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Editorial

Multidimensional and Multiscale GIS

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Abstract: The advent of new data collection technologies, such as LiDAR and drones, have made geospatial data available in large amounts and at low costs. While access to data is getting easier, geospatial tools have to evolve towards further automation and guarantee the reproducibility of the process and the quality of the results. As such, algorithms and data structures for handling geospatial data also need to be more and more robust and efficient to model complex, multidimensional geospatial phenomena in GISystems and provide higher levels of analysis. Articles in this special issue address two complementary aspects of the problem. They introduce new algorithms and data structures that allow for a more efficient handling of multidimensional data but also present complete processing chains dealing with the integration and the dissemination of multidimensional data.

Keywords: 3D model; spatiotemporal modelling; multiscale representation; city modelling; building modelling; indoor navigation; 3D web

1. Introduction

With the advent of technologies such as LiDAR and drones, but also crowed-sourcing and web technologies, geospatial data are becoming more and more available. These technologies have the ability to provide denser data over larger areas in a short time. Therefore, they can help in making analyses and decisions in a rapidly changing environment. However, datasets are becoming bigger and bigger, leading to higher levels of complexity. Existing methods that still rely on user interventions to format or integrate the data, to correct some errors, to generalize the data or simply to disseminate data, have become outdated. Manual interventions can no longer be considered when dealing with data that amounts to millions or more records.

New models must provide efficient algorithms at all steps of the data process. More specifically, new methods are required to bring raw data such as point clouds or crowd-sourced data into more sophisticated, higher levels of representation for direct interpretation from users. Methods must be robust and handle consistency issues in the data, such as topological errors. They also need to provide adequate representations for different purposes and users. Hence, issues related to multiple representation and web dissemination of data are still relevant, but with a focus on 3D visualization and big datasets.

2. Content of the Issue

The content of this special issue deals with all aspects of multidimensional GIS data from processing raw data to their visualization and their dissemination. While multidimensional data mostly refers to 3D data, other dimensions such as time and scale are also considered. Different kinds of data are also addressed: LiDAR point clouds, building geometries (in 2D and 3D), terrain models and participatory data.

A first group of papers deals with urban data and more specifically with building modelling. The first two papers address the issue of topology in CityGML. While CityGML can store building models at different levels of data, it cannot record topological relationships between the different building elements. It can lead to some inconsistencies with faces or lines not connected properly. The first paper [1] proposes an efficient approach to check the topological consistency of a CityGML model. It captures the topology from the building geometry and compares it with an intersection matrix describing all possible relationships. Paper [2] proposes a new model based on a combinatorial map data structure to record topological relationships. Hence, the authors propose an extension to their CityJSON format that records the topology through explicit relationships between nodes, edges and faces.

The multiscale representation of buildings has been a long studied problem in cartographic generalization, but the work in [3] tackles it with a novel approach based on deep learning. While a recent focus on generalization was to combine different operators to generalize groups of buildings, the present approach deals with a raster representation of the buildings on which a convolutional network implicitly learns generalization operations.

The last two papers on urban data provide a web GIS for handling and disseminating multidimensional data. The web GIS in [4] models the spatiotemporal evolution of a city in four dimensions. The platform provides dynamic 3D city models that are used to promote citizen participation by letting them visualize and assess different scenarios. The second paper [5] describes a 3D web GIS that handles the whole processing chain—from integration to dissemination—of LiDAR point clouds. The application is based on open standards. The GIS reads a LiDAR file, builds surfaces and objects, and provides different services for visualization and dissemination. Both papers provide innovative solutions focusing on user accessibility from various platforms.

A second group of papers focuses on indoor navigation. The first of them [6] is concerned with the detection of obstacles in indoor navigation. It proposes a complete processing chain, from the LiDAR point cloud to the computation of the final path, through the modelling of the indoor environment. Obstacles can be defined according to users' characteristics, providing a flexible solution to pathfinding. The next paper [7] focuses more specifically on the computation of navigation routes. The authors propose an original approach, producing smoother and more natural paths than other existing methods. The third paper [8] proposes an ontology of indoor space, incorporating both a geometrical and a semantic component. While existing models like IndoorGMLs can already capture the geometry, the ontology is used to provide a semantic extension to IndoorGMLs allowing for a much more comprehensive description of the indoor environment.

The last paper of this issue [9] focuses on another kind of geospatial data: Digital terrain models. It specifically looks at the influence of resolution on roughness computation. Authors assessed different roughness computation methods on a terrain model, bringing relevant conclusions of their performances on different types of terrain.

Overall, the contributions presented in this special issue introduce new algorithms and data structures that allow for a more efficient handling of multidimensional data. They also present complete processing chains dealing with the integration and the dissemination of multidimensional data. These two aspects are complementary in the development of more advanced GIS. On the one hand, they help with handling data that are more complex, where the geometry is considered but also the topology and the semantic. On the other hand, this increasing complexity requires advanced standards and solutions to assist the users in analyzing and making the right decision. Research on multidimensional GIS requires the integration of both aspects to answer the challenge of further data integration and process automation.

Conflicts of Interest: The authors declare no conflict of interest.

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