

Web-based Visualization and Animation of Geospatial Data Using X3D

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Abstract—In this case study we utilize X3D (eXtensible 3D) for the geoscientific visualization of an interferometric (InSAR) data set of Kilauea volcano, Hawaii. We describe the modeling and animation of the geospatial data using X3D features and tools and demonstrate the web-based interaction of the user with the displayed 3D content.

Keywords-X3D; visualization; animation; internet; interferometry;

I. INTRODUCTION

The efficient and appealing presentation of 3D geospatial data on the internet presents a challenging task for ongoing research on geoscientific visualization [1]. The web-based modeling and animation of static and dynamic remote sensing data allows a faster dissemination of recent research results within the scientific community and provides a powerful tool for the user-friendly presentation of geoscientific products for commercial exploitation.

In this paper, we present a case study in which we employ the *eXtensible3D* (X3D) Standard, which has been introduced recently by the Web3D Consortium [2] for the unified specification of 3D content on the web. As opposed to its predecessor VRML (Virtual Reality Modeling Language) [5], X3D utilizes XML (eXtensible Markup Language) as description language and thus provides a uniform and powerful tool for the presentation and animation of 3D geometries on the web as well as the interaction of the user with the presented 3D content.

We utilize X3D for the visualization of an interferometric (InSAR) data set of Kilauea volcano, Hawaii. Our test data include a DEM derived from NASA's SRTM mission as well as deformation measurements computed from interferometric phase observations. Geocoded 2D images and digital maps are used as texture that can be superimposed onto the 3D surface model. We describe the modeling and animation of the Kilauea test data using X3D features and tools and demonstrate the web-based user interaction with the displayed 3D scene.

II. OVERVIEW OF EXTENSIBLE3D (X3D)

X3D is an Open Standards XML-enabled 3D file format and the successor of the widely used VRML format (Virtual Reality Modeling Language). Compared to VRML, X3D has a

component-based architecture in which components can be individually extended or modified. X3D allows developers to support subsets of the specification (*Profiles*), composed of modular blocks of functionality (*Components*). [2]

Every object or command (for example, to perform a transformation) is defined in *Nodes*. Nodes can contain specific fields (properties) and one or more children nodes. The resulting hierarchical data structure is also known as an X3D scenegraph. The XML-structure in X3D allows to define the properties and appearance of simple solid 3D objects (spheres, cubes, cones, etc.) as well as complex geometric structures such as height maps (*ElevationGrid*) and surface models based on polygons (*IndexedFaceSet*).

Changes in the scenegraph, as used for alteration and animation of the scene, are communicated via so called *Events*. Some nodes - mainly Sensor- and JavaScript-Nodes - are capable of sending events that contain information to modify the parameters of the objects that receive them. In the case of an animation, an optional Interpolator-Node can act as an intermediate step on this route to provide a smooth transition.

Interaction with the user is achieved by different Sensor-Nodes. An example is the *Touchsensor*, which is the main component to alter the scenegraph corresponding to the position and state of the mouse pointer.

III. DATA SET

Our test site is Kilauea volcano on the Big Island of Hawaii, which is one of the most active volcanoes on Earth. The website of the Hawaiian Volcano Observatory (HVO) [4] provides information about past and ongoing volcanic activities in this region. Related data sets include satellite images, interferometric surface observations, GPS data, in-situ measurements, digital maps, and photographs.

We derive our static 3D model from a DEM which was computed using interferometric height measurements from NASA's SRTM mission. Our animation model is based on deformation measurements derived from ERS-2 differential interferometry. A coherence map was used to mask those areas of the interferometric phase image where no valid phase measurements could be extracted (for example, due to vegetation).

IV. METHOD

A. Data Preprocessing

The design of a web-based system requires to restrict the data size in order to ensure reasonable download times. We found that a maximum size of 1.5 Megabytes for the X3D file provided a good compromise between acceptable response times and the required level of detail for our application.

We reduced the resolution of the SRTM DEM in order to cover the area of interest by a 100 x 100 pixel subsection of the resized DEM. Some minor gaps in the original DEM were filled during the resampling step. After cropping the appropriate subsections from the available ancillary data (2D images, maps), some additional manual adjustments were performed to remove remaining distortions between the different data products.

B. X3D Modeling and Animation

We transformed the preprocessed input data into text files in order to build the X3D file. At this early stage of the project, we used a common text editor to manually include the data into our X3D structure. One possibility to store the elevation data is the X3D node *ElevationGrid*, which specifies a uniform, rectangular grid of varying height in the local X3D coordinate system. Another, more complex possibility to represent height data would be the X3D node *IndexedFaceSet*, which allows to define a surface model based on polygons derived from irregularly distributed height points.

After creating the initial (static) X3D/XML file, we need to combine and animate the height data with the deformation data. The X3D specification allows creating a pointwise transition (“morphing”) between two surfaces, thus resembling an animation between the initial and final state of a three-dimensional grid. However, such a standard interpolation would not suffice for our application, since we need not only to animate the data over a given period of time, but also to scale the terrain for a better representation of the deformation. The solution in X3D is provided by scripting elements in the specification’s *Interchange-Profile*, which allow a modification of the complete graphical structure.

C. User Interface

We implemented a graphical user interface that enables the user to interact with the static and animated 3D model. Our goal was to build an intuitive and efficient interface using only X3D and JavaScript features. We decided in favor of a two-dimensional control panel which allows the user to interact with time and amplitude parameters at the same time. Horizontal displacement of the control cube refers to the animation corresponding to the time-dependent deformation, while the amplitude of the deformation data can be scaled by the vertical displacement of the cube. In this context, amplitude refers to the amplitude (or magnitude) of the surface deformation and not to the amplitude of the complex interferometric signal. Since the surface deformation is usually very small - typically in the range of several centimeters - compared to topographic variations, we need to amplify the measured deformation values for 3D viewing.

D. Web Browser

Since the X3D Standard has been introduced relatively recently, there are no fully implemented X3D web browsers available at this time. However, several browser plugins support already a subset of the X3D specification, which may suffice in many applications. For our project, we use the Contact VRML/X3D viewer developed by Bitmanagement Software [3], which is compatible with both Netscape and Microsoft Internet Explorer.

V. ILLUSTRATIONS

Figure 1 shows a digital map of the Kilauea region with interferometric fringes overlaid. (The fringes can only be distinguished in color representation.) The differential phase measurements were derived from a descending ERS-2 orbit. One can recognize areas of missing phase information which need to be excluded from the animation.

Figure 2 shows a perspective view of the 3D elevation model with the fringe pattern from figure 1 overlaid. The VRML/X3D browser allows the user to explore interactively the 3D model by changing the viewpoint or selecting a different rendering style. By clicking on the sphere buttons on the left border of the display, the user can choose from a set of georeferenced 2D images which can be overlaid as texture onto the static and animated 3D model. Currently available textures include an optical Landsat image, interferometric amplitude, coherence, and fringe images, as well as several types of maps.

Figure 3 shows three different moments of a corresponding animation. The simulated deformation follows the fringe pattern around Kilauea computed from an ascending ERS-2 orbit. The graphic in figure 4 describes the animation route: when altered, the Userinterface-Touchsensor generates an event that is processed by the JavaScript-Node. From height and deformation data, a new event containing the interpolated graphical structure is generated and sent to the model.

VI. CONCLUSIONS

We have described an experiment in which we utilized the recently established X3D Standard for the web-based presentation of an interferometric data set. We discussed some of the X3D and JavaScript features which we used for animation and user interaction with the rendered 3D model. In future investigations, we will explore in more detail how to handle data size constraints imposed by the available bandwidth as well as possible strategies to display time series of interferometric motion/deformation data on the web.

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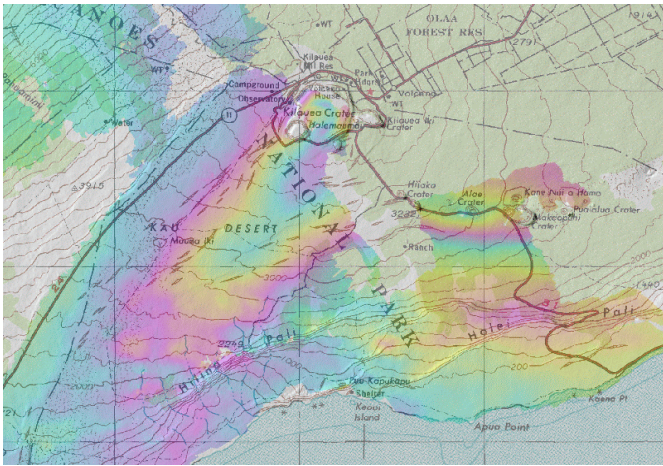


Figure 1. Map of Kilauea region with interferometric fringes overlaid.

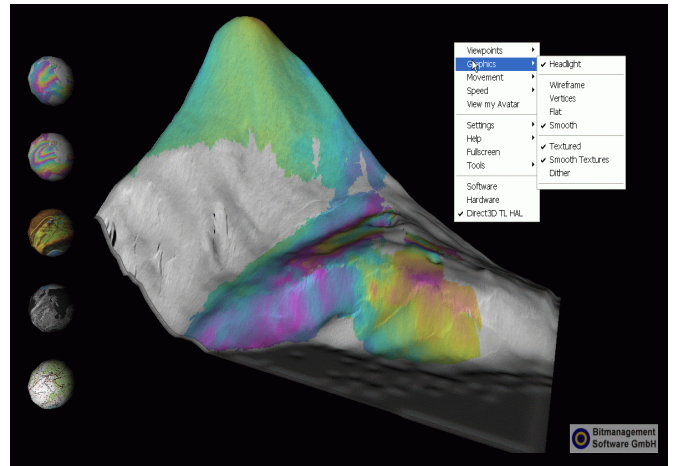


Figure 2. Exploration of the textured 3D model using the Contact VRML/X3D browser.

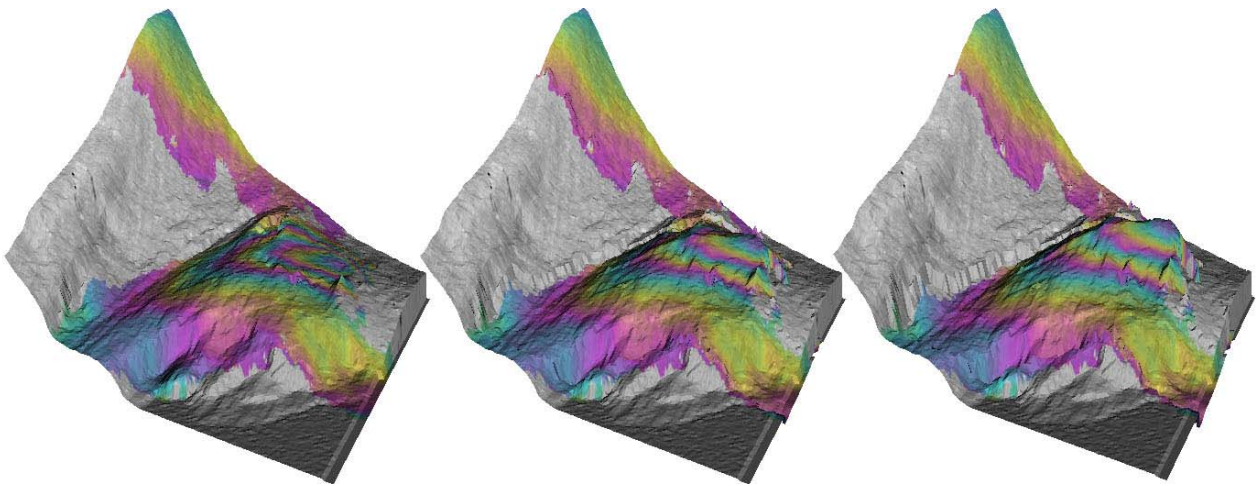


Figure 3. Animation of the 3D model based on the interferometric fringe pattern.

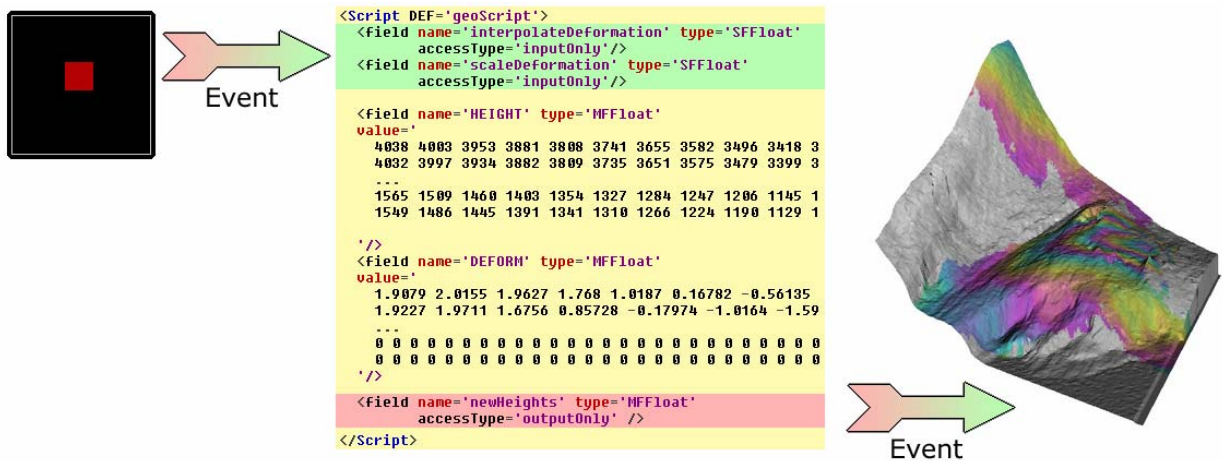


Figure 4. Illustration of the animation route. A user request triggers an event that is processed by the JavaScript-Node.