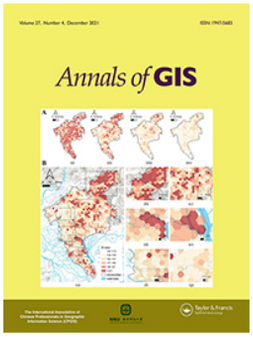

Annals of GIS

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tagi20

GIS and urban data science

Yijing Li, Qunshan Zhao & Chen Zhong

To cite this article: Yijing Li, Qunshan Zhao & Chen Zhong (2022): GIS and urban data science, Annals of GIS, DOI: 10.1080/19475683.2022.2070969

To link to this article: https://doi.org/10.1080/19475683.2022.2070969

Published online: 07 May 2022.

ANNALS OF GIS
https://doi.org/10.1080/19475683.2022.2070969

Taylor & Francis
Taylor & Francis Group

INTRODUCTION

GIS and urban data science

Yijing Li [a], Qunshan Zhao [b] and Chen Zhong [c]

[a]CUSP London, Department of Informatics, King's College London, London, UK; [b]Urban Big Data Centre, School of Social and Political Sciences, University of Glasgow, Glasgow, UK; [c]Centre for Advanced Spatial Analysis, University College London, London, UK

ABSTRACT

With the emergence of new forms of geospatial/urban big data and advanced spatial analytics and machine learning methods, new patterns and phenomena can be explored and discovered in our cities and societies. In this special issue, we presented an overview of nine studies to understand how to use urban data science and GIS in healthcare services, hospitality and safety, transportation and mobility, economy, urban planning, higher education, and natural disasters, spreading across developed countries in North America and Europe, as well as Global South areas in Asia and the Middle East. The embrace of diverse geo-computational methods in this special issue brings forward an outlook to future GIS and Urban Data Science towards more advanced computational capability, global vision and urban-focused research.

KEYWORDS

GIS; urban data science; urban analytics; informatics

Background

In the information age (Castells 1998), new forms of urban big data demand an in-depth understanding and diversified interpretation of human interactions with contemporary society. Urban Informatics (Shi et al. 2021) has surged as an interdisciplinary subject encompassing urban data science, informatics, GIS, various information and communication technology, big data analytics, smart cities, etc., and encourage people from academics, industry and public sectors to jointly explore the open data emerging in the context of urban environments (Foth, Choi, and Satchell 2011), such as social media data (Wang and Li 2021; Wang, Gerber, and Brown 2012; Chen, Cho, and Jang 2015), mobile data (Bogomolov et al. 2014; Ros'es, Kadar, and Malleson 2021), Geolocational data (Kikuchi, Amemiya, and Shimada 2012; Hutt, Bowers, and Johnson 2021; Song et al. 2019; Tu et al. 2021), image data (Law et al., 2020; Woodworth et al. 2014; Liu et al. 2020) and video data (Ashby 2019; Lindegaard and Bernasco 2018). It has often been applied to visualize the digital information from the society we reside in, to interpret the human interactions with surrounding urban socio-economic environments, and to provide data-driven evidence for decision-making and industrial innovation.

In parallel boom of 21st century's development of computer science and data visualization, GIS, geocomputation and urban analytics research methods, such as Kernel Density Estimation (KDE) (Bailey and Gatrell, 1995), geographically weighted regression (Cahill and Mulligan, 2007; Fotheringham, Brunsdon, and Charlton 2002), spatial autocorrelation and regression models (Anselin, 2009), spatio-temporal Bayesian modelling (Hu et al. 2018; Haining and Li 2020; Law, Quick, and Jadavji 2020), Risk Terrain Modelling (RTM) (Caplan, Kennedy and Mille 2011), etc., had been utilized widely in urban fields, such as healthcare accessibility (Kim, Byon, and Yeo 2018), services resilience especially against the pandemic (Li, 2021); urban safety and crime mapping (Hart, Lersch, and Chataway 2020), crime pattern detection (Chainey, 2020) aggregated at street segments (Tom-Jack, Bernstein, and Loyola 2019) and urban mobility (Sinclair et al. 2021: Sarim et al., 2021), hence brings forward the essentiality to apply such computational techniques in a geographically holistic sense. The special issue of *Annals of GIS* on GIS and Urban Data Science had compiled nine novel and original manuscripts demonstrating research on the main aspects of geo-informatics applications in urban contexts, in the hope of drawing follow-up inspirations towards further contributions to the literature.

Overview of this special issue

The articles included in this issue make significant contributions to the research in GIS and urban data science. These nine papers represent the diversity of urban data applications in different sectors, healthcare services (e.g. hospital services), hospitality and safety (e.g. Airbnb and crime), transportation and mobility (e.g. bike sharing),

CONTACT Yijing Li yijing.li@kcl.ac.uk CUSP London, Department of Informatics, King's College London, London WC2B 4BG, UK

economy (e.g. retail business and labour force), urban planning (e.g. nightlight data), higher education (e.g. big scholarly data) and natural disasters (e.g. winter storm) across broad regions in North America, Europe and Asia, as depicted in Table 1. In combination of administrative data (e.g. Census) with the emerging forms of data such as bike sharing, airbnb, tweets, or night time light images, rich methods had been deployed including traditional (spatial) statistical or optimization methods such as OLS regression, GWR, and MCLP, as well as some advanced methods from GeoAI such as spatial clustering, travel pattern recognition, and text mining.

Outlook to the future

Computational methods and data sciences are transforming the conventional GIS into a new comprehensive discipline, with the notation of urban analytics, location intelligence, and more recently GeoAI (Janowicz et al. 2020; Kandt and Batty 2021). As showcased in the paper on this special issue, geospatial research has been applied in various applications, e.g. transport, retail, social interactions, using conventional methods, e.g. OLS regression; kernel density estimation and comparatively more recent computation methods, e.g. spatial network analysis and density-based spatial clustering methods. In pursuing further advancements in GIS and data, the next three sub-outlooks present a research agenda for achieving such objectives.

Advanced computational methods

A clearly pointed research direction is to build on the knowledge and skill around the different domains. We see how much GIS has been advanced by new computational methods and the 'invasion' of data science. This trend will continue, as the 5Vs of big data challenge the conventional GIS way of handling and analysing data. Moreover, domain knowledge becomes even more important to assist and solve real-world problems with the support of AI.

Table 1. Publication summary of the special issue.

Publication	Topic	Data	Spatial scale	Methods
Wang & Wang (2022)	Hospital services	• 2011 State Inpatient Databases (SID) of Florida (2,392,066 records); • ZIP Code Tabulation Areas (ZCTAs)	County/State (Florida, US)	• Refined Dartmouth method for defining HSAs; • Spatialized network community detection methods for defining HSAs (constrained Louvain method-ScLouvain, and spatially constrained Leiden method- ScLeiden); • 3 quality measures for HSAs: localization index (LI), geographic compactness, and balanced region size.
Beairsto et al. (2021)	Sharing economy	• Bike sharing data from Nextbike Glasgow (2018–2019) • Scottish Index of Multiple Deprivation 2020 • Scotland 2011 Census • OpenStreetMap	City (Glasgow, UK)	• OLS regression • Two-step floating catchment area (2SFCA) methodology • Maximum covering location problem (MCLP)
Hladík et al. (2021)	Retail services	• Places data from Facebook Graph API (6,800)	City (Brno, Czech Republic)	• Choropleth map • Nearest Neighbour Index • Kernel density analysis • Normalized Difference Index
Maldonado-Guzmán (2020)	Crime and sharing economy	• Number of crimes against property and people in 2017 (55,911) • Airbnb lodging (InsideAirbnb) • Census data	City (Barcelona, Spain)	• OLS regression • GWR model with Monte Carlo non-stationarity test
Wu & Huang (2022)	Human mobility patterns and social segregation	• Geotagged tweets December 2013 to May 2015 • ACS data from US Census	Cities (50 in US)	• DBSCAN for spatial clustering • Race-ethnicity-economic mosaic • Movement pattern analysis (home-activity)
Yang et al. (2022)	Urban morphology and urban planning	Luojia-1A night-time light data	Cities (331 in China)	• urban centre development index (UCDI)
Zuo et al. (2022)	Spatial/Social network in higher education	Scholarly data crawled from the ACM Digital Library	Yangtze River Delta (China)	• Social Network analysis (gravity centre) • Domain analysis • Geovisualisation (3D symbol map, flow map, treemap, chart map, interactive interface)
Xu & Qiang (2021)	Natural disaster	Tweets during Winter Storm Diego in December 2018 (47,604)	City (Diego, US)	• Text mining (spaCy, NLTK, Gensim and VADER) • Geocoding (Google API) • Spatial pattern of retweets: SDE, average diffusion distances, choropleth map and kernel density map.
Mansour et al. (2020)	Labour market	Omani Census Data in 2010	County/ Governorate (North Oman)	• OLS regression • GWR models

Global vision

The vast amount of data being generated around the world provides a unique opportunity for globally collaborative research and comparative studies of regions. Unlike in the old days, most research is based on locally generated data. Nowadays many data sets are available globally in a uniform format, for instance, Airbnb, Twitter, and Google mobility. It is now promising to promote the global research community and solve problems collectively. In particular, most of the research is in the context of developed countries and more attention needs to be given to the developing countries in the Global South and marginalized groups.

Urban focused research

As most of the world's population is moving to cities (UN report, 2018), they also generate new urban challenges, e.g. social inequality, housing issues, ageing society, and health hazards. Data-driven methods have been proposed and demonstrated in this special issue to further tackle these problems, but more research and exploration need to be investigated to generate practical solutions and policy implementations for different urban issues.

Acknowledgements

We want to thank the authors who contributed to this Special Issue, as well as the reviewers who provided the authors with comments and very constructive feedback. Dr Qunshan Zhao has received UK ESRC's ongoing support for the Urban Big Data Centre (UBDC) (ES/L011921/1 and ES/S007105/1). Dr Chen Zhong has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 949670), and from ESRC under JPI Urban Europe/NSFC (grant No. ES/T000287/1).

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Yijing Li http://orcid.org/0000-0002-9831-0298
Qunshan Zhao http://orcid.org/0000-0002-5549-9457
Chen Zhong http://orcid.org/0000-0003-3582-1266

References

Anselin, L., I. Syabri, and Y. Kho. 2009. "GeoDa: An Introduction to Spatial Data Analysis." In *Handbook of Spatial Data Analysis*, edited by M. Fischer and A. Getis, pp. 73–89. Berlin, Heidelberg and New York: Springer.

Ashby, M. P. J. 2019. "Studying Crime and Place with the Crime Open Database." *Research Data Journal for the Humanities and Social Sciences* 4 (1): 65–80. doi:10.1163/24523666-00401007.

Bailey, T., and A. Gatrell. 1995. *Interactive Spatial Data Analysis*. Essex, England: Longman Scientific and Technical.

Beairsto, J., Y. Tian, L. Zheng, Q. Zhao, and J. Hong. 2021. "Identifying Locations for New Bike-Sharing Stations in Glasgow: An Analysis of Spatial Equity and Demand Factors." *Annals of GIS* 0 (0): 1–16. doi:10.1080/19475683.2021.1936172.

Bogomolov, A., B. Lepri, J. Staiano, N. Oliver, F. Pianesi, and A. Pentland. 2014. "Once upon a Crime: Towards Crime Prediction from Demographics and Mobile Data." *Proceedings of the 16th ACM international conference on multimodal interaction (ICMI)* 12–16 November 2014. Istanbul Turkey: 427–434. doi: 10.1145/2663204.2663254. https://dl.acm.org/doi/proceedings/10.1145/2663204

Cahill, M., and G. Mulligan. 2007. "Using Geographically Weighted Regression to Explore Local Crime Patterns." *Social Science Computer Review* 25 (2): 174–193. doi:10.1177/0894439307298925.

Caplan, J., L. Kennedy, and J. Miller. 2011. "Risk Terrain Modeling: Brokering Criminological Theory and GIS Methods for Crime Forecasting." *Justice Quarterly* 28: 360–381. doi:10.1080/07418825.2010.486037.

Castells, M. 1998. *End of Millennium, the Information Age: Economy, Society and Culture Vol. III*. Cambridge, MA; Oxford, UK: Blackwell.

Chainey, S. 2020. *Understanding Crime: Analyzing the Geography of Crime*. Redlands, California: ESRI Press.

Chen, X., Y. Cho, and S. Y. Jang. 2015. "Crime Prediction Using Twitter Sentiment and Weather." *2015 Systems and Information Engineering Design Symposium* 24 April 2015. Charlottesville, Virginia, USA: 63–68, doi: 10.1109/SIEDS.2015.7117012.

Foth, M., J. H. Choi, and C. Satchell. 2011. *Urban Informatics. Conference on Computer Supported Cooperative Work (CSCW)*. New York, NY, United States: Association for Computing Machinery, 1–8. 10.1145/1958824.1958826.

Fotheringham, A. S., C. Brunsdon, and M. Charlton. 2002. *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships*. Wiley.

Haining, R. P., and G. Li. 2020. *Modelling Spatial and Spatial-temporal Data: A Bayesian Approach*, 608. Boca Raton: CRC Press.

Hart, T. C., K. M. Lersch, and M. Chataway. 2020. *Space, Time, and Crime*. Durham, North Carolina: Carolina Academic Press.

Hladík, J., D. Snopková, M. Lichter, L. Herman, and M. Konečný. 2021. "Spatial-Temporal Analysis of Retail and Services Using Facebook Places Data: A Case Study in Brno, Czech Republic." *Annals of GIS* 0 (0): 1–19. doi:10.1080/19475683.2021.1921846.

Hu, T., X. Zhu, L. Duan, W. Guo, and E. Arcaute. 2018. "Urban Crime Prediction Based on Spatio-temporal Bayesian Model." *PLoS ONE* 13 (10): e0206215. doi:10.1371/journal.pone.0206215.

Hutt, O. K., K. Bowers, and S. D. Johnson. 2021. "The Effect of GPS Refresh Rate on Measuring Police Patrol in Micro-places." *Crime Science* 10: 3. doi:10.1186/s40163-021-00140-1.

Janowicz, K., S. Gao, G. McKenzie, Y. Hu, and B. Bhaduri. 2020. "GeoAI: Spatially Explicit Artificial Intelligence Techniques for Geographic Knowledge Discovery and

Beyond." *International Journal of Geographical Information Science* 34 (4): 625–636. doi:10.1080/13658816.2019.1684500.

Kandt, J., and M. Batty. 2021. "Smart Cities, Big Data and Urban Policy: Towards Urban Analytics for the Long Run." *Cities* 109: 102992. doi:10.1016/j.cities.2020.102992.

Kikuchi, G., M. Amemiya, and T. Shimada. 2012. "An Analysis of Crime Hot Spots Using GPS Tracking Data of Children and Agent-based Simulation Modeling." *Annals of GIS* 18 (3): 207–223. doi:10.1080/19475683.2012.691902.

Kim, Y., Y.-J. Byon, and H. Yeo. 2018. "Correction: Enhancing Healthcare Accessibility Measurements Using GIS: A Case Study in Seoul, Korea." *PLOS ONE* 13 (3): e0194849. doi:10.1371/journal.pone.0194849.

Law, J., M. Quick, and A. Jadavji. 2020. "A Bayesian Spatial Shared Component Model for Identifying Crime-general and Crime-specific Hotspots." *Annals of GIS* 26 (1): 65–79. doi:10.1080/19475683.2020.1720290.

Law, S., C. I. Seresinhe, Y. Shen, and M. Gutierrez-Roig. 2020. "Street-Frontage-Net: Urban Image Classification Using Deep Convolutional Neural Networks." *International Journal of Geographical Information Science* 34 (4): 681–707. doi:10.1080/13658816.2018.1555832.

Li, Y. 2021. "Health Resilience among European Countries in the Face of Pandemic: Reflections on European Countries' Preparedness for COVID-19. In Mapping COVID-19 in Space and Time: Understanding the Spatial and Temporal Dynamics of a Global Pandemic." In *Human Dynamics in Smart Cities Book Series (HDSC)*, edited by Shaw,Shih-Lung and Sui, Daniel, 309. Switzerland: Springer. doi:10.1007/978-3-030-72808-3_16.

Lindegaard, M. R., and W. Bernasco. 2018. "Lessons Learned from Crime Caught on Camera." *Journal of Research in Crime and Delinquency* 55 (1): 155–186. doi:10.1177/0022427817727830.

Liu, L., H. Zhou, M. Lan, and Z. Wang. 2020. "Linking Luojia 1-01 Nightlight Imagery to Urban Crime." *Applied Geography* 125: 102267. doi:10.1016/j.apgeog.2020.102267.

Maldonado-Guzmán, D. J. 2020. "Airbnb and Crime in Barcelona (Spain): Testing the Relationship Using a Geographically Weighted Regression." *Annals of GIS* 0 (0): 1–14. doi:10.1080/19475683.2020.1831603.

Mansour, S., T. Al-Awadhi, N. Al Nasiri, and A. Al Balushi. 2020. "Modernization and Female Labour Force Participation in Oman: Spatial Modelling of Local Variations." *Annals of GIS* 0 (0): 1–15. doi:10.1080/19475683.2020.1768437.

Ros'es, R., C. Kadar, and N. Malleson. 2021. "A Data-driven Agent-based Simulation to Predict Crime Patterns in an Urban Environment." *Computers, Environment and Urban Systems* 89: 101660. doi:10.1016/j.compenvurbsys.2021.101660.

Sarim, M., Q. Zhao, and N. Bailey. 2021. "Citizen Mobility and the Growth of Infections During the COVID-19 Pandemic with the Effects of Government Restrictions in Western Europe." In *Mapping COVID-19 in Space and Time: Understanding the Spatial and Temporal Dynamics of a Global Pandemic*, edited by S.-L. Shaw and D. Sui, pp. 279–294. Springer International Publishing. doi:10.1007/978-3-030-72808-3_14.

Shi, W., M. Goodchild, M. Batty, M. Kwan, and A. Zhang. 2021. *Urban Informatics*. Singapore: Springer. doi:10.1007/978-981-15-8983-6.

Sinclair, M., Q. Zhao, N. Bailey, S. Maadi, and J. Hong. 2021. "Understanding the Use of Greenspace before and during the COVID-19 Pandemic by Using Mobile Phone App Data." *GIScience 2021*. 10.25436/E2D59P. September 1.

Song, G., W. Bernasco, L. Liu, L. Xiao, S. Zhou, and W. Liao. 2019. "Crime Feeds on Legal Activities: Daily Mobility Flows Help to Explain Thieves' Target Location Choices." *Journal of Quantitative Criminology* 35: 831–854. doi:10.1007/s10940-019-09406-z.

Tom-Jack, Q., J. Bernstein, and L. Loyola. 2019. "The Role of Geoprocessing in Mapping Crime Using Hot Streets." *ISPRS International Journal of Geo-Information* 8: 540. doi:10.3390/ijgi8120540.

Tu, W., T. Zhu, C. Zhong, X. Zhang, Y. Xu, and Q. Li. 2021. "Exploring Metro Vibrancy and Its Relationship with Built Environment: A Cross-city Comparison Using Multi-source Urban Data." *Geo-spatial Information Science* 1–15. doi:10.1080/10095020.2021.1996212.

United Nations Department of Economic and Social Affairs. 2018. "2018 Revision of World Urbanization Prospects."

Wang, X., M. S. Gerber, and D. E. Brown. 2012. "Automatic Crime Prediction Using Events Extracted from Twitter Posts." *Social Computing, Behavioral - Cultural Modeling and Prediction*, edited by S. J. Yang, A. M. Greenberg and M. Endsley. SBP 2012. Lecture Notes in Computer Science, Vol. 7227. 231–238. Berlin, Heidelberg: Springer.doi: 10.1007/978-3-642-29047-3_28.

Wang, Z., and Y. Li. 2021. "Could Social Medias Reflect Acquisitive Crime Patterns in London?" *Journal of Safety Science and Resilience*. doi:10.1016/j.jnlssr.2021.08.007.

Wang, C., and F. Wang. 2022. "GIS-Automated Delineation of Hospital Service Areas in Florida: From Dartmouth Method to Network Community Detection Methods." *Annals of GIS* 0 (0): 1–17. doi:10.1080/19475683.2022.2026470.

Woodworth, J. T., G. O. Mohler, A. L. Bertozzi, and P. J. Brantingham. 2014. "Non-local Crime Density Estimation Incorporating Housing Information." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 372: 2028. doi:10.1098/rsta.2013.0403.

Wu, M., and Q. Huang. 2022. "Human Movement Patterns of Different Racial-Ethnic and Economic Groups in U.S. Top 50 Populated Cities: What Can Social Media Tell Us About Isolation?." *Annals of GIS* 0 (0): 1–23. doi:10.1080/19475683.2022.2026471.

Xu, J., and Y. Qiang. 2021. "Analysing Information Diffusion in Natural Hazards Using Retweets—a Case Study of 2018 Winter Storm Diego." *Annals of GIS* 0 (0): 1–15. doi:10.1080/19475683.2021.1954086.

Yang, Z., Y. Chen, Z. Zheng, and Z. Wu. 2022. "Identifying China's Polycentric Cities and Evaluating the Urban Centre Development Level Using Luojia-1A Night-Time Light Data." *Annals of GIS* 0 (0): 1–11. doi:10.1080/19475683.2022.2026472.

Zuo, C., L. Ding, Z. Yang, and L. Meng. 2022. "Multiscale Geovisual Analysis of Knowledge Innovation Patterns Using Big Scholarly Data." *Annals of GIS* 0 (0): 1–16. doi:10.1080/19475683.2022.2027012.