part, we will focus on a few local urban systems in France (Berroir et al., 2017) where data is available from 1968 to 2008 regarding : density of population and jobs ; commuting flows ; travel speeds. Four « triangle » configuration of city networks with strong links (according to Berroir et al., 2017) are studied regarding the classical chicken and egg problem between flows and transportation infrastructures : Orléans Montargis Gien ; Caen Vire Saint-Lô ; Amiens Saint-Quentin Compiègne ; Sens Auxerre Troyes. We will study the chaining of events between increase of potentiel flows (as measured by gravity model, due to changes in settlement system or changes of transportation speeds) and the increase of flows, in the fashion of the coevolution « regimes » suggested by Raimbault (2018). This empirical study is then used as an external criteria to validate the behaviour of the LUTECIA model, implemented on the Netlogo platform, and which predicts endogeneously the growth of land use and transportation networks on simple theoretical situations. In particular, we wish to challenge the model's capacity to reproduce the three types of trajectories towards polycentricity suggested by Champion (2001) – fusion, centrifugal and incorporation, which will be an important element of the capacity to use the model to study the dynamics of Mega-City Regions (Hall & Pain, 2006).

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KEYWORDS

polycentricity / network development / mega-city regions / model / trajectory

V # General Session: Networks

Unravelling functional areas from human behaviour: mobile phone data and copulas

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Previous research has shown that percolation theory can serve as a framework to uncover the hierarchical structure of urban systems [1]. In particular, cities and regions can be defined beyond administrative boundaries, if the street network is taken as the main underlying network.

Nevertheless, such a framework is limiting, since it is not able to capture human behaviour, that is, street networks might express the connectivity between cities but they do not capture the intensity of movement between them.

In this paper, we explore the different urban delineations encoding the interactions between individuals in space, and their proximity for such interactions to take place. We take as a proxy mobile phone data, since it provides a nation-wide human behaviour with respect to calling and movement patterns. Based on a French mobile phone dataset covering around 30% of the French users for a duration of 5 months in 2007, three networks were constructed that capture i) the amount of calls between cell towers, ii) the amount of distinct callers that have performed calls between different cell towers and iii) the amount of mobile phone users that have two cell towers as their most and second most visited cell tower.

Networks derived from mobile phone data have previously proved successful at identifying regions through community detection techniques. Nevertheless, these have not been used to define cities, since such networks are structurally dependent on the (unequal) spatial distribution of cell towers. Indeed, cell towers are never equally distributed in space (cities, for example, have a denser grid of cell towers compared to rural areas), which influences the construction and analysis of indicators [2] or networks created from them.

In addition, previous methods only consider either proximity or intensity of calls. Given that functional areas are derived from human behaviour, both proximity and intensity of interactions need to be accounted for. We hence develop a novel methodology to incorporate the dependence between distance (as derived from the location of the cell towers) and call/movement intensity (as observed in the mobile phone data), within a joint probability function, derived from a copula [3]. In other words, the copula is used to calculate links between cell towers that correspond to the probability of being close at the same time of having a high intensity of observed interactions (expressed in terms of calls, number of callers, or number of movements depending on the case).

After applying the percolation process on the network which links are given by the copula, we recover cities, metropolitan areas and regions at different transition probabilities. These results shed new light on the relations between city networks and human behaviour, while our methodology can be extended to multivariate systems whose dependencies shape different urban processes.

#ECTQG2019

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KEYWORDS

Complex Networks / Mobile Phone data / Percolation Theory / Urban Systems

How to study urban policy mobilities on a large scale? Network analysis and text mining to explore cooperation between European cities

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An increasing number of studies are focusing on transnational cooperation between cities, whether to support the idea of a government by cities on a global scale (Barber, 2015; Bouteligier, 2012; Bulkeley et al., 2003; Keiner & Kim, 2007) or to highlight the mechanisms for the circulation of urban policies (McCann, 2011). With a few exceptions (Escach & Vaudor, 2014), most of these works are built around specific case studies (urban elite group, association, or international strategy of a particular city). I suggest a complementary approach that would aim to establish a broader overview of transnational cooperation between European cities. My contribution is based on a doctoral study in geography that aims to examine, on a European scale, how the circulation processes of urban models are becoming institutionalized and how they contribute to the construction of categories of public action — in particular that of "small and medium-sized cities" (Gourdon, 2019). This objective requires highlighting certain theoretical and methodological issues.

First, I will discuss the construction of databases to list European transnational municipal network on the one hand (more than 60 associations listed from the Yearbook of the Union of International Associations), and the URBACT projects on the other (An Interreg progamme of the EU with more than 90 networks involving around 400 cities). Among the main issues are the different definitions of cities and the lack (access to member cities of an association) or low semantic value of data. This raises the question of how to define relational variables for a proper network analysis: is it possible to use only the criterion of membership of an association? At the same time, the construction of these databases provides an opportunity to revisit some theoretical aspects. (1) Can transnational associations of municipalities be treated as social networks (Wasserman & Faust, 1997)? (2) How do the hypotheses associated with research on networks of interurban policy cooperation differ from the economic approaches underlying work on system of cities?

The second part will show the different descriptive uses allowed by data mining. My goal is to explore the structure of the European area of transnational cooperation between cities. To do this, I argue that the mere cross-referencing of data on cities membership of the various networks is insufficient. Indeed, it is essential to question the different urban models that circulate. I will therefore propose a two-step approach, consisting in characterizing the texts that define the objectives of each association — using keywords extraction (Rose et al., 2010) and topic detection model (Blei et al., 2003) — and then filtering the graph of relations between cities according to the public problems identified. This opens up two challenges: (1) how to effectively combine network analysis and graph analysis (Bouveyron et al., 2018) and what are the possible modes datavisualization ; (2) How can text mining capture the transformation of urban models resulting from their circulation according to their local implementation ? In other words, how to take into account the spatiality of texts (Banos et al., 2018) that reflect urban models?

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KEYWORDS

Urban policy mobilities / European cities / Text mining / Network analysis

Containment and connectivity in Dutch urban systems: A network-analytical operationalization of the three-systems model

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This paper provides a state-of-the-art settlement geography of the Netherlands based on an analysis of urban networks. We start with the theoretical foundation of the three-systems model that understands functional settlement geographies through the interaction between the daily urban system, the central place system and the export base system. The three-systems model is operationalized utilizing spatial interactions derived from travel survey data at the finely-grained postcode level.

One of the key methodological problems associated with a network-based perspective on spatial processes is that networks ultimately have to be represented as nodes and edges between those nodes. Although such a network representation is particularly well-suited for spatial interactions, it does require us to first nodalize a spatial field, a theoretically-continuous spatial distribution of human interactions, which yields an inherent tension.

Nodalization requires us to decide what is a node and what is an edge and this choice has a potentially large effect on the outcome of any subsequent analysis (cf. MAUP). Nodalization is often done inductively through algorithmic techniques (e.g. community detection; regionalization) but here we calibrate containment (node) and connectivity (edge) based on the causal mechanism that geographically structures each system. This allows for an explicit and careful determination of which spatial interactions should be assigned to nodes (containment) and edges (connectivity).

We use postcodes as our basic spatial unit (BSU) and use different types of spatial interactions between BSUs to aggregate to larger urban systems:
- For the Daily Urban System, nodes are based on daily trips (but excluding commuting trips). Using the Infomap (Rosvall et al. 2010) algorithm, we combine BSUs into larger regions until only 5% of daily trips goes outside of a node. Commuting trips form the edges between nodes.
- For the Central Place System, we aggregate BSUs into nodes based on shopping trips, until only 1% of all shopping trips goes outside the node. This remaining 1% then forms the edges between nodes.
- For the Export Base System, we aggregate BSUs into nodes based on commute trips (until only 5% of all commutes go outside of a node). Business trips forms the edges between nodes.

This regionalization of the three systems is neither mutually exclusive nor perfectly nested. This goes counter to a prevalent assumption of nestedness in urban systems research (Neal, 2012) and also has consequences for subsequent (multiplex) network analysis. We analyse the extent of this 'non-nesting' through the application of a local Wallace Index – a measure that indicates the degree of overlap or nestedness between cluster sets. This reveals the importance of the imbricated boundaries between the urban systems: places with low nestedness are often literally 'in-between' places. We argue that these interplaces deserve more attention in both network-based research as well as urban policy as they are particularly sensitive to changes in urbanization trends.

KEYWORDS

urban systems / regionalization / urban network analysis / spatial interaction / nodalization

Globalization and specialization of Chinese cities 2010-2016: diffusion waves of foreign and domestic multinational firms

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Chinese cities integrated very quickly global economic networks since 2010. Internationalized firms transformed the economies of these cities, reinforcing previous specializations or introducing new ones. Cities' development largely depends on their industrial performance and conversely, industries' development is supported by a set of specialized cities. Activities evolve according to product cycles and are more profitable for cities' growth when they are in emerging stages. However, activities do not develop independently of each other, since a final product is often the result of a necessary contribution of different activity sectors. Their combinations create a potential for innovation, especially in cities that combine them. We assume that diversified cities, because of potential recombination of activities, are expected to have higher growth rates and because of their diversity, are more resilient to economic uncertainty than specialized ones.

The aim of the paper is to describe the fast integration of Chinese cities in global networks and the evolution of the activities of foreign and domestic global firms in such a theoretical framework. We test the hypothesis of the end of a diffusion wave of the foreign firms, which first concentrated in large cities until 2010, reaching medium and small cities in 2013-2016, while a new wave of Chinese firms expanded, fostering largest cities. Therefore, the paper proposes to evaluate the extent to which cities were hierarchized in 2010-2013-2016 by foreign or by domestic firms. In addition, we will evaluate how far cities benefited from specialization, diversity or related variety for both kinds of firms during these periods of time, for their resilience against unemployment and regarding the increase of wealth (GDP per inhabitant) considering the structural properties of their activities, and the interplay between activities' dynamics.

KEYWORDS

System of cities / China/ globalization / Multinational firms / scaling law / specialization / relatedness

Integration of Arctic Places with Multi-sources Data

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Geographers describe the world more and more on the base of networks and flows. It is a matter of fact that one locality shows its development level through its connectivity to other localities, the national core and more largely the world-system. If this quality is low or missing, locality falls into the periphery. Therefore, within a regional or a city core, one can find pockets of periphery that seem left apart. Thus, the world is no longer organized by concentric circles from the core.

The high latitudes is generally regarded as a periphery of the global system that experiences rapid and huge changes under two main drivers: globalization and climate change. Given its rapid evolution, it is difficult to represent emerging Arctic places and those that face decline.

As cities and transport network have been intertwined throughout history, this research aims to picture the integration of Arctic localities. To do so, we examine transportation as well as social networks connecting Arctic settlements within the Arctic region and with the non-Arctic region. In this study, a sample of localities was extracted from Arcticapolis, a part of the French Research Group Geopolis dedicated to a geohistorical and worldwide settlement database. Arcticapolis targets all circumpolar countries. Selected localities are located within the Arctic limit created by the Canadian geographer Louis-Edmond Hamelin on the base of physical and human dimensions of the environment such as coldness, number of inhabitants…

We look at the connection between settlements through four different networks using three different downloadable data for free on the web. First, for ground transportation, roads and railways, we use OpenStreetMap (OSM). Second, we consider for air routes, data from FlightRadar website which provides real-time flight schedules from 5,000 airports around the world. Third, as interactions between places can also be described by digital footprints, we explore connectivity through social networks using millions of geolocated data from Twitter.

At the first step, such quantitative studies require appropriate and homogeneous datasets that are sometimes difficult to collect in a large region covering several countries. We examine the quality and the biases of each dataset especially within the study area (i.e. such as penetration rate for Twitter, users and quality assessment for OSM). Afterwards, we present different methods in graph creation from different sources and we propose a typology of the Arctic localities in terms of centrality.

Finally, our study provides a picture of the Arctic places that allows us to question the common hypothesis "the closer to the north, the fewer integration". It reveals sub-regions where settlements show stronger ties together than with others Arctic regions, as well as Arctic bridgeheads, connected directly with the outside of the circumpolar zone.

KEYWORDS
Arctic / Network analysis / integration / Arcticapolis

V Special Session: Land-use modelling for Policy Support (1/2)

20 years of Land-Use Scanner in policy practice

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This year the Land-Use Scanner model has been published exactly 20 years ago. It essentially is a doubly constrained optimization procedure that is implemented efficiently in the open-source GeoDMS environment. Since its inception, the Land-Use Scanner modelling approach and technical environment has been adopted in models used by, amongst others, the Netherlands Environmental Assessment Agency, Germany's Federal Institute for Research on Building, Urban Affairs and Spatial Development, and the European Commission's Joint Research Centre. Derivative land-use models have been applied covering the Netherlands, Germany, Suriname, Bangladesh, all of Europe and all of Africa.

KEYWORDS

Land-use modelling / Discrete allocation / Quantitative optimization

Linking socio-economic and physical dynamics in spatial planning

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Many of the grand challenges in spatial planning require a thorough understanding of both the socio-economic and physical dynamics that shape the land-use system. This is particularly true when addressing the many aspects related to climate change. Integrated models of land-use change can be helpful to understand the potential implications of the interplay between expected future changes in the connected socio-economic and physical systems and evaluate the impacts of potential adaptation measures on these dynamics. This presentation gives recent examples of such integrated modelling efforts that were undertaken to support spatial planning. The applications have in common that they address socio-economic processes with the Land Use Scanner modelling framework and incorporate dedicated models of specific physical processes to simulate the changing context in which future land-use developments will evolve.

The first example focusses on the peaty meadow areas in the Netherlands that are characterized by relatively high levels of farming intensity, in spite of the challenges they bring in relation to soil subsidence because of drainage, flood risk, and salt intrusion. These challenges are expected to be compounded by climate change and its effects on, for instance, sea water levels, air temperatures and precipitation patterns. Indeed, when combined with continuing socio-economic growth, the cost of adaptation in dairy farming may sooner or later start to outweigh the benefits to society these regions bring. This example investigates adaptation in dairy production in peat areas in relation to the effects of climate change and changing water management policies using the Phoenix model for hydro-physical effects. It does so on the local scale of 100 x 100 meter grid cells, allowing the model to take into account the complex interactions of the highly local particularities of soil, hydrology and land use that characterizes the areas at hand. Soil subsidence and land-use change are simulated under different policy and climate scenarios. The modelling framework assumes that dairy farmers maximise utility in agricultural production systems while considering alternative production intensities. The utility that can be derived at each location is assumed to be dependent on a combination of factors that set the opportunities and constraints for different production intensity options. Production possibilities are determined by water level management in peat areas as determined by the model Phoenix (incorporating feedback effects of continued draining on land subsidence). The methodology allows for calculating costs and benefits at different scales. Combining cost-benefit analysis and geographical information systems allows for insights in costs and benefits at different geographical scales and to evaluate location-specific effects of more general policies.

The second example is part of the Bangladesh Delta Plan 2100, a project for which the Government of Bangladesh requested the Government of the Netherlands for advice and recommendations on how this country should deal with increasing population growth and increasing flood hazards, in this already densely populated river delta. This example simulates future flood risk by combining four scenario-based population projections and statistical analyses on historical urbanisation patterns with a spatial allocation tool based on Land Use Scanner and the Flood Impact Assessment Tool (FIAT-Delft). It explores the possible impacts of different flood risk management strategies on limiting the population exposed to flooding.

Based on our experiences in setting up the integrated modelling approaches presented in this chapter, and drawing on the discussions we had with fellow researchers and policy advisors while working on these case studies, we finalise this contribution with five lessons we have learned to

generate model results that may be helpful in a planning context; ensure credibility in the modelling approach, provide transparency throughout the study, the spatial resolution should be in line with the goal of the study, being flexible with the data at hand, and keep modelling applications in spatial planning as simple as possible.

KEYWORDS

spatial planning / socio-economic dynamics / physical dynamics / land use scanner / flood modelling / water management

SATURDAY | 13:30 | Salle des Fêtes

Localising global urban development; simulating local exposure to natural hazards in the global 2UP model

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Future population growth is expected to concentrate in urban agglomerations that are already exposed to numerous natural hazards. It is difficult, however, to assess this increase in risk as natural hazards are often concentrated in space and population growth scenarios tend to be defined at much coarser scales. By combining recently released high-resolution spatial data on land use, population density and natural hazards with a novel, computationally effective simulation approach we analyse global increases in local exposure to two important natural hazards: flood risk and landslides.

We develop global spatially explicit projections of population change and urban expansion using a land-use and population allocation model. The model is developed in the Geo Data and Model Server (GeoDMS) modelling framework, that also underlies Land Use Scanner and several other operational models of land-use change developed for individual countries, larger river catchment areas and the territory of the European Union. The model disaggregates scenario-based national-level population estimates to a high resolution spatial grid (30 arc seconds). It simulates local population development and urban growth on a global scale. The main steps include: 1) compiling current global population and urban land use data layers; 2) developing projections of future population and urban area growth; 3) defining suitable locations for future development following a logistic regression analysis explaining urban patterns around the globe; 4) allocating future urban area development and population change; 5) assessing exposure to natural hazards.

We conclude that on global scale urban development is likely to strongly increase exposure to both floods and landslides. In almost all world regions urban growth during the coming decades is larger in hazard-prone areas than in non-exposed areas. This is especially prevalent for countries in Sub-Saharan Africa and South Asia. In developed countries growth rates are much lower and show far less variation between exposed and non-exposed areas. In our presentation we will discuss the functioning of the model, its calibration and validation and the most interesting outcomes. We will briefly reflect on its usefulness for policymakers, suggesting that the model is best applied in fast developing regions where model-based risk assessments were hitherto impossible because of a lack of data.

KEYWORDS

land-use modelling / urban development / natural hazards / risk assessment

LUISA: integrated land-cover/land-function modelling for policy practice

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Spatially explicit land-use models are increasingly used as instruments in the practices of policy definition and evaluation (Koomen & Borsboom-van Beurden 2011; Wegener 1998). When overlooking the field of such land-use models, one can identify an important difference in modelling scope. On the one hand, models that focus on land cover changes, such as the CLUE and Land Use Scanner models (Verburg & Overmars 2007; Hilferink & Rietveld 1999; Engelen & White 2008); on the other hand models that focus on land functions, such as UrbanSIM and TigrisXL (Waddell 2002; Zondag & De Jong 2005). Land cover models typically simulate land-use changes as changes in discrete land surface classes, which identify the physical characteristics of land use. Land function based models typically simulate changes in the functional characteristics of land use. At a high level of abstraction, such land functions are expressed in the amounts of a good or service an area provides (Willemen et al. 2008). Practically, this may imply for example the amount of milk or wheat produced in that area, or the number of jobs, shops or residents that the area hosts.

The Joint Research Centre of the European Commission develops and applies the LUISA model, which is set up on purpose for the integrated assessment of sectoral policies. It has been used extensively in practice for policy evaluation purposes. Predecessors of the LUISA model were based on aspects of the CLUE model and strictly modelled land cover. Early evaluation projects learned that policy makers had a need for indicators that can only be computed with results from a function-oriented land-use model. To satisfy that demand, considerable effort has been put into the development of LUISA, a model that offers substantial integration of cover and function aspects of land use. As it currently is, the LUISA model simulates changes in land cover and residential population, including a breakdown of population by broad age class, for every hectare of land in the EU.

All improvements to the LUISA model have given it a broad capacity to measure integrated policy effects. For example, recent LUISA projects focus on measuring road accessibility effects of network investments, levels of agricultural land abandonment, and the costs of future service provision in regions with population decline. This presentation will outline how land cover and function modelling is integrated in the LUISA framework, what sort of indicators are currently being computed with that model, and what challenges lie ahead for the LUISA modelling approach.

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KEYWORDS

land-use modelling / land function / land cover / policy impact

V | Special Session: City size effects and Urban Systems (1/3)

Radial analysis and scaling of urban land use

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We determine the functional form and scaling law of radial artificial land use profiles in large European urban areas. The data is provided for the year 2006 by the GMES/Copernicus Urban Atlas, identifying land use very precisely across the 300 largest cities in Europe, at the level of Eurostat's Larger Urban Zones (LUZ). We note N the total population of an urban area. The city center is chosen as the location of the city hall, and land use is averaged in rings of fixed width (141 m) around it. All artificial land uses are aggregated, yielding 300 radial profiles of artificial land use. These radial profiles are fitted using different methods, in order to summarize their mathematical properties. From the results of a previous work (Lemoy and Caruso 2018), we expect a certain behaviour for the profiles $s_N(r)$ of European cities (where r is the distance to the center): they should start at a 100% artifical land use share in the center, and decrease faster for smaller cities.

Observing that the share of artificial land use decreases exponentially with increasing distance to the centre, we first try a simple exponential fit for each city, using two methods: a linear fit of the logarithm of land use, or a non-linear fit of the raw value. The results of the non-linear fit are closer to the expectations, and more pertinent. The characteristic decrease distance scales like the square root of total population, meaning that the artificial surface of cities is proportional to their population. This also means that the amount of artificial land per capita is independent of city size.

The non-linear fit describes the city center better: the logarithm magnifies fluctuations further away from the city center, putting an emphasis on the description of periurban areas. Conversely, the non-linear fit emphasises the description of central areas. Thus, the linear model is misled by small absolute (but large relative) variations of land use in peripheral areas, which the non-linear model tends to disregard.

Actually, even with the non-linear model, a large part of the cities are predicted to have more than 100% artificial land in their center, which is impossible. We then try to force this 100% value in the center, and to use a one parameter exponential fit, which results in an even clearer scaling law. Not surprisingly, coastal cities are found to be the main source of discrepancy.

As a conclusion, the artificial land use radial profiles of the 300 studied European cities are surprisingly well described by the simple mathematical expression $s_N(r) = \exp(-r/(l\_1 * sqrt(N)))$, with $l\_1 \sim 7$ m. Preliminary results indicate that this structure and scaling law is stable between 2006 and 2012, despite urban growth.

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KEYWORDS
radial analysis / scaling laws / urban land use / European cities / coastal cities

Change in Artificial Land Use over time across European Cities: A rescaled radial perspective

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Seen from a satellite, whether looking at land use in the daytime or at night lights, most cities have rather circular shapes, organised around a city centre. As a consequence, the radial distance to the main centre is surely the very first spatial differentiation to consider when studying the internal structure of many cities. We conduct here a radial analysis of urban land change in order to understand what the recent changes in urbanisation are across Europe and how it relates to city size. We focus on the most fundamental differentiation regarding urban land use: has it been artificialised for human uses (residence or roads for instance) or is it natural, or at least undeveloped (Prokop et al., 2011) Using spatially detailed data from the EU Copernicus Urban Atlas, the profiles of artificial land use (ALU) are calculated and compared between two years, 2006 and 2012. Based on the homothety of urban forms found by Lemoy and Caruso (2018), a simple scaling law is used to compare cities after controlling for population and allows for the internal structure of cities, as determined by distance to the city centre, to be compared across years. Examining cities from a monocentric perspective, with respect to distance to the main centre is long established in urban geography and economics (Alonso, 1964; Clark, 1951; Fujita, 1989; McDonald, 1989; Von Thünen, 1875). One of the advantages of using a radial analysis, is the ability to examine the complex two-dimensional intra-urban structure of a city in a one-dimensional space. The land use profiles produced from the radial analysis represent ALU with respect to distance to the centre. Similar to other studies (Walker, 2018; Wilson, 2012) the location of the city hall is used as the centre point of cities. This historical location tends to coincide with the principal residential centre (Griffith and Wong, 2007). We present evidence of tilting profiles of artificial land use which shows that given total population growth, urbanisation is relatively shrinking up to a rescaled distance of ~ 20km (using London as a reference) on average across Europe between 2006 and 2012. This contrasts with further expansion and increase in artificial land use, beyond a rescaled distance of ~ 20km. Grouping cities based on population, highlights that ALU in the largest cities (population > 1.5 million) is on average flattening around the core but increasing at distances around the periphery. For cities with a population below 100,000, ALU increases across all distances to the CBD. We explore these changes focusing on similarities between cities by disentangling the role of city size. Our findings have important implications relative to the sustainability of cities as this evidence is pointing to increasing urban sprawl and stagnant growth in urban centres across cities of all sizes. It also bears theoretical implications on the nature of sprawl and its scaling with city size.

KEYWORDS

Spatial analysis / radial analysis / land use / scaling laws / urban sprawl

Urban agglomerations in the world. Revisiting suburbanization trends through coherent city definitions

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Cities are the space where people conduct their daily activities, such as work, consumption and recreation. With increased density, preference for space and affordable daily transport options, cities have become increasingly malleable and discontinuous. Understanding and planning cities that do not conform to continuous or administrative areas requires the (re)definition of their economic boundaries. When cities are defined in terms of functional and economic approaches they are generally called urban agglomerations or functional urban areas (FUAs).

A method to consistently identify FUAs across countries was developed by the OECD jointly with the European Commission. According to such a definition, FUAs consist of high density places called cores, which are surrounded by commuting zones. The latter are generally identified using data on commuting flows between small local administrative units and provide an approximation of the spatial extent of the labour market. The sum of the cores and their surrounding commuting zone determines the total extent of FUAs.

This paper aims at extending the concept of FUAs at the global level and to provide a comparative picture of the major trends in suburbanization in different regions of the world since 1990. Suburbanization is intended here as the process of decentralization of FUA population towards commuting zone. Therefore, the main purpose of the paper is to determine the extent of commuting zone surrounding cores and assess their population dynamics at the global level. So far, the EC-OECD FUA definition has been applied in most OECD countries and Colombia, mostly because data on commuting flows is not usually available in non-OECD countries. The method we propose here is fully reproducible and applicable to any country as it does not require commuting flows data and relies only on two publicly available one square kilometre gridded global datasets. The first is the satellite-derived Global Human Settlements Layer (GHSL), which provides a built-up and population distribution grids and a settlements classification according to their density. The second is a global travel impedance matrix which allows us to consistently estimate travel times between any given cell and their closest core. Compared to other alternatives, data derived from satellite-based imagery to classify urban patterns has the advantages of being low cost, comparable and available in low-income settings.

The proposed method uses the cores identified in the GHS-SMOD dataset by applying the "Degree of Urbanization" model. It then approximates commuting zones by relying on the estimated probability that a cell with a certain population density is part of the FUA, conditional on the distance of the cell to the most proximate core, the size of the core and size of the cell. The parameters used to calculate this probability are the outcome of a logit model where each one kilometre cell with at least 300 inhabitants is classified as one if they fall within a FUA border and zero otherwise. The choice of regressors follows gravitational and spatial attraction and matching growth models that suggest that new urban areas are more likely to appear if they are close to already existing centres, as the cost of making connections decreases with distance and city size.

We use the set of observed FUAs to construct the training set for the classification problem. The choice of a population threshold of over 300 inhabitants per cell serves the purpose of closely

reproducing observed FUA boundaries while being consistent with more general population density decay with increased distance from the city centre.. After validation of the method based on model performance measures, we estimate FUA boundaries for non-OECD countries around the globe. We then proceed to describe major suburbanization trends by continent and level of development, to revisit and expand our understanding of suburbanisation. By using a definition of compact suburbs as medium density contiguous areas within commuting zones with a minimum population of 5,000 people, we are able to better characterize changes in inner suburban areas.

Results show that about 54% of world population live in FUAs, although this proportion is highly dependent on the level of development, ranging between 38.9% in least developed countries to 56.4 in developed countries (67.1% in North America). Overall, 12% of FUA population live in commuting zones. Such a share is also highly heterogeneous across level of development, with 7%, 10% and 22% of FUA population in least developed, less developed and developed countries, respectively. The proportion of people in suburban areas of FUAs has been increasing since 1990, with acceleration after 2000. While North America had the highest proportion of suburban population at the beginning of the period, such proportion continued to increase. However, the fastest increases were observed in the urban agglomerations located in Europe and Latin America. We find that commuting zone population has expanded around compact suburbs, which also make up the bulk of the suburban population.

KEYWORDS

city definition / commuting / suburbanisation / global

Trajectories of the French polycentric mega-city regions: which links between urban growth and urban form?

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Is polycentricity a strength or a weakness for the trajectory of territories? Several articles tackles these questions through different perspectives: economic development (Meijers, 2005; Terral et al., 2017), social and environmental costs of commuting (Veneri, 2010), or governance (Davoudi, 2007). At the same time, the emergence of Mega-City Regions transforms the scale at which urban dynamics need to be studied (Hall & Pain, 2006): from the urban area to the urban area network - i.e. "local urban system" in this paper, following Berroir et al. (2017) typology for France. The transformations of the spatial organization at this scale are, simultaneously, morphological and functional (Burger & Meijers, 2012; Conti, 2015). In this context, we question, using a quantitative and diachronic approach, at the scale of "local urban systems", the links between the trajectory of the spatial organization of urban systems (morphological and functional attributes).

Due to recent changes in lifestyles and the tensions on the housing and employment markets in France (Sigaud, 2014) we make the hypothesis that the evolution of the forms of spatial organization of cities and the socio-demographic trajectories have strong links at the "local urban system" scale. We are inspired by the methodology proposed by Wolff et al. (2013) on Shrinking Cities, while adapting the indicators of the wealth of urban systems: demographic growth, unemployment rate, vacant housing, share of workers working outside one's Functional Urban Area, among others are measured on several dates (1968 to 2015). Our methodology is innovative as it computes morphological and functional indicators at two scales, following Conti & Le Néchet (2017): the local urban systems and the system it forms with hinterlands (Conti, 2016). Morphological indicators include classical scaling parameter from Zipf law (Pumain, 2004) and other urban form indicators (Le Néchet, 2015). Functional indicators include: hierarchy of flows between cities within urban system, symmetry of flows between cities (Berroir et al., 2011).

By confronting the typology of evolutionary trajectories of the spatial organization of urban systems, with socio-economic indicators, we wish to illustrate the potential of that flexible approache, combining the city region framework (Parr, 2005) and the urban system framework (Pumain, 2004), which we find to be fitted to the contemporary functioning of territories in France.

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KEYWORDS

local urban system / polycentricity / urban dynamics / commuting / hierarchy / employment market

New insights from old gravitation

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We explore a statistical gravitational model (Rybski et al, 2013) and propose an upgraded version which provides population counts beyond the binary (urban/non-urban) city simulations. Numerically studying the model output, we find that the radial population density gradients follow power-laws where the exponent is related to the preset gravity exponent gamma. Similarly, the urban fraction decays exponentially, again determined by gamma. The population density gradient can be related to radial fractality and it turns out that the typical exponents imply that cities are basically zero-dimensional. Increasing the gravity exponent leads to extreme compactness and the loss of radial symmetry. We study the shape of the major central cluster and find that overall its fractality is dominated by the size and the influence of gamma is minor. The fundamental allometry, between population and area of the major central cluster, is related to the gravity exponent but restricted to the case of higher densities in large cities. The model allows to generate and investigate city structures under laboratory conditions. We illustrate that exponential attraction leads to much simpler shapes than those generated by power-law attraction.

KEYWORDS

urban growth / gravitation / population density / urban fraction / radial gradient / fractality / fundamental allometry / singularity cities

VI | General Session: Spatial Interactions

Attractive and repulsive cities for the French population: teachings from the scale mix

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Studies on cities attractiveness and repulsiveness are quite classical both in economy and geography (spatial analysis). Those analysis are characterized by two main methodological issues. First, the cities analyzed most often belong to the same scale level. The aim is therefore either to evaluate the internal attractiveness of cities that belong to the country of the respondent (ex: France) or to evaluate the external attractiveness of foreign cities that belong to the world level. In this case, the question does not allow respondent to quote cities from their own country. Second, the analysis and interpretation of the different level of attractiveness they are often based on the use of interaction models (like gravity model) to measure the relative importance of the size of the places (cities) and the distance to those places to explain their attractivity. Therefore, place attractiveness is most often explained by characters that describe the target cities (population, wealth, employment, metropolitan activities etc.) but does not take into account the individual characteristics of the respondent (age, sex, level of education, income…).

In this paper we made different methodological choices and try to test three hypotheses.
The first hypothesis is that intra-national and inter-national choices of attractive and repulsive cities are not independent part of the reality. We have no theoretical reason to constrain the answer to one scale level only: people have knowledge of their regions, country, and world level and representations of different places in the same mental map. For example, a French citizen can consider that both Lagos (Nigeria) and Bethune (Hauts-de-France) are repulsive cities and both San Francisco (United States) and Biarritz (Nouvelle-Aquitaine) are attractive ones. We propose to analyze the distributions of answers of people in a scale-free perspective and to verify how people can combine local, regional, national, European and global levels.

The second hypothesis is that the attractiveness or repulsiveness of cities depends not only from the characteristics of the cities but also of the characteristic of people that provide answer. Different kind of places are attractive of repulsive for different kind of people and this can variate according their sex, their age, their social profile and the place they live or they come from. This allow us to approach the city attractiveness or repulsiveness through the theoretical corpus of mental representations and to test some of social determinant of perception filters. We will analyze in particular if the remoteness of cities mentioned in the answers is mainly determined by social (age, gender, level of education) or spatial (region, urban hierarchy) positions of individuals.

The third hypothesis is the fact that when people are asked to provide a list of attractive or repulsive cities, we can observe path dependencies in the rank of answers. Some cities are more likely to be mentioned in first, middle or final place of the list. But we can also observe significant repetitions of dyad or triad in the list of answers, revealing the existence of "mental backbones" which are associated to "shadow networks" of repulsive and attractive cities. We assume that these significant repetitions of dyad or triads (as compared to a random model) can reveal specific combinations of cities according to scale or distance.

In this paper we propose to analyze the representation of attractive and repulsive cites in the eyes of a sample of more than 1000 individuals that are representative of the French population. The survey was realized in September 2017 by CIST on a panel provided by the DIME-SHS. People were asked to quote five cities where they would like to live if it would be possible and five cities where they would not like to live. We loaded the data received from DIME-SHS and selected the variables of interest. Analysis are made with R packages, in particular package survey for the introduction of a weighting and igraph for network analysis. We use different statistical tools (logit model, Poisson regression) and spatial analysis models (double constraint spatial interaction model, dominant flows method) for the test of our hypothesis.

Preliminary results generally validate our thee hypothesis and reveals (1) a preference for national answers (65%) but an equal proportion of positive and negative opinions in national and international answers; (2) a strong social segmentation of the mental maps of French population, with huge differences of scales and distance in the list of cities mentioned; (3) a prominent role of Paris as gateway city to international cities in the production of positive or negative list of cities. A specific role of Bordeaux as central note of attractive cities and Marseille as central node of repulsive cities

KEYWORDS

mental representation / city attractiveness / scale articulation / network analysis / survey

Gravity Model Dynamics as Heat Cycles

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The gravity model is a model of spatial equilibrium derivable in the same way as equilibrium solutions are derived in statistical mechanics. The limitations of spatial equilibrium in the gravity model are similar to the limitations of field theory in physics and in utility theory; namely that utility theory is useable in closed equilibrium models, problematic in open models with external forces, and misleading in models where utility functions are affected by the potential gradients of the field.

Thermodynamics has had some success in the dynamic analysis of heat engines and we explore the application of this kind of analysis to gravity models. We examine the extent to which standard heat engine cycles (pressure/volume, temperature/entropy) can be related to the cycle of transport congestion, relief of congestion by transport improvement, development of housing and employment locations to exploit improved transport, and the consequent reappearance of congestion. In particular we look at the separability of entropy and trip cost change from changes in the parameters of the gravity model which measure rent and consumer surplus around the equilibrium solution.

The identification of consumer surplus as an economic rent focusses analysis on questions of equity, of who gains and who loses. The gravity model permits a spatial equity analysis which emphasises the question of whether or not an increase in an economic rent can be considered as a welfare benefit irrespective of who gains or loses. The identification of the gravity model as a model of imperfect competition focusses on the overall economic efficiency of the urban system measured by the model and also on the question of whether such efficiency could ever be desirable in a functioning city.

When entropy changes so to do the degrees of freedom in the system model. We explore the relation between entropy and statistical and physical degrees of freedom as this may allow the application of the equipartion theorem to the model with consequences for model calibration and prediction.

KEYWORDS

spatial interaction / equity / entropy / development cycle / equipartition

Modelling geographical preferences from survey data

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How Turkish undergraduate students are choosing attractive or repulsive countries? This presentation investigates the key factors leading to the mention of countries as attractive or repulsive as an answer of an open-ended question which was presented in a questionnaire to more than 1400 undergraduate students located in Turkey (the questions were: "in which countries would you like to live in the near future?"; "In which countries would you not like to live in the near future?"). Based on the result of a field research conducted during an international research project (734 students in 2008, PCRD Eurobroadmap, (Beauguitte & al., 2012) and a PhD research (705 students in 2013 - Toureille, 2017), this presentation gives some elements of analysis through the exploration of several levels of formalisation of a gravity model (Poisson multiple linear regression).

Following previous experimentations on the same kind of data (Grasland et Beauguitte, 2010), the key idea is that modelling outreach the limitation of individual based analysis, leading to the emergence of structures which could be interpreted as clues for the construction of spatial representations. In this perspective, statistical models are used as supports for the interpretation of complex socio-spatial constructs.

The first hypothesis will investigate the "magnifying glass effect" related to the fact that countries close to the place of observation (Turkey) seems to be more often mentioned than remote countries. Starting from a classical Wilson model, this first part of the presentation investigates different metrics of mass (population, area, GDP) and distance (continuous vs contiguous) to illustrate that representations are related to the unequal circulation of information about countries in the world. Following Hägerstrand's theory on the diffusion of information – 1952, 1953 – distance is there considered as a social construct. An interesting result of this first experiment is that this basic model is efficient for analysing both attractive and repulsive mentions of countries.

The second part of the presentation will develop augmented version of this basic model in order to investigate the hypothesis of diverging factors of choice of attractive and repulsive countries. This part shows the relevance to integrate a HDI measure for the attractive countries, but also factors identifying regional belonging: all other things being equal to HDI effect, countries which are long lasting members of the EU 15 are more often chosen by Turkish students than new members (12 most recent members). Unsurprisingly, rich countries – according to development criterion – have a higher probability of quotation than poor countries. Therefore, a symmetric hypothesis would argue that poor countries are likely to be chosen negatively (which could explain the lack of attractiveness of African countries). But the application of this model to the repulsive countries is not working: often, poor countries are more likely to be not quoted at all (there are missing from student's representations) than quoted negatively: the choices of repulsive countries seems to be based on other logics.

Following the same approach than for the positive ones, we develop an augmented model with the introduction of two variables identifying geopolitical conflict in the countries (according to previous statistical exploratory observation and results of semi-conducted interviews with students): 1) the first identify recent conflicts, like wars (conflict leading to more than 25 death, happened less than five years before the date of survey according to the PRIO – Peace Research Institute Oslo – Armed conflict data set), 2) the second identify old conflicts with Turkey (more than 25 death according

to the COW – MIDA 4.1 database – The Correlate of Wars Project Militarized Insterstate Disputes, between 1814 and 2010). The first variable leads to the conclusion that political violence like wars are a high factor to select a country negatively. The second one shows the potential effect of conflict memories (like in some specific case like Armenia and Greece).

The end of the presentation will discuss the theoretic perspectives and limits of this work. It will also expose the surprising stability of the results over time (comparison between the 2008 and the 2013 survey) and within the diverse sub-groups of students (according to gender, field of study, the city of survey). It will also sustain that this kind of statistical modelling can be a heuristic perspective to test more qualitative and interpretative hypothesis.

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KEYWORDS

modelling / gravity model / attractiveness / repulsion / data survey / Turkey / students

SATURDAY | 15:30 | Salon LA-SI

{Cartograflow}: Filtering Origin-Destination Matrices For Flow Mapping Purposes in R

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[1]*IFSTTAR, France*

Mapping flows to depict spatial interactions patterns raises specific problems related to the complexity of the information and its graphical representation (the so-called spaghetti effect). These problems are relate to the analysis of both statistical and geographical data, for thematic cartography purposes. If they can be solved from different perspectives, solutions that can be provided are either theoretical, methodological or lies in the development of specific tools as Tobler said (Tobler, 1967, 1970) to implement proposals in a given technological context.

Considering the general interest in research issues related to the visualization of large graphs, particularly in interactive environments, one might think that the cartography of spatial interactions patterns have benefited from this context. Unfortunately, this prospect is illusory, except in a few cases. Geoweb applications dedicated to flows remain in the minority. The existing ones are limited to the direct display of flow dataset: they do not allow data processing that would enhance the figure. On the Geographic Information Systems side, despite efforts, the main software solutions, whether free or not, do not really help in the production of significant flow maps. There is also a recurring problem related to the management of the intrinsic complexity of relational data, which need at least filtered procedures before graphic representation. If issues regarding matrix filtering are carry out outside the mapping process, it is important to consider it to make an interesting map, i.e. useful for analysis in the social sciences and humanities. This is why we offer a new R/Rtudio package: {Cartograflow} by structuring and extending the appendices of Bahoken (2016).

The purpose of this communication is to present the implementation of {Cartograflow}, an R/Rstudio package dedicated to filtering Origin-Destination matrices for flow mapping purposes. It's first main interest is to combine the preparation of flow dataset and their spatial representation within the same package. The second main interest of {Cartograflow} is that the proposed filtering functions are specifically part of the corpus of quantitative analysis methods in geography. This is why they are particularly interested, for examples, in the concentration of information, as well as the role of the geographic space in terms of the spacing of places of origin and destination by the distance travelled by the flow (in terms of distance and neighborhood). Finally, it is to be part of an open and reproducible research approach (Peng, 2011), compatible with existing solutions - mainly {sp}, {sf} and {cartography} (Giraut, Lambert, 2016), while opening possibilities to data describing spatial interactions patterns.

KEYWORDS

OD matrices / spatial interactions / mapping / flow map / reproducible cartography / Cartograflow / Rstudio

A methodological approach to design strategies to deal with the impacts of exogenous shocks to urban mobility systems

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Mapping flows to depict spatial interactions patterns raises specific problems related to the complexity of the information and its graphical representation (the so-called spaghetti effect). These problems are relate to the analysis of both statistical and geographical data, for thematic cartography purposes. If they can be solved from different perspectives, solutions that can be provided are either theoretical, methodological or lies in the development of specific tools as Tobler said (Tobler, 1967, 1970) to implement proposals in a given technological context.

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KEYWORDS
urban mobility / resilience / spatial analysis / transport

VI   General Session: Urban patterns

Measuring urban forms with inter-building distances by combining MST graphs with a LISA: one step forward

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To be efficient, planning policies require to measure and to understand the effects of different built-up local patterns on, for instance, ecosystem services, or on the relationship between people and their environment. However, before doing so, it is necessary to be able to characterize quantitatively and unambiguously the built-up organizations.

In this perspective, Caruso et al. (2017) proposed an innovative approach to characterize local urbanization forms (building footprint) based on the association of graph theory and a Local Index of Spatial Association (LISA). Each building (approximated at its centroid) is put in relation to the other buildings by means of a specific graph (a Minimum Spanning Tree (MST) based on the distance between centroids. An exogenous cut-off of 200 meters (maximum length of an arc in the MST) allows the splitting of the original graph into multiple sub-graphs. A local Moran is then computed to characterize each building in function of its distance to the others in its sub-graph. It is then possible to characterize the local building organization according to a certain level of homogeneity/ heterogeneity in its inter-building distances (a high distance value surrounded by high distance values or a low distance value surrounded by low distance values or a mix of high/ low distance values with no significant relationships). In their conclusion, Caruso et al. (2017) mention a limitation of their method about the use of an exogenous cut-off of 200 meters. Although this cut-off distance is inspired by many other empirical studies, we here test how far this choice affects the final results and try to explain and justify.

We here conduct sensitivity analyses on a selection of European urban agglomerations: does the partition of each of their built-up surfaces in sub-graphs depend on the cut-off value? Is the cut-off value universal or is it necessary to adapt it to each city or even within each city? Answering to these questions enables us to make a robust partition of urban study areas according to the homogeneity of inter-building distances in each sub-graph. Based on these analyses, it is possible to characterize quantitatively and unambiguously the built-up spatial organizations and lead to more efficient planning policies. Part of our objectives is to rewrite the Caruso et al (2017) method in Python language and to make it available and usable for a broad public (on-going).

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KEYWORDS

inter-building distances / graph / LISA / built-up organizations

Using shape, proximity and functionality to define neighborhoods with morphologically similar buildings

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This research focuses on different urban forms and in particular on the desire to find a quantitative way to define neighborhoods (sets) of morphologically similar buildings.

Buildings' shapes can be studied from an architectural point of view (period, style, singularities) but this requires time-consuming work in situ and a detailed knowledge of the subject. In order to study the forms more quickly, systematically, and on a larger scale, a simpler model of the buildings is used. The latter uses the footprints of the buildings and their heights to obtain a regular structure, which does not take into account roofs, balconies, or other prominent elements. Those footprints are retrieved from OpenStreetMap for the case study of Lausanne, Switzerland. As adjacent footprints are merged into building composites, only around half of them are regular polygons of 4 sides.

From this model, the shapes of buildings are translated into multiple quantitative indicators relating to their size, height, compactness, or topological skeleton. In order to ensure that redundancies at the attribute level are reduced at a minimum, a feature selection is then performed. By clustering the buildings using the remaining attributes, it is possible to discover a typology of the building forms present in urban areas.

This result, even if it makes it possible to highlight certain groups of similar buildings that have been built next to each other, does not, as it stands, make it possible to delimit sets of near and similar buildings. In order to obtain neighborhoods that are close both spatially and on the feature space, it is necessary to include a geographical constraint to the clustering. The approach chosen to achieve this is the Geo-SOM, an artificial neural network algorithm. By applying the clustering on the output of the Geo-SOM, it is possible to obtain results that look more like neighborhoods. However, some adjustments are still necessary in order to achieve a more conclusive result.

Finally, the previous results could allow us to investigate the question of the relationship between the shape of a building and its function (residential, commercial, industrial, mixed). Does this relationship exist and, if so, to what extent is it valid? From the resulting findings, the main function of neighborhoods could be characterized and this may pave the way for further analysis using data about points of interest, socio-economic or mobility aspects.

These different results can be used in a diverse array of contexts inside and outside urban studies: ensuring morphological homogeneity when renovating buildings in urban areas, adapting and preventing climate vulnerability in similar types of neighborhoods, model the evolutionary stages and expansion styles of cities, and comparing the internal organizations of several cities.

KEYWORDS

urban morphology / urban shape / built environment / building typologies / geo-SOM clustering

Measuring urban sprawl in Flanders

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At the country level, Belgium was found to be the European country with the highest degree of urban sprawl (EEA report on Urban sprawl in Europe, 2016). The phenomenon is most pronounced in Flanders, the densely populated northern part of the country. No less than 32.6% of its territory is taken in by settlement area, and, its landscapes are highly fragmented by ribbon and scattered development. An increase of ribbon development in Flanders from 3612 km in 1989 up to 4155 km in 2012 was calculated by Verbeek et al. (2014). This means an increase of 15% over 23 years. Recently, concerns and discussions about the pros and cons of this development have been rising in the public and political debate. This has been triggered by the new Spatial Policy Plan for Flanders, which has been in preparation since 2012, and which aims to put a halt to the further urban expansion in Flanders by 2040. This causes the need for a sound quantification of urban sprawl in Flanders and to gain better insights in the societal gains and losses of policy measures aimed at limiting and counteracting urban sprawl. To get a better understanding of the problem of urban sprawl, the Flemish Department of Spatial Development has set up a scientific study regarding the quantification of urban sprawl and of the costs related to it in Flanders.

Urban sprawl can refer to both a state (level of sprawl at a certain point in time) and a process (evolution of the level of sprawl in time).

To gain better insights in the state of urban sprawl, detailed data of high quality are necessary. Several measures have been used in literature to quantify (different aspects of) urban sprawl. Depending on the measure, but also on the type of input data used, different results can be obtained which in turn can lead to completely different interpretations and conclusions regarding the level of urban sprawl at several locations in Flanders. In this study we analysed two different measures for Flanders: the quantitative WUP - weighted urban proliferation (EEA, 2016) vs. a more intuitive delineation of urban cores, ribbon development and scattered development. The latter is based on a methodology developed in cooperation with Flemish policy makers and earlier work of Verbeek et al. (2014). To analyse the relevance of WUP in Flanders, several datasets were used to calculate differences in the resulting patterns of urban sprawl. Measuring sprawl based on sealed surfaces alone leads overall to an underestimation of the space taken in by urban settlements, hence of the importance of urban sprawl. Using a map representing the total settlement area of Flanders (including sealed surfaces, but also gardens, parks etc) leads to a better representation of what is understood by 'urban sprawl' in Flanders.

The process of urban sprawl in Flanders was analysed by means of a temporal analysis using Landsat images of 1976, 1988, 2001 and 2012. The images were processed into urban settlement maps and urban sprawl was monitored by means of WUP for the different time steps. Difference maps show the temporal and spatial dynamics of urban sprawl throughout the region.

Finally, in order to make measures of urban sprawl, and hence the phenomenon itself, easier to interpret and understand for a wider public, the WUP maps were translated into an urban sprawl typology map. The typology distinguishes (1) city centres, (2) village centres and the urban fringe, (3) ribbon development and residential subdivisions and (4) dispersed buildings. This typology was used to quantify the costs of urban sprawl in a later stage of the study.

The results of the study are used to stimulate the public awareness and debate with respect to sprawl and the generally devastating effects that it has on the Flemish landscapes.

KEYWORDS

Urban sprawl / Indicators / Weighted Urban Proliferation /

Residential buildings in Tel-Aviv and their patterns of change

Anat Goldman[1], Juval Portugali[1], Efrat Blumenfeld-Lieberthal[1]
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Created by man, the city is a built reflection of its dwellers, who shape and re-shape it in a continuous and infinite process. It is a dynamic development in which the face of the city is created in practice and changes constantly through time.

It stems out of a self-organized complex system of relationships associated with technological development, political and economical processes and cultural and ethical attitudes. Despite numerous forces exerted on it, the city evolves into a unique landscape, which separates it from other cities, and can also be distinguished in time.

This work examines the process of the city's built environment and its transition as captured in residential building façades in the city center of Tel-Aviv from the 1920s to the present. The work summarizes a documentary research of more than 600 buildings and condenses the typical building façades into a genealogy assembled of nine façade types in total. The 'genetic code' it carries has evolved throughout the century: while some façades are still found in current architecture, others have gone through several 'mutations' or simply did not survive the technological advancements and disappeared from the construction arena lexicon.

We conducted a detailed research, using the municipality building archive, tracing over 600 buildings along four routes, or arteries, crossing the city center. The research focused on residential buildings, since they constitute most of the city's built inventory.

Along the studied routes, all the residential buildings were examined, excluding only buildings that were built on an exceptionally bigger parcel than the majority of the buildings, and therefore could be typified by a different façade typology. By using the building's parcel as the basic urban cell sampled, a variety of planning ideas and design approaches are already embedded in the building itself.

These 600 buildings were examined in two manners: the first was qualitative, in which a typological facade catalogue was created, detecting nine different facade types in total, thus serving as a sort of a local 'genetic code' of the buildings' facades. Although the construction details, cladding material types and standards may vary, the typological distribution is comprehensive enough to include both high-quality buildings, constructed with a considerable investment both in means and design efforts, and mundane buildings constructed with poor building details. Despite an alleged gap between them, the buildings can be grouped under the same typological categories, that form the genealogy of the typical local residential block.

The second manner was a detailed quantitative survey regarding transformation processes occurring in the parcels themselves, detecting changes in existing buildings and reconstruction of entire structures. In this way, a profound insight is obtained, for each façade type and for each construction decade: by tracking the changes each parcel went through individually since its initial construction, it is possible to trace transition patterns in the face of the city. Almost 40% of the initial buildings constructed on the parcels, were either replaced entirely or significantly altered through additional construction. These changes transform the current façade types mix, and may alter it entirely through time.

Since the research starting point is in the 1920s- only a decade after the city's establishment (with an inevitable pause caused by WW1)- this study is a rare opportunity that tracks a documented morphological emergence and development of a city nearly from scratch.

As the building facades embody the many different (and sometime conflicting) forces that operate behind the scenes, distilling their essence into a chronological catalogue, makes it possible to delineate the urban tissue's spirit. Hence, gain a better understanding of the 'sense of place' of the city.

KEYWORDS

Urban morphology / urban patterns / Tel-Aviv / Building Facades / sense of place

Urban Fabric, Configuration of the Street Network and Spatial Distribution of Retail

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Retail activity presence in urban space is of paramount importance when considering the vivacity, livability and walkability of streets and neighborhoods (Jacobs 1961). Urban designers, planners and geographers highlight how some urban morphological characteristics might define those urban spaces where higher retail densities are detected. Space Syntax and Multiple Centrality Assessment (MCA, Porta et al 2008) are two well-known approaches for studying the configuration of street networks, which have been used for this purpose. Based on the hypothesis of natural movement, these methods propose advanced calculations of proximity, accessibility and centrality-based measures, at the intra-urban level. Studies where these techniques were implemented showed how retail distribution may also be explained by network configurational properties.

Nevertheless, these studies only focus on one aspect of the urban environment (i.e., the configuration of the street network). It might well be, though, that also the urban fabric could be closely related to the location of retail and economic activities. The configuration of the street network and the urban fabric might thus represent two complementary aspects. To some extent, previous empirical works considered both aspects as they focused on areas with a continuous urban form. For example, Omer and Goldblatt (2015), highlighted how traditional studies examined urban networks "mainly in cities characterized by either a deformed grid-like street pattern or by a planned perfect grid". The same authors studied how the presence of retail and configurational properties varied across neighborhoods which had undergone different processes of urban growths (i.e., planned vs self-organized). Svetsuk (2012) focused his analysis on "dense urban environments", where the characteristics of the urban fabric could be considered homogenous.

However, as of today, a methodology that quantitively analyses the configuration of the street network and the urban fabric in relation to the spatial distribution of retail across an entire urban region is missing.

In this work, we propose a novel approach based on: (i.) the use of both the MCA and the Multiple Fabric Assessment (MFA, Araldi and Fusco 2017), a method that identifies specific urban fabrics within cities; (ii.) the implementation of advanced statistical analysis and data mining techniques, to assess the relationship between the configurational aspects of the street network, computed through the MCA, the different urban fabrics, computed through the MFA, and the spatial distribution of retail. This approach is then applied to a large metropolitan region, that of the French Riviera, a unique conjunction of natural and urban landscapes, originated by the combined effect of a highly diversified topography and several socio-political and historical events.

The resulting models show that the importance of the configurational aspects of the MCA in explaining density of retail varies according to the different urban fabrics detected by the MFA. For example, the same value of Betweenness centrality, one of the MCA indicators, assumes different degrees of importance in the traditional, regularly-meshed fabric and in the suburban/modern one. Moreover, deviations from the model highlight street segments with an over/under-representation of presence of retail. We suggest that this might be due to other morpho-functional phenomena, which deserve future investigations.

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KEYWORDS

Urban Form / Urban Fabric / Network Configuration / Retail distribution

Special Session: Land-use modelling for Policy Support (2/2)

Reinterpreting Procedural Utility in Land Use Frameworks: A Quantitative Approach

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The notion of complexity brought about the systems theory's ontology as a set of components within a system, and it brought about the chaos's theory temporal view of change from simple to complicated (Roo, 2010a, 2010b). This put forward the potential of looking into the tangibles and intangibles within the city as interactive components (Hillier, 2012); such components change the city from a simple to a more complicated state. In fact, the tangible changes within a city are reflected as the complex process of spatial urban transformation and growth while the intangible changes are a set of complex socio-economic processes (Hillier, 2012; Roo, 2010a). Hereby, the urban growth or land use transformation (spatial), from a complexity point of view, is connected with multiple land market processes (socio-economic) that lead to transforming the city to a more complex state. Despite such view, the analysis of land markets using land use simulations have been dependent the modeler's decision of choosing a theoretical framework that fits the modelling purpose (Lee, 1973, 1994) which may or may not comply to the multiplicity of socio-economic and spatial complexity. In most cases, this confined land use models to a defined set of interactions based on one, or more, chosen framework(s) such as bid rent theory (Magliocca, Safirova, Mcconnell, & Walls, 2011), location theory (Chen, Gong, He, & Luo, 2002; Lee, 1973; Mitsova, Shuster, & Wang, 2011; Ward, Murray, & Phinn, 2000), gravity modelling (Lee, 1973) and hedonic price estimation (Filatova, 2015; Xiao, 2017). In fact, each land use simulation model uses a framework for one land market process and approach land plots instrumentally (examples; Evans & Kelley, 2004; Honghui, Yongnian, Ling, & Xijun, 2010; Magliocca et al., 2011; Mena, Walsh, Frizzelle, Xiaozheng, & Malanson, 2011; Salvini & Miller, 2005). In other words, the models are designed so that land use change occurs due to decisions made in a land market in which land plots are assigned a set of instrumental attributes, such as spatial location and expected price (example for hedonic spatial price estimations; Filatova, 2015). In most cases, these attributes are weighed differently to compensate for the subjective view of users in the land market where a decision of acquiring a land is made if the degree of benefit gained exceeds the price's value (random weights example; Salvini & Miller, 2005). The simulation models define such benefit as an instrumental utility as calculated preferences of the users and make a decision. However, these models do not take into account the possibility of the presence of multiple land market processes that can be valued differently; i.e. procedural utility (Frey, Benz, & Stutzer, 2004; Frey, 2008) is not taken into consideration. In other words, by analyzing the land use transformation using one market mechanism based simulation models (examples include as previously mentioned, 1) bid rent, 2) auction and 3) hedonics price market), such models and theoretical frameworks provide a limited view of the city as a complex system with multiple processes of change.

Based on the presence such gap, this paper proposes an alternative approach to analyzing spatial changes in cities by taking into consideration the presence of multiple land market institutionalized processes which users (actors) value differently. In fact, the literature defines the concept of procedural utility as the notion that people value the process of reaching the end goal along with

the goal itself (Frey, 2008). Such understanding of utility defines it as the happiness and well-being achieved by processes rather than instrumental outputs (Frey, 2008). However, such concept does not completely fit to a land use framework since on the one hand, the procedural utility concept is indicated or measured through the well-being and happiness provided due to the fairness of a process (Frey & Stutzer, 2005); democracy is an example of such fairness aiming processes (Frey, 2008; Frey & Stutzer, 2005). On the other hand, market processes include competitiveness and is highly tied to price and materialistic gains.

Hence, this paper focuses on reinterpreting procedural definition to fit within land market frameworks and focuses on providing a quantitative approach for calculating such utility supported with empirical methods of measuring it. To do so, it provides 1) a framework for identifying the mathematical relations between the procedural utility and the output utility based on different land attributes, and 2) a simplified hypothetical case in which procedural utility is equated numerically based on a land market of buyers, processes and land plots with attributes. By reaching such quantitative approach, this paper showcases the potential of applying procedural utility in process based land use simulation models either by adding a temporal factor to simulate changes in land use, land market and procedural utility, or by coupling the procedural utility calculation model for process choice with an agent based land use simulation model.

KEYWORDS

Land Use Transformations / Procedural Utility / Land Market Processes / Complexity / Agent Based Model

Spatiotemporal modeling urban expansion and densification

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Urban sprawl is increasingly acknowledged as a significant environmental, economic, and social challenge in both the USA and Europe. Accordingly, policies have been developed to curb this phenomenon and foster a more efficient use of the land. Such policies are typically based on a combination of spatial planning with fiscal and economic measures, promoting infill development and land recycling. Infill development is expected to reduce the consumption of land and thereby lower the pressure on green and agricultural areas. This paper presents a model to simulate spatiotemporal urban expansion and densification based on a combination of a non-ordered multinomial logistic regression (MLR) and cellular automata (CA). The probability for built-up development is assessed based on (i) a set of built-up development causative factors and (ii) the land-use of neighboring cells. The model considers four built-up classes: non built-up, low-density, medium-density and high-density built-up. Unlike the most commonly used built-up/urban models which simulate built-up expansion, our approach considers expansion and the potential for densification within already built-up areas when their present density allows it. The model is built, calibrated, and validated for the Walloon region (Belgium) using cadastral data. Three 100×100m raster-based built-up maps for 1990, 2000, and 2010 are developed to define one calibration interval (1990-2000) and one validation interval (2000-2010). The causative factors are calibrated using MLR whereas the CA neighboring effects are calibrated based on a multi-objective genetic algorithm. The calibrated model is applied to simulate the built-up pattern in 2010. The simulated map in 2010 is used to evaluate the model's performance against the actual 2010 map by means of fuzzy set theory and Kappa index. According to the findings, land-use policy, slope, and distance to local roads are the most important determinants of the expansion process. The densification process is mainly driven by zoning, slope, distance to different roads and richness index. The results also show that the densification generally occurs in dense neighbors whereas lower densities neighbors retain their densities over time.

KEYWORDS

Cellular Automata / Genetic Algorithm / Wallonia

Project-Based View of Urban Growth Analysis and Modeling

Yulia Grinblat[1], Maria Marinov[2], Itzhak Benenson[2]
[1]The Porter School of Environmental Studies, Tel Aviv University, Isarel / [2]Department of Geography and Human Environment, Tel Aviv University, Israel

Cities often undergo substantial spatial changes that result in heterogeneous and complicated urban patterns. Nevertheless, the spatial cycle of cities is often described by two simple processes: diffusion and coalescence (Dietzel et al., 2005). Diffusion occurs when urban development takes place further away from the existing city's borders thereby creating a dispersed and discontinuous urban pattern. As the process continues, the diffusion reaches a point where the dispersed areas and the city begin to coalesce towards a unified urban landscape. The combination of these processes at different periods and levels results in divergent urban patterns, which may be classified into three main development types: infilling, fringe-expansion, and leapfrogging (Liu et al., 2010).

Generally, the growth mechanisms are driven by principle determinants such as economic, social, demographic and physical factors as well as planning policy. However, the urban growth process is also very sensitive to specific local determinants. Therefore, it is essential to characterize and apprehend the changing patterns of urban growth across various cities with different demographics, economic, social and physical characteristics and over a long period of time. A broader understanding of urban growth processes and patterns will improve the ability to predict urban expansion and to simulate land-use dynamics.

We investigate urban growth by considering urban land use patterns consisting of development projects of different kinds and sizes, where a project is defined as a newly developed continuous area of single land use and involves one or more developers. Within this framework, urban dynamics is a self-organizing process of establishing new built-up projects, each being the outcome of a compromise between developers and regulators – planning offices and municipalities.

The research presents two project-oriented high-resolution empirical studies of land-use dynamics in Israeli cities. The first is a study of the long-term land-use dynamics in Netanya, Haifa, and Safed over 50 years (1960-2010). Based on aerial photos taken at six moments of time within this period, we estimate the relative importance of factors that can determine the role of projects in urban dynamics – project type, size and location within the already constructed area, on the urban fringe or beyond it. The same study is repeated for the entire state of Israel for the last decade (2010 – 2018) based on data provided by The Survey of Israel and containing high-resolution layers of buildings, roads, population, and some additional characteristics as well as statutory town plans.

Both studies provide basic quantitative estimates of the urban development types (infill, fringe-expansion, leapfrogging) as dependent on the current spatial pattern of the city and project's characteristics and reveal inherent dependencies between the location of the project and its size and type. The location of a project in relation to the existing built-up area is a major factor of the urban expansion that is typically disregarded by traditional urban land use modelling. The results of our analysis emphasize the importance of local characteristics in urban development and provide useful guidelines for modeling the spatial expansion of cities from a project-based view.

KEYWORDS

urban growth / urban fringe / leapfrogging development / urban simulation / project-based land-use dynamics

SATURDAY | 15:30 | Salle des Fêtes

More urban sprawl or towards densification? Long term simulations in support of spatial policy planning in Flanders, Belgium

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Flanders, the region in the northern half of Belgium, experiences strong urban sprawl with extensive ribbon development. No less than 32.5% of its territory is taken up by settlement area, and it is at the top in the European Union with respect to urban sprawl. Flanders thus is confronted with great difficulties in meeting international objectives in policy domains with a significant spatial dimension like e.g. environmental quality, biodiversity, climate change or renewable energy. Moreover, the region will be facing a population growth of up to 800,000 inhabitants by 2050, which will put the region under even more spatial stress. During the last decade, the settlement area has grown at a rate of about 6 ha per day. In the Strategic Vision of its Spatial Policy Plan, the Flemish government aims at putting a halt to this expansion by 2040, by setting targets to the growth of the settlement area for 2025 and 2040. By 2025 the daily growth of the settlement area should be reduced to 3 ha per day and to a complete standstill (0 ha per day) by 2040. Besides, guiding spatial planning principles are formulated to concentrate urban development on locations within walkable or bikeable distance from public transport nodes, and, at locations equipped with a high level of facilities and public services, such as shops, schools, medical care etc.

In order to evaluate the effects of the targets and guidelines set by the Strategic Vision as well as to test the effect of specific policy measures, a number of land-use scenarios were simulated with the RuimteModel Vlaanderen, an activity based cellular automata land-use model operating at a mid-level resolution (1 ha). The activity-based CA model directly simulates land use, population, and employment by economic sector, at the cellular level. The annual land demand of residential land use is determined endogenously by the population growth together with factors affecting local population density. This enables the model to be used to simulate integrated scenarios. The effect of various proposed policies on the spatial distribution of population can be explored, and in particular on the annual total land take for new housing. Different to many cellular automata models, neighbourhood effects are taken into account across the whole study area in a variable grid approach, which allows us to calibrate and simulate the model in a fast and flexible framework that handles short and long distance interactions simultaneously.

We use the model to investigate the effects of key policy proposals mentioned in the Strategic Vision, such as minimum population densities for new urban development, or changes in building permits and zoning regulations. In particular we simulate the effects of several minimum density requirements for new residential developments in the areas defined by access to rail stations and a high level of facilities and services. The results indicate which policies could achieve the goal of no additional land take for urban settlement by 2040, as well as the consequences in terms of changes in the settlement pattern compared with the business as usual scenario. We also estimated the economic impact of the different scenarios as urban sprawl goes along with much higher mobility and energy costs. Recently, we have also updated the way the model deals with interactions between land use and transportation in order to simulate how growing congestion and densification will impact each other. Relative traffic flows are computed in a grid that is compatible with the variable grid of the cellular automata model.

KEYWORDS

Spatial policy / Urban sprawl / Densification / Cellular automata / Urban growth scenarios / Land-use modelling

SATURDAY | 15:30 | Salle des Fêtes

Identifying distinctive future land-use patterns that matter: An inductive model-driven scenario development approach

Bramka Arga Jafino[1], *Jan Kwakkel[1]*, *Hedwig van Delden[2]*
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Land-use modeling often uses scenario approaches to explore alternative future paths of land-use development due to external forces. The scenarios are usually constructed in a deductive, four-step approach. First, the key external forces that strongly influence land-use change decisions are identified. Second, several scenario logics, usually around 2 to 6, are constructed. Each scenario logic contains a narrative that explains how these external forces unfold in the future. Third, the scenario logics are operationalized into the land-use model parameters. These first three steps are normally performed alongside stakeholders who are experts in the land-use problem at hand. Lastly, the land-use model is run to simulate a number of future land-use patterns in accordance to the number of constructed scenario logics.

A key advantage of this approach is that it provides clarity on the scenarios development process. However, it has been argued that such deductive scenario approaches can only capture a small subset of the entire uncertainty space of future development. By using only on a small prespecified number of scenario logics, hence a small number of model parameters values, one leaves other plausible permutations of parameters values unexplored. This is especially alarming when one works with a land-use model, where the nature of the model itself is often discontinuous and non-linear. The unexplored uncertainty space may yield surprises that are relevant for the policy makers. As an alternative to the common deductive scenario approach, we propose the use of the exploratory modeling approach for land-use modeling for policy support. This approach allows for exploring a wider range of uncertainty space and performing an inductive model-based scenario identification.

There are five steps needed in applying the exploratory modeling approach in land-use change modeling for policy support: (1) delineating the uncertainty space (i.e., enumerating external forces, translating them into land-use model parameters, and defining the plausible range of their future values), (2) generating a large number of computational experiments based on the uncertainty space (i.e., automatic sampling of model parameters values from the defined plausible range), (3) simulating future land-use patterns based on the generated combinations of model parameters values, (4) clustering simulated land-use patterns based on their similarity, and (5) identifying the external forces that strongly affect the land-use patterns as well as their direction of changes that leads to each cluster of land-use patterns (i.e., scenario logics that result in substantial differences to land-use patterns). A key difference of this approach lies in the way scenario logics are constructed. Here, scenario logics are constructed inductively with the help of computational experiments by the land-use models. Identification of scenario logics is conducted after, instead of before, the simulation runs. Consequently, this approach accounts for a substantially wider uncertainty space by not limiting the computational experiments to only a small number of model parameter sets.

We applied the exploratory land use modeling approach for identifying plausible future agricultural land-use patterns in the upper Vietnam Mekong Delta. We account for both socioeconomic (e.g., rice demands), behavioral (e.g., homophily in land-use change decisions), and environmental uncertainties (e.g., water supply and flood risks). We used the Latin Hypercube Sampling algorithm to automatically generate 10,000 computational experiments. After the simulation runs, we used the Fuzzy Kappa Statistics to approximate similarities among the simulated land-use patterns. We identified five distinctive clusters of future land-use patterns based on the statistics. Next, we used the Patient Rule Induction Method (PRIM) algorithm to identify the uncertainty subspaces that can explain each

of the identified cluster of land-use patterns. These subspaces underlies the development of five scenario logics. We believe that our proposed approach could help policy makers in finding scenarios that result in distinctive land-use patterns better than inductive scenario approaches. Identifying plausible distinctive future land-use patterns is especially relevant if one wants to test and enhance the robustness of alternative land-use related policies while considering a wider uncertain future. Lastly, it is important to note that while this approach could apprehend recognized uncertainties, one may still find surprises from unknown unknowns that lead to other distinctive land-use patterns.

KEYWORDS

scenario / policy support / uncertainties / clustering / robustness

KEYNOTE 3

Smart mobile citizen sensing for wise decisions of tomorrow's digital society

Prof. Sara Fabrikant[1]
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Millions of citizens make time critical and societally relevant decisions on the go, supported by increasingly mobile, assistive geographic information technologies. How should the geographic information assistance of the future look like, to avoid a "technological infantilizing of society", that is, the reduction of our capacity to still make wise decisions without smart technological assistance? I will highlight ongoing empirical research on human and context responsive geographic information displays used in the lab and in the wild, capitalizing on ambulatory human behavior sensing methods (i.e., eye tracking, galvanic skin response, and EEG measurements, etc.). Based on collected empirical evidence, and supported by cognition and vision theories, we are guiding the process of designing smart, user, task, and context responsive geographic information interfaces for wise decisions of tomorrow's digital society.

KEYNOTE 4

Data bulimia, theoretical anorexia: a quantitative geography dystopia?

Prof. Isabelle Thomas[1]
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Illustrated with empirical examples and some general bibliometric indices, the objective of this keynote is to raise a few questions about the way quantitative geographers are working today. The present and future of the field is critically discussed under the particular scope of the development of new techniques and the availability of new real time data, but that of the general lack of integrated formalized ideas, concepts and theories that would made geography as established as economics or physics. Do we really progress or do other disciplines reinvent old geographical questions, ignoring former publications of geographers? Did quantitative geographers miss a train? Maybe it is time for a follow-up of Duranton and Rodriguez-Pose's 2005 tale published under the title "When Economists and Geographers Collide, Or the Tale of the Lions and the Butterflies"?

We here explore critically the past, present and future of quantitative geography with a specific lens on the evolving relationship between data and modelling. We argue for a commensurate effort to assemble theories and models, in the spirit of the quantitative geography turners, and their integration with the most recent technical/data expertise and tools to further strengthen geography.

VII   General Session: Geovisualisation

Cartograms Work Backwards - Towards a Generalised Cartogram Approach

Chris Brunsdon[1], Martin Charlton[1]
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Cartograms work backwards. At least, diffusion-based cartograms do, if you are willing to reverse time in the physical analogy that generates them. Why is this useful? New types of visualisation may be created - by considering patterns defined in 'cartogram space' and mapped back into ordinary cartographic projections, or by identifying grid warps that map one population density on to another — for example night-time to day-time populations in a region, or shifts in residential population over long periods of time. Here we explain how backward cartograms may be created, and gives examples of their use. Cartograms have been used as a tool for visualising population-based geographical patterns for a number of decades. Essentially a cartogram is a kind of map projection in which the area allocated to any given region is proportional to the population in that region. A relatively recent and now frequently used kind of cartogram is the Gastner and Newman diffusion-based cartogram. This cartogram is defined by physical analogy, in particular the diffusion of a fluid with heterogeneous density.

Although the equations underlying the model may appear daunting to those not familiar with multivariate calculus, the diffusion can be summed up in a more general way:
If we have raster image representing density of some fluid in 2D at time zero, the density at some time t after this can be obtained by applying a `Gaussian blur' filter to the initial image. The bandwidth of the filter is a proxy for time, so that the density after a greater time is more `blurred' than at an earlier time.

This analogy demonstrates how fluid diffusion is simulated, but how can this be exploited to create cartograms? The answer comes by noting that the fluid diffuses from an initial hetergeneous state towards a final homogeneous state. If some particles were distributed in the fluid according to its initial density at t=0, and then were carried with the fluid as it flows they would be uniformly distributed at the final state. Essentially, the mapping of particle positions from initial to final states is a cartogram transform.
This shows how diffusion-based cartograms work, but offers nothing new - these map projections have enjoyed much use over recent years. However, an interesting observation may be made. If the flow of time were reversed - or equivalently fluids were made to flow in the opposite direction along the gradients of steepest change in density - one could start with the homogeneous fluid and flow towards the initial heterogeneous state – and thus create 'reverse cartograms' mapping the cartogram projection back to the original.

Carrying out this transformation is useful in at least two applications –

'Isodems' - An isodem is defined in a similar way to an isochrone - a set of isodems are a set of contours centred on a location, with the areas between each contour pair containing the same population. One way to create an isodem diagram is to draw this as a series of conentric circles in cartogram space, and then use an inverse cartogram transform to return to standard geographical space. This provides a novel way to visulaise the spread of population. An example is given here: https://www.dropbox.com/s/15w5yqetvlsxtfo/geoisodem-1.pdf?dl=0 .

'Generalised cartograms' – applying a cartogram transform based on one density distribution, and applying an inverse transform based on another provides a map transform taking objects from the first density to the second – this allowing a warping of space effectively 'moving' population distributed according to the first population to be distributed according to the second. This can be used to provide visualisations of population shift – for example from night-time to day-time population, or resident population shifts over time. The transform may be illustrated via a warping grid: an example is here: https://www.dropbox.com/s/0llxqdse5mlj9of/ploter-1.pdf?dl=0 , or as an animation: https://www.dropbox.com/s/wsohg80bw90nfsx/ttw.gif?dl=0 .

Both of these ideas will be demonstrated in the paper, as will the underlying ideas of reversible cartograms.

KEYWORDS

Cartograms / Geocomputation / Visualisation / Mapping

Quantifying estuary landscapes and urban pressures using a remote sensing decision tree approach

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The preservation of sensitive ecosystems is highly dependent on continuous assessment of the natural resource dimensions, contained through a continuous multitemporal evaluation, the estuarine areas constitute, in this context, an environment of exchange between biotopes; "Oued-Lake-Sea" offering a great diversity of landscape (Beach, grasslands, cropland, Bare, Settlment, Lake-Water, Sea-Water…). In Algeria, these specific wetlands are located in the coastal strip, the most attractive zone of the country and which undergoes a very high pressures on freelands and a linear artificialization parallel to the coast. The aim of this work is to establish, through a multisource / multi-scale approach, an exhaustive mapping of three estuaries of the Algerian coast (Lake Maktaa in the West, Lake Reghaia in the center and Lake Mellah in the East of country), a first mapping was already done in 2018 for Lake Reghaia, by combining various types of optical satellite sensors (Landsat8, Sentinel 2, Alsat2) through a hierarchical classification based on spectral thresholding, also in order minimize the confusion of some classes, a Digital Elevation Model/DEM has also been integrated into the decision tree, it will be therefore necessary in this study, to test the reproducibility of this method "the Quick mapping of wetlands" (by assessing its quality on Maktaa and Mellah Lakes). In the second part we compare the three resulting landscapes using spatial pattern quantification as the landcover diversity and the artificialization dominance degree in the adjacent areas of those wetlands.

KEYWORDS

Landcover / Wetlands / Multisources / Remote sensing / Decision tree / Algeria / GIS / Urbanization

Heterogeneity of urban geo-data: the microcosmos of La Rambla (Barcelona)

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The city is a complex system that produces a huge amount of data, not only in quantitative terms (the traditional big data), but also in their qualitative variability. Multiple sources, both institutional and private, conscious and unconscious, formalized and not formalized generate heterogeneous sets of numbers, categories, classifications, metadata, parameters that require best practices and specific integration workflows, along with an ethical reflection.

In fact, even though geodata were rarely considered as personal data, the opportunities (and consequences) of the growing availability of geolocated data, along with the possibility to collect information from hidden or less visible sources (websites, social networks, etc.) make it easier and easier to relate spatial to individual information.

Thus, following the HER's (Human Ecosystem Relazioni is a research center coordinated by Salvatore Iaconesi and Oriana Persico) idea of an high quality relational ecosystem, that should include all the actors involved in the data elaboration process, we propose, as a case study, an investigation of the economic activity of La Rambla (Barcelona), that starts from the building and management of an heterogeneous dataset and aims at giving back to the local community (represented by the association Amics de la Rambla) a visual output of the economic activity of the street.

In the first step we have defined categories for the different typologies of economic activities (food, accommodation, shopping, etc.), focusing on the distinction between services provided for tourists and for locals. Then we have individuated the most relevant data sources: official statistics, previous studies, field exploration, but also websites and social networks.

When we have obtained a significant dataset, we have experimented different possibilities of integration between qualitative and quantitative data: what can social networks' pictures reveal about the economic system of La Rambla? What can the Airbnb map add to the economic statistics of Barcelona's casco?

Finally, we have worked on the structure of the visual output: its esthetic structure has had to synthetize the microcosmos of La Rambla, revealing the hidden traces of its economic life and configuring a tool, for the local community, able to offer, through data, a new image of the street.

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KEYWORDS

Qualitative data / Urban ecosystem / Data visualization / Economy / Barcelona

The Geovisualisation of a Location-based Game Experience: Engaging Places in Reflective Thinking

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The recently completed H2020 CrossCult project set out to develop an innovative technology platform to facilitate the creation of customised mobile applications. The platform enables different Apps to be compiled. On completion of the project, four pilot applications were developed. Each one demonstrating the use of a variety of technology modules that support user engagement in the process of understanding of history from different perspectives. The goals of pilot apps were to encourage and stimulate users to challenge the way historical narratives are presented and understood as well as foster (re)interpretation and reflection in light of cross-border interconnections between pieces of cultural heritage and other citizens' viewpoints. The CrossCult platform was realised through the use of different technologies modules such as Location-based services, Personalisation (profiling, location tracking, and recommendation), Crowd Sourcing (content, augmentation, creation or linking) Social Networks (Comments, Rating, micro-blogging, notification, chat), Content Visualisation (Graphs, Gallery's, Maps etc.) and Gamification. To demonstrate the viability and adaptability the pilot apps were designed around different venues (both indoor and outdoor), different content, different technology modules and different user scenarios.

The case study at the heart of this paper is the app known as pilot 4 - CrossCult: cities. It is the only demonstrator app that takes place in the wild, outside of a building, in and of the city. To describe it simply, it is an app that supports the serendipitous discover of places and stories from the perspective of history – akin to a treasure hunt. Through such place-based discovery, participants are encouraged to think about and contribute their thoughts. They do this via using different interactions designed with the app such as (1) answering a reflective question (2) providing a rating for the historical stories they have read at different places and (3) contribute their own story. Gamification features we designed to encourage and motivate user contributions.

During the lifecycle of the project, the ability of the app to trigger and stimulate reflection and reinterpretation has been evaluated using different experimental protocols. The results of the experiments collected a wide variety of implicit and explicit location-encoded data. In this paper, we explore and visualise geographically the results of a specific set of think aloud experiments conducted in Valletta, Malta during November 2018. We take a mixed-methods GIS approach combining qualitative and quantitative data to evaluate the results of the experiments collected from 9 different participants.

We search, code and then visualise evidence of place-based reflection that results from interacting with the Pilot 4 App. We combine GPS traces of experiment routes collected by the app, with interaction logs recorded as part of the app experience together with the user-generated content contributed during the game-play and qualitatively coded think-aloud transcripts that can be geo-tagged at different points within the interview.

The geovisualistion of the evaluation results highlight the different reflections that occur from reactions, elaborations and contemplations. They also indicate the modes in which participants experience place as the encounter them from different perspectives. The results reveal participant different interpretations of place that result from the a process of refamiliarisation that the participant experience as they explore the city from a different perspective.

KEYWORDS

Location-based Games / GeoVisualization / Mixed-Methods GIS / Public History

Special Session: Spatial computation in Archeology and History (1/2)

SUNDAY | 11:30 | Salle des Fêtes

A city within its systems of cities over two thousand years

Julie Gravier[1]
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The presentation is hinged on my doctoral research, which seeks to understand the evolution of a city along the entire duration of its existence (Gravier, 2018). This research is built upon the case study of Noyon, a French city founded in the 1st century AD. My approach can be synthesized in three stages. First, I assess the functional intra-urban structure to establish the trajectory of the city over 2000 years. Then, I identify the relative position of the city within the system of cities it interacts with. This position is studied in terms of political, administrative and economic features. Finally, by confronting the intra-urban trajectory and the relative position of the city, we can investigate to what extent the history of a city and the history of the other cities of the system are united.

The vastly long term considered raises two main issues. First, the societies studied over 2000 years are highly distinct. Comparing them involves questioning the consistency of the definition of spatio-temporal entities, in order to study their trajectories. Second, this method requires working with archaeological, textual and iconographic data, which are sporadic and scarce, especially when studying large scales processes. This turns a large part of our research into an investigation where many clues have to be collected in order to retrace some long-disappeared spatial configurations and facts.

All of this requires new methodologies, along with a need to delineate unambiguously the paths relative to knowledge building, in order to offer a reproducible study of cities in systems over the long term. I will expose these paths, punctuated by seven main steps. The first two steps refer to intra-urban level analyses. First, I build basic units of urban space. Each unit is defined by a function, a location and a duration in time. The conceptual framework of those basic units inherits from researches driven by archaeologists working on intra-urban level (inter alia, Biddle et al., 1973; Galinié and Rodier, 2002). Besides, these units are compiled in a relational database and, as a second step, these data can be easily processed to capture the trajectory of the city. Then, steps 3 to 6 refer to analyses linked to the system of cities level and inherit from researches achieved by geographers (inter alia, Berry, 1964; Bourne and Simmons, 1978; Pumain, 1997; Bretagnolle, 2009). Step 3 allows delineating the scope of the study zone by territorial and network approaches, within which the cities potentially in interaction with Noyon are contained. Steps 4 to 6 affords us to examine the relative position of Noyon within the system of cities it interacts with. Two main difficulties emerge at these stages:

1) Geographers often study interactions between cities for the purposes of defining systems thanks to human or merchandises flows. However, data linked to ancient periods usually do not allow us to quantify flows, but only to inquire about the presence or absence of relations. In order to identify interactions, I decided to combine several case study related to these relations at different times.

2) The relative positions of the cities in a system are commonly observed through spatial position and size. Yet we do not have uniform data concerning population size before the beginning of the 19th century for France. Consequently, I decided to create population estimations from urban areas thanks to a statistical model (step 6). The obvious underlying assumption of this model is that urban area is a proxy measurement of population. Thus it is necessary to discuss the form of the relation between those variables for the cities located in the study zone (step 5).

Finally, step 7 is the synthesis based on all previous steps. It allow us to propose new explanations on structural processes and events underlying the evolution of Noyon over 2000 years.

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KEYWORDS

intra-urban space / system of cities / long term / interdisciplinary

Geographical exploration and spatial statistics analysis extended to Swiss archeological data

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Archaeologists have to formulate hypotheses and to construct theoretical models in order to explain the social dynamics of past human society and its interactions with the natural world. The large amount of fragmentary data arising from ancient society's footprints is characterized both by its spatial configuration and by the surrounding environmental conditions. In addition, archeological datasets come from several sources with various variable formats and are therefore often unstructured and affected by noise. The construction of robust and comprehensive analyses for the interpretation of different archaeological contexts is becoming a dominant issue on interdisciplinary research, which may also include mathematical methods with a spatial statistic imprinting. Quantitative approaches in archaeology are a current trend that significantly highlights the emergence of data-driven based models, with the final goal of extracting as much knowledge as possible form the available information. The present study deals with ascertained evidences of settlements related to the Roman period inventoried in Switzerland. Archaeological excavations provide a collection of elements characterized by their spatial distribution and additional descriptive information. These can be embedded in a regular grid generating a new collection of regions (e.g. pixels), related to numerical or categorical features (i.e. the presence/absence of settlement and the geo-environmental variables prone to influence their presence). In this study, we constructed a weighted network to model the spatial relationship among the different regions: vertices represent the regions and edges measure the proximity between them, based on the features.

Weighted spatial network is a convenient and flexible framework to resume the notion of "where" (the spatial configuration of the regions), "what" (the features attached to the regions) and the "how much" (the weight - for example the size of the region). Computationally, the continuous neighborhood relations among the regions are described by an exchange matrix reflecting their proximity, which is weight-compatible in the sense that its margins correspond to the region-weights. Each element of the exchange matrix defines a joint probability to select a certain pair of regions at a certain diffusive time, whereas its margins are interpreted as the probability to select a certain region. The associated spatial autoregressive model can be further row-standardized in order to model the spatial relation among the regions by the transition matrix of a reversible Markov chain with a stationary distribution related to the weights. The combination of the weighted spatial network with the dissimilarity measurement of each pairs of regions (computed by squared Euclidean distances applied to the features) allows revealing the spatial autocorrelation of the dataset, assessed by means of the generalized Moran's I index. The latter can be further statistically tested under the normal approximation in order to confirm its significance. This measure is computed considering a larger neighborhood of the regions increasing the diffusive time parameter of the exchange matrix. As underlying idea, all the regions are spatially dependent and spatially auto-correlated under the Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things".

The spatial autocorrelation of the features indicates their spatial pattern, but it is far from obvious to interpret it qualitatively. To this end, we applied the Principal Component Analysis (PCA), a classical descriptive multivariate procedure. When several quantitative variables are correlated, they express together an information with a certain degree of redundancy. PCA allows to compress the initial information in a lower number of synthetics uncorrelated variables, namely components, that best

explain the variance in the data. By replacing the initial features of the regions with the factorial scores obtained from the PCA, the spatial autocorrelation is computable to reveal patterns.

This contribution is a first attempt to investigate the spatial autocorrelation of archeological data, based on their spatial distribution and predisposing variables. In order to reveal a structure, which implies dealing with the lack of information (where no archaeological evidence has been found or yet discovered) we used a spatial network framework. We also applied a semi-supervised soft and iterative classification consisting on a soft partition (membership) inferred by the spatial relationship between each pair of regions and their features dissimilarities (derived by the PCA approach).

In conclusion, our work demonstrates how the geographical exploration of past societies can benefit from statistical analyses, which allow describing and interpreting the spatial patterns of the investigated features. For instance, preliminary results indicate that settlement is weakly but positively correlated with the measurements of water storage, permeability, bare soils and water saturation. The related factorial scores have a strong and significant spatial autocorrelation. In other words, geographically grouped presence of settlement is excepted in humid regions with bare ground at lower elevations.

KEYWORDS

Spatial autocorrelation / Spatial network / Archeological settlement

Characterization of a key sequence of the French Palaeolithic: geovisualization and intra-site spatial analysis of La Roche-à-Pierrot, Saint-Césaire

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Located in Saint-Césaire, east of Saintes, in Charente-Maritime (France), the archaeological record of La Roche-à-Pierrot is at the heart of the debates concerning the Middle/Upper Palaeolithic transition. To this day, La Roche-à-Pierrot constitutes the only site to have provided a relatively complete Neandertal skeleton associated with a transitional industry, the Châtelperronian, which was until then attributed to Modern Humans. Discovered in 1976, the site was the subject of several excavation campaigns conducted by F. Lévêque from 1977 to 1987 and in 1993 (with an additional season led by A. M. Backer in 1997). Since 2013, new excavation campaigns have been conducted, first by F. Bachellerie (UMR 5199-PACEA) for two years, then by I. Crevecoeur (UMR 5199-PACEA) since 2015. The main objectives of the new geoarchaeological investigations are to 1) re-evaluate the archaeostratigraphic sequence, 2) characterize the geomorphological processes responsible for the site formation, and 3) evaluate their impact on the archaeological assemblages and their spatial integrity (taphonomy).

Spatial representations and analyses of the Lévêque's excavation data are an invaluable aid for evaluating the coherence of the first archaeo-stratigraphy established in the 1970s. A 3D reconstruction of Lévêque's spit record stemming from the reassessment of the faunal collection (Rougier et al., In Crevecoeur et al., 2016) was developed for exploratory purposes to evaluate the feasibility of modeling the data recorded during the first excavations. This visualization, associated with calculations of coherence index and similarity index, allows on one hand to understand the inconsistencies of the first described archeo-sequence, and on the other hand, to reveal the spatial organization of the archaeo-stratigraphical units. To go further, the coherence and similarity indices were analyzed according to methods usually used in geography such as the global and local Moran autocorrelation indices. As a result, an interactive visualization application allows researchers to explore the stratigraphic units spatially as well as on the value of their indices. According to a specific protocol, all of the piece-plotted objects from Lévêque's excavations have X, Y and Z coordinates (Lévêque, 2002). Thanks to this precise recording system, supplemented by archaeozoological data (Morin, 2004), a database containing almost 6000 lithic and faunal pieces, with their 3D location, has been produced. Several 2D representations along with spatial analyses (using Getis and Ord index, hot spots) of all the recorded objects from the Middle-Upper Palaeolithic levels, including the analysis of the orientation and inclination of the objects (Todisco, 2015), have been computed.

These spatial analyses contribute to a better understanding of the general organization of the artifacts / ecofacts of La Roche-à-Pierrot. They will be invaluable in anticipating fieldwork in the coming years and will be a useful tool for interpreting our observations.

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KEYWORDS

Visual analytics / 3D spatial analysis / Palaeolithic transition / Taphonomy / Archaeo-stratigraphy

SUNDAY | 11:30 | Salle des Fêtes

At the fringe of classical approaches: Random forest for archaeological risk assessment.

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Switzerland is nowadays still affected by the massive expansion of urban settlement areas and the still on-going development of transport infrastructures. Both processes occur mainly, but not exclusively, in agglomerations of urban centers. These two phenomena result in a permanent destruction of archaeological remains from all prehistoric and historic epochs and consequently of our cultural legacy. The Federal Office for Spatial Development determined that settlement areas have grown by 24% or 600 km2 since the mid-1980s, a surface range that corresponds to the area of Lake Geneva. In these circumstances, the public authorities responsible for the management of archaeological heritage should be able to provide a balance between the inevitable growth of modern settlements and industrial areas and the protection and preservation of archaeological elements.

The archaeological risk assessment becomes of a crucial importance in the general framework of the cultural heritage management. Prediction and modelling play a relevant role in this regard. Indeed, in the last decades, the research offered many examples of spatial and statistical computing, related to the study of sites distribution, trying to identify settlement patterns and improving our understanding of the past human behavior. For the heritage management services, predictive maps principally represent a tool that can help to assess where the highest probability to (re)-discover not yet unearthed archaeological evidences occurs, prior to the start of any kind of working activities.
This study intends to survey and demonstrate the effectiveness of bringing together traditional archaeological questions with cutting edge technologies related to Machine Learning. We provide a data-driven application for archaeological predictive modeling (APM); the case study is the Canton of Zurich in Switzerland. A dataset of observed archaeological sites related to the Roman period was considered and reclassified in two categories: settlements and single finds, according to the definition assigned by the archaeologists. Moreover, a dataset of the ascertained absences (where no archaeological evidence was found) was derived by extracting information from the archaeological evidences related to other epochs than the Roman.

We used Random Forest (RF) (Breiman, 2001), an ensemble ML algorithm based on decision trees. The model is capable of learning from data and make predictions starting from the acquired knowledge through the modelling of the hidden relationships between a set of input (i.e. geo-environmental features prone to influence site locations) and output variables (i.e. the archaeological sites). For each decision tree the algorithm considers only two-third of the data, keeping one-third "out-of-the-bag" that will be used to evaluate the prediction error. Moreover, at each split, only a subsample of the prone features are randomly sampled and their goodness evaluated by the Gini index. For classification problems, the prediction of new data is finally computed taking the majority or the soft voting. The ability of the model trained on the 'training dataset' to predict on the unseen data (i.e. the 'testing dataset') was also estimated; this allowed assessing the generalization performance of the model. Generally speaking, ML-based approaches are able to extract insights and knowledge directly from data, and the algorithm may successfully highlight the relationships among the observed events (i.e. the archaeological sites) and the prone features, identifying trends and patterns that can hardly be discernible for a human. Moreover, RF directly provides the measurement of the importance of each variable, allowing ranking the predictors based on their relative contribution to the model.

Computations were carried out using R free software environment for statistical computing and graphics; data pre- and post-processing was performed in a GIS (Geographical Information System) environment. As results, we obtained: 1) a predictive map expressing the likelihood of archaeological site presence at different locations in the given landscape; 2) a ranking of geo-environmental features based on their goodness for the prediction of the archaeological site occurrence.

These outputs become important not only to verify the reliability of the data, but also to stimulate experts in different ways: they are elicited to characterize the benefits and constraints of using such techniques and ultimately to think big about archaeological data.

KEYWORDS

Predictive modelling / Archaeology / Machine learning / Random Forest

VII   # Special Session: City size effects and Urban Systems (2/3)

Urban systems diversity measures

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The hierarchical structure of urban systems undergoes complex temporal dynamics which are yet to be uncovered, giving rise to changes in the rank and sizes of its components. Particularly, scaling laws and rank clocks [1, 2] approaches have proved to capture much of this dynamic at macro and micro scales respectively, correlating the variation of urban attributes with city size. Nevertheless, macro scales are sensitive to city definitions, while the microscale excludes population at an aggregated level in the analysis. Fully aware of these perhaps, intractable problems, here we argue that adding simple diversity measures to the analysis could give some insights into the self-organisation process that these urban hierarchical structures experience over time.

Taking some ideas from linguistics [3] and biology [4], we looked at the behaviour of the rank itself, defining a rank diversity measure as $d(k) = C_k/N$, where C_k is the number of different cities occupying rank k over time N. Relating d(k) with the mean clock rank shifts and the cities total turnover from one year to another, we were able to compose a rational picture of the complex temporal evolution of urban systems in terms of their population size.

We selected seven urban systems (UK, France, Italy, Spain, Mexico, USA, Canada) as a case of study and applied these diversity measures over a 110 years period (1900 to 2010) divided into 12 points roughly corresponding with official national Census. Our findings emphasise the differences between European systems and their American counterparts, reinforcing the notion that there is no ultimate rank-size universality to be found in cities. For example, the corpus of cities at lower ranks at all years sampled is more extensive for European systems that for the American ones, capturing the fundamental differences in terms of foundations dates between the two continents. American systems have higher variety (a larger d(k) value) at middle ranges reflecting a stronger interaction between their cities through these last 110 years.

Finally, taking a cumulative distribution from d(k) - k, we notice that isolating all the ranks that has $d(k) < \mu - 2\sigma$, we are basically capturing those cities that have hardly move from their original rank since 1900, i.e., we can define a set of seed cities for each country.

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KEYWORDS

HIerarchical urban structures / Zipf law / Rank clocks / Diversity measures

From micro drivers to urban systems transition: Modelling the US urban system under the first industrial revolution

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The interest in studying urban systems transitions lies in understanding how factor changes lead to qualitative and quantitative transformation of the whole system (Sanders, 2017). In particular, we are interested in the effects of changes at the micro level such as behaviors of individual agents in relation with new technologies on the structural macro characteristics of the system of cities. In this perspective, we wonder what are the drivers and how they interact? What are the roles of initial conditions? To what extent the changes of the drivers and initial conditions would lead to other characteristics of the systems of cities?

As an example, we take the US urban system that saw important structural changes in the 19th century. From a rural and mercantile in the beginning of the 19th century, the economy transitioned to industrial and urban at the dawn of the the 20th century. Such transition was accompanied by important growth and deep shuffling of the ranks of cities in terms of their sizes. In this paper we will explain, using a micro level agent-based model, the relative growth differential that shuffled the size rank of cities. Using firms as boundedly rational interacting agents within and across cities, we test whether the observed transformations were possible thanks to a combination of innovation (transportation and mechanization), the deepening of division of labor, and the rise of scale and agglomeration economies.

KEYWORDS

Systems of cities / USA / Transition / First industrial revolution / Urbanization / Industrialization

Urban scaling version of the Kaya Identity

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Urban areas play an unprecedented role in potentially mitigating climate change and supporting sustainable development. In light of the rapid urbanisation in many parts on the globe, it is crucial to understand the relationship between settlement size and CO_2 emission efficiency of cities. Recent literature on urban scaling properties of emissions as a function of population size has led to contradictory results and more importantly, lacked an in-depth investigation of the essential factors and causes explaining such scaling properties. Therefore, in analogy to the well-established Kaya Identity, we develop a relation combining the involved exponents. We demonstrate that application of this Urban Kaya Relation will enable a comprehensive understanding about the intrinsic factors determining emission efficiencies in large cities by applying it to a global dataset of 61 cities. Contrary to traditional urban scaling studies which use Ordinary Least Squares (OLS) regression, we show that the Reduced Major Axis (RMA) is necessary when complex relations among scaling exponents are to be investigated. RMA is given by the geometric mean of the two OLS slopes obtained by interchanging the dependent and independent variable. We discuss the potential of the Urban Kaya Relation in mainstreaming local actions for climate change mitigation.

KEYWORDS

urban scaling / CO_2 emissions / Kaya Identity / Reduced Major Axis

Power law and degrowth geographies

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The spatial distribution of populations and cities explained by power law has normally been used to represent growth conditions, both in demographic and economic terms. In all those situations where development phenomena have occurred, the power law has allowed us to grasp some interesting allometric relationships between cities and urban systems that have given rise to extensive debates. These "proportionate growth" relationships (well illustrated by Zipf's law) have affected territories characterized by the most diverse geographical conditions, demonstrating a certain validity of those "growth mechanics". But what happens when we are faced with decrease (or negative growth) situations? The paper intends to investigate whether the same allometric relationships that are recorded with a certain regularity in the growth periods remain even in the stabilization phases of urban systems and even in those periods in which phenomena of decrease (both demographic and economic) begin to be recorded. In this general framework, two issues are primarily intended to be explored. The first is that relating to the nature of change in the phases of decrease. During such periods it is in fact possible note two different dynamics: on the one hand, homogeneous and evenly distributed shrinkage processes can be observed and, as such, tend to preserve the original allometric relationships (even if on urban systems characterized by a set of smaller centers tend to intervene phenomena that modify the general system structure with specific threshold phenomena). Alternatively to this homogeneous decrease process, there may instead be the case in which the dynamic follows selective paths, ie there is a change in the distribution law itself and therefore changes the centrality relationships within the urban system. In both cases, it is believed that an important role is played by the morphological conditions in which the decrease process takes place. The morphological conditions are believed to be an important factor in explaining both the growth and spatial distribution dynamics of centrality, as well as (and with greater incisiveness) the decrease processes. If we then consider that decrease develops in a settlement condition where the previous development processes have already determined specific conditions also in terms of settlement morphology, it is hypothesized that the role played by these morphogenetic phenomena is of great importance. To attempt to illustrate this set of hypotheses, the contribution focuses on the analysis of the urban region of Genoa (up to consider its Padan hinterland), Liguria, Italy.

KEYWORDS

Power law / Allometry / Shrinkage / Morphology

The potential scaling of urban heat island and nitrogen dioxide with urban population: a systematic review

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The continuous city population growth exacerbates thermal anomaly and toxic air pollution, leading to problems such as Urban Heat Island (UHI) effects and nitrogen dioxide (NO2) pollution. Meanwhile, there is an emerging convergence for considering cities across the globe as similar in shape, regardless of their locations, economic drivers and size. However, the potential of having intra- and inter-scaling rules between population size and environmental problems was scarcely summarized and discussed before. This is because most relevant studies took 1 city, or chose a few cities within the top ranks of some specific world regions or globally as the research subjects. Therefore, having a systematic and holistic meta-analysis is a way to assess whether scaling of human-environmental interaction exists among cities globally. A literature review using PRISMA guidelines is being developed to generalize the urban population size effect on UHI or NO2 respectively, while hypothesizing the existence of a scaling law for each of these environmental outcomes. Researches including environmental impacts on multiple cities are collected as the raw material in view of generalizing a potential relationship (linear or not). Documented UHI and NO2 values are normalized by population to find a possible match and relationship for all cities. The effect of spatial resolutions and temporal ranges of the studies are also summarized since it may impact the measured outcomes. Tools and methods used for collecting data are listed to suggest an efficient way of carrying out similar studies in the future and provide a wider coverage. A better understanding of the scaling of urban heat island, nitrogen dioxide with urban population will unravel the dynamics of human-environmental interaction and the harbinger of future climate impacts.

KEYWORDS

urban population size / urban heat island / nitrogen dioxide

VIII General Session: Transport (1/2)

MONDAY | 09:00 | Symphonie

Is sustainable transportation limited by urban form? An international GIS-based approach

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Context & Objectives

Climate change and energy shortage are the new impose for geographical research about techniques, methods and policies reducing energy consumption and its effects on urban environment (Demirtas, 2013). Several researches focused on more sustainable technologies (gas BRT, electric vehicles, hydrogen, etc.) that could be used in cities to reduce atmospheric pollution (Hidalgo, and Gutiérrez, 2013). Even if the link between urban form and transportation is now obvious for stakeholders, few works stressed on the importance of buildings and networks configurations to concretely plan these renewed transportation modes (Wang et al., 2017). Moreover in numerous historical city districts, patrimony preservation is sometimes more important than operating changes for more ecological transportation modes. Unlike technologies that can be adapted in the future, urban form is a heritage that cannot sometimes be changed in a short term (i.e., few decades). In this context, our work assumptions are:

- (H1) The diagram of the Land Use Transport loop from Wegener and Fürst (1999) shows a well-known system of interactions between urban form and transportation. However, this loop does not quantify these interactions. Our assumption is that these correlations can be measured using spatial analysis and GIS techniques.
- (H2) According to their historical heritage, all cities in the world are not equal in terms of sustainable transportation system development. To clarify, every city is constraint by the heritage of its urban form. Our assumption is that quantifying the correlations between urban transport and urban patterns allows to determine the parts of the city where the transportation system is clearly determined by the urban form.

Study areas and data

In order to investigate these assumptions six different cities, showing different urban models, are compared. They can be categorized into three groups:

1. Cities in a recent developed country (USA): New York City, Los Angeles.
2. Cities in a historically rich developed country (France): Paris, Dijon, Strasbourg.
3. City in a historically rich underdevelopment country (Lebanon): Beirut.

Data collection for investigating H1 and H2 involves different sources. Depending on the field of study, data are provided by governmental agencies (IGN-Institut national de l'information géographique et forestière) or available on official governmental websites (like Data.gouv.fr or data.gov). When data is unavailable from those sources, open source data are used (for example open street maps-OSM).

Methodology

Collected data are standardized using a Cellular Geographical approach (Tobler 1979). Then, different types of graph theory indicators are applied (Kansky, 1963), where residential densities and land uses categorizations are investigated. Graph theory implements methods that focus on the properties of the road graphs (Lagesse, 2015). Whereas, cellular geography allows comparison and quantification of urban patterns within regular cells. The application of this methodology permits

to create a database with a geographical dimension to compare the different forms of cities at an international level.

Results

First, data are mapped in the form of grids containing both the elements of urban form and transportation. Second, it allows statistical analysis as Principal Component Analysis (PCA) and Hierarchical Ascending Classification (HCA). Those analyses show groups of cells that are characterized with same urban morphology and transportation services. Those groups with common characteristics are shown in all of the six case studies. Thus, the cells integrate specific buildings and network configurations along with specific - green or not - transportation modes. As we can conclude and dissipate, the heritage of every city strongly determines the development of future green transportation, and demands to be further integrated into urban planning and transportation policies.

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KEYWORDS

Urban Form / Transport Modeling / Cellular geography / Graph Theory

Dynamic Macro Analysis for Traffic Safety Experience

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This research focuses how to improve traffic accident fatality specifically for the developing countries such as India based on the traffic policy experience in Japan. In India, the negative impact is caused by the increase of the traffic increase because of the rapid growth of the economy. The negative impact of the traffic becomes serious condition such as the traffic accident fatality increase, air pollution by the traffic jam, and unnecessary fuel consumption. In terms of a solution for this negative impact of the traffic problem, many solutions are reviewed, e.g. already introduced as "the smart city of the traffic" which can control a minimum congestion length by the signal wait, the intelligent-transportation-system (ITS) for traffic management, the providing appropriate driving route, and so on. These solutions use the high technology which has been developed for the advanced like Japan and the other advanced countries. Therefore not all the technology works properly for the developing countries because the technology is not optimized for the developing countries. The developing country is apt to have economic growth more higher priority than the better service of the traffic control and infrastructure improvement, traffic education for the residents etc.

Therefore, it is necessary to show how the countermeasure effectively works, which has been done in many advanced countries. In another word, when and how the countermeasure for the developing country is utilized. In this paper, the author uses a quantitative traffic-analysis and shows the fundamental analysis of the countermeasure for the traffic experience in Japan. As the quantitative traffic analysis, author uses Smeed's Law and improve Smeed's Law. R.J.Smeed found special relationship between the number of fatalities and the number of population and that of vehicle in the countries and announced as Smeed's Law in 1949. This relation is the epoch-making empirical rule which relates traffic accident fatality to the traffic jam by the development countries. The Smeed's Law works when the increasing traffic is increasing and it brings about the increase of the fatality. Many researchers after Smeed are trying an analysis of the number of the traffic fatalities in the various countries by this Smeed's Law. They analyzed 20 cities and get good result between simulation result of Smeed's Law and traffic fatality record. The Smeed's equation is expressed by number of vehicle and population – $D=0.0003 (np^2)^{1/3}$ – where D is the number of the traffic fatality, n is the number of the vehicles and p is a population. Therefore, the traffic fatality goes to increase under economic growing condition because the equation is using only the increasing number of the vehicles and a population as the parameter. In order to make Smeed's equation under economic growing condition, it is necessary to add the parameter to decrease a traffic accident. Therefore, the researchers after Smeed have changed a fixed exponential constant of vehicle number and population in the equation. This method is only adjusted a equation between fatality calculation result and the fatality record which means that they changed an equation.

As for this research, author keeps original relation of Smeed's Law and introduces the parameter to utilize an equation and to decrease the number of the traffic fatality as the enhancement of Smeed's equation. The extension Smeed' equation by adding the number of the signal installation as the representative example to do traffic control in order to maintain the relation of the equation in the others. In the enhanced Smeed's equation, the author keeps the exponential constants of vehicle number and population and finds the appropriate exponential constant of the signal installation in Japanese case study. Author analyze the 50 years Japanese historical record about the traffic fatality. The exponential constant of vehicle and population of Smeed's equation is defined increasing ratio based on the GDP per capita. As for exponential constant of signal installation, author check carefully

the relationship between signal installation and GDP per capita in Japanese historical record and concludes that the exponential constant has the seven phases. By enhanced Smeed's equation, author shows validation of the new enhanced Smeed's equation by comparison between the traffic fatality record and the result of the enhanced Smeed's equation. By using the enhanced Smee's equation, author makes the analysis in India. As the result Indian simulation, it fit the record of Indian traffic fatality. In order to estimation of the future Indian traffic condition, we found that it is not enough that signal installation to reduce traffic fatality in India with signal installation exponential constant. In case of reduction of Indian traffic fatality in future, author shows necessity to take other traffic policy such as control center and more advanced signal control management after 2020. This is the first time to show enhanced Smeed's equation validation for the developing country.

Revealing Drivers' Parking Behavior with a Serious Game

Nir Fulman[1], Eran Ben Elia[2], Itzhak Benenson[1]
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Automated and connected vehicles will eventually simplify transportation and parking. Until this happens, parking search is an annoying component of any car trip. Besides waste of drivers' and passengers' time and air and noise pollution, cruising adds up another 30% to congestion. Typically, cruising for parking involves a time-money trade-off between certain but pricey off-street lots and uncertain, in space and in time, yet cheaper on-street parking. Understanding drivers' behavior in response to prices is critical for establishing parking policies that reduce cruising. We investigate this behavior with a serious PARKGAME that enables revealing drivers' decisions that cannot be estimated in field experiments.

A player navigates a virtual road network using keyboard keys, trying to get in time to a meeting at a destination. In the beginning of the game, the player is given a budget for parking and for paying delay fines if late to the meeting. The parking cost is lower than this budget allowing to save money if arriving on time . Two parking options are available: (1) A pricey parking lot which is located, at different distances from the destination, and where parking is always available and (2) Cheap curbside parking on highly occupied streets but with very uncertain search time and distance between parking spot and destination.

49 participants participated in sessions performed in a Manhattan-like city grid of 10X10 blocks. Players start a game at distance of 1-minute drive from the destination. Drivers' behavior was studied in three scenarios: In scenario A, the lot was at a distance of 45 m (45 sec walk) from the destination, and the time between a start of the game and the meeting was 3 min. Scenarios B and C were devised for studying the influence of the parking lot's location on cruising behavior. In scenario B, the lot was located 135m (135 sec walk) from the destination, and the time between the start of the game and the meeting was also 3 min. That is, in scenario B a driver has less non-fined time for the on-street search. In scenario C the game duration was longer, 4:30 min. This left to the driver the same non-fined search time as in scenario A. After initial learning period, each player played each scenario 8 times.

While cruising, a player had to make decisions of two kinds. The first – temporal – determines whether to continue the search for the uncertain yet cheap on-street parking or to cancel the search and drive to the expensive lot. In this respect, two groups of drivers, each repeating a consistent pattern of behavior, are revealed. Risk-averse players parked at the lot, accepting low gains without ever being late, whereas the rest of the players were risk-seeking. In scenarios B and C, where the parking lot is located further away from destination, almost all players responded by increased cruising, indicating that changes in parking pricing policy can likely influence parking behavior.

The second type of decision regards the spatial pattern of search – either to cruise closer to the destination, or risk driving further away and walk longer back to the destination. In this respect, the basic incentive of all drivers was to remain closer to the destination and they rarely drifted more than 300 m away. In scenario A, where the parking lot was close to the destination, cruising patterns were symmetrical around the destination, whereas in scenarios B and C the geometrical center of search wandered between the destination and the parking lot. The spatial patterns of players' search are illustrated by the standard deviation ellipse (SDE) weighted by the frequency of junction visits. In scenario A, the SDE is very close to a circle, while in scenarios B/C it stretches in the direction of the parking lot. Players cruised in loops, approaching and then driving further away from the destination.

A model of the driver's parking search was specified as a Markov process, namely, a random walk biased towards the destination. The model was verified for a parking lot close to the destination (scenario A) whereby when cruising, the decision at the next junction depends on the current distance to the destination and the decision taken at the previous junction: when close to the destination, the probability to get closer decreases, whereas further away it increases, and vice versa. The probability to quit cruising depends on driver's risk attitude where the mean cruise of risk-averse players was twice lower than risk-seekers.

Our model of parking search behavior does not yet account for the effect of distance between a parking lot and the destination. When fully established, the model of parking behavior will be incorporated into a dynamic agent-based model of parking in the city, whose goal is to minimize urban cruising.

KEYWORDS

parking search / parking search behavior/ Serious Games / parking policy / parking behavioral model

Sustainable mobility with Bike Sharing System in the city of Lyon: benefits and improvement keys

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The Lyon metropolitan area has the goal to encourage the soft mobility in the center of the city for sustainable mobility. Since 2005, a Bike Sharing System – BSS, called Vélo'v, has been implemented in the center of Lyon metropolitan area. Currently, this system is a great success, there are about 60 000 annual subscribers for more than 8 million trips in 2015 with 348 stations and 4 000 bikes. The first 30 minutes are free for all users. Lyon is the first French city where a BSS was installed on a large scale. In this study we aim to analyze the mobility of BSS users, the benefits of the BSS and the improvements that we can make in order to make the BSS more performant.

Data and methodology:
In this study, we use all the BSS trips recorded in 2015, more than 8 million trip data. For each trip, the following information is available: outbound station, inbound station, departure and arrival date and time and type of user (annual or daily subscriber). The cartographic analysis is used to describe the different trips by weekday and different hours of the day (peak hours in the morning and in the afternoon) in order to understand the usage of this system.
In the first part, we analyze the mobility of users during a week and different periods of day. The first analysis was to do visual analytic for the inflow and outflow during different periods on a weekday. The usage of bike sharing during weekday and weekend were compared in order to see the particularity of the system. We also analyze the BSS for particular day like public holiday in order to understand the different usage of this system.
In the second part we analyze Lyon's BSS with performance indicator (Médard de Chardon C. and al 2017) and also with some socio-economic indicators based on population, employment, public transport spatial data to do fine analysis. This work will enable us the success determinants of Lyon's BSS and how it can be improved.

Results and discussion:
The usage of bike sharing is very different depending on the observation period and according to the size of stations and also the geographic position of the bike station. In this case, we observe that the BSS is working very well in the areas where the urban density is high and/or near universities. We also notice that the stations located in hilly areas generate fewer trips than other stations. The Geovisualization and cartography dynamic of bike sharing trips data will be an important decision-making tool for urban planners to understand and to improve the usage of the BSS.

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VIII General Session: Spatial Analysis (3/3)

Urban street landscape and well-being in Brussels

Madeleine Guyot[1], Alessandro Araldi[2], Giovanni Fusco[2], Isabelle Thomas[1]
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Urban landscapes are the backdrop of life in more than half of the world population. The streets and public spaces provide the setting for urban activities, with buildings, gardens and parks as background. The layout of this urban street landscape influences our way of perceiving the city but also, more broadly, affects well-being. To support this assumption, it is necessary to well characterize the urban fabrics in order to link it with well-being. Finding the spatial unit at the right scale has always been a challenge for spatial analysts. Administrative partitions (wards, municipalities) often do not match with urban landscapes: each spatial unit is heterogeneous in terms of built-up and not built-up surfaces hence not fitting with further spatial statistical analyses. Araldi and Fusco (2017) have developed a new method - Multiple Fabric Assessment method (MFA) - with the idea of characterizing urban fabrics as they are perceived by the pedestrians freely moving on the streets, so from the road network. The original MFA method does not include any vegetation indicator, while the beneficial impacts of urban green spaces on psychological, emotional and mental health has already led to numerous analyses.

The MFA method is applied to Brussels (Belgium). The basic spatial unit (Proximity Bands) is first defined around each street segment. Each Proximity Bands unit is further described by 21 geometrical and spatial indicators of urban form as perceived by the city user; three of them are related to vegetation. Geostatistic analyses (ILINCS) are then achieved to identify local patterns of urban form features. Finally, Bayesian clustering is carried out to identify and describe families of urban fabrics. The application of this variant of the MFA method makes it possible to highlight twelve families of urban fabrics in Brussels. This result highlights elements specific to the city's history, such as bruxellisation - destruction of part of the historic center to build offices - and garden cities.

This typology of urban fabrics is then linked to mental health and well-being. Two types of analysis are carried out: a qualitative and a quantitative one. The qualitative analysis consists in walking interviews and mapping exercises with forty Brussels residents. The typology enabled us to define the interviews places in order to explore a different range of urban fabrics. In the quantitative analysis, Health Interview Survey (HIS) data are used to investigate the relationships between mental health and the built/non-built environment, while accounting for demographic, socioeconomic factors, lifestyle, air and noise pollution. These two analyses are ongoing and the first results will be discussed.

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KEYWORDS

Urban morphometrics / Green environment / Urban fabric / Brussels / Street segments / Multiple Fabric Assessment / Well-being

How to improve infra-communal accessibility to primary care in France to better identify underserved areas? The case of Paris region

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Within the health system, primary care plays an essential role in maintaining population health. In France, the number of primary care physicians and their medical density reached a historical level in 2007 but have been decreasing since, amplifying spatial disparities. Accessibility to health care is now a key issue on the French political agenda, conducting public authorities to encourage general practitioners to work in underserved areas.

The identification of these areas is a major challenge because the greatest obstacle to the use of the concept of accessibility lies in the difficulty of translating it into operating indicators (HANDY et NIEMEIER 1997). Moreover, accessibility itself is complex to address because of its intersectional dimension (spatial, time-based, cultural and financial) (PENCHANSKY et THOMAS 1981). Nevertheless, measuring the spatial dimension of accessibility is fundamental because it impacts the use of health care (GUAGLIARDO 2004, BISSONNETTE et al. 2012, NEUTENS 2015) and informs public authorities about low accessibility areas (APPARICIO et al. 2008). To measure it, the « Two-step floating catchment area » (2SFCA) method, derived from gravity models, has found broad consensus in the international geographical literature (ALLAN 2014, NEUTENS 2015). The indicators produced have gradually been improved to better (1) characterize the demand for care (NGUI et al. 2011), (2) quantify the healthcare supply (BARLET et al. 2012), (3) and measure the interaction between supply and demand by integrating either mobility levels of population (MC GRAIL et HUMPHREYS 2009), a decreasing probability of care use as a function of distance (E2SFCA de LUO et QI 2009, KD2SFCA de DAI et WANG 2011) or, finally, competition or relative position effects (DELAMATER 2013, LUO 2014).

This type of indicators has emerged in the French institutional landscape in 2017-2018 when an adapted 2SFCA measure was used to define shortage areas for general practitioners in all regions (VERGIER et CHAPUIS 2017). Using it as a public policy instrument raises the question of the relevance of each hypothesis included but also the impact of those who haven't been included, especially when it comes to identifying local health care needs and mobility practices.

Improvements of such measures in France are now possible by combining databases of National Health Insurance Fund, census data and accessibility matrix (on foot, by the road network and by public transport as far as possible). For this study, the geographical field of study is limited to one region, Ile de France (Paris region). The social dimension of health care needs is integrated to better characterize demand; mobility practices by type of spaces (urban, sub-urban or rural) are used to better describe mobility level and competition effects are introduced with iteration process to improve the measure of health care availability for patients. In order to capture sub-communal differences in accessibility and to get away from administrative divisions, accessibility to care is measured from a fine coverage of the region ("mesh" of 200 meters on each side). The objective is to calculate the measure for different relevant divisions (zoning of observation, of decision) by aggregating the geographical "meshes".

These refinements led us to a better measure of health care accessibility. Beyond the observation with an aggregate indicator, the measure of accessibility according to different scenarios (pedestrian

accessibility for the less mobile; accessibility by public transport for non-motorized; accessibility to health care supply without extra fees for the most deprived...) will make it possible to use constructed indicators as a decision-making tool to identify areas with accessibility deficits and to account for populations at risk.

KEYWORDS

spatial accessibility / floating catchment area / primary health care / France

Urban green and health: does the landuse database matter? A case study in Namur (BE)

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Nowadays the relation between human health and the surrounding natural environment has become a relevant and quite fashionable topic. Landuse maps and satellite images are commonly used in multiple disciplines and for different purposes (environmental studies, epidemiology, policy making, urban planning…). Oftentimes, though, a critical assessment of the database used is lacking, and the choice is guided by data availability, leading to possible biases in the study outcomes. What are the implications of such choice when discussing the benefits and externalities of green spaces on health? Here, we compare landuse database on the same study area and, after adding a health variable, we discuss the impact the database choice has on the outcomes.

This paper first aims at mapping and comparing the efficiency of several landuse databases for measuring green in one Belgian city (Namur). Corine Land Cover, Urban Atlas, NDVI and a self-developed database (created using satellite images, street view and cadastral data) are systematically compared. Similarities and discrepancies between four databases are highlighted at the municipality and at the local scale, through both descriptive statistics and more in-depth analysis of the overlap and spatial structure of the data.

In a second step, indicators of mental health, issued from the Health Interview Survey (HIS), are linked to the environmental characteristics provided by each one of the four aforementioned databases. The HIS data includes answers of over 200 Namur residents, collected in 2008 and 2013. Indicators of environmental characteristics are measured around each respondent's location and then linked to indicators of health. For privacy matters the link between the surrounding environment and the HIS answers is done by an external agency (StatBel). Multivariate logistic regression models are then used to look at the relation between environmental characteristics and health indicators.

At the municipality level, results show significant variations, not only in terms of total surface for some landuses, but also concerning the fragmentation and spatial pattern of landuse patches. These results are confirmed at a finer scale of analysis, supporting the hypothesis that the landuse database choice has an impact on the description of the residents' surrounding environment, and therefore on the role that different environmental factors may play on health.

Outcomes provide a reflection on limits and advantages of the databases. A consistent database choice through studies can lead to higher comparability and knowledge transferability, increasing the scientific impact, as well as contributing to the creation of more informed policy recommendations.

KEYWORDS
landuse database / green spaces / epidemiology / mental health

Unravelling the border-facade of France: a multi-level modelling of cross-border commuting

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Given its central position in Western Europe, France is the European country where cross-border commuting is most intense. Over 350000 residents cross the national border everyday to go to work. Cross-border commuting raises a lot of concerns for planners on both side of each border, especially for provisioning transport infrastructure and local public services but also because it impacts land and housing markets, especially when salary differentials are high. While there is a lot of research about the daily functioning of specific borders (e.g. France-Switzerland or France-Luxembourg), generalization is lacking and spatial heterogeneities impede our understanding of the very determinants of cross-border commuting, such as the role of benefits differentials, transport costs and distance, or the relative availability of jobs at residential places and across the border. Further, these effects are most likely mediated differently by the socio-demographic characteristics of workers, their employment sector, and the quality of their residential environment at large. This suggests that an individual approach and a spatially detailed approach is needed, which contrasts sharply with the fact that most European-wide studies of cross-border commuting are conducted at very aggregated spatial scales (NUTS 2 or 3).

We propose to analyse the propensity of active individuals to cross the border for the entire Border-Facade of France, from Belgium to Spain via Luxembourg, Germany, Switzerland, Monaco and Italy. The goal is to distinguish whether and to what extent a cross-border working choice is actually different from a cross-urban region choice. Especially, does the distance play a different role if you move beyond the border of your functional urban area or if you move beyond the national border?

We use the Census 2015 data at individual level (active population), with a geographical recording at municipal scale. We estimate a series of multilevel models with individual, economic sector, and 50 km Facade zones (BE; BE-LUX-DE; DE; DE-SWITZ; SWITZ -ITAL;…) as levels. This methodological choice is motivated by previous research using the 2012 Census where we modelled all workers in France (not just the Border-Facade) and from which we found significant spatial heterogeneity and very steep effect of the distance to the border.

KEYWORDS

borders / commuting / multi-level

Special Session: Spatial computation in Archeology and History (2/2)

MONDAY | 09:00 | Salle des Fêtes

SimFeodal: an agent-based model to explore the combined effects of social and demographic changes on the hierarchy of rural settlement patterns in North-Western Europe during the Middle Ages

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In North-Western Europe, regional settlement patterns that were dispersed in 800 CE became much more concentrated and hierarchical in 1200 CE (Tannier et al. 2014). This phenomenon occurred in all regions but the resulting level of concentration and hierarchy of settlement patterns differed notably among the regions. Several processes jointly explain this major transition (Cura et al. 2017).

- The dismantling of the Carolingian Empire and the dissipation of powers induced struggles among lords and thus a rise in violence. The result of this was the creation of castles as well as an increase of the need of protection for peasant households;
- The militarisation of the society mentioned previously also intensified the need of lords for money as well as their need of fighters. From this originated the so-called "feudal revolution" of the 11th century during which ever smaller lords appropriated various administrative, fiscal and judicial rights for themselves and their vassals. As a result, usage fees and rents paid by peasant households to the lords increased a lot.
- Peasant households created villager communities to increase their productivity and counterbalance the power of lords.
- The religious control of the society increased a lot (especially as a result of the Gregorian reform). From this resulted a great upwelling of piety and level of devotion, an increase of the number of parish churches, and the increase of usage fees and rents paid by peasant households to the Church.

At a regional analysis level, how all these processes reinforce or counterbalance each other and finally increase the concentration and the hierarchy of settlement patterns remains still unknown. Our interdisciplinary group, made up of geographers, archaeologists and historians assumes that four variables may have a crucial impact on the level of concentration and hierarchy of a given regional settlement pattern: the number of inhabitants in 800 CE, the number and the size of the villages in 800 CE, the demographic growth during the whole time period, and the proportion of peasant households being so highly dependent on their lord that they can not leave his grounds (serfs, slaves).

The agent-based model SimFeodal (https://simfeodal.github.io/) has been created with the GAMA platform (Taillandier et al. 2018) to explore the combined effects of these variables on the relocation of agricultural holdings (farms) in the course of time. A simulation begins in 800 CE and ends in 1200 CE. A simulation step represents a time length of twenty years, which corresponds to the average life duration of a generation at the time period under consideration, thus a simulation goes on for twenty simulation steps. The time length of a simulation (400 years) is long enough to be able to verify if simulated dynamics are lasting or not. The main simulation result is the progressive

appearance of enduring population clusters located around the castles and the churches. Population clusters (hamlets, villages, small towns) become more numerous; many of them grow (i. e. their number of peasant households increases as the agricultural holdings concentrate within them) but some clusters grow more than others.

The aim of our presentation is to show how the values of the four variables quoted above influence the simulation results, especially the rank-size distribution of population clusters. Thus we expect to better understand the combined effect of each variable on the spatial dynamics of rural settlement systems in North-Western Europe during the Middle Ages.

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KEYWORDS

Agent-based modelling / Archaeological data / Historical sources / Settlement patterns / Spatial dynamics / Middle Ages

A multi-agent simulation to model the secondary sources of siliceous raw material used in Prehistory

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The use of a Multi-Agent Simulation (MAS) tool, here engaged as an exploration method, aims to simulate potential theoretical paths of siliceous rocks nodules (or silicites), according to a gravity model and topographic data from various IGN databases. This approach is part of research projects on the exploitation of geo-resources and on the territoriality of human groups, a perspective that is currently one of the main issues in Paleolithic and Neolithic archaeology.

Thus, this work relies on the fieldwork made in several ongoing Collective Research Projects (PCR) "Réseaux de lithothèques" whose purpose is the grouping and harmonization of information on the spatial distribution of geo-resources at a national level. All these programmes have created a synergy that brings together the work of a larger number of relevant researchers, united since 2019 in the framework of a bigger project: the Research group (GDR) "Silex".

One of the working axes of these various projects is to improve the spatial knowledge of geological formations, especially the secondary sources (colluviums, alluviums ...), in which prehistoric populations extracted lithic resources. The main objective of this new approach is thus to model the natural spatial distribution of different raw siliceous material type and to identify areas where they were concentrated, in order to plan survey in areas where theory show the best chance to find such concentrations.

First results were obtained by using NetLogo (a MAS open source software) and a gravity model, initially developed to model rain fall, but here adapted to our needs and thematic.

We used two different topographical databases of French Institut Géographique National (IGN) who is in charge of editing georeferenced data and topographical maps: one at 75m/pixel and the other one at 25m/pixel.

The theoretical paths of silicite nodules along slopes were simulated as water paths after rain falls. We used our NetLogo application to calculate potential tracks numerous times, varying the parameters of density of silicite fragments as well as movements speed.

Once, watersheds basins were filled up by siliceous rock concentrations, we compared results obtained with two different topographical databases to identify the impact of data resolution.
Then we exported results in two different raster files (.png) to which we added georeferenced text files (.pgw), one for each of IGN's databases.

Thus, we identified and digitized potential areas of concentration of silicite along potential tracks. After that, we identified and created a point shapefile for fieldwork prospecting.

This model was compared to results of several survey campaigns in two different test areas situated in France. One in Auvergne Rhône-Alpes region - and more specifically focused on the Aalenian cherts from Lozere and Bajocian flints of Forez in the Loire river formations -, the other one in Nouvelle

Aquitaine region focused in the watershed of the Manaurie river. Results where uploaded on a web map application using ArcGisOnLine Web AppBuilder for ArcGIS to share results with others researchers involved in thsi project.

Benefits of such an approach were underlined as well as limits (Tuffery and al., 2018). This exploration phase is opened to other use cases and other results are necessary to improve methods and quality of data.

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KEYWORDS

siliceous material / Prehistory / multi-agent / simulation / GIS

Exploring simulation models of dressed stoned exchange during the medieval age

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In this paper, we explore an agent-based simulation model of dressed stone exchange between quarry owners, merchants and construction sites (castles and churches) during the medieval age (X-XIV centuries). The aim of the simulation model is twofold: to build an integrative view of this system and to confront a set of hypotheses, from the least to most specific one. Exploring models of various complexity level enables us to investigate how far do we have to describe the system to observe substansive changes in the market behaviour.

Using an incremental process, we compare:
– a random only driven exchange market (the selection of a particular dressed stone producer is defined by a uniform probability law)
– a spatial interaction system (the selection of a particular dressed stone producer is constrained by distance to the construction site and producing capability of the quarry)
– an expert model (the selection of a particular dressed stone producer is constrained by a set of rules proposed by historical and archaeological scientists).

Our exploration procedure evaluates the impact of several input parameters (number of construction sites across time, number and type of chalk producers, needs and capabilities, environment size and topology, etc.) on two output variables derived from an origin/destination matrix (the total volume of exchanges and the median distance travelled by chalks) and on the dynamic of the system. We also measure the interactions between the different mechanisms and the variations introduced by new behaviours (ie. sub-models of higher complexity levels).

Exploring our incremental model implies to run, describe, and compare hundreds of thousands of simulations using distributed computing [1], each of which having its own specific set of input and output values computed at each time step. This represents a huge amount of data which needs specific computation methods to compare and understand [2, 3, 4].

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KEYWORDS

agent-based simulation / incremental model / exploration process

Central place foraging and hunter-gatherer settlement patterns: how resource depletion influences population concentration

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Settlement patterns are one of the main products of the Stone Age archaeological research. Their emergence processes can be explained by different models of settlement and mobility choices done by past inhabitants. In current study we explore central place foraging (CPF) model of hunter-gatherers as a tool for exploring formation of settlement patterns.

CFP model is used for describing mobility choices of hunter-gatherer groups. It implies the groups settle at a central location and make logistic forays to surrounding areas foraging for required resources. The central location is chosen by it's optimal position in relation to those resources and the group is willing to leave the current base location if a better alternative arises.

We introduce a spatially explicit Agent-Based Model (ABM) of the CPF and explore how heterogeneous environment influences the settlement pattern formation. The motivation to move in CFP comes from changes in the environment. An important part of the change is the depletion of existing resources by the hunter-gatherers themselves.

We are using the ABM model to explore how depletion process influences the dispersal of hunter-gatherer groups in the environment and which conditions and strategies will result in higher concentration and clustering of the population.

KEYWORDS

hunter-gatherers / agent-based model / central place foraging

General Session: Transport (2/2)

Commuting satisfaction before and after a workplace relocation: what impacts?

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Literature on mobility and transport is increasingly abundant on issues of satisfaction and quality of life, as public policies have recently taken up these concerns (e.g. Lowe et al., 2015). For example, the longer travel times are, the more they can negatively impact the subjective well-being of the population (Hilbrecht et al. 2014, Zhu et al. 2017). In addition, active modes (cycling, walking) are a priori more satisfying than other modes (Chng et al. 2016). Other studies focus more specifically on the relationship between driving and stress and its outputs, or even more serious physiological risks such as cancer (Ding et al. 2014, Guberan et al. 1992).

However, many articles point the fact that it is still difficult to estimate links between mobility and well-being, especially since there are issues about definition and measurement of multidimensional concepts such as well-being, quality of life or satisfaction (e.g. De Vos and Witlox 2017, Friman et al. 2013). Some results even reveal an absence of correlations between movement and well-being (Adam et al. 2018, Dickerson et al. 2014, Lorenz 2018, Morris and Zhou 2018). Such considerations are important since issues related to travel measurement methods (e.g. travel modes or behaviours) are also subject to debate, not to mention their determinants: origin-destination matrices, GPS track measurements, mobility patterns, fragment paths or regular movements. Many authors admit that, faced with the versatility of mobility patterns, surveys collecting this information are still often difficult to implement because due to their expense and time needed (see Bonnel et al. 2018).

Objective and conceptual framework

Without claiming to resolve all of the limitations mentioned, the purpose of this presentation is to go further by examining the influence of commuting satisfaction following a workplace relocation. More precisely, measuring this change would thus make possible to identify (or not) accumulation of satisfaction already observed notably by Jakobsson Bergstad et al. (2011), by adding some original retrospective effects related to specific changes in habits and travel routines caused by the workplace relocation.

While the literature on workplace relocation is mostly devoted to job decentralisation (Zarabi and Lord 2018), this study focuses on an organisational merger within the city. It investigates the motivations and barriers of adopting low-carbon transportation modes versus car for daily home-to-work trips, using the interdisciplinary theoretical framework of mobility biographies (Lanzendorf 2003 and Scheiner 2007, 2018) and life-oriented approach (Zhang 2017). Based on random utility theory, the analysis used will be ordered and/or binary logit (e.g. Langlois et al. 2015) in order to explain the different sets of variables related to travel satisfaction in the survey.

The focus of our analysis is based on a target population of 11,000 employees working at the new McGill University Health Centre (MUHC) in Montreal, Canada. Opened in 2015, this Centre brought together four hospitals in one single peri-central location. In addition, the MUHC has various access facilities, including the presence of a regional rail station and a metro station, both integrated into the new hospital, as well highway interchange nearby. This place improves a priori all modes of transport, but gives favourable accessibility to public transport. Thanks to a retrospective online

survey conducted in May 2018 of 1,977 MUHC employees, it is possible to test our hypotheses with topics included in the survey. These topics join those of traditional transport surveys, while adding peculiarities, such as socio-psychological questions (Van Acker et al. 2010), as well as simple Lickert satisfaction scales, avoiding the burden to the participants and knowing that there is no perfect measure of travel satisfaction (De Vos et al. 2015, Singleton 2019).

Preliminary results
The initial results reveal some very interesting relationships, depending on whether one considers the trajectory between people who have been satisfied (before moving) to those who are no longer satisfied or vice versa. Thus, identity attitudes, particularly related to current workplace attachment, seem to play a predominant role: the more workers are attached to the hospital site, the more satisfied they will be. Some sociodemographic variables, initially significant, lose their explanatory power with the integration of different transport-related attitudes. The model will be further refined, especially at the level of some accessibility control variables.

KEYWORDS

Behaviour / Commuting satisfaction / Logistic model / Montréal / Retrospective survey / Transport mode choice

Dynamics of activity time-use and episodic well-being: Life-course based analysis from 2010-2013 American Time Use Survey

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Quality of life is an important dimension from a regional policy standpoint, especially with changing demographics, lifestyles and infrastructure services with demand for efficient mobility services. As transport mobility is proven to be critical and essential in maintaining individuals' life satisfaction and subjective well-being. Exploring this relationship between activity participation and subjective well-being is of immense importance, especially in the context of activity-based travel analysis.

Activity participation is heavily based on life-course of individuals and the role they play in households. This study sheds light on activity time-use and task allocation in different life-cycle stages and the resulting travel demand along with assessing and monitoring individuals' episodic feelings (or emotional well-being) that contribute to their overall quality of life. The paper contributes to existing studies that investigate aspects of traveler attitudes and perceptions, activity time-use and modal choices on their subjective well-being

Subjective well-being (SWB) is a major topic of interest in research with emergence of new fields such as hedonic psychology, positive psychology and happiness economics. Lately this topic has gained significant attention in travel behavior research that focuses on understanding the links between activity engagement, time-use and mode choice as related to global life satisfaction and episodic well-being. However, we note that most of the current studies assume a causal structure in studying SWB and activity engagement choices. In first line of research, studies have determined individuals' activity and travel patterns by utilizing well-being and quality of life indicators as explanatory variables within the random utility-based models of activity travel patterns (Abou-Zeid and Ben-Akiva 2012; Polydoropoulou et al., 2010). In second line of work, individuals' SWB is viewed as a portion of derived utility from activity engagement and time-use patterns – that focus on incorporating measures of activity and travel characteristics to predict individuals' well-being (Archer et al., 2013; Ettema et al., 2010). The construct of time-use is critical in understanding emotional well-being and quality of life for both researchers and policy makers. Essentially, activity engagement and travel entails use of time, which is a truly constrained resource in which 24 hours should be distributed across these episodes, thereby also impacting an individual's daily satisfaction.

Therefore, this study aims to jointly explore the underlying correlation structure of well-being and activity time-use patterns, thereby addressing a major gap in the literature on imposition of causality in studying these relationships. As noted by Ettema et al., (2010), unraveling this joint relationship between activity engagement and individuals' well-being poses a major issue in-terms of bias on findings that could be misleading from a policy standpoint. Furthermore, we also analyze the temporal nature of this underlying correlation by conducting an episodic-level analysis using the sample from 2010-2013 ATUS well-being module. Additionally, individuals' life-course related to household composition, age and marital status are also accounted into the analysis to further investigate the heterogeneity in time-use and well-being patterns.

The ATUS data records reported levels of well-being for an episode an individual participates in as measured using indicators related to – happiness, feeling of tiredness, stress, sad, pain and meaningful during activity engagement. In addition, the data also collects information about activity and travel characteristics along with a broad array of sociodemographic information.

To unravel the joint relationship between activity time-use and episodic feelings (or emotional well-being), we approach this in a two-stage process. First, we construct a composite measure of degree of episodic well-being that individual experiences from activity engagement using latent class cluster analysis (LCCA) framework. In the second stage, we jointly analyze and examine individuals' activity time-use (or duration) and derived degree of episodic happiness using a bivariate ordered probit model structure. This modeling framework also enables us to investigate the underlying correlation structure along with understanding the satiation levels (or thresholds) in activity engagement choices that act as turning points for activity scheduling from reported indicators to episodic feelings. This is achieved by estimating a series of econometric models using the ATUS data from year 2010 to 2013. I believe analyzing this correlation structure is significant in further understanding the temporal stability of time-use and episodic well-being. For instance, Ravulaparthy et al., (2013) report a strong negative correlation between activity duration and episodic happiness from elderly activity engagement choices based on a cross-sectional study.

Furthermore, two separate models are estimated for in-home and out-of-home activities to specifically investigate the differences in correlation structures between time-use and episodic happiness. In this process, I control for a broad array of covariates related to individual and household characteristics, activity and travel attributes and social context among other factors. Additionally, to further generalize results I also control for history-dependency by incorporating activity characteristics before the sampled activity in measuring episodic wellness. Finally, conclusions are drawn from the model estimation results along with major findings for policy implications and future methodological directions.

KEYWORDS
time-use / well-being / life-course / travel behavior

Integrating shared autonomous vehicles and public transport with dynamic pricing and elastic demand: a simulation study

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Developing multimodal centered solutions based on mobility-as-a-service concept is one of the main strategic measures of future mobility solutions. This measure suggests promoting a user-centered and flexible mobility service by an integrated system with both public and private transport based on real-time information and communication technologies. With the progress in autonomous vehicle (AV) technology, it is expected to further enhance seamless multimodal mobility by using AVs as a feeder for access to public transit. However, the issues related to business models and its operational policy design for integrated demand responsive transport service using AVs still need to be developed. Several recent studied have started looking at operation policy design and impact assessment of shared taxi in urban areas with/without using AVs, e.g. [1][2], among many others. However, most existing studies on dynamic dial-a-ride/ridesharing mainly focus on mono-modal cases only. There are emerging studies exploring the potential benefice of bi-/multi- modal ridesharing solution for solving first- and last- mile problems or providing integrated rideshare-transit service [3][4].

In this study, we consider an AV-based dynamic bimodal ridesharing problem. We proposed an integrated dynamic multimodal ridesharing using AVs by considering traveler choice behavior for dynamic price optimization. A modeling framework for AV-based dynamic multimodal ridesharing with integrated demand modeling and rideshare-transit collaboration is proposed. The model integrates customer choice behavior in dynamic pricing optimization to optimize user-defined system objectives, e.g. public transport ridership or an operator's revenue, while satisfying customer's inconvenience constraints. A nested logit model is specified to model customer choice behavior and integrated into the dynamic pricing model. Customer's time windows constraints associated with his/her pickup and drop-off locations are explicitly considered for dynamic vehicle dispatching. Moreover, the characteristics of AVs are taken into account for its operational policy design.

We conducted two simulation experiments on multimodal networks to validate the proposed approach. The first experiment considers a static case to evaluate the pricing optimization on the operator's revenue. We consider an agent-based day-to-day adjustment process to achieve the network equilibrium in a simple multimodal transportation network. The impact of pricing optimization on the operator's revenue is evaluated. The second experiment considers dynamic multimodal ridesharing with integrated pricing optimization and customer choice behavior modeling. The result shows integrating dynamic pricing optimization into AV+transit operational policy design could significantly improve the revenue of the AV operators.

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KEYWORDS

Autonomous vehicle / Mobility-on-demand / Agent-based model / Dynamic pricing / Public transportation / First-mile problem

IX

General Session: Fractals

Reliability of fractal estimations on noisy patterns

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The relevance of fractal and multifractal approaches for studying spatial organization of cities and urban networks, as well as for characterising districts and neighbourhoods is now well established (Frankhauser, 1994; Thomas et al., 2010). In all the contributions, three measuring methods predominate: (i) radial analysis, which corresponds to local dimension, (ii) box counting and (iii) correlation analysis. However, these methods are used without deepening methodological investigations. There is no effective measure of the quality of fit of a dimension estimation method to actual data. The case is even worse for multifractal analysis, where a spectrum of dimensions is obtained. Tests showed that classic methods of multifractal analysis based on box counting turned out to be, up to now, not reliable at all neither for urban patterns nor for networks. Indeed multifractal analyses yield very often curves that have shapes opposite to what they should have, and the concept of negative "orders" has no clear interpretation in the real world.

Recently the authors of this paper compared different methods for estimating fractal dimensions. Results showed problems of reliability of estimation, independently of the type of texture considered (Thomas and Frankhauser, 2014, Frankhauser and Bonin, 2017). Despite a better understanding of the biases, a fundamental question about how to obtain more reliable results persists. It is surprising that when estimating fractal dimension, results may depend on the estimation method used. Tests on mathematical toy-examples of fractals (for which the fractal dimensions are known) were carried out and made evident that these methods may provide results that are less reliable than usually supposed. This seems, inter alia, to be linked to the type of textures considered, which are binary and thus lacunar.

The previous analyses have enabled to highlight two main issues to investigate. The first one is the effect of noise on a fractal structure, be it multiplicative (i.e. present at all scales) or additive (i.e. present only at some specific iterations of the fractal generator). Moderate amount of noise may impair hardly the fractal estimation, either by log-log regression or by power-regression. We propose a systematic approach to analyse the error term in these estimations. The second one is the necessity to make a distinction between a true void of the urban form, for instance an urban block with no building in it, and voids that are actually occupied by public spaces such as streets squares, which is peculiarly true for multifractal analyses.

We present our findings and analysis on an array of fractals constructed to have either very different dimensions or similar dimension different shapes, on which we apply noise either in multiplicative way (by perturbing the generator) or additive (at some steps in the iteration). These results emphases the necessity to characterise further the fractal pattern beyond their fractals dimensions, and to go towards an adjustment of fractal archetypal patterns, based on other spatial characteristics such as connectivity and neighbourhood analysis.

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KEYWORDS

fractal / multifractal / estimation / error term

Multifractal models and their formal properties in urban geography

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Fractal analysis for exploring the spatial organization of settlement patterns is used since a couple of years. On the one hand, scaling behavior turned out to be a suitable approach for characterizing such patterns, but town sections, issued from different periods of urban history or corresponding to particular planning concepts show different types of scaling behavior what aided classifying urban patterns. However, on the scale of agglomerations these different scaling behaviors are mixed. That incites asking whether multifractal approaches could be of interest when considering urban patterns or settlement systems, as local properties like different degrees of concentration of build-up sites could be better taken into account and several researches focused on using multifractal analysis in these contexts.

However, the use of fractal geometry is not restricted to measuring scaling behavior. Their intrinsic geometric properties are of interest, too, when considering urbanization. Indeed, the particular multiscale feature of fractals brings another perspective on spatial organization. Hence, fractal urban models have been explored in the context of urban economics, and, more recently, proposed for planning purposes.

However, we must be aware, that multifractality is a rather polysemic notion. We can use it while considering the two-dimensional distribution of build-up space or network branches, but also when looking at the weights, like the heights of buildings or traffic loads, on a two-dimensional fractal or uniform support, which is soil occupation. In the first case we can still refer to self-similarity, what is no longer true in the second case where self-affinity comes into play. We distinguish these different topics and focus on their formal properties, which are nevertheless linked to the common background of multifractal theory. More explicitly, we consider the properties of Sierpinski carpets combining different scaling factors, a model which is of interest for describing central place hierarchy as well as for planning concepts. We show, too, that there exist analytically ambiguities while using the Minkowski and the Hausdorff approach for measuring fractality for those objects. We consider, too, by referring the so-called Poincarré-maps, how different degrees of concentration of build-up space across scales can be treated formally in a coherent way.

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KEYWORDS

Fractal geometry / urban modelling / urban pattern analysis

Swiss Population Distribution: Analysis of Spatial Patterns Using the Multipoint Morisita Index

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The research deals with an analysis of the spatial distribution of the Swiss population. The problem is considered within the statistical framework of marked point processes. Due to the very complex geomorphology and orography of the country, the distribution of the population demonstrates high variability at different scales with the intermittency of urban clusters and rural populated zones. Previous study [1], using fractal concepts, showed that the distribution follows a multifractal behavior. In the present study the population data are analyzed using a recently-introduced spatial clustering measure called the multipoint Morisita index (MMI) [2]. MMI is a generalization of the classical two-point Morisita index widely used in many studies – from biodiversity to earthquakes. It was shown that MMI has the power to discriminate between regular, random and clustered patterns. Moreover, it can also be used to estimate the intrinsic dimension (possibly fractal) of data. In the present research, the raw data of the population distribution are compared with random patterns generated within the validity domains delineated, in this case, by the boundaries of the country. The clustering properties of the distribution are studied in detail both globally and regionally. Finally, a functional MMI that computes the intrinsic dimension of data at different levels of the population density, highlighted the existence of hotspots of high-values, i.e., the agglomerations.

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KEYWORDS

geodemography / spatial point processes / multipoint Morisita index

Using fractal objects as primitives for spatial modelling

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Fractal geometry (objects whose fractal dimension is larger than their topological one) turned out to be a powerful approach for describing the spatial organization of urban patterns and infrastructure networks. Two synthetic books summarize the results of the early investigations (Batty and Longley 1994; Frankhauser 1994). These seminal works focused mainly on the estimation of fractal dimensions, in order to characterize the spatial organisation of objects, mainly buildings. However, the interest of fractal geometry in the context of studying urban areas and networks goes beyond dimension computation. Different morphological aspects of urban patterns have been illustrated by means of fractal models (Thomas et al. 2008, Frankhauser 2008, Chen and Wang 2013).

A first attempt has been made in Frankhauser (2008) and implemented within the MupCity model (Frankhauser et al 2011) to turn the fractal approach to cities into a tool for land planners via a cellular automaton generating fractal patterns. While useful, the results are sometimes too uniform (i.e. not so fractal anymore) and highly constrained by areas unsuitable for urban development, leading to over-determined results.

Part of the problem lies in the way spatial data is represented, either by gridded data or by vector data. By construction, a fractal cellular automaton (gridded data) produces patterns similar to Sierpinski carpets. A vector GIS uses simple primitives like points, polylines and polygons for vector data that hardly capture the shape of complex objects and are unsuitable to represent fractal objects.

The Fractalopolis approach (Frankhauser et al., 2018) is the first attempt to model spatial information with the help of true multiscale primitives: an Iterative Function System (IFS) is defined and then fitted to the actual urban data for each iteration (i.e. at each scale). The resulting irregular fractal object can be analysed and several indicators can be computed at different scales, within the framework of multiplication laws.

This paper presents an on-going work on Fractalopolis to help constructing and generalising the IFS. Since we deal with a new geometric concept, we aim at defining new types of spatial reference models based on fractal archetypes like different types of Sierpinski carpets, Fournier dusts, teragons, each of which has its particular logic. These models are in some sense the equivalent of Euclidean objects like circles, squares etc. and can, e.g. in the case of supply networks, serve for testing and better understanding properties of scale-free networks and their potential advantages or disadvantages.

The rationale for developing these trans-scale models is two-fold. On the one hand, the fractal dimension, used for quantifying these structures, turns out to be too limited to provide information about these objects since important characteristics like connectivity between elements are not explicitly considered. Additional multiscale indicators inspired by graph theory could be helpful for developing a new type of morphological classes.

On the other hand we consider how the underlying concept of iterative function systems can be enlarged in order to model changes in scaling behaviour across scales in a coherent way by means of a "generalised, transfer function". Indeed investigations have shown that some spatial systems follow rather a lognormal distribution than a hyperbolic (fractal) law, which is an example of such a more complex "transfer function", questionning the underlying geometry.

The topology and mereotopology of a fractal pattern can be analysed with the help of adjacency and neighbourhood networks that are not affected by the spatial transforms used to make the object close to the actual urban data. Graph simplification methods enable to determine the main structure of the urban pattern. Similarly, the analysis of the road and street networks reveals some important information on the archetypal fractal structure suitable to model an urban area.

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KEYWORDS

fractal modeling / topology / graph analysis

Navigating the fractal city

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Our work examines the influence of different morphological attributes of the built urban environment, on human orientation and their spatial-cognitive perception. It is based on the assumption that the physical characteristics of the built environment and their size distributions have a significant effect on the way we perceive and move within it.

To do so, we developed an algorithm that yields artificial environments with different morphological characteristics. It allowed us to control the formation and distribution of streets and buildings, on a plateau that represents an urban environment. Using this algorithm, we controlled the number of elements (i.e. streets/built volumes), their orientation, their spatial distribution, and the size distributions of their examined features (width and length of streets, and height of built volumes). We based our work on two different environments where we used two fundamentally different distributions (power law distribution and a Poisson one) to control the lengths, and widths of the open space (streets/squares) and the heights of the built volumes. The power-law distribution leads to a heterogeneous environment, where there are few very large sizes (that can be regarded as landmarks) and many very small one, and the size distribution of the entities is fractal. On the other hand, the Poisson distribution yields a rather homogenous set of sizes where most of the entities have a size equal to the average (with a narrow range of values).

We conducted a survey to determine which parameters of these distributions form environments that best resemble urban ones, and used them to create the environments that were used in our experiments. These were conducted in a VR environment, where 40 subjects were required to perform real-time navigation and orientation tasks while wearing HTC VIVE headset.

The experiments included two runs in each environment. In the first run, the subjects were asked to explore the environment and identify five buildings that were colored in different colors. After 5 minutes into the experiments, the subjects witnessed a car explosion (the explosion was set to occur in the location of the subject at that time). After the car explosion, the subjects continued to perform their task. When the first experiment ended, the subjects were asked to draw the location of the colored building on a map they were given and then, to draw the route they believed they moved in.

In the next stage, the subjects returned to the same environment, but now, they were asked to identify the colored buildings in a specific order as well as to identify the location of the car explosion. We developed a tracker that used data recording, which included the Cartesian location of the subjects at each millisecond, walking speed, angle of view, and analysis of the subject's field of view. These were output into a visual graph, which allowed a thorough analysis of these layers of information, as well as a comparison of the actual movement of the subjects to their sketch maps (that represent their assumes routes).

Our preliminary analysis suggests that there is indeed a difference between the navigation in the two environments and that the orientation in the fractal environment is greatly improved in comparison to the Poisson one.

KEYWORDS

Spatial Cognition / VR / Urban Fractal

Special Session: City size effects and Urban Systems (3/3)

MONDAY | 11:00 | Salle des Fêtes

Profile and scaling of urban volumes in Europe

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Urban areas are crucial for ensuring the sustainability of worldwide human settlements. The social, economic and environmental attributes of cities are known to be strongly related to their internal structure, including the spatial organization of their land uses and populations (Frey 1999). Thus, how this internal structure may change with total population, or urban size, has become a crucial knowledge for the design of sustainable urban policies. A simple description of this internal structure can be made in radial terms, that is, how certain attributes of cities change with the distance to their centre. Such a radial description has proven to be a useful concept cross disciplines, linking together the monocentric model of urban economics (Fujita and Thisse 2013), the urban sprawl analysis of urban geographers (Dieleman and Wegener 2004) and the compactness debate of urban planners (Ewing et al. 2014). More recently, the radial description of urban attributes has been brought into the urban allometry research strand by Lemoy and Caruso (2018). They showed that land use and population density profiles turn out to scale with city size, respectively in proportion to the square root and to the cubic root of total urban population. Hence each city is an image of each other through simple dilation.

It is clear that these scaling properties of housing land and population density profiles are intricately linked and must be related to housing development intensity and its variation across cities. Buildings height is a common morphological proxy of land development intensity. This is why the availability of new data on urban verticality almost two decades ago has generated a call for an "urban geography of the third dimension" (Michael Batty 2000). Since then, the explicit study of buildings height has already shed new lights on the dynamics of urban sprawl (Czamanski and Roth 2011) and on the ecological performance of cities (Borck 2016). In the literature on urban allometry, studies have shown that the distribution of the average height of buildings follow a scaling law (M. Batty et al. 2008; Schläpfer, Lee, and Bettencourt 2015). Yet buildings' heights do not only depict sharp variations between cities of different sizes, but also within cities, obviously with a radial component, i.e. large difference between urban cores and their peripheries. How this intra-urban structure itself changes with urban size remains a complete knowledge gap to be filled in within urban allometry research.

This paper aims at bringing a disaggregated approach of buildings' height into urban allometry through the study of the monocentric profiles of the height of buildings and of the resulting urban volume, which is obtained by multiplying the height of each building by its area on the ground (see Koomen, Rietveld, and Bacao 2009) and summing over all buildings within a certain distance of the CBD. In particular, the recent Urban Atlas data on building's heights, available for 31 European cities, is used to compute the profile of heights and the urban volume profile. The scaling behaviour of these profiles is then evaluated by minimizing a signal-over-noise ratio. The resulting scaling powers will refine previous insights on the scaling of population density profiles by confronting housing development intensity to the housing land profiles studied in Lemoy and Caruso (2018).

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KEYWORDS

buildings' height /   radial analysis / urban scaling laws

Building height distribution under zoning regulation: theoretical derivation based on Gibrat's Law and allometric scaling analysis

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Building height is one of the most important determinant factors of streetscapes along with building setbacks. In the Western countries, each building height is directly regulated by form-based codes in order to create well-arranged and harmonious streetscapes. On the other hand, in Japan, building heights are indirectly controlled by floor-area-ratio (FAR), defined as the ratio of the total floor area of a building to its lot size. The maximum FAR and building coverage ratio (BCR) are the main tools of the zoning regulations which legally regulate building shapes and volumes at a district scale. Originally, zoning regulations were developed in the United States of America where road networks are gird patterns and building lot sizes and shapes are uniform. If building lot sizes and shapes are uniform, uniform building shapes (both their plane shapes and heights) emerge under the zoning regulation. However, in Japan, building lot sizes and shapes are not uniform and irregular. Hence, it is difficult to understand the relationship between building heights and zoning regulations.

A building height under the zoning regulations can be computed by the product of the average floor height and the ratio of FAR to BCR in a building lot. In theory, if building owners choose the maximum FAR and BCR which are given as zoning regulations, building heights are almost the same since the average floor height tends to be constant (three metres). In practice, building owners tend to choose the maximum FAR in order to make the floor area of their buildings as large as possible. However, they do not always choose the maximum BCR. This is because building owners want not only building coverage area but also open space used for back or front yard in their building lots. Generally, the larger a building lot size, the more the area of open space in a building lot tends to increase. Therefore, the height of a building can be regarded as the result of the building owner's choice of BCR by considering their building lot size and their preference for the area of open space. This means that building heights at a district scale exhibit a statistical distribution.

The above observations give us the following research question: how can we estimate the statistical distribution of building heights under the zoning regulations at a district scale? To answer the question, the following two analyses were carried out in the downtown districts of the Tokyo metropolitan region. First, the relationship between BCR and building lot sizes was analysed. It was found that (1) building lot sizes and building coverage areas show a sublinear scaling relationship; (2) actual BCR can be estimated from a building lot size to the power of -0.13; and (3) building heights can be estimated from a building lot size to the power of 0.13. According to the literature, building lot sizes approximately follow the lognormal distribution which are theoretically derived based on Gibrat's law. Its parameters, mean, and variance are formulated mainly by gross building density (the number of buildings per unit area), the coefficient of variation of building lots, road network density (total length of road network density per unit area), and average road width. Second, based on these findings, the probability density function of building heights under the zoning regulations was theoretically derived. It was found that this function can be derived as a unimodal function of building height. For example, a district of building density = 40 buildings/ha, road network density = 400 m/ha, average road width = 6 metres, and the maximum FAR = 200%, respectively (these values are typical in the downtown districts in Tokyo), building heights range from 9 to 15 metres and the mode is 11 metres.

These findings are expected to provide urban planners with a theoretical basis for discussing the relationship between the variations in building heights and zoning regulations (BCR and FAR), building density, road network density, and average road width. Furthermore, form-based codes considering these variations can be reconsidered to create well-arranged and harmonious streetscapes.

KEYWORDS

building height / building lot / size / Gibrat's law / scaling laws

Scaling in urban patterns of enthnoracial segregation

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Introduction
Scaling relationships and power-law distributions have been widely studied in urban systems in the context of the city size distribution and urban population. Scaling is also observed within individual urban areas (for example division of the cities into uninhabited/inhabited areas). Here we report on the scaling in patterns of ethnoracial segregation in 41 large U.S. cities using data from 1990 and 2010. We propose that scaling in segregation patterns stems from formation on racial enclaves by the mechanism of preferential attachment.

Data and Methods
We start by segmenting an urban area into homogeneous ethnoracial enclaves using the SocScape (http://sil.uc.edu/webapps/socscape_usa/) racial diversity grids. These grids are categorical raster maps with 13 categories based on racial diversity and dominant race (Dmowska et al., 2017). We segment diversity maps into spatially contiguous patches of same-class cells using connected components algorithm (Netzel and Stepinski 2013). Each patch corresponds to an ethnoracial enclave and is described by three attributes: its class (one of the 13 categories from racial diversity grids), its area, and its population count. We test the hypothesis of power law distribution for the size of the patches measured in the area (number of cells) and population count by fitting data from 41 U.S cities in 1990 and 2010 to a power law.

Results
Altogether, in these cities, there were 91,768 ethnoracial enclaves in 1990 and 183,229 enclaves in 2010. The results show that the size of enthnoracial enclaves indeed obeys the power law, regardless whether it is measured in terms of area or a population count. In 1990 data, the value of the power law exponent α for the pool of enclaves from all cities is 1.66/1.67 for area/population count, in 2010 data the value of an exponent is 1.71/1.73. Enclaves collected only from individual cities also obey the power law; the values of exponents vary by ±5% from an average of 1.64/1.68 for 1990 data and 1.70/1.74 for 2010 data. Finally, sizes of enclaves collected only for individual ethnoracial groups also have distributions which closely resemble power laws. Departures of these distributions from the distribution of all enclaves are larger and 1990 than in 2010 indicating a process of converging.

The magnitude of the power law exponent α corresponds to a texture of urban racial mosaic. A distribution characterized by a larger value of α describes a city with more small enclaves and less large enclaves. During the 20 years period (1990-2010) area distributions of 38 out of 41 cities in our dataset increased their value of α; 35 out of 41 distributions of population count increased their values of α. This means that during this period the texture of urban racial mosaic became finer. This trend can be interpreted as a decrease in racial segregation.

Discussion and Conclusion
The universal scaling of segregation patterns suggests that an underlying dynamics of racial segregation is the same across all U.S. cities. We postulate that this is a result of social processes that express themselves in terms of the preferential attachment dynamics of enclaves' formation. This postulate follows from the fact that preferential attachment successfully explained scaling in land cover patterns (Small and Sousa (2015); Sousa and Small (2016)) – a dataset of high formal

similarity to ethnoracial patterns. It also follows from examining the near century (1910 to 2000) of maps showing the evolution of racial pattern in Chicago, IL. This sequence of maps has too coarse resolution to allow for power-law fitting, but we can visually observe the three fundamental processes identified by Sousa and Small (2016) as telltales of preferential attachment dynamics: nucleation, when new enclaves are formed; growth, when existing enclaves expand; linking, when two existing enclaves combine into a single enclave. The preferential attachment means that the growth process is most important; the growth rate of enclaves is linearly proportional to their already accumulated sizes.

The main contribution of this work is an identification of an additional urban system – the division of urban space into ethnoracial enclaves – which display scaling behavior. In addition, our findings have the following implications for the field of urban ethnoracial segregation: (1) ethnoracial enclaves have no characteristic spatial scales, (2) temporal increase in the value of exponent indicates U.S. cities evolve toward finer structure of segregation pattern - enclaves become smaller but more numerous, (3) because all feasible social theories of segregation lead to preferential attachment dynamics, and thus to the power law distribution of patches, validating such theories using actual patterns is difficult.

KEYWORDS

Power law scaling / racial segregation / preferential attachment / population grids

Internal radial profiles of road transport times in European cities

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The present study is part of a larger endeavour to formally and empirically establish the relationship between urban form and road network characteristics, and more specifically aimed at understanding how Euclidean distances, network distances, and travel times change with population size and vary across space. While there is a growing body of literature about the multiple cumulative circular causalities between population growth, urban sprawl and the expansion of road networks, and thus the increase of motorised trip, a systematic quantification of travel times across the European continent is still missing. Such quantifications can eventually highlight the relative effectiveness of the internal morphology of cities in economic or environmental terms.

The particular objectives of this study are first to discover how travel times to the main centre of an urban region evolve inside cities in a cross-sectional perspective and second, to find out whether cities have comparable levels of complexity across Europe. We aim for important empirical insights about the spatial and temporal distribution of congestion on road networks.

In this study, urban form is described in accordance with the Alonso-Muth-Mills mono-centric city model. The radial profile of 303 European cities, in terms of the Euclidean distance from all populated residential areas to the centre of the city, is examined and related to time distances after applying a shortest path algorithm. The automobile trips were first computed using the minimum average travel time at optimum traffic conditions. In a second stage, the same origin-destination trips were computed in best guess traffic conditions, and around-the-clock, resulting in one travel time per hour of the day, and giving a measure of congestion throughout a typical weekday. The massive routing calculations resulted in more than 7.5 million of simulated trips in total.

In addition to these general relations between Euclidean distances and travel times on the real-world road network, our radial profiles are compared among cities of different population size, as described by their total population. The aim of this process is to find out whether the global properties of cities (here, the road transport properties) can apply to all urban systems, as a general scaling relation with size. Scaling laws have already been established between average transport properties and city size (for example, the length of the road network, total traveled distance, or congestion), but not yet on intra-urban radial profiles. We follow here a radial-scaling perspective which has the strong advantage of not summing up a spatial pattern into a single aggregate value but use a profile more directly related to the behaviour of people within cities (as of the urban economic tradition). This empirical investigation of road travel times thus combines the study of the internal structure of cities and the study of systems of cities (intra and inter-urban scales).

Our preliminary analyses show two main results. First, travel time costs do not increase linearly with the Euclidean distance to the centre. Road transport time is concave with Euclidean distance and follows a power-law. Indeed, travel times per constant Euclidean distance unit are bigger in the centre of cities than in the periphery. In other words, the travel speed increases with the distance to the city centre, people travel faster at larger scales. The reasons for this observation are the road network shape, constrained movements on the road network like one-way streets, impasses that can lengthen the trips, and speed. For example, newly built roads in the periphery are expected to be faster and more direct, while oldest roads in the historical city centres might have been better adapted to pedestrians.

Second, the road transport times in traffic conditions allow us to identify the congestion peaks for each city, to observe the magnitude of congestion throughout the day, and to compare congestion between cities. The visual analysis already unveils that the travel time profiles have a similar concave shape to the ones without congestion, and that city size is very likely linked to the congestion effect at the peak traffic time, while the effect of city size in non-congested traffic conditions is less obvious. Travel times are not directly comparable among cities of various sizes. Indeed, the population increases the unit transport time, inhabitants spend more time to travel a fixed distance in big cities than in small cities, travel time scales with cities' size and is a major dis-economy associated with the high concentration of people.

In conclusion, our very information-rich congestion database allows us a deeper understanding of travel times inside European cities. The study needs further analyses but already calls the persistent hypothesis of many urban economic models assuming linear transport costs into question.

KEYWORDS

Urban morphology / Transport geography / Scaling laws / Travel time

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5 Thursday · 5th September 2019

09:00-16:30	R & PY - Spatial Analysis workshop
17:00-19:00	Registration
19:00-21:00	Dinner/Buffet

6 Friday · 6th September 2019

08:30-09:00	Registration
09:00-10:00	Introduction
10:00-11:30	Keynote: Prof. Luc Anselin
11:30-12:00	Coffee break
12:00-13:30	**Parallel Sessions I**
	· Housing Price
	· Big data for Geocomputation (1/2)
	· Mobilities and Health (1/2)
13:30-14:30	Lunch
14:30-16:00	**Parallel Sessions II**
	· Spatial Analysis (1/3)
	· Big data for Geocomputation (2/2)
	· Mobilities and Health (2/2)
16:00-16:30	Coffee break
16:30-18:00	**Parallel Sessions III**
	· Spatial Analysis (2/3)
	· Geo-data science and Urban Sustainability (1/2)
	· Geosimulation models Exploration Methods
20:00-22:00	Dinner/Barbecue

7 Saturday · 7th September 2019

09:00-10:30	Keynote: Dr. Elsa Arcaute
10:30-11:00	Coffee break
11:00-12:30	**Parallel Sessions IV**
	· Segregation
	· Geo-data science and Urban Sustainability (2/2)
	· Co-evolution of Networks and Cities
12:30-13:30	Lunch
13:30-15:00	**Parallel Sessions V**
	· Networks
	· Land-use modelling for Policy Support (1/2)
	· City size effects and Urban Systems (1/3)
15:00-15:30	Coffee break
15:30-17:00	**Parallel Sessions VI**
	· Spatial Interactions
	· Urban patterns
	· Land-use modelling for Policy Support (2/2)
17:00-18:30	Keynote: Dr. Sara Fabrikant

8 Sunday · 8th September 2019

10:00-11:30	Keynote: Prof. Isabelle Thomas
11:30-13:00	**Parallel Sessions VII**
	· Geovisualisation
	· Spatial computation in Archeology and History (1/2)
	· City size effects and Urban Systems (2/3)
13:00-14:00	Lunch
14:00-19:00	Excursion
19:00-21:00	Dinner

9 Monday · 9th September 2019

09:00-10:30	**Parallel Sessions VIII**
	· Transport (1/2)
	· Spatial Analysis (3/3)
	· Spatial computation in Archeology and History (2/2)
10:30-11:00	Coffee break
11:00-12:30	**Parallel Sessions IX**
	· Transport (2/2)
	· Fractals
	· City size effects and Urban Systems (3/3)
12:30-13:30	Lunch
13:30-15:00	Round Table
15:00	Departures