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Editorial: Advances and applications of geospatial modeling and analysis in digital twins

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Editorial on the Research Topic
Advances and applications of geospatial modeling and analysis in digital twins

Digital twins (DTs) have emerged as a powerful concept in the realm of information technology, enabling modeling the interaction of real-world entities in digital environments (Grieves, 2005; Chen et al., 2018; Tao et al., 2019). With the rapid advancements in Earth observation technologies, Internet of Things (IoT) and big data, our ability to monitor, model, and simulate the real world has rapidly improved (Tao et al., 2019). This progress has unlocked the potential of applying DTs in complex geospatial systems such as the environment, energy sector, smart cities, and smart coasts (Dembski et al., 2020; Duque and Brovelli, 2022). However, it also presents new challenges for geospatial modeling and analysis in the context of DTs (Fertig et al., 2022; Bumann, 2022).

One fundamental aspect of constructing DTs is the representation and analysis of various geographical features and phenomena. To achieve this, comprehensive data acquisition infrastructure needs to be developed, encompassing technologies such as vehicle-mounted or airborne LIDAR, unmanned vehicles and IoT (Teng et al., 2021; Morgan et al., 2022). Additionally, data models capable of supporting the representation and modeling of diverse data sources, dimensions and types are essential (Yuan et al., 2012). This robust data modeling foundation enables the accurate portrayal of real-world entities within the DT environment. Furthermore, emphasis should be placed on the connections and interactions between the virtual space and the real world (Qi et al., 2019; Jones et al., 2020). Dynamic updating of DT models, real-time control of physical entities and online optimization play crucial roles in facilitating improved decision-making schemes (Villalonga et al., 2021). Leveraging the virtual space to inform designs in the real world is another key aspect of DT applications and practices (Leng et al., 2021). It allows for the exploration and testing of different scenarios, leading to more efficient and effective real-world

implementations. However, attention must be given to data security, visual representation, and multi-agent distributed computing in the DT environment to ensure the integrity and reliability of the DT system (Juarez et al., 2021).

To advance the field of geospatial data and information for digital twins, a comprehensive research agenda is necessary. This Research Topic aims to attract high-quality Original Research and Review Articles that address various aspects of the Research Topic, processing, modeling, analysis, visualization and application of geospatial data and information for digital twins.

The Research Topic titled "*Advances and Applications of Geospatial Modeling and Analysis in Digital Twins*" features four outstanding contributions that provide valuable insights into the technological solutions and implementations in this field. These contributions offer a comprehensive overview of the advancements made in geospatial modeling and analysis for digital twins.

Skákala et al. explores the application of machine learning (ML) in emulating a complex physical-biogeochemical model to predict marine oxygen levels in shelf-sea environments. This pioneering study showcases how ML models can support the development of digital twins for important applications such as predicting hypoxia for aquaculture and fisheries, as well as extrapolating oxygen levels from marine observations. The authors also discuss the performance of various ML models, addressing the limitations imposed by the spatio-temporal resolution of the training/validation data.

Lu et al. focuses on the challenge of establishing a one-to-one mapping relationship between hand-drawn sketches and vector maps for map addressing and location. By employing the N-queen problem solving process and an improved tabu search algorithm, the study proposes a matching method that improves the use of potential matching points in hand-drawn sketches and spatial relation matrix structures of vector maps. The research highlights the quality of spatial relationships and the effectiveness of the proposed matching method, providing insights for enhancing map addressing and location accuracy.

Zhang et al. highlights the importance of three-dimensional (3D) real estate modeling in the context of digital twins. Specifically, it addresses the need for integrated modeling of physical entities and property rights entities in the registration of real estate objects. The research presents a multilevel 3D real estate property rights modeling technology that combines the physical and legal aspects of real estate registration. The study's application in Xinyi City's real estate registration management demonstrates its practicality and supports the issuance of the first 2D and 3D integrated real estate registration electronic license in Jiangsu, China.

Forkan et al. describes the design, development, and testing of a general-purpose scientific workflows tool for spatial analytics. The tool, known as K-span, is an extension of the KNIME scientific workflow platform and focuses on enhancing openness, transparency and automation in spatial analytics processes. The study demonstrates the effectiveness of the K-span system through a case study involving the construction of the Australian national Digital Elevation Model (DEM) in the Greater Brisbane area. The research emphasizes the benefits of open, transparent, documented, automated and reproducible scientific workflows in increasing user assurance and confidence in spatial data products.

Together, these four contributions make significant advancements and demonstrate state-of-the-art applications in geospatial modeling and analysis within the realm of digital twins. They highlight the potential of machine learning, address challenges in map addressing and location, offer insights into 3D real estate modeling, and showcase the benefits of scientific workflow systems in spatial analytics. These valuable research contributes to the ongoing development and utilization of geospatial modeling and analysis in digital twins.

Author contributions

WL drafted the manuscript. GZ provided critical revisions and important intellectual input. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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