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## **Interactive Focus+Context Visualization of spatio-temporal urban data models**

### **Abstract**

The concept Digital City is very dependent on how closely and seamlessly integrated are the distinct enabling functional layers that address spatio-temporal urban data management, from acquisition and pre-processing, to storage and management, to visualization and exploratory data analysis. This started to be a challenge due to the wide range of application domains involved, each having their domain-specific operational and strategic goals towards data management, analysis and decision making, as well as distinct enabling requirements, regarding the spatial and temporal representation of data, from snapshot 2D points, to fully featured 3D and topological models that change, at distinct rates, over the time.

Much of the challenge for geospatial data representation and interchange as been overcome through the development of several standards, in which the Open Geospatial Consortium (OGC, formerly OpenGIS) played a critical role.

Important contributions are the Geographic Markup Language (GML) for spatial data modeling and interchange, and the set of interface standards that allow requests for geographical features and maps to be retrieved across the web by using platform-independent calls (WFS, WMS, WTS, etc), making possible the development of location-based web services that effectively interchange geospatial information, from multiple heterogeneous data sources.

Considering urban data and its specificities concerning representation and interchange, a more suited contribution has been adopted as an OGC standard: CityGML, a XML-schema that is a common information model for the representation of 3D urban objects

aimed at modeling and interchanging 3D city and landscape models, extending the paradigm of location-based distributed web services to the urban domain.

Considering the concept of a Digital City, the wide application of these standards in the functional layer that addresses the storage and management of spatio-temporal data and the enablement of innovative web services has a strong impact in the possibilities of visualization and exploratory data analysis, as more, and more complex, urban datasets become increasingly available through interoperability. One reason for this increase in complexity is a better characterization of the temporal aspects (the *valid time*) of data.

Given the previous context, the current work extends the previously proposed temporal Focus+Context visualization model for handling valid-time spatial information [1], where we start by shortly reporting our developed approach for representation and storage of urban spatio-temporal data, which maps to one of the possibilities for urban data management underlying the concept of Digital City. The approach consists in a fully-fledged spatio-bitemporal database management system prototype that is able to manage CityGML features and to retrieve CityGML features as the result of spatio-temporal SQL queries. To this purpose, the prototype is capable of handling ATSQL2 query statements where spatial functions and operators are used as filter criteria.

The focus of our work is based on the developed approach and in the exploration and evaluation of the temporal F+C visualization model to the spatio-temporal interactive visualization and analysis of urban models, being the main goal to define an innovative, and visualization methodology, suitable for supporting the analysis, planning and decision-making tasks. We explore and report some possibilities in the visualization of the temporal focus and temporal context to display urban models at a particular set of time instants and/or time periods. Through these possibilities, the user can explore information concerning time, as well as interactively explore features that are made visible when displaying distinct time instants/intervals onto the same visualization. To make the features from the temporal focus and temporal context more meaningful, we experiment the use of non-photorealistic techniques as part of the mapping step of the visualization pipeline. The work will end with the presentation of the results achieved, emphasizing the strong points and limitations, as well as the most important conclusions.

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[1] Carvalho, Alexandre; de Sousa, A Augusto; Ribeiro, Cristina; Costa, Emília, *A temporal focus + context visualization model for handling valid-time spatial information*, Information Visualization, Volume 7, Numbers 3-4, 2008 , pp. 265-274(10), Palgrave Macmillan