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EDITORIAL

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Virtual geographic environment construction based on ubiquitous geographic information

The geographic environment is a vast and complex system in which various natural processes, human activities, and information interactions exist. To obtain a better understanding of this complex environment, virtual geographic environments (VGEs) were proposed as new-generation geo-analysis tools (Chen & Lin, 2018; Lin et al., 2013; Voinov et al., 2018). By constructing a VGE, the geographic environment can be simulated at a global/regional/local scale by integrating expertise from geographic information sciences, computer sciences, environmental modeling, socioeconomic modeling, and other disciplines (Chen et al., 2021; Rink et al., 2021). In addition to the visual presentation of the geographic environment, analytical, evaluative, predictive, and interactive capabilities are increasingly valued in the application of VGEs. Recently, the emerging Digital Twin and Metaverse have shared similar ideas as VGEs, and objects and behaviors from physical, social, and cyber spaces have been integrated to form a more holistic depiction of the real world.

Following this trend, the scope of geographic information science is constantly evolving and developing, especially from the aspects of high-dimensional analysis and presentation, multichannel user perception and interaction, geospatial artificial intelligence, and environment-social-economic big data modeling. In this context, the source and form of geographic information have changed dramatically. In addition to commonly used surveying, mapping and remote sensing approaches, social media data, cell phone data, traffic cameras, QR codes, and data from other channels also provide important geographic information to more comprehensively model, analyze, and simulate the real world (Chen et al., 2020; Lü et al., 2019). Therefore, the term "ubiquitous geographic information" indicates that the carrier of geographic information could exist anywhere, anytime, and in any form. Moreover, ubiquitous geographic information focuses on unstructured social-sensing information but does not exclude existing domain-related resources (such as resources from hydrology, climatology, ecology, urban management, sustainable development, and other fields). A prominent example is the recent COVID-19 epidemic, for which many studies have utilized GIS to integrate social media, human migration, air quality, and climate change data, among other data types, to analyze socioenvironmental impacts and predict the spreading trends of the virus (Barton et al., 2020; Franch-Pardo et al., 2021). Ubiquitous geographic information, supported by emerging methods such as big data mining and deep learning, can greatly enhance the analytical capabilities of GIS.

Both VGEs and ubiquitous geographic information trend in the same direction, and they are complementary to a large extent. A VGE can utilize rich resources from ubiquitous geographic information and provide processing and presentation tools for the latter. The special issue ("Virtual geographic environment construction based on ubiquitous geographic information") includes 20 articles that highlight state-of-the-art research on VGEs that rely on ubiquitous geographic information.

Andy Hudson-Smith and Michael Batty introduce the development history of the VGE; analyze metaverse, digital twin and platform economic technologies; and present their inspirations in GIS research in the article "Ubiquitous geographic information in the emergent metaverse." They also discuss and envision how these technologies can be used in urban planning.

Hao Fang, Shiwei Xin, Huishan Pang, Fan Xu, Yuhui Gui, Yan Sun, and Nai Yang focused on map presentation, which is an important function of VGEs. In the article "Evaluating the effectiveness and efficiency of risk

communication for maps depicting the hazard of COVID-19," they explore how color schemes and data presentation forms influence map readers seeking to obtain COVID-19 information, and different solutions to design better COVID-19 maps are proposed.

Jiangfeng She, Bo Chen, Junzhong Tan, Qiang Zhao, and Rongcun Ge studied the simplification method of three-dimensional building models, which is a fundamental issue in presenting VGEs. In the article "3D building model simplification method considering both model mesh and building structure," they propose a StructureTree-based simplification method that considers both model appearance and the data volume. They also discuss further support for spatial analysis using the proposed method.

Fei Guo, Jing Yang, Jingjia Zhang, Zhuo Zhang, Xin Xu, and Hong Zhang applied data assimilation methods to build a virtual environment to study water quality. In the article "Research on assimilation simulation of chlorophyll a concentrations in a virtual geographic environment," they employ particle filters to assimilate the concentration of chlorophyll a and establish a VGE-based system for water quality assimilation and simulation in Taihu Lake.

Yujia Xie, Meizhen Wang, Xuejun Liu, Xing Wang, Yiguang Wu, Feiyue Wang, and Xiaozhi Wang used video data to identify geo-objects and integrate multiple long-term videos with VGEs. In the article "Multicamera video synopsis of a geographic scene based on optimal virtual viewpoint," they propose a video synopsis method based on optimal virtual viewpoints and rebuild spatiotemporal relationships among video objects viewed from different cameras.

Jinjin Yan, Jinwoo (Brian) Lee, Sisi Zlatanova, Abdoulaye A. Diakité, and Hyun Kim studied VGEs from the aspect of navigation, especially in the indoor spaces of contemporary public and commercial buildings. In the article "Navigation network derivation for QR code-based indoor pedestrian path planning," they employ a quick response (QR) code for indoor pedestrian path planning, and QR code locations are integrated as nodes in navigation networks.

Qinjun Qiu, Zhong Xie, Shu Wang, Yunqiang Zhu, Hairong Lv, and Kai Sun focused on how to construct VGEs based on the recognition of toponyms from natural language texts. In the article "ChineseTR: A weakly supervised toponym recognition architecture based on automatic training data generator and deep neural network," they propose a weakly supervised architecture that can automatically generate training datasets and employ a neural network method for toponym recognition.

Huixin Zhang, Ya Hu, Jun Zhu, Lin Fu, Bingli Xu, and Weilian Li studied three-dimensional visualization methods for presenting disaster scenes based on mobile virtual reality. In the article "A gaze-based interaction method for large-scale and large-space disaster scenes within mobile virtual reality," they propose a gaze-based mobile VR interaction method to support users in actively roaming and exploring large-scale and large-space disaster scenes.

Yinguo Qiu, Hongtao Duan, Hui Xie, Xiaokang Ding, and Yaqin Jiao used digital twin technology to establish an online VGE for watershed management. In the article "Design and development of a web-based interactive twin platform for watershed management," they implement an interactive digital twin of the Chaohu Lake watershed that offers watershed visualization and decision support capabilities for precision watershed management.

Qiushi Gu, Haiping Zhang, Yong Chen, and Tao Li performed a spatiotemporal analysis of litter pollution on beaches. In the article "Mapping the spatiotemporal patterns of beach litter on UK beaches from 2000 to 2016: An emerging hot spot analytical approach," they find that the overall litter concentration is largely related to the intensity of human activity and that hotspots are concentrated in the southern UK, while cold spots are concentrated along the northern coast of the UK.

Linchuan Yang, Xianglong Tang, Hongtai Yang, Fanyu Meng, and Jixiang Liu investigated the factors that affect the walking behavior of older people, which is important for constructing VGEs considering social factors and psychology. In the article "Using a system of equations to assess the determinants of the walking behavior of older adults," they develop a system of equations to determine the built-environment factors that significantly influence walking behavior and the associated measures.

Wenjing Wang, Chunxiao Zhang, Heng Li, and Ziwei Xiao studied knowledge graphs with a focus on meteorological simulations. In the article "Construction of bilingual knowledge graph based on meteorological simulation," they discuss the importance of knowledge in geographic simulations (which are core functions of VGEs) and propose a cross-language knowledge graph construction framework to support enhanced meteorological simulation research.

Weilian Li, Jun Zhu, Saeid Pirasteh, Youness Dehbi, Qing Zhu, Lin Fu, Jianlin Wu, and Ya Hu reviewed and analyzed the weaknesses and strengths of existing methods for representing disaster information in recent decades. In the article "Investigations of disaster information representation from geospatial perspective: Progress, challenges, and recommendations," they discuss the possibility of integrating VGEs with various technologies, such as GeoAI, VR, and MR, in disaster management.

Yixuan Zhang, Jingzhou Zhang, Kai Xu, Daimin Tang, Yang Li, Xinchang Wang, and Kai Zhang focused on virtual urban living environments and evaluated walkability considering what pedestrians perceive through hearing and sight at the street scale. In the article "An improved method for urban Walk Score calculation considering perception of the street environment," they introduce traffic noise and green visual index calculation methods to improve the traditional walk score.

Yuling Ding, Qianqian Sun, and Qing Zhu coupled the wind-affected snowdrift and snowmelt process in building a VGE that supports simulations of snow accumulations. In the article "A dynamic snow accumulation simulation approach for forecasting snow distribution over regional scale terrain," they propose a dynamic calculation method based on computational fluid dynamics and apply the VGE in reconstructing a historical snow event at Tacheng City, Xinjiang, China.

Xuebin Wei and Xiaobai Yao integrated a social dimension into existing spatiotemporal representation models to analyze location-based social media activities. In the article "A GIS representation framework for location-based social media activities," they use Facebook data as a case study to demonstrate the capability of the model for data organization and retrieval and the analysis of location-based social media activity data in spatial–temporal-social dimensions.

Ismail Ercument Ayazli, Ahmet Emir Yakup, and Omer Bilen used the SLEUTH model to construct a VGE for simulating urban growth in Istanbul. In the article "Using the T-EFA method in a cellular automata-based urban growth simulation's calibration step," they combine total exploratory factor analysis (T-EFA) with the SLEUTH model to increase the model accuracy.

Manqi Li, Xiaoyu He, Zhuo Sun, and Yongning Wen studied VGEs from the aspects of integrated cyberspace and physical space. In the article "A framework for social media information flow analytics in cyberspace and physical space," they propose a clustering method that retains consistent identifiers for clusters over time and provide a map-based solution to analyze the distribution and evolution of social media activities.

Mina Karimi, Zana Zakariyaeinejad, Abolghasem Sadeghi Niaraki, and Ali Hosseininaveh Ahmadabadian studied approaches to improve the accuracy of augmented reality scenes in VGEs. In the article "A new method for automatic and accurate coded target recognition in oblique images to improve augmented reality precision," they propose a method for automatically recognizing coded targets in oblique images so that the camera position can be estimated more accurately.

Jingwei Shen, Kaifang Shi, and Mingguo Ma investigated knowledge graphs considering the relevant topological relations to represent spatial scenes. In the article "Exploring the construction and application of spatial scene knowledge graphs considering topological relations," they introduce the schema of a spatial scene knowledge graph and propose a method for acquiring topological relations from knowledge graphs.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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