Guest Editorial Preface

3D Web Visualization of Geographic Data

Marcus Goetz, University of Heidelberg, Germany

Jorge Gustavo Rocha, Universidade do Minho, Portugal

Alexander Zipf, University of Heidelberg, Germany

Web technologies are omnipresent; not only for distributing and sharing digital information via the Internet, but also for forming the base of a ubiquitous application platform. Within the last years, the content of the Web rapidly evolved from basic text data without any styling, over dynamic and visually appealing web pages with images, to sophisticated web applications with various kinds of heterogeneous data sources as well as multimedia elements, such as videos or live communication features. Essentially, the Web is no longer just a platform for knowledge, but more like an application platform for various (business) applications, and more and more companies move their software to the Internet. This trend also applies to Geographic Information System (GIS), as a variety of Web-GIS systems and applications has been developed in the last couple of years. This step seemed to be quite logical, because the exploration, analysis and investigation of geographic data and phenomena become very easy and efficient via web-based systems. Furthermore, web-based geo-systems brought geographic data to the fingertips of not only professionals, but also amateurs. By utilizing applications like Google Earth or the NASA WorldWind Explorer, it is possible for everybody to investigate the digital earth in great detail. It seems obvious that nowadays more and more communication media is shifting towards a three-dimensional representation of data. Especially for GIS this seems to be very important, as geographic data (due to the 3D nature of our world) often comprises three dimensions and not only two dimensions. As three-dimensional representations of geographic data typically do not only visualize physical features of the earth, but do also contain semantic and qualitative information about the past, the present and (probably) the future, the scale and granularity of different data sources can vary from global and coarse perspectives, up to fine-grained and detailed models. Nevertheless, detailed three-dimensional geographic data and its utilization already comprises a huge and important part of GIS, as it is already used for various tasks and applications, such as navigation, environmental simulations, facility management, emergency response, rescue operations, noise mapping, training simulators, architecture or city planning, market analysis, or sight analysis. Trying to gain traction and utilize the benefits of Web-based technologies, it is very desirable to adapt the beforehand mentioned applications to the Internet. For the provision of 3D geographic data via the Web, the research efforts can be basically divided into four different areas.

Web Visualization Techniques: The recent developments of computer graphics have led to modern graphics hardware which is able to display various kinds of data in a realistic and appealing manner on a variety of devices in real-time. Not only limited to the context of geo-data, web designers and application developers always aimed at creating three-dimensional content which can be consumed via the Internet. However, the main approaches were based on the integration of additional external 3D content. Such 3D content often has to be generated in proprietary applications and typically for the visualization some software or plugin, such as Java3D or VRML viewers, needs to be installed. However, this solution often represents a barrier for the consumption of the corresponding 3D content, as users are often not willing or able (due to security concerns) to install additional software. Furthermore, this approach requires the creation of at least two separate but dependent documents, which in most cases cannot communicate or interact with each other (especially not as one would expect it for a web application). The other – more appealing and web-conform – possibility of bringing 3D to the Web, is the utilization of methods which are well integrated into today's Web standards or which are at least adaptable to those standards and extensions.

When talking about browser-integrated and standard-conform 3D technology, this leads directly to *WebGL*, as it is a part of the proposed HTML5 standard. Appropriate renderers for *WebGL* content are already implemented in a number of browsers, such as the latest Google Chrome or Mozilla Firefox, as well as the new Opera Mobile browser. Microsoft currently refuses to integrate WebGL into their Internet Explorer, but it seems likely that they will catch up as more and more 3D content is published. The *WebGL* technology is very efficient, because it provides direct JavaScript binding to the OpenGL ES 2.0 API in order to render 3D content on a canvas element. Essentially, all heavy graphic related processing tasks are delegated to the parallel graphics hardware, thus *WebGL* utilizes the full potential of modern graphic processing units, not only on personal computers but also on mobile devices, such as tablets or smartphones.

Trying to ease the creation and utilization of *WebGL* content, several frameworks, such as XML3D, X3DOM etc., have been developed. Such frameworks allow the creation of rich 3D content without necessarily requiring (extensive) knowledge of 3D graphics. That is, such frameworks lower the barrier for developers, because ordinary web-designers and developers can use their well-known web techniques (e.g., HTML, CSS, JavaScript, AJAX, etc.) for the creation of rich and interactive 3D web applications.

Data Sources: The acceptance and usefulness of any web-based GIS highly depends on the quality and quantity of the underlying data. If an application does only provide poor data, it will not be accepted and used by the geo-community – regardless of how advanced the integrated features might be. Therefore, considering the data sourced for 3D web-based applications is another key domain. There are many different kinds of data sources, containing various kinds of differentially fine-grained data. Some examples of 3D data sources are 3D Computer Aided Design (3D-CAD), Airborne and Terrestrial Light Detection and Ranging (LIDAR) point clouds, Industry Foundation Classes (IFC) from the Building Information Modeling (BIM) domain or models from 3D software, such as 3D Studio Max or Cinema 4D. Some of these formats are standards, some other are proprietary applications. But they all contain 3D content, which needs to be transformed into a suitable format for web visualization. Regarding geodata, one very important standard is the Geography Markup Language (GML) and its derivative, such as the City Geography Markup Language (CityGML). Those standards are defined by the Open Geospatial Consortium (OGC) and widely accepted in the geo community. Therefore, it is essential to develop transformation frameworks for GML files, as till will allow the easy adaptation of existing geo applications to the Web.

Contrary to the beforehand mentioned 3D data sources, which are typically proprietary and captured by professionals, the last couple of years revealed a new source for geodata: crowd-sourced geodata or Volunteered Geographic Information (VGI). Thereby, individuals – both amateurs and professionals – contribute a massive amount of different kinds of geodata. Turning the citizens into a major data provider and benefiting from the crowd intelligence, future web-based GIS should definitely exploit the new opportunities arising from humans acting as remote sensors. Regarding both the quality and quantity of VGI, it has already been proven that VGI is able to compete or can even surpass commercially or officially collected data. The significance and importance of VGI as a major additional data source is furthermore expressed by the fact, that more and more communities to not only collect spatially enabled data, but also three-dimensional information, such as feature elevation, height etc.

Data Provision: It is likely that future GIS applications will provide the desired geodata in a web-based environment. However, the area of data provision is still an important area for future research, as there are several possible solutions as well as standardization efforts.

Very basic applications could integrate the 3D geodata directly into the system, thus directly into the web page. However, existing GIS applications are typically based on so called (3D) Spatial Data Infrastructures (SDI), which became omnipresent and are broadly utilized. Within an SDI, different geodata sources as well as processing functionalities are provided as a web-service, rather than being installed on one single computer. The OGC is responsible for the definition of standards for such geo-services. Some examples are the Web Map Service (WMS), the Web Feature Service (WFS) or the Web Processing Service (WPS). All OGC services can be orchestrated and combined into different (web) applications, allowing an easy access to information as well as the processing of this information in a distributed environment. There is not yet an OGC standard for actually providing 3D content, however with the Web3DService (W3DS) draft specification there is a very promising approach towards such a standard.

Regarding future web-based 3D GIS, those should definitely incorporate existing (and future) OGC standards. By doing so, it will be possible in the feature to use GIS functionality in the browser and to plug-in different processing services and data sources into the system by simply adding a new OGC web-service. Since it is desirable that web-based 3D GIS software is also consumable on mobile devices, such as tablets or smartphones, it seems promising that OGC services already provide web-adequate data, such as 3D models as *WebGL* files.

Data Preprocessing: Since 3D geographic data is typically related to huge amounts of data, which cannot be easily transferred to computers and especially mobile devices, the fourth major research area for web-based 3D GIS comprises different data preprocessing steps. Within this area, many different kinds of research efforts are made, all trying to reduce the amount of data (without losing required information), typically aiming at a fast provision of 3D geodata for the application user. Some examples of data preprocessing are data generalization, data simplification, data compression, incorporation of different Levels-of-Detail (LoD), data tiling, data streaming, data caching etc. The list of possible and important data preprocessing steps is long and – although not directly involved in the actual 3D visualization of geographic data in the browser – it is a closely related research field for realizing web-based 3D GIS.

This special issue of the *International Journal of 3-D Information Modeling* (IJ3DIM) contains a selection of the best 5 papers that were submitted for the Workshop 3D Web Visualization of Geographic Data which was held under the umbrella of the 15th AGILE International Conference on Geographic Information Science in Avignon from the 24th to 27th April 2012.

We would like to express our thankfulness to all the authors of the submitted papers as well

as all attendees of the workshop. Furthermore we would like to thank Lars Bodum, Volker Coors, Hui Lin, Stephan Nebiker, Zhu Qing, Alias Abdul Rahman, Philipp Slusallek, and Sisi Zlatanova for being part of the program committee and providing their valuable feedback and comments during the review process. Additionally, we would like to thank the Editors-in-Chief of IJ3DIM Umit Isikdag, Jason Underwood, and Sisi Zlatanova for providing us the opportunity of publishing a special issue in their journal. We are really looking forward to the future developments in these very interesting and important research areas, as well as towards a possible 2nd workshop on 3D Web Visualization of Geographic Data.

Marcus Goetz
Jorge Gustavo Rocha
Alexander Zipf
Guest Editors
IJ3DIM