Theme section: Multi-dimensional Modeling, Analysis and Visualization

Éric Guilbert (Université Laval, Canada)
Arzu Çöltekin (University of Zurich, Switzerland)
Francesc Antón Castro (Technical University of Denmark, Denmark)
Chris Pettit (University of Melbourne, Australia)

Spatial data are now collected and processed in larger amounts, and used by larger populations than ever before. While most geospatial data have traditionally been recorded as two-dimensional data, the evolution of data collection methods and user demands have led to data beyond the two dimensions describing complex multidimensional phenomena. An example of the relevance of multidimensional modelling is seen with the development of urban modelling where several dimensions have been added to the traditional 2D map representation [Sester et al. 2011]. These include obviously the third spatial dimension [Biljecki et al. 2015] as well as the temporal, but also the scale dimension [Van Oosterom and Stoter, 2010] or, as mentioned by Lu et al. (this issue), multi-spectral and multi-sensor data. Such a view provides an organisation of multidimensional data around these different axes and it is time to explore each axis as the availability of unprecedented amounts of new data demands new solutions. The availability of such large amounts of data induces an acute need for developing new approaches to assist with their dissemination, visualisation, and analysis by end users. Several issues need to be considered in order to provide a meaningful representation and assist in data visualisation and mining, modelling and analysis; such as data structures allowing representation at different scales or in different contexts of thematic information.

Such issues are of importance with regard to the mission of the ISPRS Commission II and, pertaining to both spatial data structures and algorithms and to geovisualisation, more specifically to Working Groups II/2 and II/6. Hence, this special issue presents some recent developments and review papers covering various aspects of multidimensional data modelling and visualisation. As the topic is broad and cannot be covered exhaustively, our objective was to show the diversity of contributions this topic has fostered, from more conceptual aspects with cellular automata (Jjumba and Dragicevic) to end user considerations with a web-based 3D visualisation system (Trubka et al.). Multidimensional analysis is also considered with Lu et al. who present a model for change detection based on a statistical approach. While the temporal dimension is also a concern in visualisation (Heizler et al.), Ti et al. consider scale as a dimension for the visualisation of cartographic data. Furthermore, Breunig et al. show us that between the conceptual theory and the visual analytics of the user, careful attention need to be given to the multidimensional database in order to provide a logical and efficient system.

The first two papers deal with the modelling and analysis of spatiotemporal data. Jjumba and Dragicevic first discuss the extension of the traditional 2D cellular automata (CA) model to 3D by using voxels. While 2D CA are frequently used in GIS, even with 3D data, little consideration has been given to a real 3D model that would allow the representation of more complex processes. The authors show that 3D CA lead to new spatial patterns that demand to be studied and formalised with promising perspectives and the advancement of

new models for describing the evolution of 3D phenomena. Lu et al. address change detection in time series through the analysis of a series of satellite images and the computation of spatial and temporal correlations. Attributes are decomposed into a linear trend and a harmonic component.

The third paper pertains to cartographic generalisation and addresses variable scale maps, where the scale is not uniform over the map, leading to distortions. It proposes a simple yet efficient method, based on quadratic optimisation, to balance distortions between element area and orientation in order to preserve shapes and the meaning carried by the objects.

Next, Breunig et al. (2016) propose a review paper covering the history of DB4GeO, a geospatial object-oriented database for 3D data. It shows the different aspects that were considered in the development and the lessons learnt through the process, bringing new concepts and considering multidimensional aspects that are not offered in more traditional databases. A data model was developed to handle spatial, temporal and thematic attributes. Specific concepts were also implemented to handle spatiotemporal morphing of objects. The model is also constantly evolving to integrate OGC standards such as CityGML and provide web services capabilities.

In the fifth paper, Trubka et al. (2016) discuss the design and development of a scenario planning tool known as the Envision Scenario Planner (ESP). This on-line planning support system tool was developed to visualise and analyse alternative precinct developments. The tool visualises these alternative planning scenario both in 2D and 3D and with support charts and tabular information which provide an assessment of the scenarios against a number of performance metrics. The paper provides insights and lessons learnt in building and testing this tool in the context of Australian Cities. However, it could be applied elsewhere in the world and assist planners in data driven evidenced based place making.

The sixth and last paper by Heitzler et al. (2016) offers a novel approach to visualising the evolution of multiple interacting environmental systems. In this paper, the authors extend the existing small-multiples and line graphs as they add multiple system representations and inter-system impact representations. In the process, authors also introduce a new concept that they name ‘selective branching’ to manage information reduction from the visualisations based on logical and temporal dependency considerations. Heitzler and colleagues apply their proposed system to a risk assessment methodology and validate with experts, demonstrating that the enhanced small multiples indeed was useful in such a scenario.

Together, these six papers show that multidimensional data modelling and visualisation covers many aspects and, although more attention was given to these aspects in these recent years, still more problems remain with the further development of technologies that require more modelling and visualisation in domains such as smart cities and mainly geospatial big data (Li et al., 2016).

We would like to thank all the authors who submitted a paper for this special issue and mostly our special thanks to the reviewers who contributed greatly through their constructive recommendations.

References

F. Biljecki, J. Stoter, H. Ledoux, S. Zlatanova, & A. Coltekin (2015). Applications of 3D City Models: State of the Art Review. *ISPRS International Journal of Geo-Information*, *4*(4), 2842–2889. doi:10.3390/ijgi4042842

S. Li, S. Dragicevic, F. Antón Castro, M. Sester, S. Winter, A. Coltekin, C. Pettit, B. Jiang, J. Haworth, A. Stein and T. Cheng, (2016). Geospatial big data handling theory and methods: A review and research challenges, ISPRS Journal of Photogrammetry and Remote Sensing

M. Sester, L. Harrie and A. Stein, 2011. Theme issue ‘‘Quality, scale and analysis aspects of urban city models’’, ISPRS Journal of Photogrammetry and Remote Sensing 66: 155–156

P. Van Oosterom and J. Stoter, 2010. 5D Data Modelling: Full Integration of 2D/3D Space, Time and Scale Dimensions. In Geographic Information Science, Volume 6292 of the series Lecture Notes in Computer Science pp 310-324