Development of a 4D-webgis for archaeological research

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Abstract

The usage of 3D models acquired from airborne and terrestrial laser scans within a web-based GIS environment allows a new way to conduct archaeological research but also demands new approaches and concepts in the development of infrastructure that supports such research. This article gives an overview of a design and prototypical implementation of a 4D-webgis for archaeological research. The infrastructure is based on WebGL and the three.js framework in combination with the W3DS. Initial results indicate that this is an appropriate framework for the development of a preformat 4D-webgis architecture that supports temporal visualization and analysis of archaeological data.

Keywords: 4D, webgis, WebGl, W3DS, archaeology.

1 Introduction

Recent technological advancements are resulting in new archaeological applications of LIDAR (Light detection and ranging). One common use is archaeological prospection; another is to use 3D models acquired from LIDAR to reconstruct ancient architecture and landscapes (in our case the UNESCO World Heritage Site of Copan, Honduras). A new and promising use for LIDAR is 4D-webgis where LIDAR-generated 3D models are combined with temporal information geographic information systems (GIS) functionality for documentation and analysis of archaeological sites on a web platform. Two- and three-dimensional data and models of different type and resolution can be integrated into a Spatial Data Infrastructure (SDI) with web-based interactive analysis and visualization tools permitting archaeological analysis in a geo-referenced system that facilitates interactive and collaborative research. Spatial and temporal queries of accessibility and visibility, settlement plans, and artefact distributions that were previously performed in 2D or 2.5D views would be possible in the 3D environment.

2 Related Work

Usage obstacles such as plug-ins or Java applets to realize web based 3D visualization will soon disappear due to developments of web standards like HTML5 [2, 6] and WebGL [3]. Standards based 3D visualization in web browsers will offer potential for more interactive, responsive webgis applications in many domains [1]. Currently many JavaScript libraries are developed on top of the WebGL standard with foci on different purposes. As [4] highlight, for Cultural Heritage applications it is important that such libraries support the interoperability of different 3D modeling tools and maintain the chromatic and reflectance characteristics of the models. Further, to be able to visualize and analyse archaeological 3D data in conjunction with spatial data a library must support common geodata formats and OGC standards to enable the development of a real 3D webgis.

Currently such a library is not available. There are various open-source WebGL Globe APIs like OpenWebGlobe, Cesium, WebGLEarth or ReadyMap3D that support the display of geodata, but none of them meet the requirements typical of Cultural Heritage such as visualizing highly detailed laser scanned objects or building interiors. However, there exist libraries like CubicVR, SceneJS, C3DL or Three.js that support a wide range of rendering effects for a detailed visualisation of object characteristics. While they support various 3D formats or provide conversion tools, none of them can process geographic data. To fill this gap, the Three.js library can be used and extended to support spatial data delivered by OGC-WMS or W3DS [5].

3 Archaeological representation of time

An archaeological GIS needs to be able to query and visualize objects that belong to and cross-cut different time periods. However, a major problem in archaeology is that objects may be dated using different techniques. This can lead to ambiguous classifications with varying accuracy and non-comparable temporal classifications.

The MayaArch3D project focuses on the archaeological site of Cópan where dating is based on C-14 dates, obsidian hydration, different ceramic typologies, dates from hieroglyphic inscriptions, Maya calendric cycles and architectural stratigraphy.

The current W3DS discussion paper [5] specifies a time parameter that can be specified in ISO 8601 format. This functionality of W3DS allows a combination of bounding box-based spatial selection and a temporal selection to query a spatio-temporal defined 3D Scene. Additionally, predefined attributional query filters could be used by defining server styles for a layer that then could be determined in another parameter.

Example:
www.domain.com?SERVICE=W3DS
&REQUEST=GetScene
&LAYERS=Buildings
&BBOX=…
&TIME=723P150Y
&STYLES=Temple
&LOD=1
&…

This example requests all temples from the Buildings layer in a certain bounding box in a period of 150 years starting from 723CE.

As a default the ISO 8601 format uses the gregorian calendar, which means that an additional transformation service or a client side intelligence will be necessary to translate the dates and periods from the Maya calendars or other categories and concepts into standard dates.

4 Geometry service

For archaeologists, it is essential that a 4D-webgis allows for both editing and querying of attribute data assigned to the 3D objects and to perform such tasks without an internet connection. For example, an internet connection is often not available when conducting archaeological excavations. To solve this problem, we use a Filemaker Pro database for the storage of the attribute data. This database also provides the information about the structure of buildings, sculptures and other semantically segmented 3D objects. Every structure, building or object has a unique ID and is stored in a treelike hierarchy.

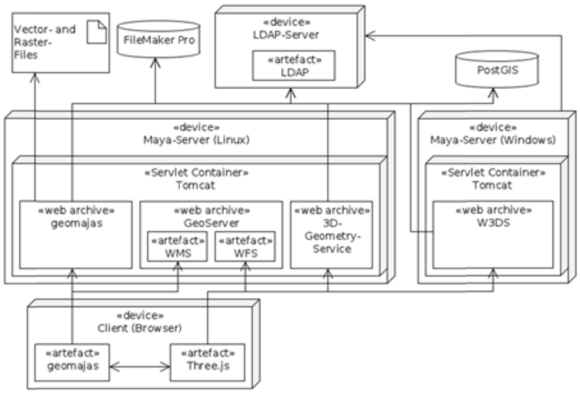
For accessing of this information, we introduce a new RESTful-Webservice-Interface (see Figure 1), which response will be merged with the W3DS-Response, and would support the query of Ids.

Our interface has the following format:

<server>/<servicename>/<output format>/<SRID>/
<feature type>/<id>/
{node,children}/
[
bbox3d/<x1>/<y1>/<z1>/<x2>/<y2>/<z2>,
bbox2d/<x1>/<y1>/<x2>/<y2>
]

If the "node"-keyword is added, the object itself will be returned. The bounding box is optional. For the query of all children, it is necessary to add the "children"-keyword.

Figure 1: Infrastructure



Source: compiled by the authors

For an archaeological GIS it is necessary to be able to search for objects at multiple scales (e.g. artefacts, temples or sites) in 2D or in the database (narrowed by time values) and to highlight them in 3D. Our service addresses these needs. First, the search task can be done in a traditional way. Second, selected IDs can be sent to the 3D-Part of the application, which uses the newly-developed service, to visualize only the queried parts.

5 Web-based visualisation of archaeological 3D-Data with WebGL

The initial tests using Three.js (Fig. 2) sought to find limitations and recommendations for high-resolution (i.e. point clouds or meshes) 3D archaeological models.

The initial test results indicate the two main limitations in web based 3D visualization with WebGL: (1) long loading times and (2) memory consumption and management with JavaScript. To overcome long loading times efficient formats (e.g. JSON) are required and to keep the memory consumption within defined margins sophisticated data handling is necessary.

Figure 2: Large 3D Test model of a Maya Ruler of Copán (Honduras) with ~1 mi. triangles and ~0.5 mi. Vertices.

Source: Data from 3D Optical Metrology Unit, Bruno Kessler Foundation, Trento, Image compiled by the authors.

6 Conclusion

In this article we gave a short overview over the conceptual model of the architecture for a 4D-webgis for archaeological research. Initial results show that while W3DS is appropriate for archaeological research. Some customizations must be made to the W3DS because not all necessary queries are in place. Most relevant, is that these customizations can deal with the problems and needs associated with differential dating techniques and resultant time periods existing in archaeological research.

In sum, the results suggest that three.js and WebGL are promising web technologies for making 3D data in a 4D webgis accessible in standardized way to a wider public.

References

[1] M. Auer, Realtime Web GIS Analysis using WebGL. In: International Journal of 3-D Information Modeling (IJ3DIM), Special Issue on Visualizing 3D Geographic Information on the Web (Special Issue Eds.: M. Goetz, J. G. Rocha, A. Zipf). Special Issue on: 3D Web Visualization of Geographic Data. IGI-Global, 2012.

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[2] R. Berjon, et al. (Eds.), HTML5 W3C Candidate Recommendation, 2011. Retrieved March 27, 2013, from http://www.w3.org/TR/2012/CR-html5-20121217/.

[3] Khronos Group, WebGL specification, 2011. Retrieved March 27, 2013, from https://www.khronos. org/registry/webgl/specs/1.0/.

[4] A.M. Manferdini & F. Remondino, A Review of Reality-Based 3D Model Generation, Segmentation and Web-Based Visualization Methods. In: International Journal of Heritage in the Digital Era, vol. 1, number 1, pp. 103-123, 2012.

[5] A. Schilling & Th. H. Kolbe, OpenGIS® Web 3D Service, Draft for Candidate. – OGC Discussion Paper, OGC 09-104r1, Open Geospatial Consortium, 2010.

[6] WHATWG. HTML living standard, 2012. Retrieved March 27, 2013, from http://www.whatwg.org/specs/web-apps/current-work/multipage/.

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