Global Smart Cities Summit
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The 3rd International Conference on Urban Informatics
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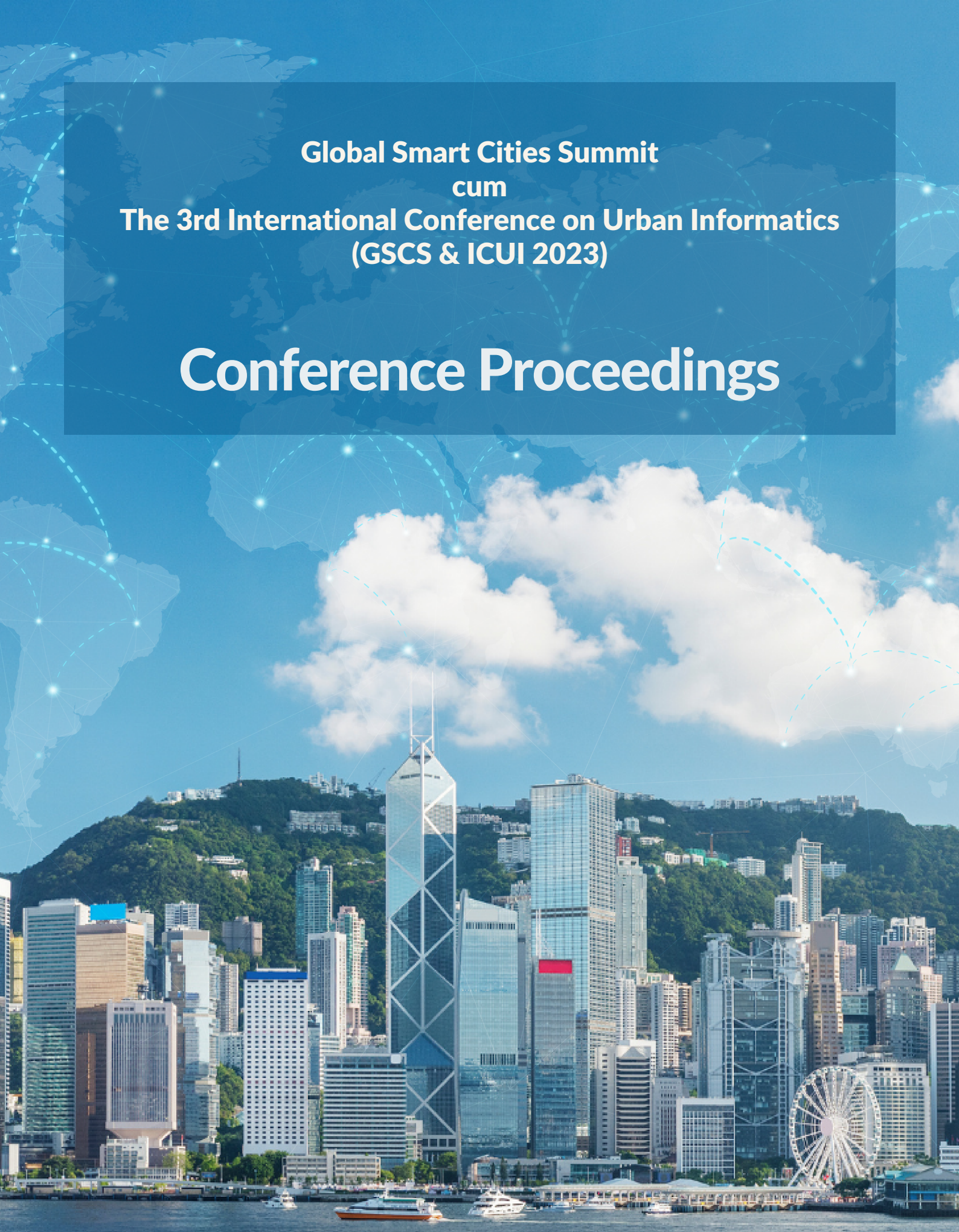
Conference Proceedings



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Theme Topics:

Regular Topics:

Invited Topics:

GeoAI for Human Mobility – 1

Act2Loc: A Trajectory Generation Method by Combining Machine Learning and Mechanistic model

Xin Jin, Kang Liu and Zhongcai Cao.

Abstract. Human mobility data play a crucial role in many fields such as infectious diseases, transportation, and public safety. Although the development of information and communication technologies (ICTs) have made it easy to collect individual-level positioning records, raw trajectory data with privacy issue are still limited in availability and usability in practice. Establishing models to generate synthetic trajectories that is close enough to the real data without recycling real information is a promising solution. This study proposed a novel trajectory generation method called Act2Loc (Activity to Location) that adaptively combined machine learning and mechanistic model to capture the temporal and spatial characteristics of human mobility behavior, respectively. First, we constructed an activity-type-sequence generation model based on machine learning, which can generate activity type sequences of given number of individuals that consist with the temporal patterns of human daily activities. Then, we proposed a spatial-location selection model based on mechanistic model, which can explicitly determine specific locations for the activity types in each generated sequence. Experimental results derived from a case study of Shenzhen City show that compared the state-of-the-art methods, trajectories generated by Act2Loc can better reproduce the spatio-temporal characteristics of the real data, proving it an effective and low-cost way to produce large-scale trajectories without privacy issue.

Analysis of Spatio-temporal Co-occurrence Phenomena and Land Use Function Interaction Based on Frequent Patterns

Jun Yong Ma, Rui Jin and Yi Liang Wan.

Abstract. With the rapid development of information and communication technology, the generation of massive, multi-source, and people-oriented geospatial data provides new possibilities for in-depth understanding of urban form, vitality, and economy. However, the existing research has limited understanding of the spatio-temporal laws of crowd movement patterns, and cannot accurately and fine-grainedly mine the phenomenon of urban spatio-temporal co-occurrence. In view of this, this paper proposes a framework for mining spatio-temporal co-occurrence phenomena in cities based on frequent patterns. First of all, this paper constructs a data set of crowd travel transactions in different periods through the trajectory data of shared bicycles in Shenzhen; secondly, through the PFP-Growth algorithm, a large number of spatio-temporal co-occurrence events in the transaction database are mined in parallel; Spatial-temporal variation characteristics and driving factors behind the co-occurrence phenomenon in different periods in Shenzhen. (1) Based on the spatio-temporal co-occurrence phenomenon of shared bicycle travel, the population of Shenzhen presents a spatial pattern of regional aggregation. (2) Taking Longhua District as an example, the co-occurrence frequency of various land users shows a large difference in

distribution. There are relatively active industrial activities on weekdays, and the proportion of co-occurrence events in industrial land during commuting is the highest. The number of co-occurrence events in industrial land decreased significantly during the period, and the hotspots of co-occurrence phenomenon shifted to commercial service land and residential land. (3) The reason is that Longhua District is designed as an area with dense industrial land in urban planning, and its industrial structure is dominated by manufacturing and high-tech industries. A large number of people enter the industrial land at the same time, forming a co-occurrence peak. People travel during non-commuting hours to meet the needs of daily life, which increases the co-occurrence of commercial service land and residential land.

Comprehensive Evaluation of Job Accessibility Based on Public Transit Using a Graph Convolutional Network Clustering

Meihan Jin, Yongxi Gong and Leiyu Liu.

Abstract. Job opportunities attract a significant population flow to urban areas, resulting in high congestion and pollution in modern metropolises. Encouraging the use of public transit is considered one of the effective solutions to address urban traffic and environmental issues. Public transit serves as a primary mode of transportation for commuting trips in urban areas. However, a substantial number of commuters experience overcrowding and long travel times in public transit systems due to a mismatch between supply and demand. Accessibility plays a vital role in measuring and addressing this mismatch. Previous evaluations of public transit accessibility for commuting primarily focused on either the demand or origin side of travel, often neglecting the accessibility connection between travel origin and destination.

This research aims to comprehensively evaluate job accessibility based on public transit, considering job opportunity distribution, public transit supply, and road network conditions. Leveraging big travel data, we extracted real commuting travel origin-destination (OD) demands along the public transit network. These three metrics, along with the OD demands, were integrated into a job accessibility network that incorporates measurements of accessibility at origins, destinations, and the OD travel connections. We employed graph convolutional network clustering methods to uncover hidden characteristics of the job accessibility network. Through a case study in Shenzhen City, we applied this research framework to reveal complex patterns of job-housing proximity and the distribution of public transit facilities. Additionally, we discussed the correlations between urban land-use and job accessibility. By applying a graph convolutional network model, this research provides novel insights into the job accessibility challenges in the city. The findings of this study can contribute to improving urban functionality and transportation infrastructure.

The effects of rail transit on land use changes considering spatial heterogeneity of rail transit accessibility in a bike-sharing context

Xingang Zhou and Zhouye Zhao.

Abstract. The integration of urban rail transit in guiding land use has been adopted as a crucial approach for fostering compact development. Proximity to rail transit stations can

increase the probability of land use change while existing literature has not analyzed the spatial heterogeneity of the impact of urban rail transit on land uses.

This study proposes a distance decay function of bike-sharing to delimitate the spatial heterogeneity of rail transit accessibility and examines the effects of rail transit on land use changes. The rail transit lines in Jiading New Town, Shanghai are selected as the case study.

Spatiotemporal big data, which provides in-depth data sets based on location services, is used to conduct research on intermodal trips. The public bike-sharing data is utilized to delimitate the spatial heterogeneity of accessibility to rail transit stations. The distance-decay function associated with cycle-metro trips is found to conform to a compound power exponential function, achieving high fitting accuracy (97%).

The parcel-based land use data for the years 2014 and 2019 are utilized to analyze land use changes. The vector-based cellular automata model, which can accurately simulate urban land use at the land parcel level, is applied in the land use simulation. By utilizing rail transit accessibility as a driving factor for training neural networks in vector-based cellular automata model, an improvement in simulation accuracy is achieved compared to the model using a linear distance decay function. Future land use prediction for 2035 under the rail transit planning scenario demonstrates an increasing trend in public service and commercial land use within the station catchment areas.

The significant contribution of this study lies in the generality of the optimized land use vector-based cellular automata model considering the spatial heterogeneity of rail transit accessibility, which could also be applied to bus station and road accessibility.

CityWise: A Novel Approach for Urban Data Analytics and Data Panel using Large Language Models

Xuan Li, Sugie Lee and Steven Jige Quan.

Abstract. In the Fourth Industrial Revolution characterized by digital technologies and big data, Urban Planning, Governance and Development are experiencing substantial shifts. In this context, more data were released to researchers and the public to promote government transparency, accountability and public innovation. However, due to complexity of urban data, this is often a gap between accessibility and understanding. Evolving Large Language Models shows promising potential to build the bridge.

This paper introduces CityWise, a pioneering approach that utilizes LLMs to build quarriable data panels which use natural language as interface to get access to the urban big data and professional visualization and analysis. The proposed framework employs the latest concept of LLMs As Tool Makers, where GPT-4 is used to make reusable tools which are python scripts of generate visualizations or algorithms and GPT-3.5 turbo acts as tool user which process the nature language generated by human users into structural input for tools. Afterwards, LLMs act as interpreters, offering detailed insights into complex urban issues. This LLM interpreter is enhanced by domain knowledge and delicate prompt engineering. CityWise were given more sophisticated capabilities compared with pure LLM, which is examined from three core aspects: reliability, efficiency, and informativeness.

Desensitized human mobility data with rich socio-demographic attributes and meteorology data were used as a sample. CityWise shows the following capabilities: describe human mobility data from the perspective of graph theory, automatically make tools to plot data or to calculate correlation and giving professional description.

This study illustrates the potential of LLM as an Operating System for urban big data analytics, where the natural language acts as interaction tools. In the future, there is a great potential to achieve data fusion, serving not only the public but also researchers in urban planning and other relevant fields.

GeoAI for Human Mobility – 2

Integrating smart card records and dockless bike-sharing data to understand the effect of the built environment on cycling as a feeder mode for metro trips

Yuan Zhang and Yongxi Gong.

Abstract. Recognized for its innovative contribution to augmenting the effectiveness of public transportation, DBS addresses the first and last-mile conundrums. Our research targets cycling trips as a feeder mode to metro stations and introduces a groundbreaking approach of data fusion methodology that merges metro smart card records with DBS data. This method is capable of unveiling the full travel trajectory of the feeder mode, which encompasses both metro and bike trips. Furthering our investigation, we employ a Partial Topological-Adjacency-Based Spatial Durbin model to decipher the complex relationships between the cycling feeder mode and the encompassing built environment within the catchment area of metro stations. Analysis of real travel data from Shenzhen reveals: 1) a pronounced correlation exists between the count of cycling feeder mode trips and the station location within the metro network structure, despite a higher aggregation relative to the ratio. 2) Built environment factors significantly influence the ratio and count of cycling trips as a feeder mode for metro trips, operating at both local and sub-regional scales. 3) Factors such as feeder station location, downtown proximity, bus stop density, and the Street Greenness View Index exert significant influence on the ratio of cycling trips as a feeder mode for metro trips. Additionally, areas characterized by higher Urban communities, Urban villages, Industrial, and Commercial building density contribute to the ratio of cycling trips as a feeder mode for metro trips. In contrast with the ratio, the count is more influenced by various building density categories including Urban community, Urban village, Commercial, and Industrial. This trailblazing study provides a fresh perspective on the vital role of cycling as a feeder mode for metro trips and furnishes invaluable insights for urban planners and policymakers. The findings advocate for the harmonious integration of DBS and metro systems, propelling forward the cause of sustainable urban transportation.

Spatiotemporal patterns of human mobility during the COVID-19 pandemic in China

Jingjing Liu, Lei Xu and Nengcheng Chen.

Abstract. The COVID-19 pandemic has had a significant impact on population mobility. To understand the changes in population mobility patterns during the early stage of the COVID-19 outbreak and regular epidemic prevention and control, we analyzed data from Baidu Huiyan's migration scale index. This data was used to examine the characteristics of population movement in China during the Spring Festival and National Day in 2020-2022. We employed the Louvain algorithm and SVD decomposition to analyze the spatiotemporal patterns of population movement, the Pearson correlation coefficient to calculate the response speed of urban population arrival flow to the epidemic, and the random forest eigenvalues to analyze the factors affecting the correlation and response speed. The results indicate that the pandemic did not significantly alter daily commuting and holiday travel patterns. Over the past three years, population mobility has tended to reflect faster responses to the epidemic, and the primary influencing factor has been economic and medical conditions. The impact of the epidemic on population mobility was lower in regions with more important traffic nodes and longer outbreak times. An analysis of population movement patterns and influencing factors under COVID-19 can aid in the development of more targeted and effective prevention and control measures, ultimately improving health-related urban resilience and sustainability.

ST-LRTC: A Spatio-Temporal analysis empowered Low-Rank Tensor Completion method for missing traffic data imputation

Zilong Zhao, Luliang Tang, Mengyuan Fang, Xue Yang and Qingquan Li.

Abstract. Existing traffic monitoring approaches cannot completely cover all road segments in real-time, leading to massive amounts of missing traffic data, which limits the implementation of intelligent transportation systems. Most existing methods lack deep mining of the unique spatio-temporal characteristics of traffic flows, resulting in difficulty in application to urban traffic with complex topologies and variable states. Theoretically, a high-dimensional tensor is a desirable representation of spatio-temporal field data with multi-dimensionality. Thus, how to combine high-dimensional tensor analysis with geographic knowledge to promote the practical application of GeoAI in traffic data imputation is a current research hotspot.

In this study, we propose a novel Spatio-Temporal constrained Low-Rank Tensor Completion (ST-LRTC) method. The method utilizes a low-rank tensor to extract global features of traffic data, and a manifold embedding approach to depict the local geometric structure of spatiotemporal domains. Specifically, under the low-rank assumption, the method introduces temporal constraints based on the continuity and periodicity of traffic flow and a spatial constraint matrix reflecting the traffic flow transmission mechanism. We embed low-dimensional spatiotemporal constraint matrices into the low-rank tensor completion solving process to fully utilize the global features and local spatiotemporal characteristics of the traffic tensor. Experiments were performed using traffic data from Xi'an, China, and the results indicated that ST-LRTC outperformed state-of-the-art methods

under various missing rates and patterns. Thorough experiments have demonstrated that the incorporation of spatiotemporal analysis can enhance the adaptability of the tensor completion model to complex urban scenarios, thus promoting the application of GeoAI in smart cities.

Sensing Urban Traffics: A Graph-based Human-centric GeoAI approach for Traffic Accidents Prediction using Crowdsourcing Street View Images

Pengyuan Liu, Winston Yap, Yujun Hou and Filip Biljecki.

Abstract. In recent years, the rise of crowdsourcing street view image (SVI) platforms (e.g., Mapillary and KartaView), allowing citizens to freely and voluntarily contribute their in-suit visual experience of the surroundings, have helped assess the urban outdoor environment. This study aims to explore the correlation between drivers' multisensory experiences obtained from Mapillary SVIs and urban traffic accidents by proposing a graph-based framework which consists of a graph-level regression model and an explainable AI method. To comprehensively understand drivers' visual experiences, we calculated the visual complexities of the SVI contributors based on the surrounding urban objects using the image segmentation model DeepLabV3 for the SVIs. Meanwhile, we obtained urban object distances of each location point in sight (e.g., cars, buildings, trees, pedestrians, traffic signs, and their distances to the drivers) using YoLoV5. The object distance obtained is taken as the edge weights of the graphs, and urban objects along the driving paths are considered nodes. Through such a process, at location points where the SVIs were taken, the interactions between each driver and the surrounding built and unbuilt environments can be conceptualised as human-centric graphs. Our graph model captures such interactions among the urban objects and the drivers based on the graphs created, predicting the number of accidents in urban areas. Furthermore, we employed a graph-based explainable model GNNExplainer to explain the model performance and interpret how each urban object in vision contributes to potential car accidents. We demonstrate the use of our framework with a case study in Denver, United States. Our preliminary results reveal patterns of urban streetscapes' heterogeneities and their correlation to traffic accidents. The findings based on the explainable AI show the potential to assist the urban planning process by suggesting countermeasures to enhance urban road safety.

Electrifying on-demand mobility with trajectory analytics and deep reinforcement learning

Xiana Chen, Shengao Yi and Tianhong Zhao.

Abstract. The transportation sector's significant contribution to global energy consumption and carbon dioxide emissions necessitates the adoption of low-carbon solutions, with electrification emerging as a promising approach. Electric vehicles have revolutionized urban mobility, particularly in the form of on-demand services like taxis and ride-hailing. However, existing studies largely overlook the dynamic travel demands and the intricate "driving-waiting-charging-offline" process of electric taxi and ride-hailing vehicles. This

oversight hinders the achievement of high-quality online matching between electric cars and dynamic travel demands. This project aims to address this gap by developing an intelligent operation model that fosters collaboration between travel demands and on-demand electric vehicles. The model combines trajectory analytics and deep reinforcement learning to pave the way for efficient and environmentally-friendly E-on-demand mobility.

The overall objective of this research is to construct an intelligent operation model that facilitates a collaborative service between travel demands and on-demand vehicles. This is achieved by integrating trajectory analytics and Deep Reinforcement Learning (DRL). This comprehensive approach serves to better understand and address the dynamic needs of urban mobility. The specific objectives of the project provide a more detailed roadmap towards the attainment of this overarching goal. Firstly, we aim to extract spatial-temporal knowledge of online ride-hailing and taxi travels, which is crucial for understanding the underlying patterns and trends of urban mobility. Next, we endeavor to develop a DRL-based intelligent operation platform, specifically designed for electric online ride-hailing vehicles and taxis. This platform will optimize the operation of these electric vehicles, thereby improving their efficiency and environmental sustainability. Lastly, we plan to evaluate and simulate the promotion of electric unmanned vehicles. Through this simulation, we will provide a feasible path towards electrification, ultimately contributing to the broader goal of creating greener and more sustainable urban transportation systems.

GeoAI for Human Mobility – 3

A multi-activity view of intra-urban travel networks: a case study of Beijing

Jian Liu, Bin Meng and Xintao Liu.

Abstract. Urban structure is a vital aspect that profoundly influences the livability and sustainability of cities. Although extensive explorations have conducted on urban structure from the perspective of human mobility, there remains a gap in understanding urban travel networks (UTNs) and spatial structures from a multi-activity perspective. In this Beijing-based study, the urban travel structure is comprehensively revealed from a multi-activity view. We first inferred the locations and types of daily activity for over four million urban residents by multi-source data fusion (including mobile phone, POIs, Weibo, and questionnaire datasets). Subsequently, we aggregated eight types of travel flows at the grid scale based on the diverse travel behaviors of millions of individuals, allowing us to construct eight UTNs. Through the integration of complex network analytics and spatial analysis methods, we examined the structural similarities and disparities across multiple dimensions. Our results reported that all UTNs in Beijing exhibit significant spatial heterogeneity, hierarchical, and dependency characteristics. More importantly, the spatial organization and interaction patterns of the UTNs show a polycentric hierarchical structure, while the distribution of communities aligns with a sector model. This indicates that the current urban structure of Beijing is a hybrid pattern, characterized by the coexistence of polycentric and sector patterns. Overall, our study provides valuable insights into the

structure and functionality of urban systems, offering a new research perspective and empirical foundation for comprehensively depicting and measuring urban structure.

A cross-scale representation of tourist activity space

Xinyue Chen and Yang Xu.

Abstract. Destination, as a key concept in tourism geography, has largely determined the scale at which tourist activity space was modeled and studied. Existing studies usually focused on investigating tourists' activities and movements either at the intra-destination (e.g., within a city) or inter-destination scale. Although useful in numerous research contexts, these models based on fixed spatial scales are incapable of portraying the complex spatial structure of tourist activity spaces, which sometimes exhibit hierarchical structures, and may span across different spatial scales. In this study, we propose a new representation of tourist activity space to bridge these gaps. The representation takes tourists' accommodation locations as key reference points. At the macro-scale, the sequence of accommodation locations forms the backbone of tourist activity space, denoted as itinerary type. At the micro-scale, we introduce the concept of territory to describe how individuals organize activities around these overnight "base camps" (i.e., accommodation locations). We apply this representation over a large-scale mobile phone dataset of international travelers visiting South Korea to demonstrate its capability. Results show that four generic itinerary types capture the activity space structure of 89 percent of the tourists. The interrelationships of territories and their topological structures further categorize activity spaces into subtypes, leading to a new way of tourist classification based on their spatio-temporal activity patterns. We believe the proposed representation could enrich new perspectives and debates on how tourist activities can be studied. The representation can also be extended as a generic framework to delineate complex forms of human activity space.

Unraveling Urban Dynamic for Smart Cities – 1

Extraction of Urban Roof Information Using Remote Sensing Imagery based on DeeplabV3+ and Segment Anything Models: A Case Study in Shenzhen

Zhuoxi Li and Bochen Zhang.

Abstract. Accurate extraction of roof information is crucial for urban planning and resource management. In this study, we test the deep learning methods for extraction of urban roof information based on satellite imagery from Google Earth in Shenzhen. To balance the samples, we first divided the area into building and nonbuilding regions based on 30 m land use data. Annotated images from both regions to create the training, test, and validation dataset are then created. The basic network of DeeplabV3+ with different backbone networks, including the network of residual (Resnet), convolutional neural networks for mobile (MobileNet), Extreme Inception (Xception), and network of dual regression (DRN),

are conducted to compare the accuracy of roof extraction. The experimental results show that the accuracy of roof extraction on the test set is 0.8537 (Xception), 0.8880 (MobileNet), 0.8968 (ResNet), and 0.9264 (DRN), respectively. Among these backbone networks, DRN exhibits the best accuracy performance. Through model prediction and segmentation, we successfully extracted the urban roof information in Shenzhen using satellite images. In addition, the experimental results from both the DeeplabV3+ model and the current popular model, i.e., Segment Anything, are further compared. This study provides essential data support for urban resource management and holds great potential for wide-ranging evaluation of distributed roof photovoltaic power generation.

Socio-spatial Differentiation, Location and Mobility from an Aggregated Perspective: A Case Study of Shenzhen

Run Shi and Anthony Gar On Yeh.

Abstract. Socio-spatial differentiation has often been applied to analyze how urban space is spatially arranged and how different social groups are resided in the city. Studies from social area analysis and geodemographics have divided urban residents into different groups whose socio-economic status are similar. However, few studies have attempted to explore the mobility of these social groups, especially for developing countries where comprehensive census data with travel behavior information are not readily available. This study attempts to explore whether people in the same social area have similar work mobility and whether location matters from an aggregated perspective. A case study is conducted in Shenzhen, China with fine-grained census data and mobile phone data. Results show that although different social areas have statistically different significant work mobility, the within-group heterogeneous mobility is also prominent. Three location related factors, i.e., central/suburban, accessibility to the metro and self-sufficiency are examined and it is found that there exist variations in the influence of location-related factors on work mobility with respect to different social areas. Findings of this study will supplement the current knowledge about socio-spatial differentiation, location and mobility in urban China. In addition, the applied methodology provides a feasible framework of integrating mesoscale socio-economic information and mobility data from different sources for future urban studies.

Understanding the long-term potentials for land value uplift in new subsidiary centres: a spatial equilibrium model

Tianren Yang.

Abstract. The state of the art in land value capture is considered fairly restricted to the short-term prospects and existing centres of high land values. This leads to many missed opportunities – for instance, planned new centres if successful may well have good prospects of long-term land value uplift, but such opportunities are off the radar for existing methodologies. This research aims to develop a novel method to measure the long-term, comprehensive land value effects and related socio-economic benefits/costs pertaining to

new subsidiary centres. The results underpin the identification of key influences on value uplift in planned developments. Such an approach could materially improve local governments' abilities to explore land value capture options, not only as a financing instrument within current property hotspots, but also as part of a wider policy toolkit that can be used to promote social equity, environmental sustainability, and business productivity in a city region which is presently characterised by an overcrowded core and low-performing suburban new settlements.

Unraveling seasonal changes of street greenery using multi-temporal street-view images

Teng Zhong, Yuqi Han, Anthony G.O. Yeh and Min Chen.

Abstract. Street greenery offers various benefits to urban environments. In regions with climatic variations among seasons, seasonal changes in vegetation may lead to fluctuations in the benefits provided by street greenery. It is vital to monitor and measure the seasonal changes in street greenery. Previous studies have analyzed changes in street greenery, mainly from an aerial view. However, aerial views may not be equivalent to residents' visual experiences. This study aims to quantitatively characterize seasonal differences in street greenery based on multi-temporal street-view images which can simulate pedestrians' view. The Gulou District in Nanjing, China, is selected for a pilot study. We collected multi-temporal street-view images through an online street-view service. Deep learning and color recognition algorithms were used to extract quantitative information about seasonal street greenery from street-view images. The results revealed significant seasonal differences of street greenery in the Gulou District. We classified four street greening patterns, including (1) Deciduous and evergreen mixed pattern; (2) Deciduous-dominant pattern; (3) No-plant pattern; (4) Evergreen-dominant pattern, with distinct seasonal change characteristics. We explored possible adjustments in planting arrangements.

Unraveling Urban Dynamic for Smart Cities – 2

Urban Traffic Data Model Based on Multilayer Graph

Feng Yuan, Penglin Zhang, Anni Wang, Jing Yang and Yaqing Zhu.

Abstract. The classic single network model cannot adequately capture the complexity and diversity of the urban transportation system since it is a complex multi-level interaction system. Additionally, the association of several tables in the existing relational database-based urban traffic data storage system results in low query efficiency. In order to meet complicated query needs in urban traffic, this study provides a multi-layer graph-based urban traffic data model that organizes and manages urban traffic data at several levels and makes use of graphs.

First, the urban transportation system is abstracted into layers representing the road network, public transportation network, subway network, vehicle trajectory layer, and other layers. The urban transportation network is then built using graphs, with nodes representing the elements in each layer and edges representing the connections between them. Second, we have created suitable data models to organize and retain information on urban traffic. In order to facilitate effective data analysis and querying, we have defined the attributes of nodes and edges at each level.

In order to validate and assess the created urban traffic data model's query efficiency in terms of path query, path planning, and other factors, we used traffic data from the Wuhan region.

The findings show that by organizing and managing urban traffic data at various levels, the multi-layer graph-based urban traffic data management architecture suggested in this study can significantly increase the effectiveness of traffic inquiries. The model offers planning and decision-making for urban transportation with help from scientific data.

Heterogeneous effects of COVID-19 and policy responses on consumer spending in a tourism city: A joint investigation of urban residents and inbound travelers

Mengyao Ren and Yang Xu.

Abstract. Residents and travelers contribute significantly to the urban economy, particularly in tourism-dependent cities. The COVID-19 pandemic and policy responses greatly influenced the behavior of both groups, subsequently impacting various economic sectors. Despite extensive research on human behavior during the pandemic, there is still a lack of joint investigations into the behavior changes of both groups, hindering a comprehensive understanding of the economic challenges faced by various sectors. Leveraging transaction data from a Korean tourism city, this study estimates residents' and domestic inbound travelers' spending behavior in the first nine months of the pandemic. Findings reveal that both local and national COVID-19 situations significantly affected the spending behavior of both groups. Residents were more sensitive to local cases, while travelers were equally affected by local and national cases. Social distancing measures minimally impacted resident spending but caused over 20% reductions in traveler spending. Stimulus payments increased spending by over 10% for both groups, without diminishing the effects of social distancing. Despite the overall benefit of these combined policies, certain economic sectors benefited notably while others suffered, thus leaving them with varying fates during and after the pandemic. These findings have important implications for economic recovery and crisis response in tourism cities.

High-Definition Maps for Autonomous Vehicles

High-definition "human-vehicle-road-map" model for automatic vehicle

Shen Ying, Yuewen Jiang, Jingnan Liu and Chi Guo.

Abstract. High-definition map (HD map) is the main form of digital transportation infrastructure, which plays a crucial role in autonomous driving. With the improvement of autonomous driving level, the requirements for high-definition map are also constantly increasing. It means that high-definition map is required to have higher accuracy, richer features, and higher efficiency to update and process highly dynamic data in real-time. High-definition map is the undisturbed eyes of autonomous vehicles, providing rich road prior information and redundant safety guarantees. It can not only assist autonomous vehicles in navigation path planning, but also directly participate in command execution to achieve vehicle control.Currently, various HD map models and standards are being developed by some researchers and map manufacturers. But overall, they have less description of the relationship between autonomous vehicles and humans or roads. Therefore, this paper attempts to describe the support of HD map model for autonomous driving from the perspective of the "human-vehicle-road-map" system. We try to propose a universal HD model, including static information layer focusing on road representation, road real-time information layer focusing on road real-time status, vehicle dynamic information layer focusing on vehicle's dynamic surroundings, and user information layer focusing on human's tasks, requirements and experience. This model aims to achieve clearer layering, more comprehensive elements, and more prominent personalization. It innovatively adopts UML modeling method to build a high-definition map Logical framework, manage and express map elements, so as to promote the further development of autonomous driving.

WHU-Road3D: A benchmark dataset for large-scale detailed road surface mapping

Xiaoxin Mi, Bisheng Yang, Yuhao Li, Pangyin Li, Chong Liu and Zhen Dong.

Abstract. Accurately perceiving and reconstructing detailed road surfaces is crucial for applications like high-definition maps, intelligent transportation systems, and digital twin cities. Mobile laser scanning systems (MLS) can collect precise 3D point data on road surfaces and roadside objects, which is robust to different lighting conditions and serves as valuable source data for detailed road surface mapping.

In recent years, various methods have been proposed to extract typical road elements from MLS point clouds. These methods can be categorized into two groups: rule-based and machine learning-based approaches. Machine learning-based methods, in particular, have demonstrated impressive performance. However, many of these methods rely on labeled data to optimize model parameters and acquire domain-specific knowledge. Unfortunately, existing datasets for road perception and reconstruction suffer from several limitations. Firstly, these datasets often focus on specific road elements, lacking a comprehensive dataset that encompasses all road surface elements. Secondly, they typically contain images and/or sparse point clouds. Images are sensitive to illumination changes and lack geo-referenced 3D coordinates, while sparse point clouds may struggle to capture subtle road structures, such as distant curbs. Lastly, the annotations in most existing datasets are limited to pixel/point-level semantics or instances, lacking vectorized annotations.

To address these shortcomings, this paper introduces WHU-Road3D: a large-scale multi-modal dataset for detailed road surface element perception and reconstruction. WHU-Road3D aims to advance the research by providing over 100 km of road data, including dense point clouds, associated panoramic images, and detailed vectorized annotations. The dataset, collected in typical highway and urban scenarios, covers over 20 kinds of road elements, such as road boundaries, various road markings, and lane markings. Additionally, we conduct a comprehensive review of existing approaches relevant to this topic. Furthermore, we present a performance analysis of typical methods on WHU-Road3D, which serves as a valuable baseline for benchmarking purposes.

Digital Twin System of LiDAR SLAM for Mobile Mapping System

Zhihong Xu, Ruofei Zhong, Chi Chen, Donghai Xie, Xingyu Qi and Genyi Wan.

Abstract. The SLAM mobile laser mapping system can be used to obtain three-dimensional data of enclosed spaces, but the quality of the data is heavily influenced by the parameters of the laser device, including the scanning angle, point frequency, line frequency, and the path walked during data acquisition. Therefore, using digital twin technology to test specific three-dimensional scenes with different parameters before the development of the device can guide the selection of subsequent device components, which is of great significance for saving development costs and improving development efficiency. In this paper, a digital twin system of LiDAR SLAM for Mobile Mapping System that specifically targets two key sensor devices of mobile measurement devices: IMU and LiDAR. Firstly, the system uses the existing 3D point cloud scene as a virtual capture environment with real scene characteristics. Secondly, the virtual model of the sensor of the mobile measurement equipment is built in a digital way. Then, the acquisition trajectory is generated in a virtual-real interactive way. Ultimately, the mobile measurement raw data is generated by simulating the behavior and state of the sensor collecting data along the acquisition trajectory in the acquisition environment. The sensor data generated can be utilized for the SLAM algorithm. In addition, we verify its reliability by measuring the difference between the point cloud constructed by Fastlio2 SLAM algorithm and the original point cloud. The experimental results show that our system can generate data with an average error of centimeters.

Self-adapting Real-time Lane-Scale Map Matching with Extended Hidden Markov Model

Shenghua Chen, An Luo, Yunpeng Liu, Yunhong Shao and Wei Zhao.

Abstract. Stable real-time lane-scale map matching is crucial for autonomous driving systems. Map matching technology has always been an important connection between vehicle positioning from multi-sensor perception and prosperous semantic information from high-definition map. It is a necessary stage for autonomous driving path planning and guidance. Well balance between size of lane-scale road network in calculation and algorithm performance is the core issue during lane-scale map matching calculation. In this paper, a

real-time lane-scale map matching method based on the enhanced Hidden Markov Model is proposed. Based on the principle of space-time analysis, this paper extracts the state space and observation space in the calculation area through the inverse distance method, and constructs an adaptive real-time map matching calculation framework. When constructing the model of state transition probability calculation, this paper considers the lanes and their topological associations, lane line types and lane switching rules, and positioning error modes, and designs the calculation methods of parameters such as emission and transition probabilities in the Hidden Markov Model. In the experimental verification, multiple sets of data samples were generated by downsampling the original data and adding random errors. Under the condition of actively adding 1.0m random position error to the positioning result by sensor fusion, the algorithm still achieves an accuracy rate of 99.73%. Experiments have proved that this method achieves high matching accuracy at different levels of fusion perception positioning accuracy, and meets the needs of automatic driving positioning optimization under urban building occlusion conditions.

Semi-Automated Production and Validation Process of HD Maps for Autonomous Vehicles

Yi-Feng Chang, Yen-En Huang, Kai-Wei Chiang, Meng-Lun Tsai, Pei-Ling Li, Sean Lin and Hatem Darweesh.

Abstract. Autonomous vehicles represent a leap forward in transportation technology, demanding significant advancements in supporting areas such as High-Definition Maps (HD Maps). HD Maps, acting as an essential pseudo-sensor, significantly contribute to road safety by providing autonomous vehicles with comprehensive, detailed, and accurate road environment information. However, the labour-intensive and time-consuming manual digitization process for creating HD Maps poses significant challenges. This paper presents an innovative framework to semi-automate the production of HD Maps by 3D point cloud data. Our approach harnesses mobile laser scanner (MLS) systems to collect high-precision environmental data, subsequently utilized to extract vital road elements including lane lines, traffic signals, and other relevant information, facilitate the construction of road reference lines and geometric features of intersections. We then mathematically model the connectivity of these intersections, automating lane connections, and output the map in OpenDRIVE and Lanelet2 format. Furthermore, we propose a comprehensive procedure for the verification and validation of these HD Maps, focusing on ensuring their compatibility with autonomous driving requirements. Notably, maps conforming to these standards should display horizontal and vertical accuracy within 20 and 30 cm, respectively, and possess attributes that autonomous vehicles can utilize. The results suggest that the HD maps created by the process are applicable and feasible for the use of autonomous vehicles. The implementation of our findings is expected to accelerate the realization of a vision for fully automated vehicles soon.

An interoperable high-definition map data model for autonomous driving.

Wenzhong Shi

Abstract. Conventional maps provide important geospatial information for route planning and navigation service. Nevertheless, conventional maps are maps designed for human to use. With the success of sensing technologies and artificial intelligence, autonomous driving has become a hot topic worldwide, and a new kind of map designed for machine to use is on the agenda. High-definition (HD), a map that can provide higher precision, richer information and various services has been regarded as the critical infrastructure for autonomous driving. Due to different HD map providers from different countries and regions, HD maps are born to be heterogeneous in terms of data standards and models as well as pros and cons. It is also generally agreed that rarely a HD map can meet all autonomous driving requirements for different driving objectives. In this work, we present an interoperable map data model, the Open HD Map Service Model (OHDMSM), to provide a reference for universal HD map development. The designed OHDMSM contains three data layers and a set of corresponding interfaces, and it demonstrates high interoperability for HD map data fusion and application. As a proof of concept, a HD map data system is implemented with all functions following the designed data model and interfaces of OHDMSM. The design and development of OHDMSM data structures, interfaces and systems will benefit data requesting, updating, and interoperation for HD map data worldwide, and it would be potentially helpful for developing autonomous driving and intelligent transportation toward smart cities.

Urban AI for Sustainable Cities and Society – 1

Application of time-series analysis to urban climate change assessment

Huimin Liu, Qingming Zhan and Miao Li.

Abstract. Emerging process-based urban management creates an urgent necessity to track the process of urban climate evolution and assess the efficacy of previous plans and practices in building climate resilient cities. However, com-plex interactions between urban surface and the upper atmosphere bring about non-linear and non-stationary urban climate variations, making it challenging to isolate urban effects from other nature-induced variations. This study introduces two types of data-driven time-series analysis techniques, time series clustering and digital signal decomposition, to tackle the above challenge. Particularly, time series clustering is able to zone any study area into multiple geographical time series clusters which respectively illustrate heterogeneous temporal patterns of urban climate change while covering its intrinsic non-linearity and non-stationarity. It generates spatially zoning results benefiting comparative urban climate change assessment to identify both success and failures of existing plans in combating urban climate change. Digital signal decomposition can decompose the non-linear and non-stationary time series into multiple components with different time-scales, thereby offering the possibility to identify the part of variations induced by concerned urban effects. It can be used alone to identify the urban-

induced climate change for specific study area, or in combination with time series clustering to identify the similarities and disparities of urban-induced long-term trends across multiple time series clusters. The application of these methods contributes to more robust and precise assessment of urban-induced local climate change that will benefit effective policy-making to combat urban climate change.

Analysis of Carbon Emission Reduction Effects by Future Mobility Adaptation Scenarios Using Prompt Engineering Generative AI

Junhyeon Kweon, Taewoo Kim, Minseo Kim, Yeseong Lee, Seungbin Im, Jayyeon Chun and Sugie Lee.

Abstract. Mobility means mobile possibility and various mobility activities, and it includes various means and services. The development of such mobility affects the improvement of accessibility within the city and affects not only the spatial structure but also the environmental pollution and social equity of the city. Recently, self-driving cars and urban air mobility have emerged, and various influences on the environment and society have become issues. In this context, this study aims to build an optimal future mobility scenario (model) by deriving and designing various mobility introduction scenarios using prompt engineering based on Generative AI. Using Generative AI, it is possible to create various scenarios at a low cost and in a short amount of time, and it is possible to envision scenarios and predict effects based on various conditions through user-based prompts. For this end, this study makes a database based on various literature, factors affecting mobility change and use, evaluation indicators, policies, and businesses to use for scenario development and evaluation. Afterwards, they will be applied to various Large Language Models based prompt tools such as GPT 4.0, Agent GPT, and Auto-GPT to configure hundreds of different scenarios and compare them to each other to find the most optimized scenario. Ultimately, we will propose a framework that develops a set of scenarios based on the user's prompt and predicts future effects, so to analyze the carbon emission reduction effects. The research results will be used as basic data for future city policies and plans aimed at carbon neutrality and will contribute to sustainable urban development.

Where is Huaqiangbei? A Vague Scope Study of Urban Business District Based on the Retrieved Results of POIs

Yunfei Ma, Qiqi Deng, Yining Meng and Yongxi Gong.

Abstract. Shenzhen Huaqiangbei, as the distribution center of electronic products in China and even the world, has witnessed Shenzhen's economic and social development. With the city's development and market demand, Huaqiangbei has been continuously transformed from a counter and a street in the past to a global business district today. But where is Huaqiangbei? Is there a clear scope? How has the scope and function changed in recent years? What is the relationship between these changes and the development of Shenzhen? These questions are difficult to answer accurately because of the vague of Huaqiangbei‘s boundary.

The Internet provides the opportunity to externalize spatial cognition. Individuals and institutions will publish massive amounts of text information that contain their spatial cognition of real geography space. Among them, toponym co-occurrences on web pages can indicate the cognitive connection between two places. This connection can be reflected not only between two place names but also between a certain place and its internal points. Therefore, it is possible to determine the fuzzy boundary of the place in the real geographical space using this method.

This study extracts the vague scope and evolution of Huaqiangbei in recent years through the co-occurrence frequency of the names of points of interest (POI) around Huaqiangbei and the word "华强北" in web pages. The findings reveal a series of significant events that occurred in Huaqiangbei from 2012 to 2020, including street closures and openings, enterprise enters, epidemic control, and so on. These results are closely linked to Shenzhen's activities at different historical stages, like the construction of the National Innovation Demonstration Zone and the impact of COVID-19. By reading Huaqiangbei, this study unveils a valuable insight into urban development, providing a comprehensive understanding of the underlying mechanisms and promoting the city's prosperity and sustainable growth.

Cost-effective Sensor Placement for Urban Sewage Pandemic Surveillance: a Case Study in Hong Kong

Sunyu Wang, Ke Xu and Yulun Zhou.

Abstract. Early pandemic outbreak detection in cities is a crucial but challenging task. Metropolitan sewage surveillance offers a cost-effective alternative to massive individual testing for tracking pandemic transmission in metropolitan areas with little disruption to daily life. Given a sewage network with complicated topologies, one growing concern is how to develop a cost-effective sensor placement strategy.

This paper addresses this challenge by formulating the optimal sensor placement problem on networks as a multi-objective optimization problem and solving it using the NSGA-II algorithm. A connectivity-based objective evaluation approach is embedded into the NSGA-II algorithm to enable efficient optimization on large-scale directed graphs. We verify the effectiveness of the evolutionary algorithm on both small-scale synthetic networks and a large-scale, real-world sewage network in Hong Kong. Results show that the quality of solutions obtained by the NSGA-II algorithm improves greatly after iterations. The detailed analysis of optimized results in Hong Kong shows optimized solutions achieve higher quality due to better connectivity between sensors, higher monitoring ability of each sensor and more even distribution. Human heuristics are designed to mimic how people place sensors by ranking manholes based on their importance and selecting top manholes accordingly. The comparison shows NSGA-II algorithm always outperformed all human heuristics, highlighting the necessity for data-driven decision support for large-scale sewage surveillance. The code and sewage network datasets will be open-sourced to support future algorithmic developments in a real-world scenario.

LFEA-Net: Semantic Segmentation for Urban Point Cloud Scene

Ziyin Zeng, Jian Zhou, Bijun Li, Youchen Tang and Maosheng Yan.

Abstract. Considering the increasing prominence of 3D real city construction technology, 3D urban point cloud scene data merit further investigation. However, achieving fine-grained semantic segmentation of urban scenes remains highly challenging due to the natural orderlessness and unstructured nature of acquired point clouds, along with their large-scale points and non-uniform distributions. In this study, we present LFEA-Net, a novel neural network specifically designed for semantic segmentation of large-scale urban point cloud scenes. The network comprises two main components: (1) The local feature extraction (LFE) module, which fully exploits local neighborhoods to enhance and preserve crucial information. (2) The local feature aggregation (LFA) module, designed to emphasize both local significant features and the entire local neighbor. We have evaluated the performance of LFEA-Net with state-of-the-art networks using the photogrammetric point cloud dataset SensatUrban. The results demonstrate the superior efficacy of LFEA-Net in accurately segmenting and classifying large-scale urban point cloud scenes, highlighting its potential to advance environmental information perception.

Urban AI for Sustainable Cities and Society – 2

Urban Computing Cyberinfrastructure for Visualizing Human Sentiment and Point-of-Interest Information for Improving Situational Awareness

Diya Li and Zhe Zhang.

Abstract. Urban information discovery and the use of Geographic Information Systems (GISs) in geography and related disciplines have a long and rich history. For example, routing and Point-of-Interest (POI) searching services are key components of many GIS-based applications, particularly in urban settings. POIs are specific locations or landmarks that people might find useful or interesting such as shops, hospitals, museums. GIS has been instrumental in organizing, analyzing, and visualizing spatial data, providing valuable insights for intelligent spatial decision-making. Integration of routing and POI services in GIS-based applications has revolutionized how spatial information is utilized, making urban information discovery and spatial decision-making more efficient and intelligent. In recent years, Augmented Reality (AR) has become a growing trend to visualize spatial objects through digital visual elements. However, a research gap exists between GIS and AR systems in terms of computational efficiency and interoperability. In this paper, we developed a geospatial cyberinfrastructure that integrates urban information and AR to enhance spatial knowledge visualization and discovery. Our experiments demonstrate how spatial analysis and urban sentiment computing can efficiently be integrated into the AR-based cyberinfrastructure framework to support real-time trip planning under various conditions. For example, this application can help local residents to improve situational awareness of incidents when travel to different facilities such as shops and hospitals. It can

also help urban planners to better understand the people' needs in terms of neighborhood satisfaction.

Construction of an Agricultural Local Product Knowledge Graph System for Urban and Rural Communities

Cang Qin, Lin Peng, Zhaobo Li, Lina Yang and Wenyue Zhang.

Abstract. This study aims to establish a diversified information link between urban and rural community residents and local agricultural products, promoting residents' understanding of agricultural products and stimulating consumption. It seeks to address the issues of scattered information, information silos, and monotonous formats in the current promotion of local agricultural products. The study constructs an agricultural local product knowledge graph system oriented towards urban and rural communities, with the goal of meeting the diverse knowledge needs of community residents regarding agricultural products and providing convenient and efficient agricultural product knowledge query services. The research adopts a top-down knowledge graph construction method and, taking Hubei Province as an example, utilizes web crawling technology to collect and integrate data related to local agricultural products in counties. The RoBERTa-CasRel model is used for knowledge extraction to obtain triplets, constructing the Hubei Province agricultural local product knowledge graph. Additionally, a community-oriented agricultural local product question-answering system is designed and implemented using template matching methods, providing intelligent Q&A and knowledge query functions for community residents. The intelligent system designed and implemented in this paper offers community residents the possibility of quickly obtaining relevant information about local agricultural product brands, production environments, quality characteristics, and more. It provides a beneficial solution for promoting community intelligent services and rural revitalization.

Neighborhood Effects on Public Sentiment: A Case Study Based on ChatGPT and Explainable Neural Network

Yuye Zhou, Yiwen Wang, Yang Ju, Jiangang Xu and Minwei Kong.

Abstract. The public health crisis not only directly harms citizens' physical well-being but also generates negative cascading effects on public sentiment and mental health due to measures such as lock-downs and restrictions. These effects are particularly pronounced in disadvantaged communities characterized by substandard living environments and economic vulnerabilities. Therefore, taking Shanghai, China as our study area, this study examines the influence of the built environment and socioeconomic status on the recovery of residents' emotional fluctuations and psychological resilience in the absence of disasters. Furthermore, we explore the varying impacts of the built environment on different demographic groups, underscoring the significance of equity considerations in urban planning.

Regarding methodology, we establish an information channel for assessing residents' emotional impact by employing social media data based on ChatGPT and BERT. To analyze the effects of restrictive policies on residents' emotional fluctuations and identify stages of resilience, we employ a causal inference approach known as Regression Discontinuity (RDiT) with time breakpoints. Additionally, we utilize SHAP (Shapley Additive Explanations), an interpretable neural network technique, to assess the individual and interactive effects of community built environment factors on residents' emotional values during each stage. Our research aims to explore the impact of the community built environment on residents' sentiment and mental resilience and proposes targeted strategies to foster environmental justice.

This research deepens our understanding of the intricate interplay between the built environment and public sentiment, offering valuable insights for policymakers in promoting resilient and inclusive communities in the post-COVID era. It highlights the importance of considering the impact of community built environment factors on residents' mental well-being, with a particular focus on addressi ng the specific needs and vulnerabilities of diverse demographic groups.

From prediction to interpretation: progress of sustainable built environment studies

Chao Liu.

Abstract. AI applications in urban built environment are noticeably increasing. The influence of advanced technology on reframing the researches in the field of sustainable built environment is becoming realized. This research aims to identify the role of AI in the research on sustainable built environment.

By reviewing the conceptions of sustainability and built environment, the research summarizes several important topics in the wide-ranging field of sustainable built environment. Based on literature from Web of Science (WoS) and China National Knowledge Infrastructure (CNKI) over the last five years, the research finds that the increasing trends of ML-related research are significant for topics such as urban public health, energy consumption and carbon emission, climate and environment, ecosystem, and green travel, which may serve as a useful clue for structure organization and conclusion drawing of this research. Initially, the research elaborates on the concept, classification and algorithms of AI, and presents the application characteristics of strong prediction capability but poor interpretation capability. Then the research analyzes the trend change of AI from predictability to interpretability, followed by the descriptions of scope, taxonomy and core algorithms of interpretable ML. Moreover, the research establishes a thorough table to list multiple ML algorithms and their roles in the research.

Far from being all-inclusive, the research only tries to incorporate as many methods and objectives as possible across the world. The research particularly focuses on the predictability and interpretability of the results of ML algorithms, and the specific roles of such algorithms in the research direction, methodology and conclusion of sustainable built environment.

The Pathway of Urban Planning AI: From Planning Support to Plan-Making

Zhong-Ren Peng.

Abstract. Artificial intelligence (AI) is rapidly gaining prominence as a crucial technology to transform and reshape the field of urban planning. However, several unanswered questions persist regarding the potential impacts of AI on urban and regional planning research and practice, as well as the issues involved and the appropriate responses and plans. This paper aims to address these concerns in the AI-enabled planning process and accordingly create a typology of urban planning AI to categorize and outline the progression of AI in urban planning, ranging from AI-assisted and AI-augmented planning to AI-automated and eventually AI-autonomized planning, based on a scoping literature review.

Analysing Tourists' Choices between Rental Cars and Bus Transit for Intra-city Travel in Jeju Island, South Korea

Ke Mai and Yang Xu.

Abstract. Automobile travel is a significant contributor to carbon emissions in the tourism industry, ranking second only to air travel. Private modes of transportation, such as private cars and rental cars, have traditionally been the preferred choice for tourists in certain cities and regions. However, to facilitate sustainable cities and tourism, there is a need to encourage more tourists to utilize public transportation instead. To achieve this, public transportation planning must consider various factors that influence tourists' choices between private and public transit in different circumstances.

This study aims to provide insights into the factors that significantly impact tourists' transport mode choices between rental cars and buses for traveling within a destination city. The study utilizes smart card records and driving navigation records of domestic tourists in Jeju Island, South Korea. A bivariate analysis and a utility-based regression model are employed to examine the relationship between the mode shares and influencing factors. Four categories of influence factors are selected, including travel cost and transportation efficiency, built environment, socio-demographic characteristics, and POI categories at the trip destination.

The findings of study reveal insights into tourists' mode choices between rental cars and buses for traveling within a destination city. Specifically, travel cost and the efficiency of public transportation are the most influential factors. Additionally, a non-linear relationship between mode shares and trip distance is observed. Furthermore, female tourists and those over the age of 40 exhibit a stronger inclination towards rental cars. Moreover, the category of trip destination POIs also plays a significant role in influencing mode choices, particularly for categories that are closely related to or nonessential to the touring activities. This study suggests that accessible, efficient, and safe public transportation services, as well as adequate connectivity between desired facilities, could encourage tourists to shift from automobiles to public transport.

Disaster Monitoring and Damage Early Warning in Urban Area

Empowering Urban Wildfire Burnt Area Detection with Deep Learning

Tang Sui, Mingda Wu, Meiliu Wu and Qunying Huang.

Abstract. A wildfire, often referred to as a forest fire or a bushfire, is an uncontrolled fire that rapidly spreads across natural or urban areas. Wildfires, especially when occurring near or in urban areas, significantly affect human safety, assets, and ecosystems. Therefore, accurately and timely detecting the extent of burnt areas is crucial for estimating, preventing, and managing disaster situations.

Many machine learning models, including SVM, random forests, and convolutional neural networks, have been developed for wildfire burned area mapping. While these models have demonstrated success in specific study areas sharing similar terrain, vegetation, and soil types, their performances tend to be unsatisfactory when applied to different environments. Transferring these models to new areas with distinct environmental conditions often leads to suboptimal results. To this end, we proposed a framework based on U-Net architecture and bi-temporal (pre- and post-wildfire) Sentinel-2 satellite imagery. Within this framework, an attention gate is implemented at every up-sampling step, and a well-designed loss function is used. Accordingly, the model can focus on the burnt area and be more accurate and efficient, especially in edges and small areas where burnt areas and non-burnt areas are mixed up.

To evaluate the generalizability, five distinct areas from five continents were selected as case studies, with only one area utilized for model training, and all five areas for testing. Results indicate that the model demonstrates strong performance across diverse environments in various regions. Moreover, our model surpassed the baseline methods, including the Global Burned Area (GBA) products from the European Space Agency. The main evaluation metrics across five areas were as follows: Overall Accuracy improved by 11.56%, Precision by 29.08%, F1-score by 19.90%, and Kappa Coefficient by 29.90%. These results indicate the great potential of our proposed framework for effectively aiding in the ecological restoration and governance of burnt areas.

The rapid monitoring of flood disaster over urban area using time series SAR images

Lingli Zhao, Haozhong Wang, Jie Yang, Weidong Sun, Lei Shi and Pingxiang Li.

Abstract. The accelerating process of climate change and urbanization has led to an increasing number of people threatened by floods. Synthetic Aperture Radar (SAR) technology, with its all-weather and all-day imaging capabilities, has become one of the preferred tools for flood monitoring. The backscattering of flooding urban area has large difference with that of natural area for which there is weak backscattering. The flooded built-up area has large change in backscattering due to strong geometric distoration over buildings. The large changes induce difficulty in flood monitoring over urban area.

Time series SAR images provide detailed temporal observation and would reduce the interference from factors such as high spatial heterogeneity in complex building scenes. We analyzed the changes in the backscatter mechanism of natural and built-up areas before and after floods. The Time Series SAR-based Anomaly Flood Monitoring (TSSAFM) method has been proposed to address the balance between large-scale flood monitoring and urban flood monitoring. The study established a flood classification decision tree model that is adaptable to various scenarios, aiming to achieve large-scale flood disaster monitoring. The Google Earth Engine (GEE) has been used to reduce time cost of flood disaster emergency. The efficiency of the proposed method has been invalidated over the flooding disasters in Zhengzhou and Pakistan.

Revealing Multi-Scale Deformation of Shapu Metro Hub Caused by Underground Space Exploitation Combining InSAR and On-site Measurements

Xiaoqiong Qin, Chengyu Hong, Yaxuan Zhang, Linfu Xie and Xiangsheng Chen.

Abstract. The monitoring of deformation in metro hubs is crucial for ensuring the safety of urban transportation systems. Existing studies have primarily relied on InSAR technology to detect deformation in established subway stations and their surroundings. However, measuring the deformation evolution process during the construction phase using InSAR alone is challenging due to decoherence effects. This paper addresses these challenges by combining InSAR monitoring with on-site sensors. Taking the Shapu metro hub under construction on Line 12 in Shenzhen as an example, on-site measurements and Sentinel-1

observations are combined to reveal the multi-scale deformation in this study. This comprehensive approach increases monitoring flexibility and the number of internal observation points within the structure compared to traditional construction measurements, enabling the identification of settlement funnels that are often overlooked by conventional monitoring techniques and effectively ensuring the safety of subway structures. The cumulative deformation of PS points around the station reaches approximately 25mm, forming a settlement funnel. Furthermore, longitudinal and cross profiles along the subway station are calculated to determine the influence scope of the construction. The machine vision sensors are highly sensitive to vertical deformations caused by soil covering construction, revealing the settlement changes in the station structure during construction. In order to further explore the deformation mechanism, this paper also utilizes finite element simulation to simulate the construction and consolidation process of a single ring under backfill. The maximum vertical deformation obtained from the finite element simulation is -11.35mm, while the deformations at the three positions corresponding to the machine vision sensors are as follows: -5.64mm (left), -11.35mm (middle), and -5.47mm (right). The measured settlements on the left and right sides have an error of less than 1.2 millimeters. This result effectively demonstrates the deformation process of backfill construction and provides support for future deformation monitoring and analysis in construction.

Assessing Flash Flood Susceptibility Based on K-means and AdaBoost Models

Zheng Guan and Xiaoxiang Zhang.

Abstract. Flash floods occur frequently in China, likely to cause significant casualties and economic losses because of its suddenness, and damage to urban infrastructure. Assessing the susceptibility of different catchments geographies to flash floods is important for disaster prevention and mitigation. Although the assessment models are constantly updated, the results are still affected by the heterogeneity of hydrological big data. Hidden patterns within the big data create difficulties in model fitting. In order to study the effect of spatial heterogeneity and explore which clustering model is more suitable for flash flood susceptibility assessment, a model based on K-means and AdaBoost is proposed.

Firstly, using the assessment of flash flood susceptibility in Jiangxi Province, China, as a study case, the K-means clustering model and the Ward clustering model are respectively used to cluster the rainfall indicators with different frequencies in each time period. Secondly, the silhouette coefficient is used as the clustering evaluation index to divide catchments into two different similar subsets. Finally, for the different subsets divided by clustering models, flash flood susceptibility assessment is carried out using the AdaBoost model from the 10 flash flood conditioning factors, namely slope, elevation, shape factor, concentration gradient, topographic wetness index, normalized difference vegetation index, distance to the nearest river, rainfall, peak discharges per unit area and time of concentration.

The results find the model based on K-means and AdaBoost outperforms other models, including the AdaBoost model and the Ward-AdaBoost model, for flash flood susceptibility assessment in Jiangxi Province. The AUC values of the two subsets after K-means clustering

reached more than 0.9, which is a significant improvement over the other models. In summary, according to the clustering method can be effectively used as a strategy to address the heterogeneity of hydrological big data as a precursor process to the susceptibility assessment model.

Rapid Monitoring of Flood Events using Remote Sensing Cloud Platforms

Dizhou Guo and Wenzhong Shi.

Abstract. Remote sensing provides a rapid and extensive way for monitoring flooded events. However, the storage space and computational power requirements for individual users to acquire and extract multi-source, massive amounts of historical image information pose challenges. As a result, many existing flood extraction methods rely on two-image or single-image processing based on single-source data, which may lead to limitations in accuracy due to the lack of sufficient and reliable auxiliary data. Fortunately, with the rapid development of remote sensing cloud platforms, it has become possible to efficiently utilize multi-source, massive remote sensing data for assisting in the extraction of disaster information. In this study, the Google Earth Engine (GEE) and AI Earth platforms were utilized to leverage a diverse range of data sources, including Sentinel-1/2, NASADEM, and Google Dynamic World, for flood monitoring. An adaptive Z-score method was proposed for flood detection, and a system capable of all-weather flooding monitoring was developed. The system considered terrain factors and allowed for the simultaneous extraction of open water and urban floods. Three recent case studies (the July 2021 flood in Henan, the June 2023 flood in Kherson, and the August 2023 floods in the Beijing-Tianjin-Hebei region) were conducted to extract flood, yielding satisfactory results and demonstrating the significant potential of cloud platforms in flood monitoring applications.

Diagnosing Cities for Human Health and Emotional Wellbeing – 1

Nudges for Urban Regeneration: Environmental Cues Suggested by Eye-Tracking Evidences

Zheng Chen.

Abstract. Why do people like or dislike a street or a square? Why did they choose to sit down on this seat rather than another? Why do people feel peaceful and relaxed every time they enter this small garden? Designers often spend a lot of time trying to figure out the underlying motivations and intuitive judgements of users. Such judgements and motivations, although important for a good environmental design, are often implicit, and might be one of the hardest mysteries to be scientifically decrypted. Bio-sensing techniques, including eye movement tracking, electrophysiology, and motion tracking, provide a

possibility to look into such mysteries.

In this presentation, we are sharing with you how eye-tracking data could help designers to understand environmental cognition, and how such knowledge may help designers doing better design. Specifically, we offered three evidence-based urban regenerative design projects: i.e., Sandao Road and Goxing Road in Chengdu and Hutaizhi Road in Shanghai. Three projects explored attention calibration via design: livable streets and visual availability, street walls and visual accessibility, street edges and pro-social cues. Our experiments illustrated how small features, or environmental cues, may have an impact on users' attention and therefore, may shape their readings of environment, and eventually, may alter their judgement and decisions about the space.

Structural beauty as an effective means of guiding sustainable urban planning

Bin Jiang.

Abstract. Structural beauty, derived from the underlying living structure that permeates our surroundings such as ornaments, walls, rooms, houses, gardens, streets, and cities, encompasses a shared perception of aesthetic appeal. This phenomenon emerges through the intricate interplay of defined substructures and their inherent hierarchy. The presence of numerous substructures, along with a well-defined hierarchy, contributes to a heightened sense of beauty. This paper aims to explore the profound potential of structural beauty as a guiding force in sustainable urban planning, facilitating the gradual realization of more vibrant and living environments. Through the introduction and examination of the concept of structural beauty, bolstered by simplified yet illuminating examples, we delve into its application in various contexts. By conducting compelling case studies that encompass buildings, cities, and the analysis of geospatial data such as imagery, we exemplify how the integration of structural beauty principles can effectively inform and enhance urban planning practices. Moreover, we delve into the symbiotic relationship between Alexander's renowned 15 properties of beauty and the fundamental laws that underpin the living structure. By embracing structural beauty as a transformative framework, urban planning transcends its conventional boundaries, evolving into a robust, evidence-based discipline capable of fostering the development of sustainable, resilient, and flourishing cities. This paradigm shift empowers planners and policymakers to harmonize functionality with aesthetic appeal, resulting in urban spaces that not only inspire admiration but also facilitate social cohesion, promote cultural identity, and harmonize with the natural environment. Through the lens of structural beauty, the trajectory of urban planning is poised to be revolutionized, with the potential to shape the cities of tomorrow into havens of beauty, livability, and sustainability.

Rethinking Urban Centre Dynamics: Exploration of Infrastructure and Socioeconomic Dynamics through Head/Tail Breaks

Yue Li and Jianqi Li.

Abstract. This study sheds light on the dynamic interaction between infrastructure and

socioeconomic centres in urban areas based on the push-pull dynamic theory of cities. The push force (top-down) represents the institutionalised power, while the pull force (bottom-up) refers to individual and group power, which together shape urban development. It challenges the conventional understanding of urban centres, which often relied on interpretations of a single source of data and focused on specific aspects such as employment or population. To overcome these limitations, this study utilises panel data (2012-2019) of point of interest (POI) data and Nighttime light (NTL) data to identify the socioeconomic and infrastructure urban centres of Guangzhou, respectively. The hypotheses put forward in this study suggest the existence of a push-pull dynamic between infrastructure and socioeconomic centres. It is argued that the emergence of new infrastructure centres may precede the shift of socioeconomic centres, while the socioeconomic centres exert a pulling force on infrastructure centres, leading to their expansion and merging. The empirical analysis, based on the outlined data and methods, yields insights into the evolution and expansion patterns of infrastructure and socioeconomic centres. The results reveal various types of interactions, such as accompany, mismatch, and remain, providing evidence for the push-pull forces at play. Notably, socioeconomic centres demonstrate a faster rate of evolution compared to infrastructure centres, and the criteria of head/tail breaks indicate a higher concentration of socioeconomic centres relative to infrastructure centres. Overall, this study contributes to our understanding of urban dynamics and offers practical implications for urban planning and development.

Mapping China’s ICT Service Industry Geographies: Spatio-temporal Distribution and Evolution at the Provincial Level

Weixuan Chen.

Abstract. The information and communication technology (ICT) service industry has become a burgeoning industry at a high and stable speed. Their equitable distribution can improve national and global sustainable development. This paper aimed to verify the characteristics of spatio-temporal distribution and evolution of China’s ICT service industry at the provincial level. This uses location quotient and spatial autocorrelation methods to analyse the data from 31 Provinces in China from 2015 to 2019. The main results are shown as follows: (1) China's ICT service industry is mainly concentrated in Beijing, Shanghai, Zhejiang, Tibet, and Guangdong, with a trend of specialisation development. They are not only distributed in cities with relatively superior overall development but also in those with superior industrial and development carrier elements. Technological relevance, aggregation, and political difference might have an impact on promoting the emergence and development of these industries. (2) ICT service industry is characterised by stable and highly concentrated development. Numbers between three to five significant provinces and types with high-high (HH) and high-low (HL) clusters of local spatio-temporal association kept stable in the period. The HH was in eastern coastal areas, including Zhejiang, Shanghai, Jiangsu, and Shandong, and the HL was in Guangdong in 2015. There is a definite spatial correlation in spatial distribution with constant strengthening. Correspondingly, two strategies were put forward here: (1) accelerating the inter-provincial networking

development of the ICT service industry, and (2) strengthening government policy guidance for the ICT service industry. These outcomes can not only provide a scientific basis and theoretical support for the distribution of strategies and resources for these industries at the theoretical level but also improve resource integration from the national perspective and the efficiency of resource use at the practical level.

Study on Public Preferences of Typical Plant Communities in Urban Parks: A Case Study of Hefei Ring Park

Yan Zhu, Kun Wang, Yinan Li and Juan Ding.

Abstract. 【Objective】To investigate the influence of typical species diversity in urban parks on public recreational preferences, and to enhance the ecological service function of urban parks. 【Methods】Taking plant communities as the research object and Hefei Ring City Park as the research area, 12 typical plant communities were selected, and the field research method was used to investigate the structure of plant communities, combined with questionnaires to quantify the relevant indices, and quantitative analysis of preference factors affecting public preference to obtain the weight indices to determine the degree of influence. 【Results】1) There were no significant differences in the public's overall preference for plant communities in terms of gender, professional background, education level, and monthly income. There were differences in age, and aesthetic preferences were differentiated by life experience, as shown by the higher preference of children and the elderly in Metasequoia and Cedar communities, and the weaker preference of young and middle-aged people.2) The mean value of preference scores for the 12 typical plant communities was 2.8, with Community 6 being the highest (4.34); and Community 11 being the lowest (1.77).3) The main factors that influenced public preference were: Expectation to stay, ornamentation level and ornamentation colour. [Conclusion] The level of public preference for plant communities is positively correlated with their intention to stay in the environment; ornamentation level and ornamentation colour are the main factors influencing public preference.

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Diagnosing Cities for Human Health and Emotional Wellbeing – 2

Quantitative evaluation of urban 3-30-300 green exposure and its impact on human health

Yicheng Zheng, Tao Lin and Nicholas A.S. Hamm.

Abstract. Urban green spaces indisputably confer a range of health benefits. However, the specific implications of comprehensive green exposure standards on multidimensional health remain unclear. Green exposure also lacks uniform quantitative criteria. An innovative 3-30-300 green space rule conceptually represents green visibility, availability and accessibility as an appeal to quantify green exposure. This study aims to quantitatively evaluate the 3-30-300 green exposure and investigate its impact on physical, mental and social health. We deployed a cross-sectional study based on 902 investigated individuals aged 11-95 years in Xiamen City, China. The performance of the 3-30-300 green exposure was calculated using urban geoinformatics, including field surveys for on-site conditions, remote sensing indices of vegetation and big data from the Baidu Maps Application Programming Interface (API). Multidimensional health outcomes were obtained from the questionnaire survey. We also employ Geographically Weighted Regression and Geographically Weighted Logistic Regression to elucidate the impacts and spatial heterogeneity of green exposure on human health. In the study population, a mere 3.55% (32/902) of individuals in Xiamen fully comply with the 3-30-300 rule. According to the global results derived from GWR, 30% tree canopy coverage is significantly linked with improved physical (β: 0.76, $p<0.01$) and social (β: 0.5, $p<0.01$) health. GWLR global results show that possession of a green view, adherence to one (OR=0.46, 95%CI: 0.25-0.86, $p<0.05$) or two (OR=0.41, 95%CI: 0.22,0.78, $p<0.01$; OR=0.24, 95%CI: 0.07-0.77, $p<0.05$) green exposure indicators significant decrease in medical visits and hospitalizations. The local GWR analysis reveals a significant correlation between a 30% tree canopy coverage and enhanced social health across all locations. Meeting any two indicators also contribute to improved social health (n=511, β: 0.46-0.51, $P<0.05$). In conclusion, 3-30-300 green exposure guides healthy urban green space development. We observed multidimensional health benefits when 1/3 or 2/3 of the indicators were met.

Understanding the relationship between city perceptions and children's mental health in Hong Kong using GeoAI

Wei Yuan, Xuefei Qin, Xibin Jiang and Zhuoni Zhang.

Abstract. Ensuring the healthy development of children is paramount for sustainable and human-centered urban planning. While prior research has explored various urban features that impact children's health, such as green spaces, play areas, and walkability, the focus on children's own perceptions of the built environment has often been neglected. Present studies on urban perceptions related to residents' emotional well-being have primarily centered around perceived safety, overlooking essential factors. Considering that visual aesthetics, livability, and vibrancy significantly contribute to child-friendly neighborhoods, it becomes imperative to further explore children's perceptions of these three aspects.

This study investigates children's subjective perceptions of neighborhood environments in 191 block groups of Hong Kong, utilizing the GeoAI approach. This method proves more efficient than traditional surveys, significantly expanding the geographic scope of the research. Firstly, we extracted children's city perceptions from street view images using the pspnet ade20k model. This included assessing aspects such as beauty, vitality, boredom, depression, and safety. Street view images were collected at 50-meter intervals within street networks at the block-group level. Subsequently, we conducted multiscale geographically weighted regression analysis, which incorporated five city perception factors and 19 child health-related indicators. Our aim was to explore the associations between these factors and children's mental health. Data on children's mental well-being were obtained from representative questions taken from strengths and difficulties questionnaires, involving a sample of 512 households with children below 15.

The results of the study revealed that children display better mental health when they perceive their surrounding environment to be safer, more interesting, and aesthetically pleasing. Besides, we found positive correlations between children's mental health and the distribution of sports facilities, the degree of land use mix, and the density of bicycle lanes and pedestrian paths.By investigating children's subjective perceptions, this study provides valuable insights for the development of child-friendly cities.

Revealing the spatial co-occurrence patterns of multi-emotions from social media data

Dongyang Wang, Yandong Wang, Xiaokang Fu, Mingxuan Dou, Shihai Dong and Duocai Zhang.

Abstract. Emotions play a critical role in understanding human behaviors and are direct indicators of residents' well-being and quality of life. Assessing spatial-emotional interactions is crucial for human-centered urban planning and public mental health. However, prior research has focused on the spatial analysis of every single emotion, ignoring the intricate interactions between multi-emotions and space. To address this gap, we propose a novel framework to reveal the spatial co-occurrence patterns of multi-emotions using massive social media data in Wuhan, China. Specifically, the BERT (bidirectional encoder representations from transformers) pre-trained model is utilized to classify each post into one of five basic emotions. Given the implementation of the K-means algorithm on these emotional results, the emotion-based similarities among different grids are investigated. The qualitative and quantitative results reveal six spatial co-occurrence patterns of conflicting or consistent emotions in urban space, namely, happiness-fear, happiness-anger, balanced emotion, happiness dominated, happiness-surprise, and happiness-sadness. In particular, the balanced emotion pattern is the most prevalent and tends to be spatially concentrated in the city center, while patterns of happiness-anger and happiness-sadness are mainly observed in the suburbs. Plus, results of the Multinomial Logit Model (MNLM) indicate that the spatial multi-emotions co-occurrence patterns are significantly correlated with land use characteristics based on points-of-interest (POIs) data. These findings provide an innovative perspective for understanding the complex

interactions between emotions and space, with theoretical and practical implications for designing and maintaining an emotionally healthy city.

Exploring the Spatially Heterogeneous Effect of Built Environment on Shared Bike Riding Using GWR: A Case Study of Longgang, Shenzhen

Jiayi Jin and Yongxi Gong.

Abstract. Outdoor physical activities (walking or cycling) are beneficial for people's health and well-being. As a flexible, convenient, economical, and environmentally friendly travel mode, dockless bike sharing (DBS) plays an important role in encouraging more physical activities. Therefore, optimizing the urban built environment to promote bike-sharing usage has become an important concern for urban planners and policymakers. However, previous studies focused mostly on the origin and destination (OD) of cycling, neglecting the impact of the built environment on the cycling procedure. Moreover, the spatial heterogeneity of the effect, a key concern in geography and urban planning, is often ignored in existing research. This research aims to analyze the spatial heterogeneity of the impact of the built environment on the cycling procedure of bike sharing. By utilizing geo-tag big data, including bike-sharing trajectory data (not only OD but the cycling procedure trajectories), this research constructed a geographically weighted regression (GWR) model that considers spatial heterogeneity to explore the spatial distribution patterns of factors affecting bike-sharing usage from aspects such as urban greening and land use. Analysis of data from Longgang, Shenzhen shows that: 1) The GWR model fits better than the ordinary least squares (OLS) model, indicating that spatial heterogeneity among the variables is well captured. 2) As a demand-driven travel mode, the cycling procedure of bike sharing is highly correlated with the distribution of points of interest (POI) in the categories of residence, employment, and leisure. 3) There is spatial heterogeneity in the impact of urban greening, road networks, bus stops, metro stations, and other variables on bike-sharing, with metro stations promoting bike-sharing especially in the southern part of Longgang, and areas with excessive greening inhibiting bike-sharing usage. The findings of this research provide decision-making support for locally tailored policy formulation, helping to improve the health and well-being of the public.

Incorporating fine-grained spatial heterogeneity to predict the local-scale infections and the superspreading areas of pandemic: A case study of COVID-19 in Hong Kong

Ningyezi Peng and Xintao Liu.

Abstract. Introduction: The COVID-19 infection has been found to be unevenly distributed across social groups and urban space. Existing studies have found that population density increases infection risk, but seldom did they consider the urban scaling structure that underlies the heterogeneous population distribution. Here, we show urban scaling structure of human mobility have large effects on local infection risk. Even local areas with small differences in mobility volume may result in large disparity in infection risk due to the

underlying scaling structures.

Methods: A agent-based simulation model that incorporates urban scaling structure of human mobility is built. To validate our model, the simulation outcomes are compared with the empirical data of the Omicron wave from February to March, 2022 in Hong Kong regarding: (1) the aggregate epidemic curve, (2) local epidemic curves of 214 spatial units, and (3) a minority of high-risk local areas derived from contact tracing data.

Results: The model shows that areas with same hierarchical levels have large disparities in local infection risk. It also finds that the scaling index can explain the large disparities in local infection risk and further identify superspreading areas that account for the majority of infections. By analyzing the impact of unevenly distributed infections on local hospitals, this work finds large variations in the severity of local hospital strain.

Conclusion: Urban scaling structure is a crucial determinant for the unevenly distributed infections at the local scale, which provides a possible explanation for superspreading phenomena. This study would potentially guide future targeted interventions on superspreading areas and heavily stressed local hospitals to effectively reduce infections and deaths.

Urbanization Monitoring with Big Earth Data – 1

Simulation of the land use changes and potential expanding boundary of a typical village within the heritage site of Honghe Hani Rice Terraces based on the Markov-FLUS model

Yuanmei Jiao.

Abstract. Simulations of land use changes at the small scale of a single village to directly map and control its expanding boundary for specific conservation purposes pose a great challenge to research within related scientific fields. In this paper, a new and powerful spatial visualization prediction model of FLUS was combined with the popular quantitative Markov model to simulate the land use changes of Quanfuzhuang, which is a typical village located in the World Heritage Site of the Honghe Hani Rice Terraces. Land use changes were observed between 2005, 2009, 2013 and 2017 and verified by the model and field observations from 2013. The combined model was used to simulate the village's expansion in the year 2025 with a limiting condition of non-expansion into the rice terraces; this approach was used to help decision makers with managing land use changes and to balance tourism development with heritage conservation. The results show that: (1) In the land use changes from 2005 to 2017, the residential land area constantly increased at the expense of woodlands. (2) The predicted residential land area will increase considerably in 2025 and its distribution will become intensive. (3) The simulated limitation of the expansion of residential land into rice terraces can assist decision makers in land management. (4) The combination of the Markov-FLUS model is a suitable method for precise simulations of small-scale village expansions. The analysing framework can provide important insights

into the spatial governance of residential area expansions and help control land use changes, thereby providing sustainable development for rural world heritage sites

Fine-grained building attribute mapping based on deep learning and a satellite-to-street view matching method

Weijia Li, Dairong Chen, Jinhua Yu and Juepeng Zheng.

Abstract. Street view images (SVIs) are a kind of data with rich semantic information, which have unique advantages in the fine-grained recognition of building land use. Compared with seamless dense remote sensing image data, SVIs are sparse and unevenly distributed in space, which brings many challenges to the application of SVIs for urban mapping. To solve this problem, this study proposes a satellite-to-street data matching method between SVIs and building footprint data. This method first performed dense sampling on the nodes of building footprint vectors, then designed a constraint based on the spatial relationship of cross-view data to match the buildings recognized in SVIs with their corresponding building footprints. Based on the matching results, large-scale building scale land use mapping was conducted in the validation area. The experimental results show that the accuracy of matching can reach more than 80%. The building land use classification in the mapping result reaches an accuracy of 62.15%, 56.41%, and 0.535 for overall accuracy, F1-score, and Kappa coefficient, respectively. This study provides a new technical means for fine-grained urban land use recognition and mapping, which can effectively improve the efficiency of acquiring fine-grained attribute information of urban buildings.

A Density-Peak-Based Clustering Method for Multiple Densities Dataset

Zhicheng Shi.

Abstract. Clustering methods in data mining are widely used to detect hotspots in many domains.They play an increasingly important role in the era of big data. As an advanced algorithm, the density peak clustering algorithm is able to deal with arbitrary datasets, although it does not perform well when the dataset includes multiple densities. The parameter selection of cut-off distancedc is normally determined by users' experience and could affect clustering result.A density-peak-based clustering method is proposed to detect clusters from datasets with multiple densities and shapes. Two improvements are made regarding the limitations of existing clustering methods. First, DPC finds it difficult to detect clusters in a dataset with multiple densities. Each cluster has a unique shape and the interior includes different densities. We adopts a step by step merging approach to solve the problem. Second, high densities of points can automatically be selected without manual participation, which is more efficient than the existing methods, which require user-specified parameters. According to experimental results, the clustering method can be applied to various datasets and performs better than traditional methods and DPC.

MMRSC: A MULTI-MODAL DATASET FOR REMOTE SENSING IMAGE SCENE CLASSIFICATION

Guoqiang He, Jie Li and Menghui Jiang.

Abstract. Remote sensing image scene classification (RSSC) plays a vital role in many tasks and applications. Over the years, researchers have proposed various datasets and RSSC methods. While they have some common disadvantages: 1) The optical images in these datasets are cloudless, which is unable to handle problem in case of cloud 2) These datasets only include optical images and do not consider other modal images, such as Synthetic Aperture Radar (SAR) images. In this paper, we propose a novel dataset named MMRSC, including 7 classes and 4340 labeled images with optical and SAR modal. Based on this dataset, we present an end-to-end multi-modal RSSC method for Cloud Removing and Scene Classification (CRSC) simultaneously. Several experiments have been conducted to prove its effectiveness.

Mobility-based spatial sampling improves the efficiency of detecting emerging infections

Die Zhang, Yong Ge and Shengjie Lai.

Abstract. Efficient detection of emerging infections is paramount for outbreak control and containment of infectious diseases. However, resource-intensive methods such as mass testing pose challenges, especially for severe diseases caused by highly contagious pathogens. This study proposes the integration of heterogeneous human activities in spatial sampling to optimize the allocation of testing resources for detecting emerging infections at the community level within a city. Four spatial sampling approaches, incorporating human mobility patterns from point-of-interest clustering and population flow data, were employed for this purpose. Analyses included two actual COVID-19 outbreaks in Beijing and Guangzhou, China, during 2020-2021, and simulated outbreaks with varying transmissibility, intervention timing, and population density. By utilizing inter-community movement data and initial case locations, the case flow intensity (CFI) and case transmission intensity (CTI)-informed sampling approaches significantly reduced the required number of tests for both real and simulated outbreaks. Specifically, during the Beijing and Guangzhou outbreaks, CFI and CTI detected 85.1% (95% CI: 84.9–85.3%) and 85.5% (85–85.9%) of cases, respectively, while testing only 15.7% and 7.2% of the population. Additionally, the capacity of mobility-based sampling approaches to optimize multi-round mass testing implementation was assessed, demonstrating notable reductions in the number of infected individuals, particularly for emerging highly contagious pathogens. The mobility-based sampling offers a cost-effective solution for the optimal allocation of testing resources and early surveillance of intra-city transmission to contain emerging infectious disease outbreaks in diverse settings.

Urbanization Monitoring with Big Earth Data – 2

Scope Identification and Planning Evaluation of Urban Centers from the Perspective of Spatial Supply and Demand

Yin Dou.

Abstract. Urban centers are the core zones for urban development where resources gather. In practice, an urban center is often a geographical spatial concept, rather than a region with specific boundaries. This brings challenges to the formulation of planning policies, leading to the gap between reality and planning. Therefore, the definition of the scope of urban centers is essential for urban planning and policy-making to improve the radiation capacity of urban centers.

In the existing research, multi-source data is used to elaborate the urban centers, such as buildings, points of interest (POIs), phone signal data, etc, all of which are used to find the differences in spatial texture. These are effective ways to identify the composition and configuration of urban center system. However, the scope and boundaries of them are varying in different methods. Most of the existing studies are based on the development results, and cannot explain the deviation from the planning, so it is necessary to deduce the results from the causes.

This research aims to comb the causal mechanism of the formation of urban centers by taking Wujiaochang subcenter of Shanghai as an example. Using the data of roads, buildings and POIs, its service potential and actual scope are visualized by Urban Network Analysis (UNA) and Geographic Information System (GIS). Then the potential scope, planned scope and actual scope are compared to analyze the difference between them and the reasons. It's found that these 3 dimensions of scope differ from each other, the actual scope of Wujiaochang has partially exceeded its planned scope, and the potential scope is difficult to support the planned scope. Finally, feasible suggestions are put forward to accurately delineate the scope of special policies.

Analysis of the Evolution Characteristics and Production Relations of Industrial Agglomeration Areas: A Case Study of the Electronic Information Industry Cluster in the Pearl River Delta

Aiyuan Lin.

Abstract. As the basic unit of interaction of industrial clusters, industrial agglomeration areas have long been identified by rigid delineation of administrative boundaries. Therefore, this paper uses enterprise big data, building census data, and spatial zoning data of the Greater Bay Area to further identify the spatial scope of industrial agglomeration areas, and based on the industrial value chain through the semantic similarity method defines the types of industrial agglomeration areas, finally explores its evolution process and interaction level from horizontal production relationship and vertical production relationship. Taking the new

generation of electronic information industry cluster in the Pearl River Delta as an example, the study finds that: 1) As of 2020, the Pearl River Delta has formed 1947 industrial agglomeration areas, and the overall evolution direction shows a transformation from manufacturing to R&D and sales. 2) From the perspective of horizontal production relations, the electronic information industry in the Pearl River Delta shows a trend of specialization and division of labor, with Guangzhou and Foshan as the core, focusing on hardware research and peripheral manufacturing; Shenzhen and Dongguan are mainly engaged in core manufacturing, R&D and services. 3) From the perspective of vertical production relations, the interaction relationship between industrial agglomeration areas crosses metropolitan circles and forms a vertical interactive network of industrial chains with Guangzhou and Shenzhen as the core, but the peripheral cities are deficient, and the overall interaction level needs to be strengthened. Compared with the existing research, this paper updates the identification method of industrial agglomeration area, based on the horizontal and vertical production relationship of the value chain, it can provide a more specific and comprehensive evaluation of inter-city industrial interaction.

RFE-LinkNet: LinkNet with Receptive Field Enhancement for Road Extraction from High Spatial Resolution Imagery

Hua Zhang and Hua Zhao.

Abstract. Road extraction from high spatial resolution imagery (HSRI) has been a hot research topic in recent years. Especially the fully convolutional network (FCN)-based methods had achieved good performance in road extraction from HSRI. However, most of these FCN-based approaches suffer from such deficiencies of convolution in losing spatial details, insufficient multi-scale features fusion and lacing long-range dependencies, thus accurately extracting road from HSRI remains a challenging task. To address these challenges, this paper presents a novel neural network, named RFE-LinkNet, which adopts U-shape structure, multiple receptive field enhancement modules and dual attention modules for road extraction task. Based on LinkNet architecture, RFE-LinkNet incorporates receptive field enhancement module and dual attention module in each encoder branches. Specially, to enhance the perception ability of spatial information and long-range dependencies information, the multiple receptive field enhancement module is designed to enlarge the receptive field without reducing the resolution of the feature maps. And dual attention module is provided for capturing accurate features for road extraction by refining multi-scale features from the different-level feature maps in the view of their relative importance. Experiments on Massachusetts road dataset and DeepGlobe road dataset are conducted to evaluate the performance of RFE-LinkNet, respectively. Experimental results indicate that the proposed method achieves the state-of-the-art performance, compared with previous approaches for road extraction, and hence provides an effective approach for road extraction from HSRI.

Deep learning-based remote sensing time-series change detection in urban areas

Haixu He, Jining Yan and Lizhe Wang.

Abstract. In order to clarify the frequent and complex land cover changes in the process of urban development, it is a challenge to obtain accurate change areas, dates and types, but there are currently few models that can span the semantic gap between time series changes and land cover changes. Based on this problem, this study proposes a land cover semantic change monitoring model using the Transformer architecture. In the encoding stage, remote sensing time series features are extracted, and the uneven time series modeling caused by cloud pollution is realized by integrating time coding. In the decoding stage, the land cover type information is introduced, and the continuous semantic recognition of the time series is carried out by autoregressive method, and the change time and type information are obtained at the same time. The method proposed in this paper completely gets rid of the traditional model's dependence on temporal morphological features, and the flexible decoding output can be applied to a variety of change detection scenarios. In this study, the experimental data of Landsat from 2007 to 2022 in Wuhan was used to evaluate the detection results of the model, which greatly improved the accuracy and efficiency compared with the traditional change detection model.

Urbanization Monitoring with Big Earth Data – 3

The Feasibility of 5G Positioning with Multi-beam Signals in Urban Canyon

Ye Su and Liang Chen.

Abstract. The advent of 5G technology has introduced promising opportunities for advancing positioning systems through multi-beam transmission capabilities. This study focuses on verify the feasibility of 5G multi-beams fingerprint localization system in urban canyon. It’s found that geographical heterogeneity of 5G multi-beams signal indicates promising potential for enhancing localization, by collecting the 5G multi-beams signals, a unique fingerprint database is constructed. During the positioning process, the test fingerprints are matched to infer the terminal's location based on the KWNN-DBScan algorithm. Experiments are carried out in typical urban scenario, results show that the positioning error at the 68% confidence level is 7.9m, which shows the effectiveness of the proposed 5G multi-beam fingerprint localization system in real urban canyon.

Understanding changing public transit travel patterns of urban visitors during COVID-19: A multi-stage study

Yuqian Lin and Yang Xu.

Abstract. COVID-19 has caused huge disruptions to urban travel and mobility. As a critical transportation mode in cities, public transit was hit hardest. In this study, we analyze public transit usage of urban visitors with a nearly two-year smart card dataset collected in Jeju, South Korea – a major tourism city in the Asia Pacific. The dataset captures transit usage

behavior of millions of domestic visitors who traveled to Jeju between January 1, 2019 and September 30, 2020. By identifying a few key pandemic stages based on COVID-19 timeline, we employ ridge regression models to investigate the impact of pandemic severity on transit ridership. We then derive a set of mobility indicators – from perspectives of trip frequency, spatial diversity, and travel range – to quantify how individual visitors used the transit system during their stay in Jeju. By further employing time series decomposition, we extract the trend component for each mobility indicator to study long-term dynamics of visitors' mobility behavior. According to the regression analysis, the pandemic had a dampening effect on public transit ridership. The overall ridership was jointly affected by national and local pandemic situations. The time series decomposition result reveals a long-term decay of individual transit usage, hinting that visitors in Jeju tended to use the transit system more conservatively as the pandemic endured. The study provides critical insights into urban visitors' transit usage behavior during the pandemic and sheds light on how to restore tourism, public transit usage, and overall urban vibrancy with some policy suggestions.

Measuring the correlation between urban carbon emissions and heat island: evidence from Shenzhen, China

Lin Jiang, Wei Zhu, Wuyang Hong and Yuxia Kuang.

Abstract. With the rapid development of global urbanisation and the intensification of climate change, such as rising temperatures, the urban heat island effect has become an essential environmental issue affecting human survival and development. As carbon emission is an essential factor that significantly affects the urban heat island effect, measuring the coupling relationship between carbon emissions and the urban heat island can help mitigate the urban heat island effect and achieve the energy conservation and emission reduction goal. Combined with the Shenzhen Statistical Yearbook, this study uses multi-source geographic data (such as night-time light images, land use, building distribution and social economy) and other relevant information in Shenzhen (such as transportation, industrial activities, energy consumption, etc.) to construct a carbon emission calculation model to estimate urban carbon emission intensity. The inversion of the surface temperature of Shenzhen was carried out using Landsat remote sensing images and MODIS surface temperature products to characterise the urban heat island effect. Based on this, this study uses spatial and correlation analysis to reveal the spatial and temporal variation characteristics of urban carbon emissions and urban heat islands and then explores the coupling relationship between them. The results of this study have essential reference significance for alleviating urban environmental problems and promoting low-carbon urban development.

Energy Networks and Urban Environment

Further classification of large-scale façade materials obtained from street-view images

Fan Xu and Man Sing Wong.

Abstract. Distributed solar photovoltaic (PV) harvesting is an effective way to collect solar energy in metropolitan cities. To facilitate the installation of PV modules at solar abundant locations, an accurate estimation of solar PV spatial potential is indispensable. Solar energy could be reflected on high-albedo building surfaces inside the urban canyon. However, using conventional ways to construct albedo datasets for different building surfaces is extremely labor-intense. In previous work, we proposed to use semantic segmentation to identify façade materials from street view images. The materials were divided into six categories: mosaic tiles, ceramic tiles, paint, glass, hybrid, and metal. Due to the distinguishable features between materials like texture and patterns being subtle, identification requires more details from images. However, resolution, insufficient data, and distance from the camera to buildings make it difficult for the model to further classify materials into detailed subclasses. In this work, we propose to use Jensen-Shannon divergence to measure the color distribution similarity between materials in street view images and dataset samples for further classification. We first project the 2D segmentation results from the segmentation network onto the 3D model by the collinearity equation. That makes the pixel-based results converted to building-based results. Then the color distribution of specific buildings can be estimated. Next, we compared the color distribution of the building with the samples in the dataset and calculated their similarity using the Jensen-Shannon divergence. The façade materials will be classified into the sample category with the highest similarity. According to the experimental results, the proposed method can further classify the initial semantic segmentation results into 15 subcategories. This could provide more detailed façade albedo information for solar potential estimation.

A study on the quality of the main entrance of the Chengdu industrial heritage creative industry park under the background of public participation

Kun Wang, Yan Zhu, Juan Ding and Yinan Li.

Abstract. In recent years, there has been a significant adjustment in the industrial structure of cities, with many industrial relics being transformed into emerging industrial agglomeration areas with high added value, such as cultural and creative industry parks. However, during the process of transforming industrial relics into cultural and creative industry parks, the research on cultural and creative industry parks mainly focuses on the parks themselves, neglecting the relationship between the parks and their users, as well as the real demands of the main user groups.

From a public participation perspective, this article explores the quality characteristics of the entrance space of industrial heritage renewal-based cultural and creative industry parks.

Based on previous research, an evaluation index for reusing old industrial heritage was constructed. Combining the characteristics of the entrance space of industrial heritage renewal-based cultural and creative industry parks, an evaluation model for the quality of the entrance space was built using the Analytic Hierarchy Process method. Five actual cases in the main urban area of Chengdu were selected for a quantitative evaluation through a questionnaire survey. The evaluation results were statistically analyzed using SPSS software, and seven optimization strategies for the main entrance were summarized. The aim is to promote the further development of the integration of industrial heritage renewal and cultural and creative industry parks, and to provide a basis for the design of the external space of industrial heritage renewal-based cultural and creative industry parks.

Fund Projects: Key Projects of Natural Science Research in Colleges and Universities in Anhui Province（2022AH051874）, Anhui Xinhua College Research Team Project（kytd202202）& Natural Science Research Key Project of Anhui Provincial Department of Education: Application of BIM-based design management in landscape engineering（KJ2020A0796）Co-financing

The effects of dynamic urban thermal environment on floating photovoltaic electricity generation: A case study in Singapore

Ziyi Huang, Rui Zhu and Linlin You.

Abstract. The utility-scale photovoltaic systems have been widely incorporated to pursue sustainable urban development. However, the fluctuating photovoltaic conversion efficiency (PVCE) influenced by the mutable urban thermal environment engenders an unpredictable variability in electricity generation, thus posing substantial challenges for installed-capacity planning and load-balancing operations. To address this issue, this study presents a PVCE estimation model composed of four hierarchical modules. The first module is dedicated to the retrieval of photovoltaic surface temperatures (PVSTs) from satellite imagery, alongside the collection of meteorological features to encapsulate the dynamic thermal environment. Subsequently, the contribution of each feature to the PVST estimation is accessed through the Mean Decrease in Impurity, Permutation Importance, and SHapley Addictive exPlanations. The third module utilizes machine learning models, specifically the Support Vector Machine, Random Forest, and XGBoost, to construct robust regression analyses between the selected features and PVSTs, thereby ensuring a precise estimation of PVST spatio-temporal variability. Finally, the spatio-temporal corresponding PVCEs are computed, thus providing a more precise annual electricity generation estimation. An exploration of four floating PV systems located in Singapore discovered insignificant variation in their PVCEs throughout the year, which could be potentially attributed to the cooling effects of waterbodies and the region’s stable climate. The proposed model is straightforward and efficient, exhibiting its influence on PV electricity generation estimation in the presence of substantial urban thermal effects.

Integrating Photovoltaic Power Generation in Landfills: A Feasibility Analysis for Economic and Environmental Benefits

Zhang Zichen, Zhang Haoran and Yu Qing.

Abstract. Landfill is one of the most effective methods for managing large amounts of urban solid waste, and has been widely used in various countries around the world. However, landfill sites occupy a large amount of land resources, especially in economically developed cities where land resources are precious, which has caused serious economic losses. Therefore, this paper proposes the idea of constructing photovoltaic power stations in garbage landfills for the first time, which can ensure the amount of garbage landfills while generating considerable economic and environmental benefits. First, we investigate the feasibility of installing photovoltaic power generation in landfills based on detailed technical and economic analysis, and then consider the life cycle process of photovoltaic projects to explore how landfill operators can benefit from it, as well as the potential environmental impact of installing photovoltaic power generation in landfills.. Finally, this study explored the feasibility of installing photovoltaic power generation in other landfills through a specific analysis of a typical landfill. Finally, based on the specific situation of landfills, proposed measures to improve the feasibility of installing photovoltaic power generation.

Assessing Vehicle-to-Grid Potential: A Comprehensive Study on Electric Taxis, Buses, and Private Vehicles in Shanghai

Yu Qing, Zhang Haoran and Zhang Zichen.

Abstract. Vehicle-to-Grid (V2G) technology is widely recognized as a fundamental facilitator for the integration of renewable energy, enhancement of grid stability, and reduction of carbon emissions. Private electric vehicle, electric taxis and electric buses are three common types of electric vehicles that may differ in their potential for V2G utilization. In this paper, an estimation model for Vehicle-to-Grid potential is presented, encompassing three distinct types of electric vehicles. Subsequently, a bottom-up, agent-based model is introduced to simulate the potential variations within the system during different Vehicle-to-Grid events. The validity of this approach is confirmed through comprehensive case studies involving 16,790 electric taxis, 8,567 electric buses, and 2,000 private electric vehicles in Shanghai, enabling an in-depth exploration of the Vehicle-to-Grid potential. The result find that a city's V2G system can potentially provide hundreds of MWs of power during peak hours, with taxis being the most stable contributors. Buses have moderate potential, while private vehicles face challenges due to lower and irregular power contribution and higher costs for achieving significant scale. These insights can guide future V2G strategies and policies for optimizing energy usage and grid stability.

An urban scale optimization of rooftop photovoltaic charging of electric vehicles

Nanfan Ji, Rui Zhu and Linlin You.

Abstract. Distributed photovoltaic (PV) systems are increasingly being used to power a

variety of urban systems, such as electric vehicles (EVs). Although many studies have developed dynamic EV charging prediction and scheduling models, few of them have coupled rooftop PV electricity generation with the spatiotemporal EV charging demands at an urban scale. Thus, this study develops a research framework containing three interconnected modules to investigate the feasibility of EV charging powered by rooftop PVs. The framework is constructed by the statistics of time serial EV charging demands at each station, the planning of rooftop PV installations associated with all charging stations, and the development of a dynamic dispatching algorithm to transmit surplus electricity from one station to another. The algorithm can maximize the overall balance between supply and demand, maximize the total PV electricity generation and minimize the total PV area, minimize the number of PV charging stations used as the suppliers for dynamic dispatch; and minimize the total electricity transmission distance of the PV power station under the condition of the same power supply. The experiment utilizes a complete EV charging dataset containing 5574 charging piles with more than 9.7 million records in June and July in Guangzhou, China. The results show that rooftop PVs can supply more than 90% of the charging demand. The result is encouraging and inspiring us to generalize and promote such a solution in other cities. Future work can refine the algorithm by adapting varying PV sizes into charging stations to further improve the electricity generation capability and the dynamic dispatching efficiency.

Urban Science and Systems – 1

Trajectory-driven urban mobility pattern discovery and route planning

Wei Tu.

Abstract. Transportation is experiencing data and artificial intelligence reform. Massive vehicle trajectories are generated by transport monitoring. However, the value of these trajectories has not been well extracted. This study presents a comprehensive study to reveal the personal pattern and spatial pattern of urban mobility with multi-source trajectory. The spatial-temporal knowledge of these patterns are unraveled. Then, the got knowledge is integrated into a routing planning framework to improve the route choice of taxi drivers or ride-hailing vehicle drivers. The results demonstrate the proposed algorithm will significantly improve the drivers' revenue. These results provide useful insight to fusion trajectory analytic and spatial artificial intelligence for future smart urban mobility.

Identifying global ghost cities based on urban vitality with multi-source data

Ying Long and Yecheng Zhang.

Abstract. With the process of global urbanization, numerous new urban areas have been emerging in rapidly expanding built-up land. However, many new urban areas are inadequately developed at a low socioeconomic level, resulting in ghost cities negative for sustainable urbanization. The overall understanding of global ghost cities is still limited.

Based on multi-source data, this study identifies ghost cities by evaluating 8841 cities on the globe with the theory of urban vitality. The worldwide density of road network, density of points of interest (POIs) and population density are used for measuring urban vitality by morphological dimension, functional dimension and social dimension. The vitality difference of new (developed after 2005) and old (developed before or in 2005) urban areas are then compared to identify ghost cities. The results illustrate a comprehensive map of ghost cities at the global scale. This study shows that the average vitality value of new urban areas accounts for 41.01% of that of old urban areas at the global level, indicating that new urban areas have an obviously lower vitality level than old urban areas, generally. Typical cities including new and old urban areas are specifically validated at the regional, city, and block levels. This study also notes that ghost cities are mainly from the functional dimension. The findings of this study may provide a new perspective for promoting global sustainable urbanization strategies.

The Spatial Evolution Law and Driving Factors of Gradient Expansion of Chinese Cities and Towns

Yuefeng Jiang and Liang Zhou.

Abstract. Urban expansion, as a key process driving the adaptive adjustment and change of the global human land system, continues to drive the changes and reshaping of surface landscapes. The loss of arable land and ecological land in the context of urban expansion is a global phenomenon, and the expansion of towns in the terrain gradient space leads to conflicts of different land types. Therefore, from the perspective of China's county scale, the study analyzes the slope change under the interaction of construction land, ecological land and cultivated land, systematically divides the expansion type combination of cities and towns in slope space, and explores the driving factors of different expansion types with the combination of random forest and geodetector. The results indicate that: (1) The expansion of slope gradient in Chinese urban areas is mainly driven by the construction of land climbing slopes towards the outskirts of towns, with a proportion of 78.18% in all county units. This is mainly distributed east of the Hu line, with 63.76% of cultivated land climbing slopes, and 52.90% of ecological land climbing slopes. (2) Among the nine types of slope variation combinations of three land uses, the proportion of types with simultaneous increase in slope gradient for construction land, cultivated land, and ecological land is 35.73%, and multiple types of gradient expansion are concentrated in the South China region, with geographic concentration indices of three types all greater than 50. (3) The regional topography, topography, and agricultural production intensity are the main driving factors that affect the significant differences in the three-dimensional terrain of urban gradient expansion in China. Characterizing the spatial pattern of urban gradient expansion and exploring its internal mechanism is of positive significance for the rational development of slope land resources, alleviating land conflicts, and promoting sustainable and high-quality urban development.

Exploring Variabilities of Multi-Week Activity-Travel Patterns: A Deep Clustering Approach

Xiao Fu and Zhoujian Yao.

Abstract. A good understanding of activity-travel pattern (ATP) variabilities in transit networks can help government or transit operators improve the accuracy of travel demand forecasts and adjust transport supply. Previous studies on ATP variabilities are often limited to a short period and cannot comprehensively reflect the interpersonal and intrapersonal variabilities. In addition, the traditional clustering methods lack sufficient learning ability for high-dimensional feature space, and clustering variables are simple aggregated indicators. In this study, we propose an ATP inference algorithm that reconstructs multi-week individuals' discrete trips into an ATP, and the ATP is modeled as stochastic process. Indicators considering travel time, number of trips, and ATP entropy are applied to explore the intrapersonal variability of ATPs. These indicators provide aggregated information of intrapersonal variabilities. We also consider the entropy rate of ATPs as an indicator which takes account of the order in which activities or trips occur. The intrapersonal indicators combined with individuals' ATP are used as the input module of deep clustering approach. Interpersonal variability is investigated by dividing people into groups based on their ATPs through deep clustering approach. The proposed deep clustering was tested using massive smart card data collected from the metro system in Nanjing, China. Finally, four comparative experiments validated that the variabilities investigated by deep clustering approach can help realize a more accurate ATP prediction.

Intra-urban Heterogeneities of Agglomerative Industrial Activities: Spatial-functional Evidence from the China's Greater Bay Area

Zidong Yu and Xintao Liu.

Abstract. Geographic agglomeration of economic activities has long existed in cities that can be alternatively understood as spatial heterogeneity caused by industrial activities at various levels. Despite the previous relevant evidence at regional or municipal scales, scanty attention has been devoted to the heterogeneous nature of agglomerative economic activities given their intra-urban patterns. This study seeks to investigate the intra-urban heterogeneous nature of de facto industrial activities within China's Greater Bay Area (GBA), via the industry-related Points of Interest (POIs). By dividing cities into fine-grained grids, the first step is to employ rank-size and spatial distributions for quantitatively revealing the size and spatial patterns of industrial agglomeration, where apparent decay effects can be clearly observed in all cities. Such patterns suggest a considerable amount of industries tend to concentrate in a few areas of cities. Meanwhile, the utilization of Moran's and GINI index all reveal that industrial activities in cities of the GBA are significantly clustering and concentrated within a small number of areas. Spatial clustering regularities of various industrial functions are then deciphered using association rule mining analysis, helping us to quantify the co-location patterns of industrial functions. Undirected networks are constructed to depict the spatial co-location patterns of various industrial activities. Industrial sectors such as metal material and electronics are featured with a high degree

centrality, which can be considered as the principal industries in cities. Our analytical results also unveil noticeable network characteristics that are distinct among various cities. Practical implications derived from research findings can be beneficial to understand mitigate uneven economic development and intraregional inequalities.

Urban Science and Systems – 2

Enriching the Semantics of CityJSON Road Objects with OpenStreetMap

Rui Ma, Chendi Yang and Xin Li.

Abstract. Semantic 3D city models are highly valuable in geospatial science, computer graphics, and urban studies. As a standardized open format of semantic 3D city models, CityJSON allows for the exchange and storage of semantic models of cities and landscapes. Such semantic information, including fine classification and detailed attributes of city objects, is essential for the application of city models. However, existing city models primarily rely on the model builder for semantic information and lack mechanisms for further semantic enrichment. This study aims to address this issue by exploring how to leverage publicly available datasets to complement the semantics of CityJSON-formatted models, with a specific focus on roads. The proposed method involves mapping CityJSON 3D geometric information to a 2D plane and enriching the semantics by integrating OpenStreetMap data. Two case studies were conducted to test the effectiveness of this approach. Results revealed that the proposed method achieved 100% accuracy in enriched semantics while providing opportunities for more complex compound queries such as querying a complete road or identifying buildings along a specific road. This approach can also be extended to other city objects like buildings, water bodies, vegetations, and so on. Overall, the proposed method represents a promising solution to enrich existing semantic 3D city models with external public data and could help improve their utility in various fields.

Spatial Network Structure and Optimization of Coal-Related Industries in Resource Exhausted Cities

Xiaotong Feng, Ming Tan, Hua Zhang and Jihong Dong.

Abstract. The majority of businesses in resource-exhausted cities that rely on coal as a fuel have a coal mining reserves to recoverable reserves ratio of over 70%. The study uses the typical resource exhausted city of Xuzhou in China as an example: (1) Established the parameters for the spatial gravitational model of the coal-related enterprises. First, assignment of scale, distance, and attributes to 17 coal-related businesses in Xuzhou City, including major, medium, and small coal mines. Second, the specific location of coal-related industries was established by using geographic matching in ArcGIS. Finally, the gravitational model's parameters were updated, and an association model was built. (2)

Analysed the geographic distribution of coal-related industries in resource exhausted cities. On the one hand, we examined the centrality/association, relationship density and frequency, and accessibility of 17 coal-related firms in Xuzhou City. The centrality of the coal-related industries ranged from 2.0 to 8.0 percent, with an average of 5.529. As a result, Xuzhou's 17 coal-related businesses were split up into municipal and Feng-Pei subgroups. On the other hand, according to the results of the cluster analysis of subgroups, came to the conclusion that seven coal-related industries urgently require transformation, including two subgroups under the municipal and five subgroups of Feng-Pei. (3) Optimization of Multi-Energy Network Structure in Xuzhou City. The future development direction of energy enterprises belonging to the municipal subgroup should progressively and orderly withdraw from coal-related industries, and the future development direction of energy companies in production belonging to the Feng-Pei subgroup should be low-carbon-efficient-sustainable, building a multi-energy network steady state. The study aims to form a development scheme path of urban multi-energy complementarity, propose the optimization of the spatial structure of coal-related industries in resource-depleted cities, and provide data models and useful guidance for the development of low-carbon transformation in resource cities.

An Overview of Pre-design Evaluation and Application System for Urban Design based on the RDF Framework

Xinzhe Wang.

Abstract. Cities represent complex and dynamic systems that are influenced by a multitude of continuously changing parameters. Traditional urban design theories and methods have relied on experience and successful design cases to a certain extent. However, the utilization of methods such as surveys and statistics for post-evaluation of urban design introduces inherent delays, leading to significant uncertainties in the design process. The inability to effectively assess urban design outcomes before completion hampers loss prevention, optimization of design and construction processes, and cost reduction. While post-evaluation is valuable for analyzing existing conditions and refining theoretical foundations and methods, this approach is limited in providing customized evaluations for specific urban design projects.

Advancements in artificial intelligence technology, computing power, human flow simulation in complex environments, and the study of environmental psychology now enable us to simulate the usage patterns of urban spaces on a certain scale. However, existing research predominantly focuses on simulating and modeling geometric features of urban spaces, neglecting the description of spatial and contextual meanings, as well as the intricate relationships and interactions among elements within the urban space.

This paper proposes a descriptive framework and application scenarios for a city information model based on the Resource Description Framework (RDF) technology. In addition to the traditional study of geometric topology relationships, we introduce the concept of topological relationships to provide a theoretical foundation for investigating the mutual significance of urban space elements and their interactions with people.

LiDARPro: Intelligent Geographic Scene and Entity Reconstruction Solutions for 3D Real Scene

Yongjun Zhang and Xinyi Liu.

Abstract. 3D Real Scene (3DRS) is a digital virtual space that reflects and expresses human production and ecological space in a real 3D and time-sequential manner, which becomes a new standardized product type of national fundamental surveying and mapping. 3DRS modeling aims to establish a digital 3D space interconnected with real urban infrastructures and provides a unified spatiotemporal information base for urban construction and smart city solutions. However, the efficient reconstruction of super large-scale geographic scenes and the automatic reconstruction of city-level entity models are still obstinate with off-the-shelf methods. To tackle these challenges, strategies considering satellite images, aerial multi-view images, and Light Detection and Ranging (LiDAR) point clouds are researched. To reconstruct geographic scenes, intelligent digital terrain modeling from satellite images is proposed using a hybrid feature-fusion network for satellite stereo matching. For city-level geo-entity model reconstruction, theories and methods of 3D entity modeling are established resorting to the integration of aerial multi-view images and LiDAR point clouds. Firstly, the image and LiDAR are registered and high-accuracy and full-coverage aerial point clouds are generated by LiDAR-guided stereo matching from the registered multi-modal data. Secondly, ground filtering, classification of off-ground objects, and building instance segmentation are successively conducted from space terrain models or aerial point clouds. Finally, the structural building entity models are reconstructed by the robust segmentation of 3D linear and planar primitives from point clouds and a hierarchical LoDs generation algorithm based on structure-constrained triangulation. A 3DRS modeling software system, LiDARPro, is developed integrating with the above strategies, which supports the whole process and fully automatic production of terrain-level 3DRS scenes and city-level 3DRS geo-entity data. Relevant achievements are extensively served in surveying and mapping, urban planning and management, etc., which can assist the construction of 3D real scene of China and lay the foundation for smart city.

The Study on the Construction of the City Information Modeling Platform (CIM platform) Empowering the Entire Process of Planning and Construction Control

Yihui Wu, Shenghao Zhuo and Hui Wang.

Abstract. The City Information Modeling Platform (CIM platform), since being included as an important initiative in China's "14th Five-Year Plan," has provided reliable new technological means for urban planning, urban construction, and management. An increasing number of government departments are exploring how to utilize the CIM platform to reshape and optimize their government process.

Shenzhen experiences a significant contradiction between population and land, with numerous challenges in the development and construction of new areas. These difficulties are often manifested in the synchronization of planning and construction, the coordination

of interfaces between above-ground and underground projects, the involvement of multiple construction entities, and the short construction cycles.

This article examines the workflow and control granularity of managers from urban planning to construction phases and outlines the implementation strategies and effects of CIM technology. Taking the Shenzhen Airport New City CIM Planning and Construction Coordination Platform project as a case study, it discusses the technical aspects of data aggregation repository, data update mechanisms, and data standards. It also explores the government's control requirements in high-frequency workflow such as planning, review, tracking, and early warning, as well as the ease of operation and frequency of data update and maintenance for the CIM platform. Finally, it proposes a planning and construction control process centered around the CIM platform, outlines the relationship between CIM data and data generated during the government workflow, and provides reflections and recommendations on the design direction and depth of the CIM platform in the field of planning and construction.

Urban Science and Systems – 3

City Spatio-Temporal Sensing Base Station: A cyber-physical infrastructure for pervasive sensing in smart city

Dong Chen, Nengcheng Chen, Xiang Zhang, Zeqiang Chen, Wenying Du, Yingbing Liu and Gaoyun Shen.

Abstract. Smart cities and integrated urban sensing are inseparable from highly efficient sensing architecture powered by cutting-edge communication、GIS and urban information technologies. In recent years, the sensing devices applied to city observation have presented a trend of multi-theme multi-platform, multi-protocol. Nevertheless, these massive observation devices result in more critical requirements on self-adaptation and self-organization for collaborative observation at edge-side with real-time observation services. To solve these problems, this research proposes an innovative solution named City Spatio-Temporal Sensing Base Station (CBS), inspired by the Base Stations for cell phones that address similar concerns. The CBS is designed as an edge cyber-physical infrastructure and is considered intermediate between the sensing devices (terminal) and cloud sides. A prototype of CBS was also implemented for the first time. Results and analyses demonstrated that the most valuable feature of the CBS enabled the unified but also readily accessible for heterogeneous sensing devices, including surveillance video, unmanned aerial vehicles, and ground sensor webs. Moreover, the collaborative observation capability was also realized by multi-observation platform based on advanced Sensor Observation Service and Sensor Planning Services that evolving by Sensor Web Enablement. Experiments on traffic accident represented the proposed CSS greatly improved the sensing ability and intelligence analysis level in typical city scenarios. Compared with the legacy method, the CBS significantly reduces the redundant internet connections and latency to the cloud side

while maintaining high efficiency. This innovation provides a strategic exploration to meet the challenge of utilizing massive sensing resources in our city and serves as a cyber-physical infrastructure for the digital twin of cities.

To share or not to share? Revealing determinants of individuals' willingness to share rides through a big data approach

Guan Huang, Ting Lian, Anthony Gar On Yeh and Zhan Zhao.

Abstract. Ridesplitting has been widely recognised as a promising mobility mode for sustainable transportation, but its success largely depends on a sufficient number of passengers who are willing to share their rides. To uncover the determinants of willingness to share (WTS), prior studies typically relied on either individual-level survey-based or aggregate-level data-driven methods. To combine the former's strength in capturing individual choice preferences and the latter's advantage in utilising available multi-source big data, this study proposes a big data approach to modelling individual choices between the solo and shared options for each trip. To reconstruct the choice process, we leverage large-scale real-world trip records and propose a learning framework to not only retrieve the trip time and fare of the chosen option (solo or shared), but also impute the likely time and fare of the alternative option. These reconstructed trip attributes are then integrated with the sociodemographic, built environment and traffic features from other data sources. Finally, all these variables are fed into a random coefficient logit model to reveal passengers' ridesplitting preferences. Through a case study of Manhattan, New York City, we reveal the spatiotemporal pattern of WTS and its determinants. Results show that WTS varies greatly across space and time. The time-fare trade-off is identified as the most essential factor, with the value of time revealed to be about \$28-36/h. WTS decreases with longer trip distance/commuting time/distance to the urban centre, lower road speed, and higher speed fluctuation/bus station/crime density, but increases with a higher proportion of middle-class/female/young residents, residential land use and metro station. The proposed methodology can be used to explain and monitor WTS in a cost-effective way, complementing traditional survey-based methods to better design and promote ridesplitting services.

Data-driven refined modeling of street trees for mobile laser scanning point clouds

Jintao Li, Hangbin Wu, Yanyi Li, Zhihua Xiao and Yuanhang Kong.

Abstract. As an indispensable part of the urban digital twin and smart city framework, the structured and refined model expression of street trees at the branch level has many important applications, such as detection and pruning simulation of branches that blocking traffic signs, street tree structural aesthetic analysis, and digital tourism. However, there is still limited attention paid to street tree refined modeling, and street trees in existing 3D

urban models are often underrepresented (not expressed, expressed using orthogonal images or parameterized models). With the development of laser scanning and point cloud processing, it is possible to perform branch level reconstruction of trees based on laser point clouds. However, due to the complexity of tree structure and the limitation of scanning positions, there are still some challenges in reconstructing complete, refined, and structured models of street trees from mobile laser scanning (MLS) point clouds with data missing and uneven density. Here, a new method for street tree modeling driven by MLS point cloud is proposed. By skeletons extraction and iteratively optimization, the skeletons of small branches and twigs with data missing are restored and the complete and refined topology structure of the tree is reconstructed. By fusing cylindrical primitives with scanned point clouds, the detailed geometric model of tree branches is expressed. The proposed method is tested with evergreen and leafy street tree point clouds. The results show that the proposed method can effectively improve the modeling inaccuracy caused by point cloud missing and density difference, and can effectively reconstruct structured, refined and completed street tree models from MLS point clouds.

Urban Science and Systems – 4

Automatic extraction and modeling of tunnel components based on mobile laser scanning data

Shida Wang and Hangbin Wu.

Abstract. The construction of tunnels can greatly improve the utilization rate of land resources, which is crucial for cities with high population densities and a large number of buildings. However, the operation and maintenance of such urban infrastructures is challenging due to the lack of effective technology to ensure information updates. At present, the increasing use of Building information modeling (BIM) technology has promoted the creation and updating of existing tunnel models. However, the construction of geometric models is time-consuming and expensive. To meet this demand, this research proposes a method for quickly extracting tunnel structures (such as lining, ground), internal infrastructure (rails, platforms, pipelines, etc.), and calculating modelling parameters, and then using mobile laser scanning data to create 3D models for tunnels. This method involves two core operations: point cloud classification and model parameter estimation. Specifically, we develop several classification algorithms based on spatial information such as relative position, geometric features, and intensity features of points to find point groups belonging to each tunnel component. Based on these point groups, the model parameters of each component are estimated to generate the final tunnel model. The experimental results on several operational tunnel datasets show that the proposed method can effectively identify components within the tunnel and achieve high-precision model construction.

Indoor staircase space reconstruction based on local-global combined optimization from point cloud

Junyi Wei and Hangbin Wu.

Abstract. Connectivity space is a vital component of urban indoor environments, responsible for integrating independent spaces at different heights and positions. Accurate models and spatial benchmarks of connectivity space play a significant role in analyzing and simulating urban spatial aspects such as spatial accessibility, emergency response, and comfort analysis. Existing connective space modeling approaches predominantly rely on voxel and grid-based methods, lacking accurate modeling and vectorized representation of staircase elements. Furthermore, the modeling techniques for staircases are limited, lacking automated methods for continuous and curved staircases. To enhance the detailed representation of connectivity space and expand its applications, we propose a super-voxel segmentation-based approach for staircase recognition and clustering within connectivity space. The connectivity space is initially over-segmented using super-voxels, and staircase planes are then extracted based on the geometric attributes of neighboring super-voxels. Subsequently, leveraging prior information about staircase geometry, such as perpendicular, collinearity, and curved shapes, we propose a joint optimization method that combines local and global features. This optimization simultaneously optimized the local primitive of staircase steps and the global primitive of staircase edges, improving both the geometric semantic consistency and accuracy of the staircases. To validate our approach, we conduct staircase reconstruction experiments using our self-owned dataset and the public Matterport dataset, encompassing various types of staircases within connectivity space. The experimental results demonstrate the effectiveness of our method in accurately extracting staircase planes and reconstructing different types of staircases. The combined optimization ensures the geometric semantic consistency aligns with prior assumptions, achieving a geometric accuracy at the centimeter level.

Estimating experienced the daily dynamics of urban polycentric structure in Chinese cities using large-scale human locating-request data

Nan Wang.

Abstract. Securing the orderly and efficient development of urban spatial structure in the face of increasing population and urban size is one important challenge faced by humanity in sustainable development. However, understanding the differences of daily urban dynamic spatial structure characteristics between cities remain in question, especially on a national scale. We developed a novel framework to describe and compare the dynamic polycentric structure characteristics and patterns across 287 cities in China based on the one billion users' historical locating-request data, providing valuable insights into the residents' everyday activities. We introduce the Lorenz curve-city cluster algorithm based on the nature of the Lorenz curve to extract daily dynamic urban human activity centers. Furthermore, we proposed the Trajectory-Polycentricity Graph Model and developed several indices to facilitate modeling, representation, and comparison of polycentric

structure's continuous spatiotemporal processes and patterns among cities. We also explore the relationship between these dynamic polycentric characteristics and commuting efficiency. The findings reveal that small and medium-sized developing cities exhibit more pronounced monocentric urban structures as a whole and are widely distributed in the western and northeastern regions. The Chinese cities' urban structures show regular rhythmic fluctuation characteristics within a day, with 90.3% of cities tending to have more monocentric urban structures during daytime hours. The mean value of intraday structural variability intensity for 287 cities is 0.10, and the strength of urban structure's variability shows strong associations with urban size and specific polycentric structure patterns. Moreover, we find that cities with more polycentric structure and stronger intraday structural stability tend to exhibit higher commuting efficiency. This research makes a substantial contribution to enhancing our comprehension of the disparities in urban dynamic spatial structures at a national scale. It underscores the critical importance of polycentric urban planning and management in fostering efficient commuting and sustainable urban development.

City Network Connections of Greater Shanghai Metropolitan Area Based on Baidu Migration Data

Bin Zhuge, Kaike Li, Mengwei Chen, Juncheng Hong and Siyi Chen.

Abstract. The metropolitan area, as an essential carrier supporting urban development, is the focus of China's next urban construction phase. While existing research on the Shanghai metropolitan area mainly concentrates on business and logistics connections to reflect intercity relationships, population mobility represents the most fundamental connection within the metropolitan area. Measuring population mobility can effectively illustrate the characteristics of intercity connections. However, obtaining reliable population mobility data in the past has been challenged by issues of feasibility, cost, and privacy concerns. This study utilizes Baidu Migration big data, which is low-cost, open, and large-scale, to characterize the intercity connections and network features of various cities within Greater Shanghai Metropolitan Area. Social network analysis is employed to calculate network density, in degree, out degree, and centrality to reflect the spatial network features of Greater Shanghai Metropolitan Area. The research findings reveal that Greater Shanghai Metropolitan Area has developed a city network structure with Shanghai as its core and expanded from Shanghai to Suzhou with an imbalance in the flow of elements within the region. Advices has been proposed that future development in Greater Shanghai Metropolitan Area needs to accelerate the connections of "information flow" and "transportation flow" between cities. It is also suggested to establish a multi-level, multi-centered, and multi-nodal functional system, promote regional synergy and balanced development, and achieve the vision of " coordinated an efficient region with smooth mobility" as envisioned in the "Spatial Cooperative Plan of Greater Shanghai Metropolitan Area".

Multi-Systems Engineering Complexity in Smart Community Development: Evidence from China and USA

Yuan Lai.

Abstract. Understanding contemporary cities as complex physical-cyber-social systems are essential for conceptualizing, designing, engineering, and operating smart city development, especially at the neighborhood and community scale. From a combined view of urban planning and system engineering, this study investigates smart communities' basic configuration and operation as an evolving network that connects various physical, social, and cyber elements to support the human habitat. Focusing on the ongoing development in China and the United States, the discussion further elaborates on the success and challenges of smart community projects, as well as the critical role of data analytics as the technical enabler connecting various sub-systems, processes, and interactions for future city development and innovative urban living.

Urban Science and Systems – 5

A Task-based 3D visualization for life-cycled BIM activities

Chengpeng Li, Renzhong Guo, Shen Ying, Zhigang Zhao and Haojia Lin.

Abstract. Various BIM activities utilize 3D visualization to obtain information are dependent on professional experience in operating 3D models by stakeholder（including architectural knowledge and continuous 3D graphics operation skills）， the transmission of BIM visualization information in the same industry can be easily recognized. For different groups in life-cycled BIM activities, the results of 3D visualization may cause communication obstacles due to knowledge gaps. Creating a reasonable 3D view can establish a bridge for cross group information understanding. This paper designs the GMV framework to generate views from a graphical perspective, thereby avoiding information comprehension errors caused by differences in semantics or knowledge systems. The foundation of GMV is the visualization requirements in a large number of BIM activities. We transform the collected BIM activity intentions into an information transmission process, which is composed of view creators, view representations, and view receivers, refine the essential task of visualization, and propose a 3D View generation flow to build and distribute the BIM activities. Two cases in Shenzhen demonstrate the value and significance of our framework in the application of life-cycled BIM.

A Method for Measuring Network Spatial Structure Based on Trajectory Data: A Case Study of Harbin's China Baroque Historical Block

Haixuan Zhu, Zixuan Zhao, Cuiling Wu and Xiaoyu Hou.

Abstract. Cities are the material spatial carriers of human activities, and structure is the foundation and key to forming urban spatial cognition and organization. However, the

widespread dissemination of social media information has guided people's spatial use behavior and spatial cognition, leading to changes in crowd behavior and ultimately resulting in a mismatch between the existing spatial organization and the actual activity space of the crowd. In order to cope with this change, we must seek algorithmic and digital analysis methods to re recognize the patterns of spatial use and behavior from both spatial organization and crowd activities. The spatial structure displays the laws of physical spatial organization, while the trajectory structure characterizes the preferences of population spatial use. Therefore, exploring the similarities and differences between the two structures is necessary for re understanding the logic of human behavior. This paper takes the China Baroque Historical Block as an example. Based on the spatial background data and trajectory data within this range, through digital Analysis of algorithms, the spatial structure and trajectory structure are quantified and graphically expressed, and then the similarities and differences between them are compared. The research results show that there is a significant inconsistency between the spatial structure and trajectory structure, with extreme aggregation of crowd activities and low spatial utilization in the eastern region. This indicates that crowd behavior is jointly regulated by the environmental characteristics of the block and social media information. The spatial measurement method we propose is equally applicable for evaluating structural problems in other types of spaces.

Research on spatial structure of linear history based on trajectory data -- Take Harbin Central Street as an example

Haixuan Zhu, Cuiling Wu, Xiaoyu Hou and Zixuan Zhao.

Abstract. The development of ICT (information and communication technology) has promoted the digital and information transformation of cities and society, and the spatial structure and population behavior have also presented new characteristics. Meanwhile, the development of data analysis technology has also brought new challenges and opportunities for the cognitive and practical research of urban space.

Based on graph theory and trajectory data, this research discusses the similarities and differences between physical space structure and crowd behavior space structure by taking Central Street as an example through comparative analysis. The research design is as follows: First, based on graph theory, the nodes and edges of the Central Street are selected and measured to form a physical space structure. Secondly, based on trajectory data, feature points and spatial flow are extracted to form the behavioral spatial structure of crowd perception. Thirdly, the similarities and differences of the two structures are analyzed from three directions: overall feature, nodes and feature points, edges and space flows. Finally, the factors of human spatial cognition and the rules of spatial behavior under the development of ICT are discussed to provide reference for space optimization.

The results show that there are obvious differences in the spatial structure characteristics of the two. Compared with the physical spatial structure, the behavioral spatial structure is more inclined to the middle position of the whole street - the concentration area of high frequency words and hot words on the network. It can be seen that under the influence of ICT, network information has an increasingly important impact on people's spatial cognition and spatial behavior, and relevant research is of great significance for the construction of cognitive models and spatial optimization strategies.

Exploring Pedestrian Network Choice Behavior between At-Grade and Bridge Networks in Hong Kong using Machine Learning with SHAP Approach

Umer Mansoor, Ho-Yin Chan, Junbiao Su and Anthony Chen.

Abstract. Developing a safe and sustainable pedestrian network is a top priority for transportation planners. Hong Kong has developed a distinctive multilevel pedestrian network consisting of at-grade and grade-separated networks, such as bridges and tunnels, to promote a walkable society. This provides pedestrians with the option to choose their preferred network to complete their journey. To ensure that the pedestrian network effectively caters to pedestrians' needs, it is crucial to understand their network choice behavior, which can be influenced by factors such as pedestrian and trip characteristics, as well as their perceptions of the network. Prior studies have predominantly focused on pedestrian choice behavior between short-span footbridges and at-grade crossings. However, there currently exists a dearth of research exploring the perceptions and network choice behavior of an extensive footbridge network in conjunction with the at-grade network. Using a questionnaire survey, this study investigates pedestrian perceptions of such comprehensive networks and how these perceptions affect pedestrian network choice behavior. To understand the complex interaction effects on network choice behavior, this study adopts machine learning with Shapley Additive Explanations (SHAP) technique. This approach facilitates the exploration of nonlinear relationships among pedestrian characteristics, trip characteristics, pedestrian perceptions, and network choice. The findings have important practical and policy implications for appropriate planning and design of the pedestrian network.

visual attention stepwise guiding augmented representation method of bridge numerical analysis model

Jun Zhu and Jianbo Lai.

Abstract. Conducting structural diagnostic analysis in virtual geographic environment holds profound significance for the lifecycle information management of bridge engineering. The key to realizing this analysis lies in effectively integrating the numerical analysis model of the bridge with the virtual geographic environment. Current research on numerical analysis of bridge structures faces issues such as handling large volumes of data, requiring strong domain-specific expertise, and lacking spatial correlation. These problems result in oversimplified visualization content of the numerical analysis results, low rendering

efficiency, and consequently, reduced user comprehension of the results. To address these issues, first. the paper establishes a method for integrating the bridge numerical analysis model with the 3D geographic scene based on spatial relationship constraints, and designs a dynamic dispatching and lightweight optimization method for the bridge stress numerical analysis model, enhancing the overall rendering frame rate of the numerical analysis results in the 3D scene. Second, we construct a step-by-step guided enhancement visualization method for the bridge numerical analysis model, which increases the efficiency and accuracy of user cognition for bridge stress information. we develop a prototype system and select a case study area for the fusion modeling and enhanced visualization experiment of the bridge numerical analysis model scenario, confirming the effectiveness and feasibility of our method. The method proposed in this paper enables the rapid modeling of bridge numerical analysis models and deep integration with virtual geospatial environments, thus contributing to the enhancement of intelligent management throughout the entire lifecycle of bridge engineering projects.

A building skeleton theory for compact building reconstruction and 3D urban morphology abstraction from urban-scale reality capture data

Yijie Wu, Anthony G.O. Yeh and Fan Xue.

Abstract. In the smart city era, compact 3D building representations at urban scale are demanded for processing increasingly available reality capture data to urban informatics. However, the 3D reconstruction of lightweight building models and extraction of 3D morphology features from raw huge-volume 3D data is still a challenge, especially for complex and dense urban scenes. Existing methods emphasized low-rise or low-density urban scenes and failed when processing complex urban scenes, because these methods did not guarantee or reconstruct the global structures of buildings.

Our recent study defines a novel Building Section Skeleton (BSS) theory to parametrically describe and systematically generalize the geometry and design patterns of buildings for complex urban scenes. As an analogy of animal skeletons, BSS represents the perceived 3D medial axes/planes of buildings and reflects architectural design regularities, i.e., symmetry, parallelism, orthogonality, planarity, and repeatability. The BSS segments intuitively decompose the building boundaries into volumetric parts, of which the connections and patterns empower BSS to parameterize and categorize various buildings' 3D geometries. The global structures of buildings are thus internalized in BSS, enabling robust compact reconstruction and pattern abstraction. Our two-stage building reconstruction based on BSS has validated the claimed merits. Experiments confirmed that the BSS method for building reconstruction simultaneously pushed the knowledge frontiers in terms of four evaluation metrics, including compactness, robustness, geometry accuracy, and efficiency, against four state-of-the-art methods in contrast. Beside of compact building reconstruction, BSS also sketches a new paradigm of automatic abstraction of 3D urban morphology. We believe that BSS can serve as an expressive 3D morphology descriptor of buildings and a new perspective from urban informatics and smart city applications, e.g., automatic clustering building design styles in a city and generating new urban blocks with the city's local design

styles.

Urban Sensing for Smart City – 1

A prior knowledge guided deep learning method for building extraction from high-resolution remote sensing images

Ming Hao, Shilin Chen, Huijing Lin, Hua Zhang and Nanshan Zheng.

Abstract. Traditional deep-learning-based building extraction methods from high-resolution remote sensing images have poor interpretability and insufficient generalization ability. Therefore, a novel building extraction model BPKG-SegFormer is proposed, that combines prior knowledge of buildings with data-driven methods. This model utilizes prior knowledge of buildings in high-resolution remote sensing images to construct an attention module for building texture features and an optimization module for building shadow loss for optimizing building extraction. The experimental results show that the proposed model outperforms FCN, Deeplabv3+, and SegFormer models on the WHU building dataset, with accuracy, precision, recall, and average intersection to union ratios of 96.82%, 89.53%, 94.15%, and 76.41%, respectively. The proposed BPKG-SegFormer model can extract buildings with more regular shapes and accurate edges, with very few voids inside the buildings.

Quantifying Urban Colors and Emotions with Street-view Image and Deep learning

Dingyiqi Li, Lv Zeng, Tongxin Liao, Chengji Zhu and Wei Tu.

Abstract. Color is a unique element of urban landscape, which that not only shape the city imagery, but also influences the emotional perception of city residents. However, previous studies have paid limited attention to quantify the spatial distribution of colors in the city and the associate human emotions. To fill this gap, this study presents a street-view image (SVI)-driven framework to sensing colors and quantify human emotions. Massive SVIs are collected and segmented with deep learning. Machine learning were used to extract primary colors in SVIs. Deep neural network were trained to quantify the relationship between color and emotions. The color distribution and the correlated emotion were analyzed. An experiment in the Luohu District, Shenzhen were conducted to verify the presented framework. The results found that the downtown of the Luohu District are dominated by the color gray and black, while the eastern Luohu is primarily green with additional vibrant hues. Regarding human emotions, disordered high values exhibit spatial clustering on Yanhe South Road and Shennan East Road, while tedious high values gather along Luosha Road. Comfortable low values demonstrate spatial clustering on Shennan East Road and Aiguo Road, while happy low values gather in Luosha Road and Aiguo Road. People will feel the disordered when they are in the street with multiple urban color tones. They will feel

comfortable in the street with a single dominant hue and feel happy in the bright street with a wide variety of hues. This study provides valuable insights into spatial distribution of urban color and the associated human emotions, which can also inform urban color planning and design strategies for more emotionally friendly cities.

Enhanced Indoor Positioning through Human-Robot Collaboration

Zhou Baoding, Tang Mengyuan, Zhong Xuanke, Liu Xu and Li Qingquan.

Abstract. Indoor positioning is a critical component for numerous applications and services. However, GNSS systems face challenges in delivering accurate positioning information in indoor environments. Current indoor positioning research primarily concentrates on enhancing the positioning performance of individual terminals through various techniques, including multi-source data fusion positioning, integration of dedicated positioning modules, and scenario enhancement. As we transition into the era of the Internet of Things, it is evident that these traditional techniques could benefit from further refinement. In this context, the emergence of human-robot collaboration shows the possibility for more comprehensive and advanced positioning solutions.

This paper introduces a novel approach to indoor positioning that capitalizes on the potential of utilizing indoor robots as mobile base stations. The main concept behind this approach is to address the prevalent problem of inadequate fixed base stations in indoor environments. Furthermore, it aims to enhance indoor positioning performance by integrating pedestrian inertial navigation data. Firstly, the mobile robots perform self-localization to determine their own positions accurately in the indoor environment. Secondly, pedestrians utilize the PDR technique on their smartphones, combined with UWB distance measurements from the robots, to estimate their own positions. To ensure consistency between the coordinate systems of the robots and pedestrians, coordinate transformations are performed. Lastly, an Extended Kalman Filter (EKF) is applied to fuse the multiple sources of data, considering various sources of errors, resulting in enhanced and integrated positioning.

Experimental results demonstrate the capability and effectiveness of our solution to indoor positioning difficulties, grounded in human-robot cooperation. Numerous scenarios involving robots could benefit from this method, enhancing pedestrian positioning accuracy and system robustness. This paper will offer a comprehensive exploration of this proposed method, its implications, and suggest potential directions for future advancements.

Knowledge transfer with limited labels in urban remote sensing semantic segmentation

Xiaokang Zhang and Weikang Yu.

Abstract. Semantic segmentation from remote sensing imagery has long been intensively investigated for urban land monitoring and management. In recent years, deep learning models have achieved great success in semantic segmentation due to their ability to mine representative features and spatial relationships from image data. However, when limited

labeled samples are available for model training, these models will encounter weak representative capability and severe performance degradation. To address this issue, we develop novel learning and optimization approaches for knowledge transferring with limited labels. First, we propose a prototype-guided progressive learning (PGPL) approach to transfer semantic segmentation models from the source domain with limited labeled samples to the large-scale unlabeled target domain with high data heterogeneity. A near-to-far adaptation scheme is proposed to gradually align the representation distributions of all data in the target domains with the source domain in an adversarial learning framework, considering various feature discrepancies. The prototype learning is fully exploited to generate reliable pseudo-labeled samples to aggregate representations across domains using a cross-domain prototype consistency loss to reduce the intra-category representation variance and improve the discriminative capability of representations. Second, we propose a weakly supervised local-global anchor guidance network (LGAGNet) using image-level labels to reduce labeling efforts. LGAGNet excavates rich semantic contexts across images through anchor aggregation to recognize more accurate object localization regions. Finally, we propose a novel federated learning scheme with prototype matching (FedPM) to collaboratively learn a richer deep model by leveraging remote sensing data distributed among multiple clients. This scheme conducts the federated optimization of deep models by aggregating knowledge in the gradient space from remote sensing data distributed among various institutions without compromising data privacy. Extensive experimental results derived from aerial and satellite image datasets verify the effectiveness of our approaches in urban remote sensing semantic segmentation using labeled samples.

An image captioning method with improved attention for road states of the urban

Fanyu Liu, Yaohua Yi, Yinkai Liang and Ziwei Tang.

Abstract. With the advancement of remote sensing technology, high-resolution remote sensing images are widely applied in many various fields. The accurate understanding of urban road status is the foundation of smart cities, and there is relatively little research on image description of urban road conditions. In order to obtain a deeper understanding of the urban roads and contribute to the development of smart cities, we propose an attention mechanism based on the remote sensing image description method for the road status. Firstly, we utilize the information about the position and the class of image objects to improve the image feature performance and to propose a position enhanced image feature extraction method. Then, we propose an improved self-attention mechanism to further enhance the significance of the goals and enhance the internal connections between the goals. Finally, we propose a cross modal mapping method between visual features and language descriptions by studying the cross-modal alignment of the image visual features and language descriptions, which can achieve the generation of remote sensing image descriptions. The experimental results indicate that our method can accurately describe the state of urban roads in the dataset which can help the smart urban control the urban road status.

Urban Sensing for Smart City – 2

Scene Text Image Super-Resolution Fusing Semantic Segmentation and Content Perceptual

Ying Zhou and Yaohua Yi.

Abstract. In urban scenes, street text images often contain rich semantic information, which is a key clue to perceive and understand the scene. Recovering high-resolution text images from low-resolution ones is a challenging task due to the complex background of street scene text images with irregular text shapes, blurred images, and distorted deformations. Existing approaches mainly use recurrent neural networks to mine text-specific contextual information, which cannot effectively capture long-range correlations in text images and fail to effectively exploit semantic information of text images. In addition, they tend to have weak generality when dealing with cross languages. To address the above problems, we propose a scene text image super-resolution method that fuses semantic segmentation and content perceptual. The separation of text and background regions in street scene images is achieved by semantic segmentation, which enhances the model's focus on text regions and improves the modeling effect on text. Content perceptual supervises the content semantics of text reconstruction using multi-scale text recognition features, thus effectively incorporating content perception into the framework. In addition, this paper also uses Swin Transformer to implement feature extraction for street scene images, which reduces the number of parameters of the model. Experiments on the benchmark TextZoom dataset show that the proposed method not only achieves state-of-the-art performance in PSNR/SSIM metrics, but also significantly improves recognition accuracy in downstream text recognition tasks. Experiments on the benchmark TextZoom dataset show that the proposed method not only achieves state-of-the-art performance in PSNR/SSIM metrics, but also significantly improves recognition accuracy in downstream text recognition tasks.

Evaluation of BDS-3 positioning performance with broadcast ephemeris

Mengni Zhang, Wenyu Guo, Cheng Yang, Zhouzheng Gao and Zhuo Zhang.

Abstract. The BeiDou Global Navigation Satellite System (BDS-3) is a global satellite navigation system independently developed by China. It provides high-precision positioning, navigation, and timing services. BDS-3 broadcasts five signals include B1I, B1C, B2a, B2b, and B3I. This study first performs a comprehensive analysis of pseudorange positioning performance worldwide with different frequency combinations, namely B1I/B3I, B1C/B3I, and B1C/B2a. The results indicate that BDS-3 achieves higher positioning accuracy in Africa, Asia, Europe, Antarctica, and Oceania, while the accuracy of those is lower in South America and North America. Among the three selected frequency combinations, B1C/B2a demonstrates the best positioning accuracy, followed by B1C/B3I and B1I/B3I. In addition, the signal-in-space range error (SISRE) comparison between broadcast ephemeris and final products from GFZ is carried out. The results indicate the broadcast ephemeris orbit accuracy is comparable to that of precise orbit. The SISRE of the

broadcast orbit has root mean square (RMS) value of 0.536 m and the standard deviation (STD) is 0.261 m. The broadcast clock offset, on the other hand, exists an hourly discontinuity, and results in a relatively large STD of 0.672 ns. Furthermore, the performance of PPP with broadcast ephemeris is studied, the positioning accuracy of which is limited by the update period of ephemeris. In this study, we construct a Kalman filter with systematic parameters to improve the positioning accuracy of broadcast ephemeris PPP. Eight IGS MGEX stations are selected to verify the proposed algorithm. The results indicate that an average three-dimensional root mean square error (RMSE) of 22.8 cm can be obtained by the proposed algorithm while that of the normal method is 117.7cm.

Analysis of the External Attractiveness of Shanghai Urban Functions Based on the Travel Characteristics

Peiling Li, Yuhan Yu, Zeyu Wang and Feng Zhang.

Abstract. The external attraction of urban functions refers to the ability of specific urban functional areas to attract foreign populations, which can reflect the importance of urban functions in the regional and even global scope. Existing research tends to discuss urban attraction at the macro level. Thus, the detailed descriptions of urban functional attraction and real human activities are insufficient. The interpretation of urban function attraction from the aspect of travel characteristics reveals the distribution and preference of foreigners, contributing to the sustainable development of cities. We combined POI data and cellular signaling data to identify urban functional areas and people's travel patterns in Shanghai from human perceptions. We use the I-index to quantify geographic flow information to reflect travel characteristics and evaluate the external attractiveness of Shanghai's functions. The results show that Shanghai’s urban functional area presents a "ring" distribution with the city center as the core. The highest population concentration is in the central business district (CBD) and gradually decreases outward. The overall external attraction also presents a gradual decrease from the center outward. At the same time, the regional sub-center of Shanghai also has a high value of external attraction. Universities, well-known business districts, industrial districts, and famous tourist spots are the leading functional factors of high external attractiveness. In addition, there is a certain difference in the attractiveness of urban functions to local and foreign populations. The high-value area of externality, that is, the area where the proportion of foreign populations is especially high, is located outside the center with a “ring-radial” distribution. Our research provides valuable insights into Shanghai’s global city vision and lays a scientific foundation for future urban development and planning.

Initial Evaluation of Indoor Pseudolite Real-Time Positioning Involving Only the Smartphone Receiver

Xiangchen Lu, Liang Chen and Nan Shen.

Abstract. With the rapid development of society economy and information service, people's demand for indoor positioning is gradually increasing. However, Global Navigation

Satellite System (GNSS) signals have difficulty penetrating buildings and cannot provide effective positioning services indoors. As a supplement to outdoor GNSS signals, pseudolites have achieved good results in various scenarios, and have become one of the research hotspots in the field of indoor positioning. In indoor positioning based on pseudolites, it usually focuses on issues such as initial position determination, carrier phase integer ambiguity resolution and so on. However, post-processing of data and complex calculations have caused most of the current studies to remain in the research stage. In order to avoid the limitations of the above factors, this paper proposes a real-time indoor positioning method based on pseudolites single strength that only involves smartphone reception. Thanks to the smartphone's built-in GNSS chip, it can effectively obtain pseudolites signal information. A simple signal attenuation model is established by using the distance and received power between the pseudolites and the smartphone receiver. The simple and low-complexity model and the TDOA positioning method can quickly obtain the user's position. In this paper, the effectiveness and low complexity of the method are verified through data collection and experiments in the actual scene of the underground garage. After preliminary analysis, its navigation and positioning accuracy is sufficient to meet the needs of daily life. It provides a new idea for fast and effective pseudolite-based indoor positioning of in the future.

Research on Urban Green Space Distribution of Multi-Perspective

Jiayu Yan and Huiping Liu.

Abstract. Traditional urban green space evaluation uses indicators such as percentage of greenery coverage. However, as more attention is paid to the people-oriented concept in urban construction, indicators obtained from the overhead perspective gradually cannot represent the cognition and demand for green space. Green View Index (GVI) is an index that measures people's perception of green space in the environment.

In this paper, a comparative analysis of GVI distribution based on street view image and urban vegetation type distribution based on remote sensing image SPOT was carried out to explore the difference of urban green spatial distribution in the Fifth Ring Road area of Beijing from the perspective of human-oriented and overhead looking, and to propose an improvement plan for urban greening construction. The street view image is obtained by using 250m grid as a unit. 10,912 Street View images were used, corresponding to 2,728 samples. Through image segmentation technology, the sum of the proportion of ground objects contained in green space in the images was calculated to obtain the GVI of a single image, and the average GVI of all street view images corresponding to the sampling point was calculated to obtain the sampling point GVI. The viewing direction rate of GVI (VDRGVI) was established to analyze the effects of vegetation on GVI on both sides of the road. A comparative analysis of the distribution space of GVI and green space coverage rate was carried out. The results show that green comfort zone is 65.27%, the green focus area is 9.0% and the improved green areas is 25.73% of the number of analysis grids. Analyzing the causes of low green space coverage but high GVI is helpful to improve urban greening and enhance people's green perception in the city.

Research on the Strategy of Establishing a "Cool Corridor" of City Block Based on Mobile Pedestrian Perception

Tingting Liu, Xiaoyi Wen, Zhijing Liu, Zijing Wang and Xuening Wang.

Abstract. The accelerated expansion of the city and the change of climate conditions have caused the continuous enhancement of the Urban heat island effect. In the context of achieving the Sustainable Development Goals, it is of great significance to improve the urban thermal adaptation and mitigation capacity, improve the comfort and use efficiency of public space, and enhance the vitality of street space for the construction of sustainable cities and communities. At the city block scale, establishing a green infrastructure system consisting of waterways, greenways, and parks has become a widely adopted detailed planning strategy. However, the stability and sustainability of cooling cannot be maintained, and its role in enhancing the efficiency of public space use and the vitality of the block is limited. Therefore, based on multiple identification and evaluation methods, this study establishes a continuously connected "cool corridor" through cooling strategies such as greenery, shading, and adaptive activities, and proposes a new method for block scale high-temperature adaptability planning. Taking the central city of southern Yunnan in Honghe Prefecture, Yunnan Province, China, which has a significant high-temperature environment, as the research object, multiple data were used to identify areas with significant heat island effects. Through mobile pedestrian perception methods and land constraints, the activity path of a multi scenario "cool corridor" was designed, and establishing an evaluation model to theoretically predict the comfort and usage efficiency of the cool corridor strategy before and after its application. Results show that various scenarios of cool corridor can increase physical comfort to varying degrees, improve the willingness and efficiency of public space use. Cool corridors can be an effective strategy for high-temperature adaptability planning.

Urban Sensing for Smart City – 3

Subpixel change detection based on abundance optimization for remote sensing images with fine spatial and temporal resolutions

Zhenxuan Li.

Abstract. In recent years, land cover change detection (LCCD) has become a research hotspot in remote sensing. To achieve LCCD with both fine spatial and temporal resolutions from remote sensing images, subpixel mapping-based approaches have been widely studied in recent years. The fine spatial but coarse temporal resolution image and the coarse spatial but fine temporal image are used to accomplish LCCD by combining their advantages. However, the performance of subpixel mapping is easily affected by the accuracy of spectral unmixing, thereby reducing the reliability of LCCD. In this paper, a novel subpixel change detection scheme based on improved abundance values is proposed to tackle the

aforementioned problem, in which the spatial distribution of fine spatial resolution image is borrowed to promote the accuracy of spectral unmixing. First, the coarse spatial resolution image is used to generate the original abundance image by the spectral unmixing method. Second, the spatial distribution information of the fine spatial resolution image is incorporated into the original abundance image to obtain improved abundance values. Third, the fine spatial resolution subpixel map can be generated by the subpixel mapping method using the improved abundance values. At last, the fine resolution change map can be obtained by comparing the subpixel map with the fine spatial resolution image. Experiments are conducted on a simulated dataset based on Landsat-7 images and two real datasets based on Landsat-8 and MODIS images. The results showed that the proposed method can effectively improve the performance of LCCD.

Indoor Positioning with Multi-beam CSI of Commercial 5G Signals

Xin Zhou, Liang Chen and Yanlin Ruan.

Abstract. The fifth-generation (5G) network has been deployed for a vast number of users. The advanced capabilities of 5G technology have opened up opportunities for accuracy positioning and navigation. However, when it comes to indoor positioning using commercial 5G signals, there are persistent challenges. One particular challenge arises from the fact that in numerous indoor scenarios, there is only one base station (called gNB) heard from the receiver. This limitation makes the traditional geometric methods difficult to be applied indoors for 5G positioning. To solve the problem of indoor positioning with single 5G gNB, we propose a fingerprinting method based on the multi-beam of 5G downlink signals. This method utilizes the multi-beam Channel State Information (CSI) and employs an Extreme Learning Machine (ELM) for dimensionality reduction, aiming to improve both the accuracy and efficiency of indoor positioning. To assess the effectiveness of this method, field tests were conducted in different indoor scenarios. The results demonstrate that, by taking the advantages of multi-beam property in 5G signals, it is able to achieve the mean absolute errors of positioning within 1.55 m. The proposed method effectively enhances the positioning performance of 5G, providing an efficient solution for 5G positioning in indoor single base station scenarios.

Low-cost online real-time surveying and mapping technology of unmanned aerial vehicles

Xiongwu Xiao, Deren Li, Zhenfeng Shao, Bingxuan Guo, Huayi Wu and Jianya Gong.

Abstract. Real-time and high-precision UAV photogrammetry technology can meet the urgent needs of various fields such as rescue and disaster relief, emergency response, military investigation, border inspection, Land Surveying and Mapping. This paper proposed an online real-time surveying method for UAVs based on SLAM technology, which has addressed the complex processing process, poor real-time performance, low intelligence and high-cost of the traditional UAV photogrammetry technology, as well as

the problem of non-planar scene distortion in existing real-time image stitching methods. The method utilizes high-precision GNSS/RTK technology, visual SLAM fused with complementary invariance features, and an adaptive selection keyframe pose optimization strategy based on GNSS assisted bundle adjustment and improved loop detection to achieve high-precision real-time pose reconstruction of UAV images without any ground control point; Utilizing high-precision real-time dynamic construction and optimization strategies for 3D Meshing based on dynamic 3D points, as well as dynamic texture mapping technology, to achieve real-time generation of DSM/DEM/DOM. The main innovations are as follows: (1) According to the characteristics of UAV image data, a filtering method of fuzzy and redundant frames is proposed, which effectively improves the robustness and efficiency of the SLAM system. (2) To address the problem of non-planar scene distortion in existing real-time image stitching methods, considering the dynamic characteristics of SLAM map points, a strategy of dynamic insertion, adjustment and deletion of Delaunay triangulation vertices is designed, which realizes online real-time dynamic generation of Mesh/DSM/DEM/DOM. The experimental results show that the proposed method can generate DSM/DEM/DOM products in real time on the UAV airborne computing platform, the real-time generated DOM with an average accuracy of 0.16 meters.

OmniCity: omnipotent city understanding with multi-level and multi-view images

Weijia Li and Jinhua Yu.

Abstract. In this work, we propose OmniCity, a new dataset for omnipotent city understanding from multi-level and multi-view images. More precisely, the OmniCity contains multi-view satellite images as well as street-level panorama and mono-view images, constituting over 100K pixel-wise annotated images that are well-aligned and collected from 25K geo-locations in New York City. To alleviate the substantial pixel-wise annotation efforts, we propose an efficient street-view image annotation pipeline that leverages the existing label maps of satellite view and the transformation relations between different views (satellite, panorama, and mono-view). With the new OmniCity dataset, we provide benchmarks for a variety of tasks including building footprint extraction, height estimation, and building plane/instance/fine-grained segmentation. Compared with the existing multi-level and multi-view benchmarks, our OmniCity contains a larger number of images with richer annotation types and more views, provides more benchmark results obtained from state-of-the-art models, and introduces a novel task for fine-grained building instance segmentation on street-level panorama images. Moreover, OmniCity provides new problem settings for existing tasks, such as cross-view image matching, synthesis, segmentation, detection, etc., and facilitates the developing of new methods for large-scale city understanding, reconstruction, and simulation. The OmniCity dataset as well as the benchmarks are available at https://city-super.github.io/omnicity/.

Building instance segmentation of street view imagery using large deep learning models

Yizhen Yan, Bo Huang, Weixi Wang and Renzhong Guo.

Abstract. Building instance segmentation enables precise detection and localization of individual buildings, facilitating detailed analysis of urban environments and the creation of realistic 3D city models. It supports various applications related to urban planning and management. However, in the segmentation of street view images, buildings are often treated as background and not individually segmented, posing a challenge. The scarcity of annotated data with building instance labels further complicates the task.

To address these challenges, this research integrates large deep learning models, specifically the segment anything model (SAM), for building instance segmentation. The approach involves the use of an object detection model called Grounding Dino to obtain the bounding box of a building. Subsequently, SAM is employed to segment the building within the obtained bounding box. Since buildings can be partially obscured by objects like trees, vehicles, and street lamps, the resulting building masks may exhibit irregular cavities or holes. To mitigate this issue, image inpainting techniques using stable diffusion models are applied to remove occluding items and enhance the integrity of the masks. Additionally, a post-processing step is implemented to refine the boundaries, improving their regularity and alignment with real edges.

Experiments conducted on real street view images demonstrate the effectiveness of the proposed method in detecting and segmenting individual buildings. However, the boundary refinement process may encounter challenges in complex scenes, which warrants further investigation in future studies.

Urban Sensing for Smart City – 4

A novel land cover-to-land use method to map clustered rural settlements from Landsat images incorporating semantic information

Yan Wang, Xiaolin Zhu and Tao Wei.

Abstract. Clustered rural settlements are a main type of land use consisting of many land cover components, which provides living space for rural populations. Landsat provides us with the longest satellite image archives with a spatial resolution of 30 meters, which can help us understand the spatiotemporal dynamics of rural settlements caused by environmental factors or policies. However, the ability of existing Landsat-based land cover products is limited, as they can only detect some scattered houses rather the complete spatial structure of these settlements. Therefore, we proposed a novel method called the hierarchical land cover-to-land use (C2U) method to map clustered rural settlements from Landsat imagery. The key innovation of the method is to transform the pixel-level land cover map (Phase 1) to the object-level land use map (Phase 2) by incorporating semantic information

among land cover objects. Our results showed that the C2U method outperformed compared Landsat-based land cover products, with F1 scores ranging from 0.81 to 0.89 across five globally selected experimental areas. The average F1 score for the five areas improved by 20 percent compared to the products. This study demonstrates the feasibility of using semantic features among land cover objects to map clustered rural settlements based on Landsat imagery, which can support the long-term dynamics research on rural settlements.

Human labeling errors and their impact on ConvNets for satellite image scene classification

Longkang Peng, Tao Wei and Xiaolin Zhu.

Abstract. Convolutional neural networks (ConvNets) have been successfully applied to satellite image scene classification. Human-labeled training datasets are essential for ConvNets to perform accurate classification. Errors in human-labeled training datasets are unavoidable due to the complexity of satellite images. However, the distribution of human labeling errors on satellite images and their impact on ConvNets have not been investigated. To fill this research gap, this study, for the first time, collected real-world labels from 32 participants and explored how their errors affect three ConvNets (VGG16, GoogleNet and ResNet-50) for high-resolution satellite image scene classification. We found that: (1) human labeling errors have significant class and instance dependence, which is fundamentally different from the simulation noise in previous studies; (2) regarding the overall accuracy of all classes, when human labeling errors in training data increase by one unit, the overall accuracy of ConvNets classification decreases by approximately half a unit; (3) regarding the accuracy of each class, the impact of human labeling errors on ConvNets shows large heterogeneity across classes. To uncover the mechanism underlying the impact of human labeling errors on ConvNets, we further compared it with two types of simulated labeling noise: uniform noise (errors independent of both classes and instances) and class-dependent noise (errors independent of instances but not classes). Our results show that the impact of human labeling errors on ConvNets is similar to that of the simulated class-dependent noise but not to that of the simulated uniform noise, suggesting that the impact of human labeling errors on ConvNets is mainly due to class-dependent errors rather than instance-dependent errors.

Large-Scale Urban 3D Sensing of Micro-weather and Pollutions in Micro-Environments: A Feasible Approach for Massive Monitoring of Physical Environment in a Smart City

Yau Yuen Yeung, Yan Yang and Chi-Chiu Cheung.

Abstract. To collect data in urban informatics for improving urban planning and advancing urban studies or urban science, the traditional approaches often employ satellite remote sensing equipment. Their main limitations are that they are expensive, rather low spatial resolution, long time interval for data update and lack of altitudinal profile. For monitoring and dealing with environmental problems in a smart city, it is highly necessary to collect

various environmental parameters of micro-weather and pollutions in micro-environments (e.g. outdoor concentration of particulate matters and carbon dioxide, noise level, ambient lighting at night, surface temperature of land and buildings) in thousands of locations at land surface and above as there are many high-rise buildings. As driven by our recent invention of a low-cost (~USD100 each), handy and easy-to-deploy device called UEI (Urban Environmental IoT) logger, a feasible large-scale implementation scheme is proposed to package it as a citizen science event for STEM education to engage a few thousand participants, including students (from a hundred secondary schools and higher education institutes), working adults and retired elderlies (through collaboration with various social service organisations). The event includes (1) online self-learning of basic concepts in computational science, urban science and informatics, (2) on-site self assembling of an UEI logger by each participant and (3) deployment and maintenance of the logger in each participant's home or working place. Despite of voluntary participation, an importance sampling strategy will be employed to select the locations of schools and other partners. Each UEI logger will automatically and continuously collect specific types of environmental data and upload them to a server for open public access. Urban researchers and planners can use that big data for not only monitoring the present environmental situation but also predicting future/extreme scenarios by extracting real-world parameters for refining their computer simulation models.

Cross-Scene Land Use Classification Based on Open Set Domain Adaptation

Zhendong Zheng and Yanfei Zhong.

Abstract. The goal of remote sensing image scene classification task is to automatically assign semantic labels for remote sensing high resolution images. However Due to the different natural imaging conditions and economic development of high-resolution remote sensing images across regions, there are distribution discrepancy. Recently, to diminish the distribution discrepancy of cross-regional high-resolution remote sensing imagery which may cause the decrease of classification accuracy, transfer learning, specially domain adaptation, has been introduced to cross-scene remote sensing image scene classification task. Exiting domain adaptation approaches on remote sensing image scene classification task usually explore the transferability of feature representation and classifier under the hypothesis that the source domain and target domain shares identical category space. However, in a new region, novel categories may appear. The feature discriminability also may decrease because of different category spaces in remote sensing open set domain adaptation scenario. In this article, to overcome different feature distribution caused by different class spaces and feature discriminability decrease in remote sensing open set domain adaptation scenario, we propose unknown class detector using one vs all network considering classes distance is proposed to find the unknown classes in target domain, we also introduced the target domain neighborhood clustering loss to improve target domain feature discriminability. The proposed method can improve cross-scene land use classification and auto label the unknown classes samples in target domain.

Urban Big Data Infrastructure for Smart City – 1

Smart City Ontology Framework for Urban Data Integration and Governance Applications

Xiaolong He and Xi Kuai.

Abstract. The diverse, heterogeneous and dynamic nature of urban data poses challenges for semantic integration, knowledge sharing and urban governance for smart cities. However, traditional urban data standards mainly focus on hierarchical classification and lack explicit representation of semantic relationships between Operational Urban Entities (OUE, such as buildings, roads, sensors, etc.). A semantic framework of OUE is needed to integrate data and reuse professional models /algorithms in various urban governance applications. In this paper, the semantic ontology modelling methods were employed and some significant principles were proposed for identifying key OUE classes and formally representing their relationships to achieve explicit expression of semantic information and integrate existing data standards across multiple domains, such as Industry Foundation Classes (IFC), OGC SensorThings API, OGC City Geography Markup Language and GB/T 13923-2022. Then, we designed a smart city ontology framework with three major OUE categories (i.e. natural entities, artificial entities and management entities), covering fields such as IoT perception, building information model (BIM), geographic information system (GIS), and intelligent transport system (ITS), etc. Finally, we developed specific urban governance scenarios including emergency management, traffic flow optimization and urban planning, and discussed the practical governance applications to demonstrate the feasibility of the proposed framework. The results show that, by integrating various information resources in dynamic urban environments, the proposed framework can not only provide efficient and foundational information support for various urban data integration tasks, but also present a general and flexible solution for refined governance in smart cities.

Spatio-Temporal Data Fusion Techniques for Modeling Digital Twin City

Yuejin Li, Shengpeng Chen, Kai Hwang, Xiaoqiang Ji, Zhen Lei, Yi Zhu, Feng Ye and Mengjun Liu.

Abstract. The digital twin city technique maps the massive city environmental and social data on a three-dimensional virtual model. It presents the operational status of physical world and supports intelligent city governance. However, the inefficient utilization of distributed data resources, and the lack of sharing and collaboration among multiple departments restrict the data formulation of digital twin city construction.

This research proposes a new cross-domain spatio-temporal data fusion framework. It integrates the heterogeneous urban information generated and stored by different government departments with multiple information techniques. A specified geographic base reflecting the real city status is established, using geographical entities with unified address as identifiers to encapsulate the urban elements information. We introduce a comprehensive urban spatio-temporal data center construction process, which has already supported multiple urban governance projects. The two distinct advantages in using this data fusion system are: 1) The proposed Bert+PtrNet+ESIM based address mapping method associates the urban elements information to their corresponding geographic entities with 99.3% F1-Score on real world dataset. 2) The Wuhan City Hotline project supported by our data fusion framework shows the cross-domain spatio-temporal dataflow transmission time cost has been reduced from T+1 day to hourly level, which effectively improves the overall efficiency. This integrated system engineering provides reference and inspiration for further spatio-temporal data management, which contributes to the future digital twin city platform construction.

Construction and Conversion of Physical Information Model and Legal Property Information Model for Apartment Buildings

Yunfei Shi, Lingling Zhang and Xipeng Gao.

Abstract. City Information Modeling (CIM) primarily focuses on the realistic physical representation of urban objects, but it neglects the virtual legal property aspects associated with these objects. It is proposed that CIM should construct both a Physical Information Model (PIM) and a Legal Property Information Model (LPIM) for urban objects. These models provide comprehensive perspectives from both the physical and legal standpoints. Based on the theories of cell, cell complex and IndoorGML standards, the paper presents a three-dimensional data model that considers the topology and partial semantics of buildings, aiming to represent the PIM and LPIM of buildings. The simultaneous construction of PIM and LPIM poses various challenges, including increased modeling and storage costs, as well as potential inconsistencies resulting from variations in modeling environments and methodologies. To overcome these challenges, a novel method for PIM to LPIM conversion is proposed. The method employs the Poincaré duality transformation to map PIM cells to dual points, while semantic connectivity boundaries between cells are converted to edges, resulting in the transformation of the PIM into a Semantic Node Relation Graph (SNRG). By applying semantic constraints and utilizing graph segmentation algorithms, the SNRG is partitioned into sub-SNRGs that represent private and shared legal property objects. Subsequently, non-common boundary surfaces extracted from the corresponding cell sets of the sub-SNRGs are used to construct legal property objects, ultimately generating the LPIM. Experimental results show that the method only requires the construction of the PIM for an apartment-style building, and through the conversion algorithm, a geometrically and topologically consistent LPIM can be obtained. This approach not only reduces modeling costs but also facilitates data updates and maintenance.

Fast Site Selection of 5G Base Station Considering Signal Propagation Loss Based on a Linear Programming Model

Yuquan Sun, Lanruo Wu, Lianna He and Zhuning Wang.

Abstract. As a new generation of mobile communication system, 5G will be used in more diverse scenes and require better coverage. Due to its higher frequency and greater signal loss caused by obstacles during signal propagation, more 5G base stations need to be built in the same area compared to 3G/4G networks. However, traditional base station site selection methods mostly rely on the experience of professional technicians to confirm one by one, which is inefficient. Additionally, mainstream signal simulation software requires professional knowledge such as propagation model tuning and key parameter configuration, making it difficult for non-experts to use. Moreover, the final location selection plan often requires multiple rounds of adjustments due to complex real-world situations. Therefore, a fast, simple and scientific pre-site selection method would be more universal.

This paper uses spatial analysis tools such as visibility analysis to simulate the 5G signal propagation, considering the signals loss caused by buildings and terrain obstacles based on Pathloss Models of the 3rd Generation Partnership Project (3GPP). An integer linear programming model is then used to generate the layout scheme with optimal signal coverage performance of 5G base stations. This method can provide two location optimization schemes: "full coverage at minimum cost" and "maximum coverage at specified cost". It takes into account the accuracy of signal simulation and the convenience of decision-making, and has a low application threshold and high calculation efficiency. This enables quick and intelligent site selection of 5G base stations, supporting smart city planning decisions.

Exploring the Potential of Sharing Private Charging Posts: A Data-Driven Micro-simulation Approach

Xiong Yang, Jiaxing Liu, Chengxiang Zhuge, Andrew Tin Chak Wong and Pinxi Wang.

Abstract. The lack of charging infrastructure has been one of the main barriers to the uptake of electric vehicles (EVs), and sharing private charging facilities could be a promising solution. However, little is known about the potential of this advanced sharing service in the era of EVs. In response, this paper explored the potential of private home charging post sharing (PHCPS) in Beijing using a data-driven micro-simulation approach. In the simulation, private EV users' travel and charging behaviors were defined with empirical findings from a large-scale GPS trajectory dataset collected from over 76,000 private EVs in January of 2018. We quantified the potential of PHCPS (e.g., its impact on the usage of EVs and charging posts) by comparing the results of simulations with and without PHCPS. The results suggested that PHCPS could provide more charging opportunities for private EV users and decrease private EV users' dependence on public charging posts. On a working day, PHCPS gave rise to 6.32% (from 87.91% to 94.23%) increase in the proportion of parking events with accessible charging posts, and 33.37% (from 9.62 to 6.41 kWh)

decrease in the average electricity provided by a public charging post. Further, both the willingness of private home charging post (PHCP) owners sharing their PHCPs and the willingness of EV users using the shared PHCPs were significantly influential factors to the potential of PHCPS. Every 10% increase in private EV users willing to use the shared PHCPs, the decreased rate of electricity provided by a public charging post would increase around 3.34% on a working day, on average. The findings above would be particularly useful for the decision-making of charging facility planners and operators.

Urban Big Data Infrastructure for Smart City – 2

Representational Spectrum of Pan-maps in the ICT era

Chen Yebin, Renzhong Guo and Zhigang Zhao.

Abstract. In the natural world, both light spectra and sound spectra exhibit characteristics of continuous transitions. The light spectrum, based on the wavelength variation of electromagnetic waves, can form a sequential and continuous distribution of ultraviolet light, visible light, infrared light, microwaves, and so on. Similarly, the sound spectrum, based on different frequencies, transitions continuously from infra-sound to sounds audible to the human ear and further to ultrasound. We can observe that the concept of "spectrum" effectively reflects the complex interconnections between objects in the real world.

Maps serve as vital information carriers in the process of smart city construction. In the field of cartography, traditional maps, due to technological limitations, mostly express the spatial distribution of scene objects from discrete perspective, such as topographic maps or geomorphologic map. In recent decades, with the rapid development of information and communication technology (ICT), there have been significant changes in the theoretical methods of cartography and technological conditions in which they mature. Map-making technology has continuously innovated, resulting in a wide variety of map-like representations that differ from "traditional maps" in terms of objectivity, intuitiveness, and comprehensiveness, such as whisper map, kriskograms map, virtual reality map, etc. Maps exhibit significant characteristics and trends of diversification, and Guo collectively referred to traditional maps and various innovative map forms as Pan-maps.

This paper focuses on the diverse characteristics and trends of Pan-maps, drawing inspiration from the continuous expression of spectrum. It aims to break through the discrete nature of traditional maps and attempt to connect maps that express diversity, multiple types, and multiple themes. We propose a representational spectrum Pan-maps, encompassing both realistic and abstract directions. The concept of representational spectrum of Pan-maps proposed will help broaden the research scope of cartography in the ICT era, facilitating the rapid transmission of information in smart cities.

Research on data management and analysis of BIM technology

Zhaofeng Yang.

Abstract. BIM technology is the soul of information and digital. Accompanied by the development of big data, cloud computing, Internet of Things, artificial intelligence and other cutting-edge technologies, the digitisation and informatisation of BIM technology is also in constant depth.BIM technology, as an important supportive technology for digital construction, plays an active guiding role in infrastructure projects. This paper provides new thinking and solutions for the construction of tunnels and underground projects through the data management and analysis of BIM technology in the construction of tunnels and underground projects. It is not only the key to the future field of urban underground space, but also an important trend in the development of global digitalisation and information technology.

Automatic generation algorithm for indoor floorplans based on point clouds

Yunlin Tu and John Shi.

Abstract. Laser Detection and Ranging (LiDAR) is a rapidly evolving measurement and sensing technology that plays a crucial role in various fields, including smart cities, basic mapping, heritage and ancient building restoration modeling, among others. In the construction industry, Building Information Modeling (BIM) generated from LiDAR data is indispensable and essential throughout the construction lifecycle. However, many existing buildings lack BIM usage for refurbishment and maintenance due to limitations and challenges in the manual BIM creation process. This manual approach is tedious, time-consuming, and requires specialized knowledge. Moreover, the ever-changing layouts of existing buildings make the generation or updating of BIM more difficult. To address these difficulties, we propose an automatic method for generating 2D floor plans from point cloud data to facilitate BIM modeling. Specifically, our approach detects and segments the geometric and topological relationships of building structural elements from the point cloud data to create 2D floor plans. The main contributions of this paper include the introduction of a point cloud semantic segmentation model to aid in identifying and extracting structural elements from indoor point cloud data. The paper is organized as follows: Section 2 presents the background and related work, while Section 3 describes the proposed method in detail, including data pre-processing, structure element extraction, 2D plan generation, and refinement steps. Section 4 discusses and evaluates the experimental results for accuracy. Finally, Section 5 concludes the paper.

A Data-Driven Approach to Deploying Wireless Charging Lanes on a Large-Scale Electrified Bus Network

Shiqi Wang, Yuze Li, Anthony Chen and Chengxiang Zhuge.

Abstract. This paper aims to propose a data-driven simulation-based optimization model to deploy both traditional charging stations/posts and wireless charging lanes (WCLs). With the model, we are able to explore the technical and economic suitability of deploying WCLs in an electrified bus network. We developed a data-driven micro-simulation-based bi-objective optimization model to deploy charging facilities for large-scale bus networks on a

large-scale electrified bus network, using real-world bus trajectory data in NYC. In particular, two scenarios were designed to compare the performance of traditional charging posts and wireless charging lanes (WCLs), namely Scenario A (i.e., only charging stations with fast and slow charging posts are available) and Scenario B (i.e., both WCLs and charging stations are available). This optimization model consists of three key components, including two objectives (i.e., minimizing the total system cost and maximizing the level of service), four constraints (i.e., battery capacity constraint, sufficient electricity for the next loop, dedicated bus lane length constraint on WCL length, and the parameter constraints) and three connected sub-models (i.e., simulation of E-bus's possible queuing at a charging station, simulation of E-bus's electricity consumption, and simulation of E-bus's charging event). We combined back propagation neural network-genetic algorithm (BP-GA) and non-dominated sorting genetic algorithms-II (NSGA-II) to solve the optimization model. The results showed that the scenario with both charging posts and WCLs deployed had a significantly higher level of service (with its total delay time being 48.11% shorter), more energy saved and fewer emissions than the scenario with only charging posts deployed, though its total cost was 0.76% higher. Moreover, the sensitivity analysis results show that the parameters associated with electric buses and charging facilities could heavily influence the outputs of interest.

Urban Computing for Smart City – 1

Modeling individual travel behavior in the real-time context: An space-time prism approach with isochronous circle

Zuopeng Xiao and Jingying Liao.

Abstract. The space-time prism derived from time geography has been intensively used to measure the potential space reachable in schedule-given and time-fixed settings. However, the increasingly-common ICT applications and LBS in the modern lifestyle challenge the above activity-fixed setting. With these digital applications, as well as the real-time information exposure, persons may frequently adjust all travel elements during the whole action course including destination, task bundling, travel mode, path, and time budget. All these generate the fact that people move in a dynamic context and interact in real-time with virtual and physical and social environments. It gives rise to a new task of modeling the real-time interaction between individual behaviors and geographical environment. Whether the classical approach of space-time prism is applicable to measure the dynamic potential activity space for moving people with frequent on-way decisions? By reviewing the ongoing development of probability time geography and real-time geography (Miller, 2020), this paper demonstrates how the space-time prism evolves into a space-time disc when an activity is cut into a sequence of small activities that constitute the whole activity. To depict the sequence of subset activities, this paper acknowledges the decision points and conceptualized some potential alteration scenarios. This conceptualization provides the knowledge for measuring the potential reachable space varying simultaneously in the real-time activity/travel context. Referring to the space-time slice, this paper incorporates the

API service provided by navigation maps and generates the sequence of isochronous circles that measures the reachable space at a time moment. Two hypothesis cases demonstrate the applicability of the above methods to compute the reachable space during the whole moving process. This study contributes to providing digital services such as hailing-riding and instant delivery that need real-time engagement from the third party.

A user-friendly assessment of six commonly used urban growth models

Yuzhi Zhang and Jun Yang.

Abstract. An accurate grasp of urban expansion patterns is conducive to efficient urban management and planning. Various urban growth models have been developed to meet this need in the last two decades. As more models become available, users increasingly face the challenge of choosing the right one for their purposes. In this study, we first reviewed the recent usage pattern of urban growth models (UGMs) and identified the top ten UGMs accounting for 73.3% of total usage from 2000 to 2021. We then compared the performance of six commonly used UGMs in simulating urban expansion, including the Cellular Automata-Markov model (CA-Markov), Slope, land use, excluded layer, urban extent, transportation, hillshade (SLEUTH), Conversion of Land Use and its Effects at Small extent model (CLUE-S), Future land use simulation model (FLUS), Land Use Scenario Dynamics model (LUSD), and Land Change Modeler (LCM). The behaviors of the six models were verified against descriptions in the model's documentation. We also analyzed the models' documentation, focusing on data requirements and the user's flexibility in the modeling process. The results showed that the validation accuracies of the models varied with the inputted data, indicating a model does not have an intrinsic accuracy. CA-Markov, FLUS, LUSD, and LCM could be verified, while CLUE-S and SLEUTH failed to meet some verification criteria. In addition, SLEUTH has the highest requirement for input data among all studied models. FLUS and LCM allow for higher user flexibility in modeling than others. This study's findings can help users decide which of the six urban growth models suits them.

An Entity Recognition and Semantic Clustering of City Complaint hotline Data for uncovering urban hot problem

Tianyou Chu, Yumin Chen, Jianshen Ma, Guodong Chen, Wankun Min and Yuejun Chen.

Abstract. City complaint hotlines are an essential channel for the public to report everyday problems and safeguard their rights. This bottom-up data source provides an opportunity for the timely and effective identification of diverse urban problems. This paper proposes a method that utilizes entity recognition and semantic clustering to extract synonymous entities from hotline data. By implementing this approach, the paper aims to identify valuable topics and trends generated by the public, which often involve well-defined entities. The proposed method utilizes UIE for extracting different types of entities and employs a two-stage process to evaluate entity similarity, including entity recall and entity match. Finally, the DBSCAN algorithm is utilized to cluster all entities. In the comparative

experiments, the proposed method demonstrates superior performance in entity recognition and entity clustering on the sample dataset. Furthermore, the effectiveness of the proposed method is validated on a real hotline complaint text dataset spanning one month. The results illustrate that the method exhibits stable performance on large-scale datasets with limited training samples, enabling accurate extraction of the spatial-temporal distribution of hot topics discussed by the public.

Remote sensing and social media data fusion based on two stream transformer coupled self-attention model for urban region function classification

Sun Ruiyang, Su Xin and Yuan Qiangqiang.

Abstract. Urban management and planning can benefit from the classification of urban functional zones. Existing research has demonstrated that remote sensing data can give essential urban surface information for the identification of urban functional areas, and human activities may characterize the dynamic aspects connected to social and economic features in various urban functional regions. For automatically extracting aspects of both and incorporate them into urban functional district categorization, we propose a novel two stream transformer coupled self-attention for remote sensing and social media data. As opposed to the deep learning two-branch fusion network of remote sensing and social data, we couple self-attention to create a crucial semantic fusion path, using the semantic information gleaned from remote sensing and social data branches. By modifying the loss function, remote sensing and social branch network are deeply supervised and distilled. The efficiency of the suggested strategy in merging remote and social media data for urban region function detection has been extensively tested on public datasets.

Urban Computing for Smart City – 2

A graph-based multimodal framework to predict gentrification

Javad Eshtiyagh, Baotong Zhang, Yujing Sun, Linhui Wu and Zhao Wang.

Abstract. Gentrification—the transformation of a poor urban area caused by the influx of affluent residents—has many revitalizing benefits. However, it also poses extremely concerning challenges to low-income residents. To help policymakers take targeted and early action in protecting low-income residents, researchers have recently proposed several machine learning models to predict gentrification using socioeconomic and image features. Building upon previous studies, we propose a graph-based deep learning framework to predict gentrification mainly using urban networks built based on the locations of schools, hospitals, and subway stations. We train and test the proposed framework using data from Chicago, New York City, and Los Angeles. The model successfully predicts gentrification with 0.9 AUC on average. Moreover, the framework discovers a previously unexamined strong relationship between schools and gentrification.

A Feature-hybrid Network for Satellite Image Stereo-matching

Zhi Zheng and Peifeng Ma.

Abstract. Stereo-matching of satellite images is one of the core steps in generating a large-scale Digital Surface Model (DSM). Recent studies have demonstrated the superiority of deep learning-based technologies for image stereo-matching. However, applying deep learning-based methods on satellite images is still challenging, especially in intractable regions like texture-less and occluded regions. To tackle this problem, this paper proposes a novel feature-hybrid network (FHNet) for satellite image stereo-matching, aiming at enhancing the matching performance on intractable regions. The network comprises feature extraction, cost volume construction, cost filtering, and disparity estimation. In the feature extraction step, we design a novel cross-scale feature extractor, which enables feature differentiation in complex geographical scenes. Since structural features and context information are unmixed into two asymmetric branches, the feature extractor can aggregate long-range information only with the context branch,thus enhancing FHNet's performance on intractable regions without introducing much computational burden. Then, FHNet takes the unary features from stereo images to establish concatenated matching volume. Next, we design a multi-scale cost filter, which filters out most mismatches to ensure accurate disparity estimation. At last, the normal-filtered cost volume and three cost volumes after the designed multi-scale cost filters are joined to estimate the final disparity map. Experiments on the public US3D dataset showed better accuracy than state-of-the-art methods, indicating the proposed method's superiority. Experiments on Gaofen-7 satellite stereos further demonstrated its effectiveness and scalability.

A machine learning-based surrogate model for urban inundation modeling

Qiang Yu and Shuo Wang.

Abstract. Urban pluvial flooding has emerged as a significant and escalating threat to numerous cities, exposing lives and property to considerable risks. In order to gain a comprehensive understanding of areas susceptible to flooding within urban settings, the implementation of urban flood hazard mapping becomes essential for effective city planning and disaster mitigation. Accurate assessment of urban flood risk plays a pivotal role in fortifying stormwater risk management, empowering decision-makers to proactively address potential flood-prone zones and minimize the socioeconomic disruptions that accompany urban inundation. Presently, physically-based hydrodynamic models, readily accessible via various commercial software platforms, stand as the predominant approach for appraising urban pluvial flood hazards. Streamlining these intricate and computationally intensive physically-based models could offer an effective and pragmatic avenue to support real-time flood prediction, denoted as surrogate models. The application of machine learning or data-driven methodologies has solidified its presence in water resources applications for well over a decade. This study is motivated to propose a machine learning-based surrogate model for urban inundation modeling which incorporates urban building footprints and storm drain systems.

Exploring the association between built environment and moving behaviors using street-view imagery

Ding Ma, Biao He, Chengyue Zhang and Wei Zhu.

Abstract. The complex network structures and diverse perceptions of the street environment result in high levels of heterogeneity and uncertainty in personal trajectory choices. However, little research has quantitatively evaluated the relationship between the first-person view of street space and travel choices in Shenzhen, China. To address this, we employed a deep learning model to extract 19 street features from street view images at the city level. These features were categorized as buildings, sky, and greenery, and were used to evaluate street quality. We then extracted trips from half a million real large-scale taxi trajectories and calculated three path modes for each trip based on its origin and destination: the shortest distance, the fewest turns, and the least number of segments. We assigned street features to the three types of driving routes and serialized each trajectory category into vector sequences. By comparing similarities among route selections with regard to street quality, spatiotemporal patterns, and other influencing factors such as distances and turns, we were able to gauge the effect of geometric and landscape factors on the utility of street space. Additionally, the comparison between simulated and observed routes can facilitate relevant strategies for transportation planning and sustainable mobility.

Urban Spatial Data Analytics – 1

World Cup reshaped the pattern of urban green space of Qatar

Xi Wang and Liang Zhou.

Abstract. Human activities have accelerated the transformation of urban green spaces, World Cup, as one of the most influential sporting events in the world, has a profound impact on the green spatial pattern of the host city with its huge economic investment and infrastructure input in the short term. However, the process and pattern characteristics of how the World Cup reshapes green space patterns remain unrevealed. Therefore, to better understand the impact results between the two, we quantitatively assessed the role of the 2022 World Cup in reshaping the green spatial pattern of Qatar, used the landscape pattern index and the population green exposure index to quantitatively assess the green spatial of Qatar. The landscape pattern evolution and the spatial and temporal relationships with population changes were investigated. The results found that (1) the urban green space area in Qatar expanded more than threefold from 2000 to 2022, and the urban green space grew by an area equivalent to 38 Manhattan Central Park, contributing 73.23% and 94.31% of the green space growth in the main built-up areas of Qatar and its major built-up areas during the pre-World Cup period and World Cup period. (2) The World Cup caused the urban green space landscape to become more complex and fragmented during. (3) The hosting of the World Cup effectively increased the level of green exposure of the population, and the

minimum value of green exposure of the population increased by 7.59 times. The study confirmed that the hosting of the World Cup reshaped the urban green space pattern in Qatar, providing new insights into the promotion of sports for urban sustainable development and green space improvement.

Hierarchy and spatial heterogeneity of metropolitan area expansion and land surface temperature evolution: A twin city perspective

Mengqiu Cui and Liang Zhou.

Abstract. Twin city integration leads cities to be more functional, cultural and institutional, but increases the potential eco-environmental risks, such as thermal environment deterioration, which is an obstacle to resilient cities. However, the impact of the integration process on the urban thermal environment has not been clarified. Here, we adopt local contour tree algorithm to explore the spatiotemporal characteristics of urban expansion and land surface temperature (LST) over Xi'an-Xianyang Metropolitan Area (XXMA), a rapidly growing twin city in China. Our results indicate that: (1) The urban integration of XXMA is obvious, and the spatial scope of XXMA converges towards Weihe River between the two cities. Besides, its structure tends to be more complex, which develops from 3 levels and 8 centers to 10 levels and 33 centers from 2000 to 2020. (2) The heat islands area of XXMA tends to connect, but the LST evolution in two cities is not synchronized. The LST contour tree of Xi'an evolves to 6 levels and 26 centers in 2000-2015, and simplifies to 5 levels and 17 centers in 2020, while it continues to be complex from 1 to 4 levels in Xianyang. (3) Synergistic effects exist between urban expansion and LST evolution. The High-High type agglomeration of nighttime light and LST significantly increases in area and converges in scope. The study results can provide a scientific basis for thermal environment management and urban climate improvement in XXMA.

Contribution of natural and social factors to land surface temperature within urban local climate zones in different climate zones around the globe

Liping Zhang and Liang Zhou.

Abstract. Overheating in urban areas affects the overall livability of cities and poses a threat to the health of urban residents. Understanding surface temperature (LST) characteristics is critical to improving the urban thermal environment, but inter-regional climate differences and urban morphological heterogeneity influence the level and spatial distribution of surface temperature, and few studies have examined in depth the extent to which natural and social factors influence LST within local climate zones (LCZs) based on global climate belts. Therefore, this paper uses stepwise linear regression models to quantitatively explore the contribution of NDVI, MNDWI, population density, and road kernel density to LST within the LCZs of 12 cities located in four global macroclimatic zones. The results show that (1) even though the urbanization rates are similar, there are significant inter-city structural differences. The percentage of urban building type LCZ ranges from 54.96% to 91.42%, and the anthropogenic surface occupies the main urban space; (2) there is an overall

similarity in the LST characteristics of LCZ in each climate zone, but the LST in the arid zone regulated by climate possesses greater variability, and the LCZ is well adapted to LST in different climate zones with outstanding significant differences; (3) Vegetation and water bodies act as natural thermal mitigation spaces, and the LST of each city decreases in the range of 0.06 to 3.17°C for every 0.1 increase in NDVI/MNDWI. The LST increase is within 0.04°C when the population per km² is increased by 1000, and an increase in road nucleus density by 1000 causes a maximum LST increase of 2.64°C. Our study will provide targeted measures for LCZ-based urban thermal environment improvement in different macroclimatic zones.

Deep learning-based remote sensing time-series change detection in urban areas

Haixu He, Jining Yan and Lizhe Wang.

Abstract. In order to clarify the frequent and complex land cover changes in the process of urban development, it is a challenge to obtain accurate change areas, dates and types, but there are currently few models that can span the semantic gap between time series changes and land cover changes. Based on this problem, this study proposes a land cover semantic change monitoring model using the Transformer architecture. In the encoding stage, remote sensing time series features are extracted, and the uneven time series modeling caused by cloud pollution is realized by integrating time coding. In the decoding stage, the land cover type information is introduced, and the continuous semantic recognition of the time series is carried out by autoregressive method, and the change time and type information are obtained at the same time. The method proposed in this paper completely gets rid of the traditional model's dependence on temporal morphological features, and the flexible decoding output can be applied to a variety of change detection scenarios. In this study, the experimental data of Landsat from 2007 to 2022 in Wuhan was used to evaluate the detection results of the model, which greatly improved the accuracy and efficiency compared with the traditional change detection model.

Representing Spatial Codes with POI Data: An Effective Mean of Decoding Social Space

Jin Zeng and Yang Yue.

Abstract. After more than half a century of advancement, geographic information science (GIS) has made significant strides in capturing and portraying physical space, such as land, architecture, and landscapes, with finer granularity. However, space transcends its role as a mere container or stage for material production; instead, it encapsulates intricate social relations shaped by social values and meanings. It thus becomes crucial to decode social space in order to thoroughly investigate the connections between space and the practice of everyday life that occur within it. From the fragmented clues in Henri Lefebvre's "The Production of Space," this study discerned that spatial codes are a crucial means by which social space can be "read" and "interpreted." Additionally, Points of Interest (POI) data, a widely accessible and extensively utilized source of geospatial information, was identified

as having the potential to serve as a proxy for spatial codes. This study further established a method framework known as "social space → spatial codes → orders of signification → POI data," which provides a systematic and tangible approach for decoding social space. To validate the effectiveness of the proposed framework, this study applied it to quantitatively identify and analyze urban scenes. Urban scenes represent a typical social space where various elements and features bear profound cultural connotations and symbolic meanings, manifesting as spatial codes; the utilization of POI data achieves an accurate portrayal and quantification of urban scenes. This study established a feasible and easily implementable bridge between social space and geospatial data, which emphasizes digital reconstruction and visualization of real world in terms of social space. This would contribute to GIS substantial and long-term development in urban intelligent and digital transformation, such as digital twin and "Digital China".

Urban Spatial Data Analytics – 2

Based on Remote Sensing Multi-level dynamic analysis of urban landscape pattern

Xiaomei Yang, Yuyang Cui and Zhi Li.

Abstract. The analysis of urban land cover categories and their spatial patterns is an important issue in smart cities. Due to the diversity of urban landscape components and the complexity of spatial patterns, dynamic monitoring of urban remote sensing faces enormous difficulties. We propose to combine the "bottom-up" detail classification of high-resolution remote sensing with the "top-down" structural division of urban artificial landscapes to construct a multi-level model based on high-dimensional features for built-up areas, blocks, object primitives, and pixels. On this basis, the multi-scale maps of urban built-up areas, urban blocks and land cover types in different periods are established through spatio-temporal mapping expansion, and the multi-scale dynamic analysis and quantitative evaluation of urban landscape pattern are realized. This study can not only evaluate the change rate of landscape architecture and vegetation density within a city, but also reflect changes in the external expansion of the city. Taking the mega city of Beijing as a case study, we conducted a multi-level dynamic analysis of the urban landscape pattern from 2016 to 2021, and achieved good results. Through the collaborative extraction technology of multi-source remote sensing information, the accurate dynamic spatial information of land cover in urban built-up areas can be provided in a large area, periodically, objectively and accurately, which has important research significance and practical value for the sustainable development, planning management and ecological protection of cities.

Detection and spatial heterogeneity analysis of terrain fragmentation on the Loess Plateau

Yong Dong and Liang Zhou.

Abstract. Terrain fragmentation is an important factor leading to poor spatial connectivity and accessibility in mountainous areas, which seriously restricts regional transportation accessibility and urban-rural integration development. The study takes the Loess Plateau with dense valleys and highly fragmented terrain as an example, and constructs a terrain fragmentation index system based on DEM data from overall fragmentation, positive and negative terrain, and terrain transition, and uses the spatial clustering method Automated Zoning Procedure-Simulated Annealing and the objective weighting method Criteria Importance Though Intercrieria Correlation to generate Spatial zoning and evaluation grading of topographic fragmentation at the county level explores the spatial heterogeneity of topographic fragmentation in the Loess Plateau. The research results show that: ①The spatial distribution of terrain fragmentation indicators are generally characterized by contiguous clusters; ②The Loess Plateau can be divided into 8 spatially continuous topographic fragmentation zones, and the 4 largest zones are located in the northern Shaanxi Plateau which is located in the central part of the Loess Plateau, the Lvliang Mountains, and the Ordos Plateau in the north. It accounts for 66.37% of the total area, and it is distributed in a shape of Chinese character "田"; ③The terrain fragmentation degree of the Loess Plateau can be divided into 5 levels, and the high fragmentation area accounts for 13% of the total area of the plateau, which is mainly distributed in the Longzhong Plateau and the northern part of the Qinling Mountains. 55% of the total area of the plateau is mainly distributed in the northern Shaanxi plateau and Shanxi plateau, which are located in the central and eastern part of the plateau. This study can provide some reference for the formulation of urban-rural integration development policy and transportation infrastructure planning in the Loess Plateau.

Measurement and analysis of fragmentation and connectivity of green belts in Chinese megacities from a resilience perspective: A case study of Beijing, Xi'an and Chengdu

Yangchun Gong and Liang Zhou.

Abstract. Urban green belt is an important means to prevent urban sprawl and improve urban ecological security pattern. However, the city is a complex and open giant system, the actual development and construction process will often break through the planning expectations. In order to explore the non-linear changes of urban green belts with urban development in different periods and different cities, based on the perspective of resilient city construction, this study measured and analyzed the fragmentation and connectivity of green belts in three typical circular megacities of Beijing, Xi'an and Chengdu from 2000 to 2020 by using quantitative methods such as land use transfer matrix and landscape pattern index. The results showed that: (1) From 2000 to 2020, the expansion modes of the three cities were mainly the outlying expansion, and the green belts were continuously eroded by urban construction land. The distribution range of cultivated land in the three urban green belts and their buffer zones decreased significantly from the center to the periphery. (2) The proportion of construction land in the green belts of the three cities continued to rise. The rapid expansion of construction land occupied the most significant ecological land in the

green belt of Beijing, followed by Xi'an and Chengdu, accounting for 44.09%, 43.21% and 37.02% respectively. (3) From 2000 to 2020, the fragmentation degree of green belts in the three cities decreased as a whole, the connectivity of green belts in Beijing gradually decreased, and the connectivity of green belts in Xi'an and Chengdu showed a "V" trend of decreasing first and then increasing. However, the changes of landscape fragmentation and connectivity in different urban green belts were significantly different. The fragmentation degree of cultivated land in the green belts of the three cities increased, the connectivity decreased.

cuSTSG: an Enhanced Spatial–Temporal Savitzky–Golay Method for Reconstructing High-Quality NDVI Time Series

Xue Yang, Jin Chen and Qingfeng Guan.

Abstract. The spatial–temporal Savitzky–Golay (STSG) method for noise reduction can address the problem of temporally continuous normalized difference vegetation index (NDVI) gaps and effectively increase local low NDVI values without overcorrection. However, STSG largely depends on the quality flags of the NDVI time-series data, and inaccurate quality flags yield misleading final results. STSG also requires extensive computing time when used in large-scale applications. This study proposes an enhanced method, called compute unified device architecture (CUDA)-based STSG (cuSTSG), to address the aforementioned limitations of STSG. First, cosine similarities between the annual NDVI time series were used to identify and exclude the NDVI values with inaccurate quality flags from the NDVI seasonal growth trajectory. Second, computational performance was improved by reducing redundant computations and parallelizing computationally intensive procedures using the CUDA on graphics processing units (GPUs). Experiments on four MODIS NDVI time-series datasets of various sizes and regions showed that compared with the original STSG, cuSTSG reduced the mean absolute errors of the final products by 4.90%, 7.77%, 11.76%, and 2.06%, respectively. The results also showed that cuSTSG on a GPU achieved more than 75 speed-up compared with the Interactive Data Language implemented STSG, and more than 30 speed-up compared with the C++-implemented STSG. cuSTSG can effectively mitigate the impacts of inaccurate quality flags on final products and generate high-quality NDVI time series at large scales with high accuracy and performance. The source code of cuSTSG is available at https://github.com/HPSCIL/cuSTSG.

Knowledge and topology: A two layer spatially dependent graph neural networks to identify urban functions with time-series street view image

Yan Zhang and Nengcheng Chen.

Abstract. A large number of human socio-economic activities exist in cities. In recent years, physical sensing (Sensor Network) and Social Sensing technologies have been advancing, 5G and smart devices have gradually become popular, and social big data have achieved wide coverage in urban space. Smartphones, wearable devices, electrical appliances,

medical equipment, industrial detectors, surveillance cameras, automobiles, and other sensing terminals with wide coverage have greatly contributed to the development of urban sensing capabilities, and everyone can be regarded as a "sensor" to provide feedback on events and entities in the urban reality space, generating a large amount of multimodal urban data with location information in real time. The data includes not only numbers, but also natural language text and images and videos. This data has greatly deepened the understanding of urban systems and has brought about a dramatic change in social computing research. However, the data has limitations of low quality, low information density, and high processing complexity, and cannot be directly transformed into geographic knowledge. In this paper, based on over 30 million multimodal data containing location tags in recent years, we use data mining and machine learning techniques, combined with domain expertise, to reasonably interpret and analyze the data and extract reusable geographic trivia based on several application scenarios such as city census, social survey, epidemic observation, and community resilience assessment. We compare the research results with the actual survey results, and the results show that urban social big data has better real-time and foreseeability, which is an effective reference and supplement to the existing perception methods.

Research on economic value estimation and spatial-temporal variation of typical urban eco-civilization in the Yangtze River Economic Belt

Anni Wang, Penglin Zhang, Yuqi Tang, Jing Yang and Feng Yuan.

Abstract. The Yangtze River Economic Belt, a pioneer demonstration belt for high-quality economic development and ecological civilization construction in the country, is an important area for the study of urban eco-civilization, which is important for the study of sustainable development of urban eco-civilization However, the existing ecological environment estimation system lacks a unified standard system for assessing the construction of ecological civilizations, and in particular, there is less research on the economic benefits brought by urban ecology, which leads to inadequate ecological service provision and excessive consumption of ecological services. To assess the economic value of the urban eco-civilization in the Yangtze River Economic Belt and monitor its trend of spatiotemporal change, this study constructed an economic value estimation model for ecological civilization elements. Based on land usage/coverage data and Net Primary Production data, combined with statistical yearbook data, this paper estimated the economic value of four typical ecological civilization elements in the Yangtze River Economic Belt from 2005 to 2020, including farmland, forest, grassland, and water, and quantitatively analyzed and evaluated their quantitative changes, spatial distribution, and spatiotemporal changes. Experimental results show that the total economic value of the four types of typical ecological civilization elements in the Yangtze River Economic Belt is 2,556 billion yuan, of which the forest economic value contributes the most, accounting for about 65% of the overall economic value. Moreover, the economic values of each factor of ecological civilization are spatially positively correlated, and the overall economic values are clustered and distributed in regions with decreasing regional differences. Over the past 15 years, the

economic value of ecological civilization factors in the Yangtze River Economic Belt has increased by 921.4 billion yuan, while the GDP has increased by 39.2 trillion yuan, effectively achieving coordinated economic and ecological development.

Urban Spatial Data Analytics – 3

Impact of land use change on net primary productivity in Guangdong Province

Jiayun Yan, Jiangping Chen, Zijian Li, Ying Qi and Lizhen Lei.

Abstract. In order to understand the spatial and temporal variation characteristics of vegetation NPP in Guangdong Province and its influencing factors, this paper used the Theil-Sen slope estimation method and Mann-Kendall method based on long time series NPP data and land use data for NPP temporal variation trend . This paper analyzed the spatial and temporal characteristics of vegetation NPP in Guangdong Province from 2000 to 2020, explored the influence of land use changes on vegetation NPP changes, and provided scientific basis for regional ecological environmental protection management and effective management of natural resources. This study indicated that the temporal changes of total NPP in Guangdong Province from 2000 to 2020 show a fluctuating increasing trend; the spatial distribution characteristics of the mean NPP generally showed a trend of low center and high circumference. And the unused land dominates the change of total NPP during 2000-2020, among which the total change of NPP from 2000-2005 contributed more.

Funding: This work was supported by the Fund of Department of Natural Resources of Guangdong Province(GDZRZYKJ2022001)and the Open Fund of Key Laboratory of National Geographical Census and Monitoring, Ministry of Natural Resources (No. 2022NGCM02).

Simulation of possible future urban development under consideration of the extension of the urban rapid transit network on the example of the metropolitan region of Cologne, Germany

Mirko Blinn, Anne Fischer, Sven Lautenbach and Theo Kötter.

Abstract. The metropolitan region of Cologne is one of the fastest growing settlement areas in Germany. An influx of up to 200,000 inhabitants is expected by 2050. In order to assess the suitability of different settlement development scenarios in terms of the Sustainable Development Goals, a random forest-based land-use model was developed. The basis of the model is a spatial database which includes information on land use, environmental aspects, nature conservation, agriculture, transport, commerce and housing . The scenarios reflect different assumptions on building density and the ratio between internal and external development of housing areas. A particularly interesting scenario in this context was the simulation of the effects of planned extensions to the existing rapid transport network. For this purpose, the results of various planning studies on new rapid

transport lines were aggregated, georeferenced and then fed into the existing database. The results show that even small changes in the location of bus stops have an influence on the structure and location of new settlement areas. For example, a more compact settlement structure can be achieved by a clever location of the new bus stops. A more compact settlement structure reduces, for example, the amount of land used for agriculture and the protection of biodiversity and is thus more sustainable in the sense of the UN's Sustainable Development Goals. These results are made available to political decision-makers and can be used as supplementary information in the context of planning and approval procedures. In order to make the model and its data basis transparent and easily transferable to other regions, the source code is under GPL and open source data was used as far as possible.

Calculation of ecological value of cultivated land based on geographical weighted regression model: A case study in Guangdong, China

Mengyan Zhu, Jiangpin Chen, Bing Zhang, Yilu Zhao, Gang Xu and Shaolan Zhen.

Abstract. Farmland is a crucial part of the terrestrial ecosystem. However, at present, it is still difficult to reasonably assess the ecological value of cultivated land in the city, since the status of cultivated land ecosystem changes dynamically with time ,location and other factors. Based on equivalent factors rectified by spatial heterogeneity coefficient and correlation analysis, this study firstly used geographically weighted regression models to calculated the ecological value of cultivated land in Guangdong, China.

Firstly, we introduced the spatial heterogeneity coefficient to rectify equivalent factors of ecological services and construct a calculation model for ecological value based on equivalent factor method. Correlation analysis and geographical weighted regression were adopted to identify the relationship between regional ecological value and each impact factor in Guangdong. Based on the geographical weighted regression model, ecological value of cultivated land was predicted according to regional GDP which turned out to be the most suitable factor to represent the impact of spatial heterogeneity on the ecological value of cultivated land.

We collected data from USGS website, Resources and Environmental Sciences and Data Center, Chinese Academy of Sciences, China Statistical Yearbook 2022 and Guangdong Statistical Yearbook 2022.

The calculation method considering spatial heterogeneity calculated the spatial heterogeneity coefficient of different plots based on the net primary productivity data, and made a more accurate calculation by comprehensively considering multiple ecosystem ecological service value equivalent factors. It is concluded that the highest ecological value of Guangdong Province is Zhanjiang City, with a value of 3.098 billion yuan, the lowest is Shenzhen City, with a value of 0.29 million yuan. According to the reclassification results of correlation analysis, it was analyzed that the biggest impact factor was GDP. Therefore, balancing economic and agricultural development is the key to protect and improve the ecological value of cultivated land.

Research on Remote Sensing Estimation and Spatial Distribution of Pinus Densiflora Single Wood Biomass

Fei Gao, Jiangping Chen, Chen Rao, Ying Qi and Huibin Li.

Abstract. Forests are a key component of the carbon cycle in the global ecosystem. But most Above Ground Biomass（AGB）estimation methods of forests by remote sensing are based on the plot level, which lead to the limitation of biomass estimation models for specific tree species, and cannot completely meet the needs of Forestry Management.

This study discusses the difference among the estimation results under different parameters and bias correction methods by focusing on the AGB estimation of single pinus densiflora tree in the Culai mountain forest farm.Specifically, we analyze the result of the optimal parameter combination and the model of the AGB estimation of a single pinus densiflora tree.

The paper concludes that the optimal features combination for estimating pinus densiflora AGB is point cloud 90% height, 10% height, average height, leaf area index, point cloud 0th density, 4th density, 70% intensity, maximum intensity, tree crown area, green reflectance, blue reflectance, ExG-ExR index, variance and correlation. Compared with using only one kind of data source, using both LiDAR（Light Detection And Ranging）and visible light images data can significantly improve the accuracy of AGB prediction.

The three bias correction methods of the RF（Random Forest）model can all effectively improve RF AGB estimation accuracy, with the overall effect ranking from good to bad as follows: BC（Bias Corrected）>SLR（Simple Linear Regression）>RR（Residual Rotation）>RF.

The influencing factors of AGB include architecture, terrain, and transportation. The pinus densifloras located near building areas, roads, or steep slopes generally have lower AGB values.

Funding: This work was supported by the Fund of Department of Natural Resources of Guangdong Province(GDZRZYKJ2022001)and the Open Fund of Key Laboratory of National Geographical Census and Monitoring, Ministry of Natural Resources (No. 2022NGCM02).

A generalised flow-based 2SFCA method for evaluating hospital accessibility: a case study in Wuhan

Pengfei Chen and Yi Jian.

Abstract. Efforts have been made worldwide to prioritize equal access to hospitals, recognizing their crucial role in achieving health equality and creating healthy cities in the post-pandemic society. However, the widely used two-step floating catchment area (2SFCA) method, which identifies underserved areas, has faced criticism for its reliance on presumed parameters that can lead to biased and misleading results. Fortunately, with the increasing availability of urban mobility data, it is now possible to integrate people's actual service-seeking behaviour into the methodological framework of the traditional 2SFCA.

To address these concerns, this study introduces the Generalized Flow-based 2SFCA (GF2SFCA) method, which leverages the demand-driven nature of healthcare facilities and incorporates underlying patterns in geographical flow data. The GF2SFCA method adaptively measures the influential range, distance-decay effect, and attractiveness of hospitals. To evaluate hospital attraction from the perspective of actual healthcare demand, two new indicators are proposed: the global popularity index and the local preference index. These indicators consider visitation counts, travel distance, and the collective preference of communities associated with each hospital. By doing so, the GF2SFCA framework overcomes the subjectivity introduced by pre-selected parameters, leading to a more precise evaluation of healthcare accessibility.

To validate the effectiveness of the proposed framework, an experimental case study was conducted in Wuhan, China. The results affirmed the realistic estimations produced by the GF2SFCA method. Moreover, the data-driven nature of GF2SFCA enables its practical implementation in diverse contexts. This capability would greatly benefit the assessment of regional healthcare equality and its dynamic changes over time.

Urban Spatial Data Analytics – 4

PM25 Exposure Disparities Among Different Populations in High Mobility Urban Areas: A Case Study of Beijing, Shanghai, and Shenzhen

Ma Zhifeng, Zhong Leiyang and Xia Jizhe.

Abstract. Background: Although the significant health impacts of particulate matter, especially those with diameters less than 2.5 micrometers (PM2.5), are well recognized, deeper exploration into the disparities in PM2.5 exposure across different populations at the individual trajectory level, especially in cities with high population mobility such as Beijing, Shanghai, and Shenzhen, remains to be undertaken.

Objective: The aim of this study is to investigate the disparities in PM2.5 exposure across different populations over multiple temporal scales from the perspective of individual trajectories, and to examine the impact of factors such as socioeconomic structure and urban layout on these disparities.

Methods: We initially obtained approximately 6 million de-sensitized user trajectory data from "Jike," a Chinese positioning technology company. Subsequently, we developed a PM2.5 concentration prediction model employing a Random Forest algorithm in conjunction with MODIS remote sensing data, meteorological factors, and other geospatial big data. This model allowed us to estimate PM2.5 concentrations over multiple temporal scales in Beijing, Shanghai, and Shenzhen. Following this, we integrated these PM2.5 concentration data with user trajectory data, thereby creating an estimation of PM2.5 exposure. Finally, we plan to investigate how factors such as socioeconomic attributes and urban layout affect the disparities in PM2.5 exposure using Geographically Weighted Regression (GWR).

Findings and Conclusions: We anticipate significant disparities in the degree of PM2.5 exposure among populations with different social attributes such as age, gender, and income, and expect these disparities to exhibit spatial heterogeneity in terms of urban structure. These findings will aid in understanding the characteristics of PM2.5 exposure disparities among different populations and cities, providing valuable insights for urban policymakers to develop tailored policies for groups with different social attributes in order to reduce health disparities among them.

Urban expansion analysis based on multi-source geographic data: A case study of Wuhan City

Tao Xie, Ruyi Feng and Lizhe Wang.

Abstract. The construction of spatial information in cities has emerged as a pivotal aspect of modern urban development, driven by the continuous advancement of information technology and the rapid process of urbanization. Urban spatial expansion plays a crucial role in this context. Accurate annual land cover mapping is instrumental in effectively reflecting the patterns of urban spatial expansion and providing valuable decision-making references for sustainable urban development. This paper presents a novel method for large-scale time-series land cover mapping, using Wuhan city as a case study. High-quality training samples are obtained from OpenStreetMap data and archived data from Google Earth Engine. Leveraging unsupervised change detection algorithms, the high-quality training samples are transferred to historical years to acquire annual training sample data. Subsequently, the annual training samples are input into an integrated random forest model for training. Finally, the outputs undergo spatio-temporal consistency correction, resulting in annual land cover maps for Wuhan city spanning from 2000 to 2022. Validation samples demonstrate the method's high accuracy, providing a robust scientific basis for urban planning and development.

Analyzing spatial relationships between built environment and urban vitality at multi-scale

Luxiao Cheng.

Abstract. Urban vitality is an essential indicator of urban development. The relationship between the urban built environment and urban vitality is necessary to guide better design for urban development. However, the current research is mainly based on multi-source urban data to measure urban vitality at a single scale (e.g., subdistrict level and grid-scale), lacking multi-scale urban vitality analysis and providing a suitable urban analysis scale. This study proposes a new framework for analyzing the relationship between the built environment and urban vitality on different scales. Using urban POIs, social sensing data, and land cover classification remote sensing data, we quantified urban vitality and analyzed its spatial pattern by using Geographic detector and Geographical weighted regression model (GWR) based on three dimensions of human activity, urban built environment, and their interactions at multi-scales. This study theoretically reveals the spatial variation pattern of urban vitality and its significant correlation with the built environment. Research findings conclude that:

There are substantial spatial correlation characteristics of urban vitality and significant differences in its spatial distribution; Urban built environment interaction forces are more vital than physical and social factors at different scales for urban vitality; Compared with other scales, the spatial scale at 1km is the best measure of urban vitality. That is, the best-fitting results were obtained by integrating built environment and urban vitality (Including Local and Global vitality) into GWR model. This study contributes to the development of policy development of sustainable urban space development.

A basic Graph Convolutional Network with Attention

Zhao Chen, Yaohua Yi and Hui Jin.

Abstract. There are lots of data in daily life with irregular spatial structures, called Non-Euclidean data, such as social networks, citation relationships between documents, etc. This kind of data has both node information and structural information, which traditional deep learning networks, such as CNN, RNN, and Transformer, can not represent well. Graph Convolutional Network(GCN) can automatically learn node features and association information between nodes. For example, social networks are very suitable for using graph data to express, such as nodes in social networks and the relationship between nodes. Users (with ID information, etc.), posts are nodes, the relationship between user A and user B is attention, and the relationship between users and posts may be published or forwarded. Through such a graph, it is possible to analyze who and what users are interested in, and further generate the recommendation system. The core ideology of a graph convolutional network is to aggregate node information by using edge information, thereby generating a new node feather. Considering the different contributions of neighbor nodes to the central node, this paper designs a novel adaptive attention mechanism based on the traditional graph convolutional network, which generates different weights for each neighbor node of the central node to model the structural information better. Experiments on the CORA dataset show that the initial classification accuracy is improved from 81.5% to 83.9%.

Cross-modal fusion and graph attention-based segmentation model for mapping of mining land covers at fine scale

Xianju Li and Tianyi Li.

Abstract. Semantic segmentation using high-resolution remote sensing images is of great value in resource management, environmental monitoring, and urban planning. However, the existing semantic segmentation methods cannot make full use of the complementary information between spectral-spatial and elevation data for mapping of land covers in complex landscapes, e.g., mining geo-environment. Moreover, there is an issue of salt and pepper noise in the prediction map. In this study, we proposed a cross-modal fusion and graph attention-based semantic segmentation model for mapping of mining land covers at fine scale, by using ZiYuan-3 imagery in Wuhan City of China.

(1) Cross-modal fusion module introduces self-attention to extract features between image blocks at different positions by splicing the two modal data, and fully obtains complementary information.

(2)The channel activation module enhances the representation ability of different features by weighting channels.

(3)The graph network divides pixels into superpixels through linear spectral clustering, and then improves the integrity of the segmentation results through graph attention mechanism, thereby reducing the generation of noise.

Results show that the proposed model can effectively suppress the generation of prediction noise, and the segmentation accuracy is better than the baseline networks. In conclusion, the model can effectively utilize cross-modal information to reduce noise and achieve accurate segmentation result.

Urban Spatial Data Analytics – 5

Adaptive Fusion Model of Object-Based Multi-Channel Graph Convolutional Networks for Fine Land Cover Classification

Xianju Li and Zihao Li.

Abstract. Fine land cover classification of complex landscapes is a popular and challenging task in the remote sensing community. In complex open-pit mining landscapes, researchers have employed pixel and object-based machine learning and deep learning algorithms to conduct fine land cover classification. However, the pixel-based algorithms pose difficulties in effectively expressing geographic objects and their topological relationships. When using objects as input nodes,.graph convolutional networks show better semantic information representative ability but need further investigation. This study proposed an adaptive fusion model of object-based multi-channel graph convolutional networks. It had the following keypoints: (1) object-based multi-channel graph construction: using object spatial relations and features to build topology and feature graphs, respectively; (2) adaptive fusion of graph features: using attention mechanism to learn weights of topology, feature, and topology and feature fused graph features; (3) fusion of graph and another object-based residual network features. The model was tested by using a ZiYuan-3 satellite imagery in 2020, within a 109.4 km2 area of Wuhan city, China. Results showed that the proposed model improved the overall accuracy by 5.58% and 3.22% compared with the baseline graph convolutional and residual networks. In conclusion, the proposed model was beneficial for the fine land cover classification of complex landscapes.

Analyzing Neighborhood Environment Factors of Daily Travel Distance by Age Groups using the Mobile Phone-based Big Data

Yejin Kim and Sugie Lee.

Abstract. The city of Seoul, Korea, has established a self-sufficient neighborhood living area where functions such as work, leisure, culture, and commerce can be enjoyed within 30 minutes on foot by utilizing the concept of n-minute city, as one of the seven goals of the "Seoul 2040 Comprehensive Plan". However, existing studies analyzing the neighborhood living zone based on the actual daily living activities of urban residents are lacking. This study identified the actual neighborhood living zone of residents and analyzed the built environment factors that affect the travel distance. In particular, this study assumed that the results would be different depending on the different age groups and travel purposes. This study utilized spatial regression models using the mobile phone-based mobility big data. As a result, the older the age, the shorter the living zone boundary, and the living zone boundary of non-commuters was smaller than that of commuters. In addition, this study found that the better public transportation accessibility is, the more long-distance travel is induced. Finally, this study suggests that it is essential to consider the age groups and the travel purposes for the identification of neighborhood living zones.

Evaluating the change of urban land use efficiency based on population-land-economy dimension—A case study of 35 main cities in China

Xingrui Li, Zixuan Pei and Qiang Li.

Abstract. To comprehensively understand the challenges posed by rapid urbanization and resource utilization, it is essential to investigate the spatio-temporal dynamics and the efficiency changes of urban land use by considering the three key elements of population, land and economy. Taking 35 important and advanced cities in China as examples, the research attempts to study the changes in urban land use elasticity and efficiency in China. A series of data spanning the years from 1998 to 2018 was used, which encompasses population data, global artificial impervious area data, GDP data, and environmental data. Focused on the elasticity coefficient and Malmquist index, the long-term changes of urban construction land expansion and its elasticities to the increases of both economy and population were analyzed. The trends of land use expansion rates and the elasticity coefficients in 35 cities were found to be U-shape. The urban economic benefits depending on land area expansion were gradually decreasing by decomposing the elasticity coefficient. The Slacks-Based Measure (SBM) model with consideration of undesirable outputs, was used to find meaningful insights into urban construction land expansion and the types of elasticity changes in subregions in China. The internal among cities within the same region were higher than the external ones in different regions. Late-expanding cities tended to exhibit lower land use efficiency compared to the early-expanding cities. Although the deficiency rates of urban environmental efficiency output were decreasing, the redundancies in undesirable outputs were still significant. Notably, both the deficiency rate of desirable output and the redundancy rate of undesirable output tended to increase with urban growth.

Determining Factors of Land Use Land Cover Change in a Mid-sized City of the Seoul Metropolitan Area

Yein Nam, Sugie Lee and Changyeon Lee.

Abstract. In recent decades, industrialization and urbanization around the world have led to urban problems such as climate change, transportation, and energy issues, and the concept of sustainable urban development has emerged. Among them, detecting land use/land cover (LULC) change and understanding its spatiotemporal dynamics is important for land use planning and sustainable land resource management. In Korea, urbanization has been particularly active in the metropolitan area, and Yongin-si, located in southeastern Gyeonggi-do, has experienced the fastest population growth among Korean cities since the early 2000s, requiring sustainable land management. Therefore, the purpose of this study is to detect land use and land cover changes in Yongin-si and to derive the influencing factors that contributed to the transformation into a urbanized area through quantitative analysis. The study was conducted in two stages: change detection and impact factor analysis. LULC change patterns were monitored using the national LULC map of Yongin-si provided by the Ministry of Environment for 2010, and 2020 and the Land Chang Modeler (LCM) technique within Terrset software. Then this study used a logistic regression model to analyze the influencing factors of the changes to the urbanized area. The results showed a significant increase in urbanized areas by 2020. After that, we analyzed the factors that influenced the changes to urbanized area, and found that transportation accessibility such as distance to highways, distance to local roads, and distance to subway stations were the main determinants. The results of this study will be useful for monitoring and managing LULC prediction model will help decision makers in the process of planning urban development and management in Yongin-si in the future.

Analysis of spatio-temporal movement patterns of one-way shared electric vehicles: A case study of Shanghai

Banshao Hu and Junqing Tang.

Abstract. Transportation activities are crucial for sustainable development strategies. Shared cars complement urban public transportation for short-distance travel. Studying the mobility behavior of shared car users optimizes station layout. Although there have been numerous studies evaluating the usage patterns and user preferences of shared cars, few have focused on evaluating and describing the shared mobility behavior of one-way shared electric vehicle users over long time series based on user order data. In this study, we utilized a dataset of user orders for one-way shared electric vehicles in the Shanghai area to describe the differences in shared mobility behavior among different groups of stations under different built environments at different spatio-temporal scales. From the perspective of built environment heterogeneity, we explained the differences in shared mobility behavior. By comparing the shared mobility behavior of different stations at multiple spatio-temporal scales, we found that: (1) In a homogenous external built environment, daily order quantities at shared stations exhibit similar temporal patterns, reflecting consistent shared electric vehicle travel demands. For station clusters with similar travel demands, the flow characteristics of shared mobility behavior remain relatively stable on a quarterly scale throughout the year but show more distinct changes on an hourly scale within a day. (2)

Spatial clustering of shared stations is conducted based on the spatial proximity of the stations and the connectivity revealed by order data. At the regional scale observed by these clusters, the intra-day flow characteristics of shared mobility between different regions are relatively stable. However, noticeable changes occur across different quarters throughout the year, indicating variations in the supply and demand of shared electric cars in different urban areas during the development of the shared system. This research offers insights for shared car operators and urban planners regarding site selection for new stations and maintenance of existing ones.

Urban Spatial Data Analytics – 6

Evaluating the improvement of service availability for e-hailing in Hong Kong: a data-driven approach for spatio-temporal analysis

Xinyu Wang, Mingxi Li and Wei Ma.

Abstract. This paper aims to compare the service availability of taxis in Hong Kong with and without e-hailing. Specifically, we have collected massive taxi location data using HKTaxi, and these data will be utilized to evaluate the level of difficulty in hailing a taxi using street-hailing and e-hailing, respectively. The study could enhance the understanding of how e-hailing could contribute to the spatio-temporal service availability of taxis. With a better understanding of the service availability patterns of taxis in Hong Kong, we hope to propose possible suggestions and recommendations for public agencies regarding how to improve taxi service availability in Hong Kong.

Exploring the Impact of Built environment on Bike-sharing Ridership in Spatio-Temporal Dimension：A Case Study in Nanshan, Shenzhen

Zou Shanlai, Li Xiaoming, Wang Weixi, Hong Wuyang, Ma Ding and Tang Shengjun.

Abstract. Bike-sharing has promoted green and low-carbon travel, but it also brings challenges to urban management. It is necessary to optimize bike-sharing travel through the urban built environment. However, few studies have focused on the impact of urban built environment on bike-sharing ridership in the spatial and temporal dimensions. Taking Nanshan, Shenzhen as an example, the data of built environment in five dimensions of density, design, diversity, distance to transit and destination accessibility and the order data of shared bicycles on weekday and weekend are used for aggregate statistics base on regular grid. The stepwise regression model is used to analyze the significant factors affecting the bike-sharing ridership at different times. And the global regression model(OLS) and geographically weighted regression(GWR) model is used to analyze the relationship between ridership and significant influencing factors at different space. The results indicate that compared to weekend, there are more significant factors that affect bike-sharing ridership on weekday. On a global scale, food service Point of Interests(POIs) in the

dimension of destination accessibility has the most significant impact on shared bike travel. Compared to the OLS model, the GWR model is more superior from the perspective of goodness of fit. In the GWR model, all significant factors simultaneously have a positive and negative impact at different spatial distribution, and the regression coefficients of medical service, catering service, life service and financial service POIs present great differences in spatial distribution. By discussing the distribution of regression coefficient under different spatial and temporal dimensions, the correlation between built environment and bike-sharing ridership can be studied in detail, providing suggestions for the development of bicycle-friendly city and low-carbon transportation.

Research on Key Industrial Spatial Evolution and Spatial Interaction in Shenzhen

Chen Yirun.

Abstract. Reasonable industrial spatial layout needs to grasp the spatio-temporal evolution law of industry and its spatial interaction characteristics. At present, research on the evolution of industrial space at the city scale mainly focuses on the location choice behavior of enterprises from a micro perspective. There is still a lack of research on the evolution of different links within the industry, and insufficient attention has been paid to the interactive phenomenon of industrial space in the era of “flow space”. Therefore, this study takes key industries in Shenzhen as an example, and uses multi-period spatial information and stream data to analyze the spatial evolution laws and interaction characteristics of key industries. The research results show that after years of shifting the center and spatial reconstruction, the manufacturing industry shows more obvious characteristics of multi-center and decentralized distribution, while the service industry shows a strong centripetal agglomeration feature; secondly, different value links within the manufacturing industry present a pattern of concentration and decentralization, that is, service links such as information or sales departments gradually gather in the city center, and manufacturing links mainly spread to the peripheral areas; different industries also show obvious differences in the spatial interaction characteristics of investment interaction and people interaction. The long-distance investment characteristics of labor-intensive manufacturing industry are relatively obvious, while technology-intensive manufacturing industry is closely connected to university research institutions and transportation hubs. These analyses will help to further reveal the evolution law and interaction mode of industrial space, and explore the spatial demand characteristics of industrial evolution and upgrading, so as to provide recommendations for the allocation of space resources.

Urban Spatial Data Analytics – 7

A Hyperspectral Image Denoising Method based on Land Cover Spectral Autocorrelation

Shuheng Zhao and Xiaolin Zhu.

Abstract. Developing denoising algorithms for hyperspectral remote sensing images (HSIs) can alleviate noise problem, improve data utilization as well as the accuracy of subsequent applications. However, existing denoising techniques are usually unstable due to the variations of landscapes, resulting in local distortion of HSIs, especially in heterogenous areas. To tackle this issue, we propose a spatial-spectral interactive restoration (SSIR) framework by exploiting the complementarity of model-based and data-driven methods. Specifically, a deep learning-based denoising module that incorporates both convolutional neural networks (CNN) and Swin Transformer (TF) blocks is designed. This denoiser can achieve local-global dependencies modeling and content based interactions to better capture global heterogeneity differences in HSIs. Moreover, we introduce an unsupervised unmixing module that utilizes spectral autocorrelation as prior information to effectively capture the differences in reflectance characteristics among different land cover components. This parameter-free module further improves the generalization ability of SSIR and enables stable denoising performance across different scenarios. Both modules are iteratively updated and fuel each other in SSIR. The proposed SSIR is shown to outperform others in preserving spatial details, maintaining spectral fidelity, and adapting to different landscapes based on simulated and real experiments conducted on various HSIs under diverse noise conditions.

Transport-oriented built environment, accessibility, and the intra-urban spatial distribution of innovation activities in Hong Kong

Yuting Hou, Xiaohang Ruan and Yuk Tai Lau.

Abstract. This study examines the relationship between transit-oriented development (TOD) and innovation outcomes at the intra-urban scale, using Hong Kong as a case study. Patent data obtained from the Intellectual Property Journals by the Hong Kong Intellectual Property Department (IPD) are applied to represent innovation activities and further differentiated into high-tech manufacturing and knowledge-intensive knowledge sectors. The innovation impacts of transit accessibility and a full set of transit-orient built environment features, including density, land use diversity, street connectivity/walkability and access to local facilities/amenities are explored, while controlling for regional accessibility effects. A zero-inflated negative binomial regression model is applied to account for the excess counts of neighbourhoods with zero innovation capacity at the intra-urban scale. The results indicate that proximity to rail-based transit stations, better road network accessibility, and better access to bus stops significantly reduces the chances of neighbourhoods having zero innovation capacity. Those neighbourhoods within 400 and 800 meters of railway interchange transit stations are more likely to have overall innovation capacity and innovation in high-tech manufacturing sectors. Moreover, neighbourhoods with and better access to the 8 main universities in Hong Kong are more likely to foster innovation activities in high-tech manufacturing sectors, while neighbourhoods with better access to other higher education institutions and better local access to various amenities, such as clubhouses, hotels, markets, and public open spaces are more likely to have stronger

innovation capacity in knowledge-intensive service sectors. The results of the study provide some suggestions on future transport and land use planning in facilitating Hong Kong's transformation from a financial centre to a global innovation hub.

Cross-temporal Chinese urban scene classification and change analysis based on a deep adaptation network and high spatial resolution remote sensing imagery

Sunan Shi, Yanfei Zhong and Yinhe Liu.

Abstract. Multi-temporal urban scene classification and change analysis based on high resolution (HR) remote sensing imagery can provide reliable time-series information for the semantic interpretation of urban land use and the transitional relationships, which is important information for urban planning and sustainable development. However, there are still some difficulties encountered when applying the existing multi-temporal scene classification methods to analyze urban development in China due to the complex urban structure and scene shape. The main reasons for this can be summarized as follows: 1) the multi-temporal data labeling workload caused by the differences of the data distributions among multi-temporal images; and 2) the lack of practical socio-geographical urban unit boundaries resulting from the uniform grid based segmentation. In this paper, a spatial-temporal-aligned multi-temporal scene classification framework based on a deep adaptation network (STADAN) is proposed. In the STADAN framework, multi-temporal OpenStreetMap (OSM) road networks are introduced for the scene segmentation at the land parcel level, to build clear and meaningful geographic boundaries for the scene units. The problem of large scale difference of parcels is solved by area-weighted voting (AWV). In order to solve the problems of the high workload of multi-temporal data labeling in the cross-temporal scene classification task, a gradient reversal layer is used in the proposed STADAN to obtain deep features with invariance relative to the shift between the domains. A spatial-temporal-aligned module is used to capture the invariance features associated with urban scene changes and post-classification is finally performed to obtain the scene change information. Experiments with tri-temporal datasets in Chinese areas demonstrated that the proposed framework can obtain a significantly improved performance in the cross-temporal scene classification and change analysis task. In addition, compared with previous studies based on bi-temporal classification, the use of three time phases can provide more time-series information about urban structure changes.

Automatic Identification and Reconstruction of Stairs from LIDAR Point Cloud

Feng Li and Wenzhong Shi.

Abstract. Stairs are important structural components of indoor scenes, which are widely found in the vertical connections of multi-storey buildings. The reconstruction of stair not only enriches the semantic information of indoor 3D models, but also provides the connectivity information of indoor space. It is important in a variety of fields, such as indoor path planning, room segmentation and building management. However, fewer studies have focused on reconstructing stair models from point clouds, or only the geometric features of

the steps are computed while ignoring the slab space. To this end, we design a method that automatically reconstructs steps, floor slabs and handrails of a stair from point clouds. The input of the algorithm is the point cloud obtained by the backpack laser scanner, and the whole mesh model of the stair space is taken as the output. Firstly, the extent of the wall is acquired by the normal information obtained from the principal component analysis, which is used to roughly determine the location of the stair space. Then, mean shift clustering is utilized to obtain the location of slabs from the height histogram of the point cloud. Next, the tread and riser of the stair, as well as the number of steps are extracted using an axis-constrained plane segmentation algorithm. Finally, individual parts are reconstructed one by one in terms of the computed geometric sizes and integrated into the output. The effectiveness of the method is verified on the test dataset.

An Efficient Unfolding Network with Disentangled Spatial-Spectral Representation for Hyperspectral Image Super-Resolution

Denghong Liu, Jie Li, Qiangqiang Yuan, Li Zheng, Jiang He, Shuheng Zhao, Yi Xiao and Xiaolin Zhu.

Abstract. Hyperspectral image super-resolution (HSI SR) is dramatically impacted by high spectral dimensionality, insufficient spatial resolution, and limited availability of training samples. Current approaches mainly rely on complex data-driven models to address some of these challenges, and the characteristics of HSI are not fully considered in the model design. In this paper, we propose an efficient unfolding network with disentangled spatial-spectral representation (EUNet) for HSI SR by combining domain knowledge (i.e., spectral correlation, degradation model, and structure prior) with deep learning. Specifically, the optimization process of the super-resolution prior-driven Maximum A Posterior (MAP) framework is unfolded into an interpretable multi-stage network, which inherits the advantages of deep learning-based image super-resolution (e.g., feature extraction in low-resolution space) and explicitly imposes the degradation model constraint. To well incorporate the structure prior of HSI, spatial and spectral feature extraction is disentangled by a variant of depthwise separable convolution, and spectral correlation is embedded by a lightweight spectral attention mechanism, so that the difficulty and computational complexity of feature learning are greatly reduced. Experiments on benchmark datasets with different degradation models demonstrate the feasibility and superiority of the proposed EUNet over other state-of-the-art methods in terms of evaluation metrics and computational complexity.

Smart Cities Solutions – 1

A coupling model for measuring the substitution of subway for bus during snow weather: a case study of Shenyang, China

Jie Liu and Shaolei Wu.

Abstract. The development of integrated public transportation network has received widespread attention in recent years. Especially in global northern cities, improving the substitution of subway for bus could meet the population travel demand during snow weather, which minimized the impact of snow weather on the public transportation network. Therefore, in this study, we selected a Chinese northern city-Shenyang as a case study. For obtaining the population travel demand, we collected the actual population flow data in the morning and evening peaks during snow weather. The network analysis was used to identify the loopholes and key stations in the subway and bus networks, respectively. And a coupling model was built to measure the coupling value of each station in subway and bus networks, according to its population travel demand and supply capacity, which in further measure the substitution of subway for bus in the morning and evening peaks during snow weather. The results indicated that some subway stations were in a coupling state, while their surrounded bus stations were in a decoupling state. These subway stations could replace the bus network to reduce the impact and damage of snow weather on public transportation network. However, some subway stations and the surrounded bus stations were all in a decoupling state, which were under great pressure to meet the population travel demand during snow weather. This study can provide insight into optimizing public transportation network planning and design in many northern regions.

Construction and Application Research of Economic Evaluation System Model in Urban Renewal Project——Taking Zhuhai City Urban Renewal Application as an Example

Jidong Liu and Zili Zhao.

Abstract. Economic evaluation is an important reference for adjusting the volume ratio and other indicators in urban renewal projects. However, in the actual work process, the competent department of urban renewal lacks guidance and effective means of checking the economic evaluation results submitted by the project applicant. It is urgent to establish a fair and reasonable long-term mechanism for economic evaluation of urban renewal projects. In response to this problem, this paper attempts to establish a set of quantitative and qualitative analysis evaluation system based on the research of predecessors on urban renewal and evaluation. In response to this problem, based on the previous studies on urban renewal and evaluation, this paper attempts to establish a set of quantitative and qualitative analysis evaluation systems which can provide a decision-making platform and basis for correctly handling the relationship between economic evaluation and urban renewal unit planning. The research content of this paper mainly includes: (1)Study the economic evaluation and measurement model and economic evaluation system for urban renewal projects, and provide an automatic measurement mechanism for the multi-program comparison analysis of urban renewal projects. (2)Apply GIS technology and database management platform to integrate and manage multi-source data such as various layers, project information, planning data and urban POI data in urban renewal, and provide basis for determining cost parameters. (3)Research on refined model management based on BIM and 3D GIS, providing dynamic update mechanism for data management and auxiliary program review

of urban renewal projects to realize the programmatic, automated and precise management of the economic indicators of urban renewal projects.

Study on the Digital Empowerment of Shanghai Huangpu River for Tourism Quality Improvement

Jia Tang, Jingwei Li, Rui Liu, Mijun Zou and Jia Song.

Abstract. With the growth of people's needs for a better life, the mismatch between supply and demand in China's tourism has become increasingly prominent. Especially in recent years, the construction requirements of Digital China have put forward transformation and upgrading requirements for tourism development. Taking the Huangpu River in Shanghai as an example, this study uses diversified means such as field surveys, questionnaires, enterprise interviews and expert seminars to explore identify the current development situation and problems in constructing tourism quality for the Huangpu River under the goal of building a world-class waterfront. And then, after investigating international cases, this study proposes to upgrade the tourism quality of Huangpu River with the support of digital technology and concepts. The results show that the Huangpu River has abundant tourism resources, but under the high development requirements, there are still problems such as the weak linkage between river and its bank, the inconvenience of some service along the river, and the insufficient collaboration between management departments. Meanwhile, international experience shows that using digital techniques to improve the tourism quality is an inevitable trend. Finally, this study suggests using digital means to develop river-bank linked tourism products, to create a one-stop tourism service, as well as a collaborative platform to reform the tourism experience of Huangpu River.

An ESG-centric Exploration of Factors Influencing Urban Economies within the 15-Minute Living Circle

Jingxue Xie and Jiaqi Song.

Abstract. The 15-minute living circle, advocating basic amenities within a 15-minute walk, is a pivotal concept in strategies for sustainable and inclusive cities. Coupled with the rising significance of environmental, social, and governance (ESG) principles in urban development, there is a growing need to understand the interplay between urban form, economic vitality, and ESG performance in these urban landscapes.

This study employs deep learning (DL), geographic information systems (GIS), and extensive urban economic data to investigate factors shaping urban economies within seven selected 15-minute living circles in Shenyang, China. Analyzing street view images using DL, we classify urban elements, subsequently integrating this information with urban economic data such as property values, business performance indicators, and point-of-interest (POI) data.

The fusion of these datasets is processed in ArcGIS for spatial analysis and visualization. Our goal is to discern spatial patterns and correlations between urban landscape features, public facilities distribution, and economic indicators. We aim to reveal how the built environment and amenity accessibility influence the health and sustainability of urban economies, within the broader ESG framework.

The study's findings will offer valuable insights for policymakers, urban planners, and businesses, enabling optimization of the interplay between urban form, accessibility, and economic prosperity within the 15-minute living circle. Our research also highlights the value of combining advanced machine learning techniques with GIS for complex urban economic research, underlining its relevance to the global ESG agenda.

Modeling the Impact of Chinese New Intervention Measures on COVID-19 Transmission: A Study on the Omicron B11529 Outbreak in Shenzhen, China

Taicheng Li, Jizhe Xia, Zhong Leiyang and Ying Zhou.

Abstract. As the Chinese government issued a significant swift of COVID-19 intervention policy (so-called new ten COVID-19 intervention regulations), which canceled the zero-COVID such as temporary containment and required health code to enter public spaces, it is questionable how this change may impact COVID-19 transmission within Chinese cities. Here we developed a data-driven spatial compartment model of coronavirus disease 2019 (COVID-19) Omicron (B.1.1.529) variant transmission for Shenzhen, China, which combines mobile phone data and control measures. We employed our model to assess the effectiveness of different combinations of control measures to contain the COVID-19 outbreak, and to simulate the outbreak in Shenzhen after the cancellation of the zero-COVID policy in China. Our result showed that, given economic and resource constraints, nucleic acid testing in zero-COVID is most effective in stopping COVID-19 transmission, and infection incidence peaked on 11 December when control was completely removed.

Anomaly Detection of InSAR Time-series Deformation based on Generative Adversarial Networks

Zhichao Deng, Siting Xiong, Bochen Zhang and Qingquan Li.

Abstract. Interferometric Synthetic Aperture Radar (InSAR) has become a widely applied and highly efficient tool for monitoring large-scale long-term deformation of the Earth's surface. Currently, in most applications, evaluation of the InSAR results on land deformation is primarily dependent on the deformation rate/velocity, which is derived by applying a linear fit to the time-series results. However, fully exploitation of the time-series information is becoming increasingly important as the monitoring term becoming longer and longer, during which the deformation status is evolving. Therefore, effectively utilizing the full time-series of deformation data has been a challenge in InSAR post-analysis. Deep learning techniques, particularly the Generative Adversarial Networks (GAN), have shown promise in addressing various issues in the field of remote sensing. Motivated by this, we propose a novel approach that employs an unsupervised GAN method to automatically

detect abnormal deformation time slots in InSAR derived time-series deformation.

Our method involves inputting the time-series deformation into the GAN framework to generate a reconstructed version representing the normal deformation pattern. Subsequently, a comparison is carried out between the InSAR derived time-series deformation and the GAN-generated time-series deformation to identify areas exhibiting abnormal deformation. By applying our approach to the InSAR results of Shenzhen, we have successfully detected abnormal deformation time slots and accurately pinpointed the specific locations and severity of these abnormalities.

Smart Cities Solutions – 2

Urban Heat Vulnerability Analysis Using a Novel Classification System of Local Climate Zone

Siyeon Park and Sugie Lee.

Abstract. The urban heat island(UHI) effect, which means that the temperature of the 'urban' area is higher than that of the surrounding 'rural' area, is emerging as a severe urban problem, and especially the intensity and frequency of UHI are increasing due to the modern cities' structural and functional characteristics. By 2050, the detrimental effects of UHI will escalate as the urban population is expected to grow to roughly 70%, so it is imperative to implement UHI mitigation strategies based on urban planning. As interest in UHI increased, the concept of Local Climate Zones (LCZ) was devised to provide an objective framework for UHI research, which allows for a microscopic scale definition of UHI within urban areas by considering 'urban' and 'rural' as a continuum without dichotomically distinguished. However, in contrast to its purpose of considering microscopic observations and human activity characteristics, most LCZ types are classified only by surface structure and coverings, which seem irrelevant to climatological and microscopic concepts. In addition, microclimate is influenced by urban metabolism related to human activities as well as the structural effects, but the LCZ classification system does not contain the concept of this functional aspect. Therefore, this study proposes a novel urban classification system that addresses the limitations of the LCZ concept by microscopically quantifying the structural and functional elements of the city at the pedestrian level using S-DoT sensors and semantic segmentation techniques. This study holds significance as it suggests a New-LCZ to support the classification framework of highly valid urban types and follow-up studies related to UHI. Moreover, it is highly valuable as it offers a regional and reasonable urban planning strategy for sustainable development by deriving UHI vulnerable areas and analyzing spatial distribution characteristics through a more valid classification system.

Food Deserts and COVID-19: Utilization of Location-Based Smartphone Mobility Data in New York City

Devina Widya Putri and Sugie Lee.

Abstract. An urban environment where the primary needs are not equally distributed and accessible, such as a food desert, contributes to health disparities, particularly for minority and low-income communities. A food desert was often examined as the number of or the distance to the closest healthy food source in the area, while how often and how far the people access the sources remained unknown. Especially during the COVID-19 pandemic when activity and mobility were restricted, access to healthy food could be more segregated as well. Thus, this study attempted to examine the food disparity in New York City and how it differed due to the COVID-19 pandemic, by utilizing the POI and mobile phone GPS data provided by SafeGraph. We measured the number of visits and the distance travelled to grocery stores, in which lower visits and longer distances reflected food disparity, then analysed the relationship with ethnicity, household income, educational background, and employment in 2019-2020. We found that people living in Bronx had a lower number of visits and longer travel distances to grocery stores compared to other boroughs. Moreover, despite the no segregation in the spatial distribution, residents of the census block group with a higher percentage of non-white people travel farther distances when visiting grocery stores, and the distance got even longer during the pandemic period. Finally, our findings suggested some implications for reducing food deserts and mitigating the pandemic situation, in a diverse and highly-dense urban area context.

A semantic segmentation dataset of rich window view contents in high-rise, high-density cities based on photorealistic City Information Models

Maosu Li, Fan Xue and Anthony Gar On Yeh.

Abstract. Many existing studies examine urban views at the ground level, e.g., through street view imagery, or from overhead, e.g., through airborne and satellite images. By contrast, urban-scale window views of varying heights are less assessed despite their social-economic values regarding housing selection and valuation and quantified evidence for improving the neighborhood built environment. Recently, Li et al. (2022) introduced an automatic assessment of photorealistic window views on City Information Models (CIMs) to quantify the proportions of view features, such as greenery, sky, waterbody, and construction through deep transfer learning and regression. However, the estimated proportions of view features lack spatial distribution of window view features, which limits the quantification of structure-based window view characteristics e.g., fragmentation levels of visible sea, sky, and greenery for window view quality assessment. The root cause is the absence of annotated window view images for direct pixel-level semantic segmentation of window views. This paper presents a CIM-generated Window View (CIM-WV) dataset comprising 2,000 annotated images for advancing pixel-level window view assessments. The CIM-WV collected in the high-rise, high-density urban areas of Hong Kong includes seven semantic labels, i.e., road, terrain, building, vehicle, vegetation, waterbody, and sky. Last, we showcase an automatic assessment of fragmentation levels of sea, sky, and green views for housing selection and valuation using DeepLab V3+ trained on CIM-WV. The CIM-WV dataset is publicly available for researchers for future vertical urban view applications; examples include semantic segmentation of window views and comparative

studies of real view images and CIM-generated view images.

Problems and Suggestions on Smart City Construction in Wuhan

Huali Xiang and Jun Yang.

Abstract. Smart cities use technology to make cities more inclusive, resilient, adaptable and sustainable. Wuhan has successively created smart transportation, digital urban management, Wuhan smart city spatio-temporal information cloud platform, and urban space integration services, etc., which are influential in the country.The main problems in the construction of smart cities in Wuhan are: (1) Smart products have a short lifespan, poor maintainability and scalability; (2) Smart products rely too much on low-end equipment such as cameras and the Internet, and rely on big data and AI algorithm automation Not much has been dealt with; (3) The public has insufficient understanding of the value of big data, limited to the processing of current business work, and fails to understand the optimization of business processes and the prediction and processing of future conditions through big data.(4) Public participation in the design of smart products is insufficient, and products often fail to meet user needs. Based on this, it is suggested: (1) Customize smart products through AI technology, so that the generation process of smart products has learning ability, and can continuously update the current smart products through learning to enhance their maintainability and scalability; (2) through Measures such as competitions and scientific research projects encourage the R&D and transformation of automation products and equipment; (3) strengthen the training of the public, so that the public can further understand the value of big data and increase the acceptance of smart products; (4) Strengthen system design, promote public participation in smart product design, and make smart products closer to public needs.

Spatial and Temporal Analysis of Urban Carbon Neutrality and Shrinkage in China: Implications for Environmental Challenges

Shuo Peng.

Abstract. This research paper investigates the spatial and temporal evolution of urban carbon neutrality and urban shrinkage in northeast China, employing panel data from 2000 to 2020. By employing a spatial panel data model, the study aims to analyze the potential problems associated with these phenomena. Specifically, the paper explores the possible spatial interaction between urban shrinkage and carbon neutrality, assessing the impact of urban shrinkage on achieving carbon neutrality. The findings reveal the following key insights: (1) In Northeast China, due to the prevalence of developed industries and limited progress in ecological restoration, carbon emissions from shrinking cities exhibit an increasing trend. Although there is also an increase in carbon sinks, the overall level of carbon neutrality tends to decrease. This suggests that the growth of carbon emissions poses a challenge to achieving carbon neutrality in the context of urban contraction. (2) The analysis of the relationship between urban shrinkage and carbon emissions, as well as carbon sinks, indicates a correlation between these variables, implying that urban shrinkage exerts

a certain influence on carbon neutrality. Population loss and low fertility associated with urban shrinkage lead to reduced city size and population density, which in turn hampers the timely transition of industrial structure, affecting economic activities and energy consumption and ultimately resulting in a decline in carbon neutrality. (3) Notably, population decline emerges as a distinct characteristic of shrinking cities. This reduction in population may lead to inefficient utilization of urban land and buildings, subsequently affecting the sustainability of the urban environment and resource efficiency. These findings shed light on the complex relationship between urban shrinkage, carbon neutrality, and environmental sustainability, underscoring the need for targeted interventions to address the environmental challenges arising from urban contraction.

Smart Cities Solutions – 3

A Multiview Spatiotemporal Model for Bus Travel Demand Prediction using Graph Neural Networks

Tianhong Zhao, Zhengdong Huang and Wei Tu.

Abstract. The accurate prediction of travel demand for bus services plays a pivotal role in the effective management of urban mobility demands. However, existing models for predicting bus travel demand mainly focus on the spatiotemporal dependence of bus travel demand, while neglecting the intricate interactions between buses and other modes of transportation, such as metros and taxis. In this study, we propose a novel approach, namely the Multiview Spatiotemporal Graph Neural Network (MSTGNN) model, to forecast short-term travel demand for bus services. This model places significant emphasis on capturing the interdependencies among the travel demands of buses, metros, and taxis. Firstly, we construct a multiview graph comprising bus, metro, and taxi views, where each view encompasses both local and global graphs. Secondly, we develop a multiview attention-based temporal graph convolution module to capture the spatiotemporal dynamics and cross-view interaction dependencies among different modes of transportation. Notably, to address the uneven spatial distributions of features in multiview learning, the cross-view spatial feature consistency loss is introduced as an auxiliary loss. Finally, to evaluate the effectiveness of our proposed MSTGNN model, we conduct extensive experiments utilizing a real-world dataset obtained from Shenzhen, China. The experimental results demonstrate that our proposed MSTGNN model outperforms existing models in terms of predictive accuracy. Additionally, ablation experiments are performed to validate the contributions of various modes of transportation to the enhancement of the model's performance.

Wise choice of showerheads: understanding the impacts of shower water spray patterns on heat transfer coefficient between water and human skin

Dadi Zhang, Kwok-Wai Mui and Ling-Tim Wong.

Abstract. Heat transfer coefficients between shower water and human skin could significantly impact occupants' thermal sensation and energy consumption during showering. A recently published study found that heat transfer coefficients varied considerably among showerhead patterns. However, no specific effects for overall showerhead patterns were concluded because of the limited characteristic parameters of showerheads. Nonetheless, the impacts of water spray patterns on the heat transfer coefficient between water and flat surface were investigated and identified by several studies on spray cooling. Similar effects were expected for the heat transfer coefficients between shower water and human skin during showering. Hot water showers are the opposite process of water spray cooling. This study conducted experiments to quantify the water spray patterns during showering and define their impacts on the heat transfer coefficient. Five showerheads with 18 water spray patterns were tested in this study. These patterns' resistance factor, water supply pressure, and nozzle area ratio were measured to qualify their shower performance. Each pattern was tested under six showering conditions (two water flow rates × three water temperatures), and the heat transfer coefficient of each condition was calculated using the method proposed by a previous study. Results indicated that the heat transfer coefficient was significantly correlated with the resistance factor ($r=0.331$, $p<0.001$), water supply pressure ($r=0.271$, $p=0.006$), and nozzle area ratio ($r=0.283$, $p=0.004$) of the water spray patterns in general. Although these correlations were not always significant if examining the showerhead individually, clear trends still can be observed. The influence of water spray patterns on the heat transfer coefficient could provide residents with scientific references when selecting showerheads in their bathrooms.

Does neighbourhood environment matter for people-centric street transition? An associational study of Covid-19 pandemic-induced street experiments

Jianting Zhao and Guibo Sun.

Abstract. Pandemic-induced street experiments (e.g., pop-up bike lanes, outdoor cafes, shared streets) emerged globally during the COVID-19 pandemic. Over the past three years, these experiments underwent distinct development trajectories, with some converted into permanent structures while others ended shortly. This study aims to understand what neighbourhood environments are conducive to longer-lasting street experiments. Our findings may contribute to the explanation of people-centric street transition.

The analysis incorporated three major datasets. The Global mapping of pandemic-induced street experiments: We mapped locations of 540 pandemic-induced street experiments across 230 cities; the Street-level built environment indicators: We include population density, intersection density, link-to-node ratio, street closeness centrality, betweenness centrality, amenities density and amenities diversity; and the Street experiment outcomes: a binary outcome of 'ongoing' or 'cancelled' was classified based on the current status collected through case-related news reports, press releases, and social media as of January 2023. We applied a gradient boosting decision tree model and logistic regression to understand the associations at the street level and the intervention program level.

Our preliminary results show higher population density, closeness centrality, and amenities

diversity tend to contribute to ongoing interventions. Interventions that are strategic responses with a transport focus and a long-term development intention are more likely to continue. This study contributes to the explanation of why some street experiments that emerged from the pandemic could stay and why some ended from the aspect of the neighbourhood environment and experiment characteristics. Scholars speculated a critical juncture towards a people-centric street transition from these street experiments. Our study examines the nuances of this transition process.

Spatial Mapping and Differentiation Characteristics of Urban Residential Environment Green Space in Inner Mongolia Based on Remote Sensing

Junjie Yang, Guijun Zhang, Quan Wu, Jun Hao and Xin Yu.

Abstract. The sustainable development of cities and the improvement of the quality of human settlements are the important goals of the construction of a community with a shared future and a beautiful home. The ecological environment in northern China is fragile. The current research needs to go deep into the spatial mapping of urban human settlements green space in arid and semi-arid areas. Based on the method of multi-source data fusion, using the mixed pixel decomposition model, cooperating with human-computer interaction to interpret the sub meter high-resolution remote sensing image, this study developed the green space area components and park green space data sets of 12 prefecture level cities in Inner Mongolia. The results show that the complex correlation coefficient (R^2) is 0.87. The urban green area of Inner Mongolia is 295.40km², the green area of hubao'e urban agglomeration accounts for 74.92% (151.72km²) of the total land area of the built-up area, and the green area accounts for more than 20% of the built-up area on average in 2019. The green area of urban parks in Inner Mongolia is 73.14 km², accounting for 24.03% of the total area of urban green space; the regional differences of the green area of urban parks are obvious, and the area scale of the western region (Hubao'e city group, etc.) is larger than that of the eastern region (Hulunbuir, Xing'an, Tongliao, Chifeng, etc.), with an area scale of 0.05-0.5 km² accounting for the largest proportion (35.22%).

Gross Primary Productivity is More Sensitive to Accelerated Flash Drought

Yangyang Jing and Shuo Wang.

Abstract. Flash droughts have substantial impact on terrestrial ecosystems and the human environment, appear to be coming on faster. However, little is known about the global quantification of relationship between the ecosystem productivity response and the rapid onset development of flash droughts. Here, we investigate ecological impacts of flash droughts within different plant functional types on a global scale during the period 2001—2019 by considering decline rate of root-zone soil moisture and standardized gross primary production anomaly (saGPP) decreasing rate. We find that the ecosystem productivity is more sensitive to flash droughts that coming on faster, and there is a significant increasing trend in the response frequency of saGPP during flash droughts with the 1-2 pentad onset time. Moreover, the saGPP do not respond to rapid-onset flash droughts at shorter time-

scale, just decrease more rapidly. We also find that there are higher sensitivities of vegetation types have deeper roots. Our results indicate that the accelerated flash drought poses an increasing threat to terrestrial ecosystem in a warming future world.

Emerging Topics in Smart City Development – 1

Identifying the built environment factors for revitalizing the vitality of commercial districts

Chendi Yang, Rui Ma and Siu Ming Lo.

Abstract. Revitalization of business districts in the post-pandemic period cannot be achieved without vitality, which is not only necessary but also beneficial for offline retail. Therefore, identifying the predictors of vitality in the built environment is increasingly becoming an aspect of interest and concern for urban planners and decision-makers. However, the current exploration of vitality indicators in the built environment remains at the urban level, and little attention is paid to specific areas in the city. Therefore, it is still a challenging task to explore the vitality factor of commercial areas. Shenzhen is one of the fastest-growing cities in China. This study describes the built environment of the commercial districts from five dimensions (design, density, diversity, destination accessibility and distance to transit) based on multi-source city data such as street and building vectors, point of interest (POI) and street view images. Then the spatial and temporal distribution of the vitality of Shenzhen's typical commercial districts is investigated by using location-based service (LBS) data as a proxy of vitality. This study found that the vitality of the commercial districts is related to some indicators of the built environment, and there are significant differences between weekdays and weekends. The findings of this study are helpful to further understand the relationship between the vitality of commercial districts and the built environment, and provide new insights for solving the vacancy of commercial space and realizing temporal use.

A quantitative study of the effectiveness of industrial metaverse construction - an example of a smart site application scenario

Zeyuan Dong.

Abstract. A large amount of local fiscal funds have been invested in the digital transformation of urban planning, construction, and management, among which the civil engineering and construction industry is one of the key areas. The digital transformation of the civil engineering industry is mainly reflected in the application scenarios of smart construction sites, which use computer information technology to carry out digital transformation on the basis of traditional engineering workflows to form a digital twin of engineering mapping in cyberspace, which can be considered as one of the scenarios of the industrial metaverse.

However, the construction of smart construction site application scenarios requires additional manpower and funds, and the results achieved are difficult to quantify, which makes the confidence of relevant units in smart construction site construction gradually decreased. Other scenarios of the industrial metaverse face similar problems, and it seems that the input-output ratio of building the industrial metaverse is very low.

In response to this problem, we hope to find an effective way to measure the effectiveness of the industrial metaverse. Taking the smart construction site application scenario as the starting point, this paper investigates the influence of traditional civil engineering operation mode and smart construction site operation mode on engineering variables through regression analysis, obtains a number of weight parameters, and finally forms a smart construction site effectiveness measurement formula that dynamically changes with the development of computer technology. Combined with the development trend of smart construction site construction in recent years, predict the market trend of smart construction site application scenarios in the future. Through the above research, we will explore the deep benefits of smart construction sites and even the industrial metaverse, reflect the correctness of relevant investments, and provide a basis for increasing investment in industrial metaverse scenarios in the future.

Satellite-based urban scale real-time PM25 and ozone retrieval using improved deep learning models

Xing Yan.

Abstract. This study proposes a new deep learning model called Simultaneous Ozone and PM2.5 inversion deep neural Network (SOPiNet), which allows for daily real-time and full coverage of PM2.5 and O3 simultaneously. We believe that our study makes a significant contribution to the literature because it addresses the limitations of conventional deep learning models for pollution data collection. The highlights of this research are:

1.A Simultaneous Ozone and PM2.5 inversion deep neural Network (SOPiNet) was developed.

2.The relationships between extreme O3 and PM2.5 events are shown for China.

3.The attention mechanism to better capture temporal variations in O3 and PM2.5.

4.Joint learning of PM2.5 and O3 improved retrieval performance especially at high concentrations.

Intergenerational and Multi-scenario Mobile Landscapes: Spatiotemporal Patterns of Human Activities in Different Age Groups under Normal and Abnormal Scenes

Yichen Xu, Miao Shen and Feng Zhang.

Abstract. Contemporary urban development is increasingly diversified, complex and dynamic, and exploring the spatiotemporal patterns of human activities is important for understanding complex urban systems. However, most studies think less about the variety

of spatiotemporal patterns of human activities between different age groups in multi-scenes. In this paper, we propose a project named Intergenerational and Multi-scenario Mobile Landscapes to explore spatiotemporal patterns of different age groups in Shanghai from January to March 2022 under normal and abnormal conditions. The results show that in normal scene, the working-age population tend to gather in commercial or working places, while the elderly are more scattered in the regular state. When there are anomalies, the spatiotemporal dynamic characteristics of working-age people change before those of the elderly, and tourist attraction areas are affected first with high impact. The results of Intergenerational and Multi-scenario Mobile Landscapes can be used to provide scientific reference for urban planning, improving urban safety resilience.

Three-dimensional Transportation Smart City - An Exploration of Pilot Demonstration Zone in China

Xiang Li, Cheng Shen, Hua Zheng and Yuzhu Rao.

Abstract. China's National Transportation Strategy plans to complete a modern, high-quality national comprehensive three-dimensional transportation network by 2050. The existing research lacks the consideration of the integration of urban low-altitude airspace transportation and urban planning. This research innovatively introduces the concept of "Urban Three-dimensional Transportation (U3DT)", summarizes the pain points and needs of conventional urban transportation, and builds a "three-dimensional transportation smart city (3DTSM)" based on a three-dimensional transportation network. The 3DTSM, in addition to the integration of the existing "water, land, and air traffic", coupled with the application of urban low-altitude traffic, is a further understanding and augmented of the smart city, also a breakthrough in the traditional urban transportation mode, a longer-term outlook for future transportation construction. It is a new adaptation round based on modern urban production modes and transportation systems to the existing product development level. 3DTSM also puts forward further requirements for the combination of urban systems and three-dimensional transportation networks. Urban systems like urban space, function, form, development direction, society, economy, industry, etc. Through the wide application of new technologies, the concept planning of digital, networked, intelligent, and green future cities is realized. The research makes overall consideration from the aspects of goals and visions, functional formats, spatial forms, scene design, public space, and comprehensive transportation, and innovatively integrates advanced transportation with smart city planning and future transportation. At the same time, it fully considers the existing social systems and future new urban systems, with the theme of designing a new system of modern urban three-dimensional transportation and building a new model of urban future transportation. 3DTSM proposes a future-oriented conceptual planning of urban three-dimensional transportation, which is both innovative and operable.

Emerging Topics in Smart City Development – 2

Co-benefits of floating solar power for air pollution and carbon emission reductions to aid mining cities transition

Qiping Wu and Zhongbin Li.

Abstract. Cities in Northeastern China have suffered heavy air pollution for many years because the energy and heating provision has long been dependent on coal-fired power plants. The power cuts occurred in September 2021 because of coal shortages highlighted the importance of accelerating renewable energy transition. Solar energy is a critical alternative to replace fossil fuels and phase out coal-fired power plants. However, large-scale solar photovoltaic (PV) deployment requires vast amount of land. To mitigate land competition, deploying solar PV over unproductive lands is an effective strategy. However, investigations to convert abandoned open-pit mines into artificial lakes and deploy floating solar PV over them are still lacking in China. We selected Fuxin and Fushun, two typical resource-exhausted mining cities, to explore the potential of open-pit mine-based solar power stations. The results show the west open-pit mine in Fushun can provide an 8.25 km2 of water surface area to install a 904.64 MW floating solar power station, and the Haizhou open-pit mine in Fuxin can provide 5.21 km2 to install a 564.96 MW floating solar power station. The two designed floating solar PV stations can generate 46.38 TWh of electricity over their 25-year lifetime. They can replace a 474.54 MW coal-fired power plant, reducing 13.98 million t coal consumption and emissions of 38.4 million t CO2, 4680 t SO2, 7050 t NOX, and 1280 t PM2.5 in 25 years. Our study indicates that deploying open-pit mine-based floating solar PV stations can help local mining cities reduce carbon emissions and air pollution while facilitating their transition towards environmentally friendly and low-carbon cities. Future studies could analyze the strategy's potential at a national or global scale.

Health effects of multiple air pollutants on renal health in children and adolescents

Cui Guo.

Abstract. Background: Associations between multi-pollutant air pollution and renal health remained unclear, especially in children and adolescents. This study aimed to examine the effects of long-term exposure to air pollution and renal health in children and adolescents in Taiwan and Hong Kong.

Methods: This study included 10,942 children and adolescents aged ⩽ 25 years from 2000 to 2017. PM2.5, NO2 and O3 concentrations were estimated using satellite-based spatiotemporal regression models. Two-year average concentrations, those of the year of visit and the preceding year, were used. Linear mixed models were used to examine the association between air pollution and yearly changes in estimated glomerular filtration rate (eGFR). Cox regression models with time-dependent covariates were used to examine the association between air pollution and the development of chronic kidney disease (CKD). Both single- and multi-pollutant models were used.

Results: For the single-pollutant models, each 10μg/m3 increase in PM2.5 was associated with a 0.45μL/min/1.73 m2 [95% confidence interval (CI): 0.28−0.63] reduction in the yearly increase in eGFR and 53% [hazard ratio (HR): 1.53 (95%CI: 1.07–2.2)] greater risk of CKD. Each 10μg/m3 increase in NO2 was associated with a 7% [HR (95%CI): 1.07 (1.00–1.15)] higher risk of CKD, while an equivalent increase in O3 was associated with a 19% [HR (95%CI): 0.81 (0.67–0.98)] lower risk of CKD. For multi-pollutant models, the air pollution–CKD associations were slightly attenuated.

Conclusions: Long-term exposure to ambient PM2.5 and NO2 was associated with a slower growth of eGFR and a higher risk of CKD in children and adolescents. Our findings suggest that air pollution control in early life is imperative to improve lifelong renal health and alleviate the CKD burden.

Spatio-temporal Information for GBA Synergistic Development

Geographical Technology for Synergistic Development in the Guangdong - Hong Kong - Macao Greater Bay Area (GBA)

Zhengdong Huang

Abstract. Shenzhen University, in collaboration with other nine universities, research institutes, and enterprises, undertook the National key research and development program project, titled "Research and Application Demonstration of Comprehensive Decision-Making and Synergetic Service in the City Cluster of Guangdong-Hong Kong-Macao Greater Bay Area". This presentation introduces several key findings of the research, including measurement of synergistic relationships between cities, cross-border data integration, industrial collaboration, large-scale simulation of spatial distribution, travel flows between cities, and a platform. Details of the technologies will be reported by the six speakers of this session.

Measurement and Evaluation of the Synergistic Development in the GBA

Changjian Wang

Abstract. On the basis of fully understanding the scientific connotation of synergistic development of urban agglomeration in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), the evaluation index system of synergistic development is constructed from five dimensions: industry synergistic innovation, service synergistic sharing, resources synergistic allocation, environment synergistic governance, and institution synergistic arrangement. The theory and method of space of flows, big data, network analysis and interlocking network model are comprehensively used to quantitatively analyze the interurban relationship, liquidity, connectivity and boundary effect. The research shows that: 1) Interurban capital flow is concentrated between Guangzhou and Shenzhen, and interurban knowledge flow is concentrated among Hong Kong, Guangzhou and Shenzhen. Macao, Zhuhai, Zhongshan and Jiangmen have higher level of environment synergistic governance, while Shenzhen-Dongguan-Huizhou and Guangzhou-Foshan have lower level of environment synergistic governance. The interurban service synergistic sharing level of infrastructure such as transportation, communications, logistics and banking is higher among cities of Guangzhou-Shenzhen, Guangzhou-Foshan and Shenzhen-Dongguan. And Hong Kong and Macao have institutional advantages in cross-border regional cooperation. 2) Guangzhou and Shenzhen, Guangzhou and Foshan, Shenzhen and Dongguan, and Hong Kong and Shenzhen have the best level of synergistic development in the GBA. At the same time, Guangzhou and Dongguan, Shenzhen and Foshan show a linkage trend. Although the de-boundary trend is obvious and the interurban liquidity is enhanced, the synergistic development level of the GBA is generally not high. 3) The synergistic capacity of Guangzhou and Shenzhen is the strongest, and there is still much room for improvement in the synergistic capacity of the two international cities, Hong Kong and Macao. It is of great practical value to deeply understand the typical characteristics and potential trends of the synergistic development of urban agglomeration in the GBA for the construction of international first-class bay area and world-class urban agglomeration.

Cross-border Spatial Data Fusion in the GBA

Anshu Zhang

Abstract. To realize synergistic decision-making and smart-city services in a city cluster, the spatial datasets of different cities often need to be fused to form a unified dataset for computation and analysis. However, unlike the situation of other Chinese city clusters, Guangdong, Hong Kong, and Macao have different spatial data specifications, and there are significant and intricate distinctions between the spatial data in the three regions. In this presentation, we will be introducing the methods that we have developed to overcome such difficulty and realize cross-border data fusion in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA). First, systematic approaches have been developed to fuse the land use data in Hong Kong (27 level-2 classes), Macao (20 level-2 classes), and Guangdong (106 level-2 classes), and the conversion of data in each region to match the land use classification systems of the other two regions is realized. In particular, a land use data subcategorization method

based on multi-source point-of-interests (POI) and base maps is invented to deal with the conversion between complex built-area land use classes, which has been difficult to achieve through semantic analysis or remote sensing imagery classification. The average conversion accuracy of the method exceeds 90%, showing its usefulness to greatly reduce human labor in land use data fusion of the GBA. Secondly, a new POI data fusion method for high-density urban areas is developed. With enhanced data processing and matching strategies, the method may overcome the difficulty of POI data fusion in high-density urban areas and performs well in fusing multi-source open data into a cross-border location-based service platform. This enables the enrichment and correction of POI data on the platform, and, further, the improvement of cross-border location-based services.

The Study on the Knowledge Mapping and Synergistic development of Industrial Clusters in the GBA

Yu Chen

Abstract. The synergistic development of regional industrial clusters is crucial for regional economic development. In this study, big data on enterprise registration, investment, and mobile position are utilized to establish the knowledge mapping of regional industrial clusters in Guangdong, Hongkong and Macau Greater Bay Area (GBA), so as to analyze the development advantages and spillover trend of different industrial clusters in GBA. Furthermore, this study provides an indicator system to assess the synergistic development level of different industrial clusters between different cities. Based on the results of assessment, policy implications on regional industrial development are provided.

Spatial Synergistic Simulation of Land Use - Population - Economy in the GBA

Wei Tu

Abstract. The fast urbanization has eroded the city boundaries and made the mega-city region. It also brings great challenges to the sustainable development goals, such as excessive exploitation and population explosion. Classical cellular automata (CA) has been widely used to independently simulate the change of spatial features, i.e., land-use, population, economy production, etc., which fosters the spatial planning and policy-making. But they focus on one feature thus ignore the intertwined influences among them. This study proposes the spatial cooperative simulation (SCS) approach to simulate the land use-population-economy changes in the megacity region. CA is used to forecast the spatial process of one feature. The interactions among multiple features are represented by taking one feature as the dynamic driving factor. The CA model is iteratively trained to capture the cooperative influence of multiple features. The train process will be repeated until the total errors are converged. The experiment was conducted in Greater Bay Area, China to examine the performance of the proposed approach. The simulation result reaches a Figure of Merit of 0.270 for land use and a mean absolute percentage error of 19.09 and 24.41 for population and economy production,

respectively, which significantly outperformed baseline methods. It demonstrates that the presented SCS approach can well capture the simultaneous change process of land, population, and economy production. This approach can be used for the megacity region future development scenarios forecasting, which will benefit the spatial planning and infrastructure synergy.

Collaborative Decision Making Platform and Applications in the GBA

Yuelong Su

Abstract. The Greater Bay Area urban agglomeration needs to establish a comprehensive decision-making and collaborative service in terms of land space, population, transportation, environment, industry, infrastructure, public services, as an application demonstration. It provides support for integrated management of project data, model and application. Ten mobile application services are developed and integrated into Amap for demonstration in the GBA. The service demonstration has been launched in the nine cities of the GBA. The research results provided support for the implementation of the national strategy for the GBA, and promoted the modernization of the governance system and governance capacity.

New Infrastructure: A New Proposition for the Synergistic Development of the GBA in the Information Era

Yuyao Ye

Abstract. Throughout the history of global development, the construction of new infrastructure during each technological revolution has been the foundation for igniting a paradigm shift in the social and economic landscape. Currently, as the global moves toward the intelligent era, data has become the core production factor for the new stage of regional integration development. "New infrastructure," represented by 5G, data centers, supercomputing centers, and artificial intelligence, broadly empowers the transformation of the Greater Bay Area from synergistic manufacturing to synergistic creation, becoming a new proposition for synergistic development in the information age. In this context, by reviewing the concept of "new infrastructure" and the multi-scale development trend from the global to the Bay Area, this report puts forward the scientific issue of "new infrastructure" enabling the synergistic development of the Greater Bay Area. It shows that the new stage of synergistic development of the Greater Bay Area, characterized by data-driven innovation, needs to rely on the systemic transformative role of the "new infrastructure". This report aims to clarify the core driving forces behind the synergistic development of the Greater Bay Area in the new era, providing new perspectives and viewpoints for further exploring how new infrastructure empowers regional integration and promotes high-quality development.


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