INTERACTIVE PRESENTATION OF 3D REMOTE SENSING DATA ON THE INTERNET

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Summary

The interactive presentation of 3D remote sensing data on the internet presents a challenging task for ongoing research on geoscientific visualization. In this presentation, we discuss the potential use of the new X3D (eXtensible3D) Standard, which has been introduced recently by the Web3D Consortium[1] for the unified specification of 3D content on the web. We present a case study in which we employ X3D for the geoscientific 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 ERS-2 interferometric phase observations. Geocoded 2D images and digital maps are used as texture that can be superimposed onto the 3D surface model. We give an overview of the modeling and animation of the Kilauea test set using X3D features and tools and demonstrate the web-based user interaction with the displayed 3D scene.

1. Introduction

The development of suitable algorithms and software tools for the presentation and visualization of geospatial data constitutes a topic of increasing importance within the remote sensing community [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 focus on the use of the newly established *eXtensible3D (X3D)* Standard, which was established 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) [3], 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 displayed 3D content.

We first outline some of the basic concepts and features of the X3D format with a view towards user interaction. Then, we describe the application of X3D to the web-based visualization of a remote sensing data set of Kilauea volcano, Hawaii. The test data comprise an SRTM DEM along with surface deformation measurements made by differential ERS-2 interferometry. Geocoded images and topographic maps are presented to the user as additional information. In the context of ongoing work, we also address the use of Macromedia Director as a multimedia authoring tool for the web presentation of 3D remote sensing products and related user interaction.

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[1] See: http://www.web3d.org

2. Test Site and Data Set

For our experiments, we employ an interferometric data set of Kilauea volcano, located on the Big Island of Hawaii, which is among the most active volcanoes on Earth. More detailed information about past and ongoing volcanic activities in this region is provided by the Hawaiian Volcano Observatory (HVO) [4] and other related websites (e.g., [5]). Available data sets include satellite images, interferometric surface observations, GPS data, in-situ measurements, digital maps, and photographs. Due to the high volcanic activity and rich amount of ancillary information, the Kilauea region provides an attractive data set for experimental multimedia presentations.

Starting point of our tests is a static 3D model which was computed from interferometric height measurements acquired during NASA's SRTM mission. Our animation model is based on deformation measurements derived from ERS-2 differential interferometry. An illustration of the test site and data set is given in figure 1. Figure 1 (a) shows a map of the Kilauea region, which is located in the southeastern part of Big Island, with an interferometric fringe pattern overlaid. The fringes indicate deformation measured by a descending ERS-2 pass. The crater of the volcano can be recognized in the central upper part of the map.

Figure 1 (b) gives an example of an interferometric deformation pattern derived from an ascending ERS-2 orbit. Regions of low interferometric coherence are masked in both subfigure (b) and the corresponding amplitude image in subfigure (c). The areas where no valid phase measurements could be extracted need to be excluded from the animation.

A major requirement for the design of a web-based system is to ensure reasonable download times. Therefore, 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 geocoded interferograms and ancillary data (2D images, maps), we performed some additional manual adjustment to reduce the effects of non-perfect geocoding.

3. Method, Implementation, and Demonstration

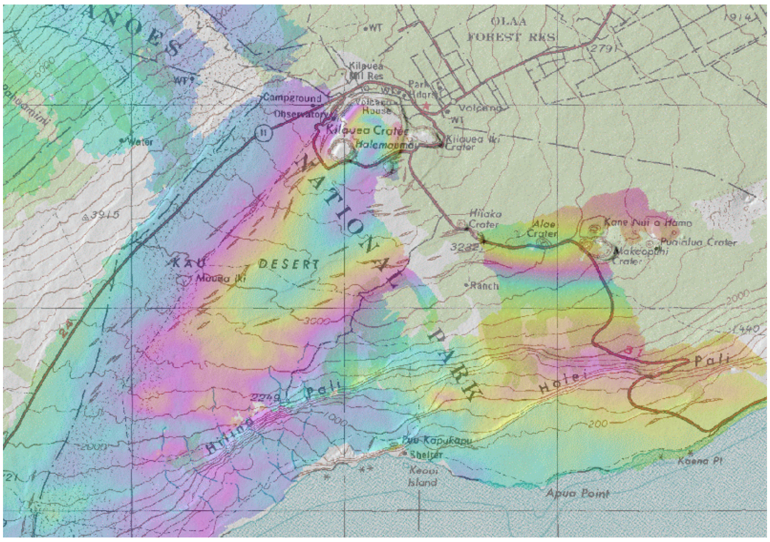
3.1 EXtensible 3D (X3D) Standard

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]

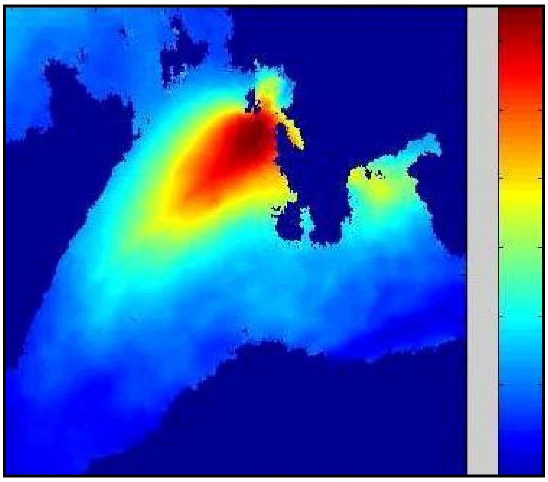
Every object or command (for example, to perform a transformation) is defined in *Nodes*. Nodes can contain specific fields (properties) and one or more children nodes. The resulting hierarchical data structure is also known as an X3D scenegraph. The XML-structure in X3D allows to define the properties 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.

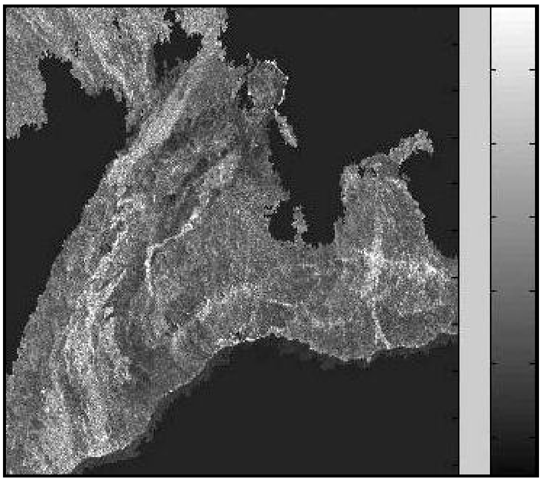
Interaction with the user is achieved by different Sensor-Nodes. An example is the *Touchsensor*, which is the main component to alter the scenegraph corresponding to the position and state of the mouse pointer.



(a) Map of Kilauea region with interferometric fringes overlaid.



(b) Interferometric deformation pattern.



(c) SAR amplitude image corresponding to (b).

Figure 1: Kilauea map and interferometric data set.

3.2 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.

3.3 User Interface and Web Browser

The interaction of the user with the displayed 3D model is illustrated in figure 2, which gives a perspective view of the 3D elevation model with the topographic map from figure 1 overlaid. The VRML/X3D browser (see below) allows the user to explore interactively the 3D model by changing the viewpoint or selecting a different rendering style. For interaction with the static and animated 3D model, we implemented a graphical user interface that relies on X3D and JavaScript features. A two-dimensional control panel allows the user to interact with time and amplitude parameters at the same time. The control panel can be seen on the right side of figure 2. 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. 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. The current values of the animation status ('Time') and amplitude scaling ('Scale') are displayed in the control panel. The interface also allows the user to select from a set of textures (for example, rasterized maps) that can be superimposed onto the static or dynamic 3D model.

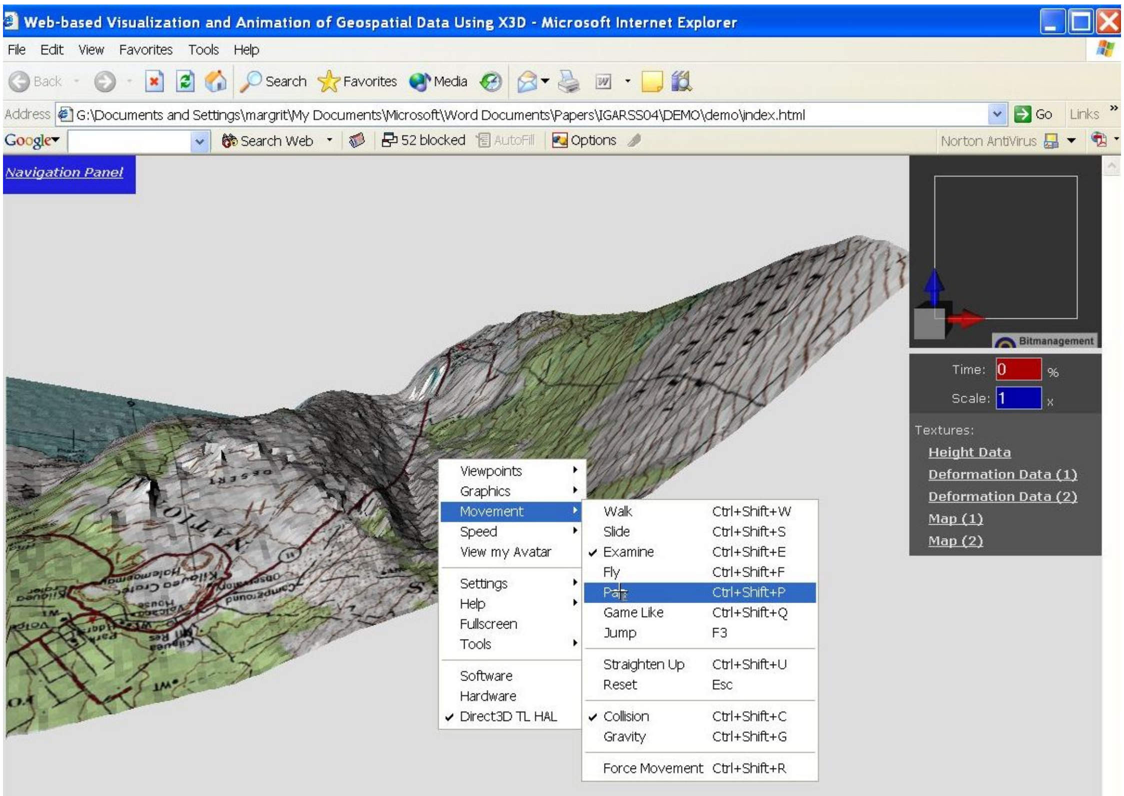


Figure 2: User interaction with the static and animated 3D model.

Figure 3 shows three different moments of an animation. The simulated deformation follows a fringe pattern around Kilauea computed from an ascending ERS-2 orbit (compare figure 1 (b)). The graphic in figure 4 describes the animation route: a user request triggers 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.

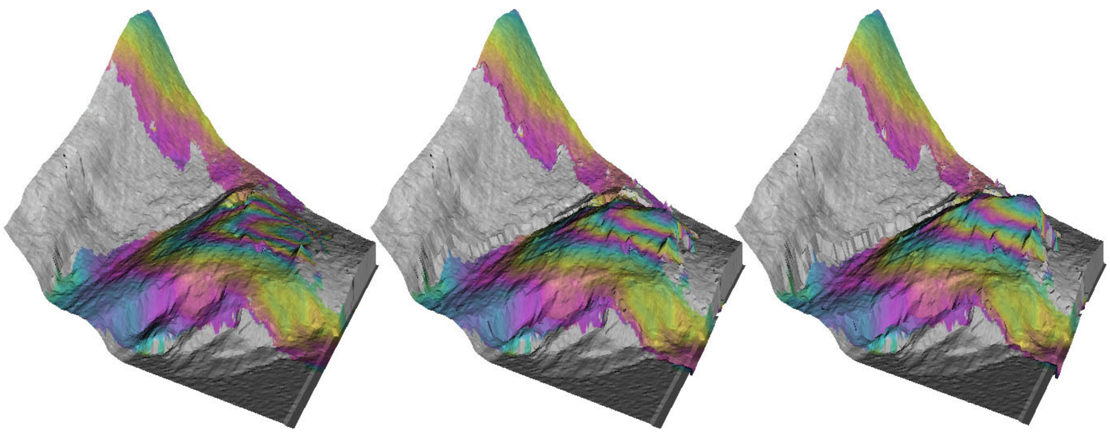


Figure 3: 3D view of an animated height model. The corresponding fringe pattern is superimposed as texture.

Figure 4: Implementation of the user-driven animation. The Userinterface-Touchsensor generates an event that is processed by the JavaScript-Node.

A certain drawback of the X3D approach is that there are no fully implemented X3D web browsers available at this time, since the X3D Standard has been introduced relatively recently. 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 [6], which is compatible with both Netscape and Microsoft Internet Explorer.

3.4 Macromedia Director

In addition to our work based on the X3D standard, we also consider the use of Macromedia Director [7] for the production of a web-based multimedia presentation of the Kilauea data set. Macromedia Director is a commercial multimedia authoring tool that allows combining features such as text, images, vector graphics, videos, animations, speech, and sound in an interactive web presentation. Recent versions of the software have incorporated 3D functionalities [8] that allow the user/developer to work on imported 3D models provided in Shockwave 3D (.w3d) format. The 3D model may have been created using 3D modeling software such as 3D Studio Max or Cinema 4D. The screenshots in figures 5 and 6 illustrate the work with Macromedia Director. For web-based interactive access to the developed 3D presentation, the user needs to download a Shockwave player, which is freely available on the web.

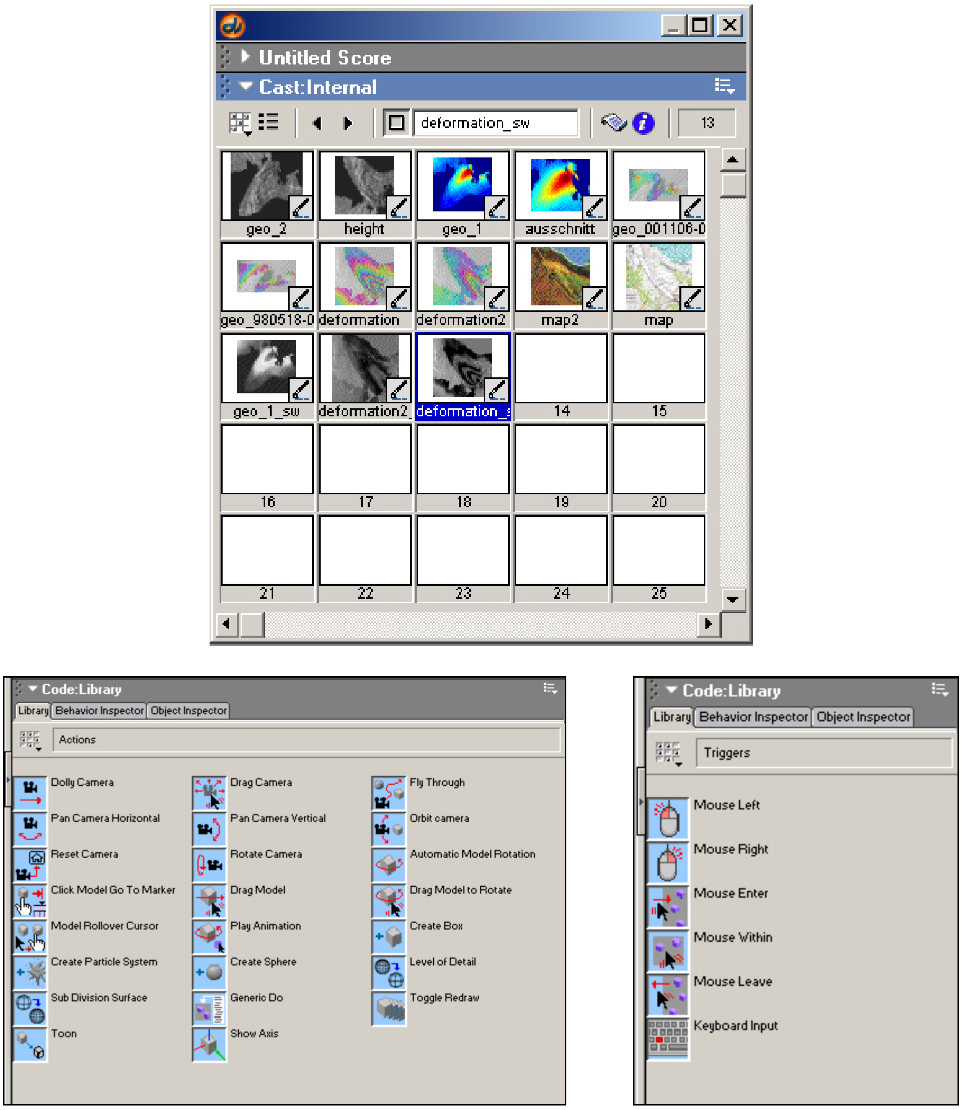


Figure 5: Illustration of the Macromedia Director environment. The top row shows a ‘cast list’ with the imported interferometric data set. The windows in the bottom row give examples of actions and triggers that can be applied to the 3D model.

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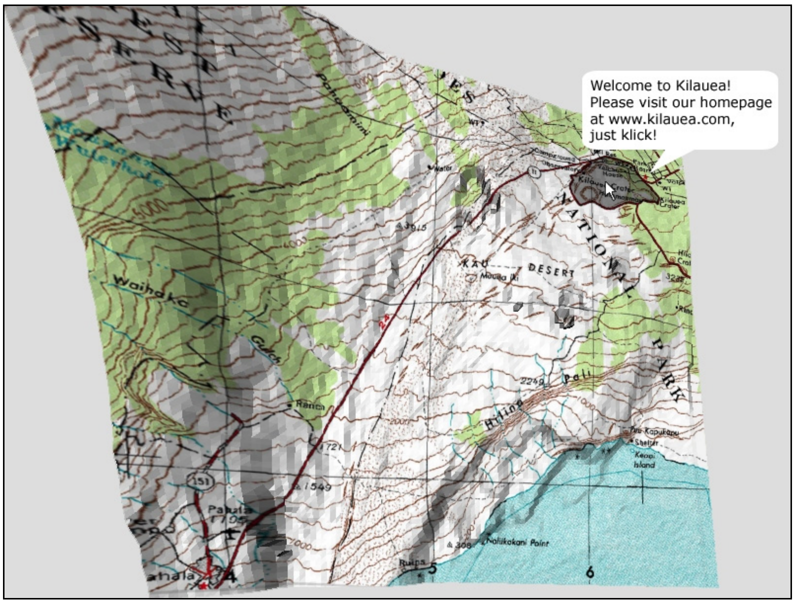

Figure 6: Illustration of a possible interaction with the 3D model. As the cursor moves into the crater region, the area is highlighted and the user is offered to follow a link for more information.

4. Summary and Outlook

In the context of ongoing work on a web-based presentation system for an interferometric deformation dataset of Kilauea volcano, Hawaii, we proposed the use of the recently established X3D standard for modeling of the static and dynamic 3D scene. We discussed some of the X3D and JavaScript features that we employed in our implementation and demonstrated the user interaction with the animated data set.

In future work on X3D and other multimedia authoring tools for web presentation, we will study the handling of larger data sizes and explore possible strategies for displaying time series of interferometric motion/deformation data on the web.

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