

# Globe4D, time-traveling with an interactive four-dimensional globe

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## ABSTRACT

Globe4D is an interactive four-dimensional globe. It is a projection of the Earth's surface on a physical sphere. The sphere can be freely rotated along all axes, viewed from any angle and enables the user to control time as its fourth dimension. An application was created that shows the historical movement of the continents, known as continental drift. Besides the Earth, any planet or spherical object can be projected. This paper describes the background, aims, results and progress of this student project.

## Categories and Subject Descriptors

**H.5.2 [Information Interfaces and Presentation]:** User Interfaces *Input devices and strategies, Interaction styles, Prototyping, Screen design, User-centered design;* **H.5.1 [Information Interfaces and Presentations]:** Multimedia Information Systems --- *Animations, Video;* **B.4.2 [Input/Output and Data Communications]** *Input/Output Devices --- Image Display.*

## General Terms

Experimentation, Performance, Design, Human Factors

## Keywords

Globe Projection, Earth, Spherical Display, Physical Interaction, Direct Manipulation Device, Continental Drift

## 1. INTRODUCTION

Globes have been the traditional three-dimensional scale model of the Earth for more than five hundred years. With digital technologies becoming more and more part of everyday objects and with new, advanced ways of projecting data, it was inevitable that the traditional globe needed a makeover.

Current related research typically has few or no options for interaction. First, in Japan, the National Museum of Emerging Science and Innovation exhibits a 6½ meter spherical display, called Geo-Cosmos, which projects a dynamic satellite feed onto the display. A second example is ViBall [5] which uses 2 projectors to project images of the Earth onto a sphere. The projection cannot be influenced in other ways than rotation, which limits it to an expanded ability to rotate the globe and does not take advantage of the flexibility of digital content. A third project is Gullivers' World [6]. It uses a blanc hemisphere

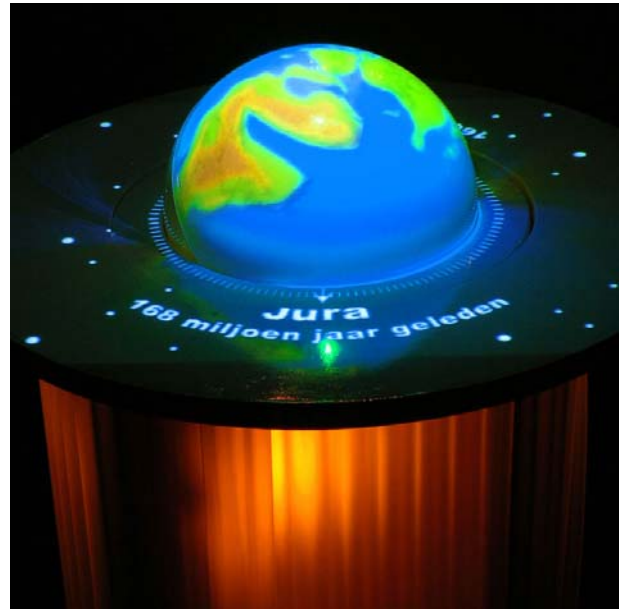


Figure 1: A prototype of Globe4D with a projection of the Earth's continents 168 million years ago.

on which a virtual world is projected. Children can stamp virtual objects onto the hemisphere to make it part of their virtual world. A fourth example of related research is to be found on the Geology floor of the natural history museum Naturalis in Leiden in The Netherlands. This museum has flat displays with digital maps of the Earth which enable users to observe animations of seismic activity over the last hundred years.

## 2. GLOBE4D

Globe4D is an interactive installation that consists of a physical sphere on which three dimensional images are projected by a video projector. The current setting uses animations of the Earth's surface. It was developed as a student project, focusing on the creation of novel multimedia systems. A picture of a prototype Globe4D is shown in figure 1.

Unlike conventional globes, Globe4D can be freely rotated along all axes, causing the projected image to rotate synchronized with the input movement. As a fourth dimension, time is included in this installation. The tabletop, in which the sphere rests, contains an outer ring. When this ring is rotated, the user scrolls backward or forward in time and can observe continental drift, earthquakes or other natural processes that occur over time. Especially the fourth dimension of time sets Globe4D apart from other traditional or digitized globes. This function allows users to modify the contents of the globe, which makes the installation more interactive and extends the purposes for which Globe4D can be used. Many other aspects of the Earth's history can be projected onto the sphere, such as human migratory paths or flora and fauna distributions on variable time-scales.

### 3. IMPLEMENTATION

Globe4D consists of the following parts: A video projector, a sphere to project the images on, an outer ring for scrolling through time, a trackball and scroll wheel of a mouse both for measuring the rotational input, and a computer with software for processing the projected images.

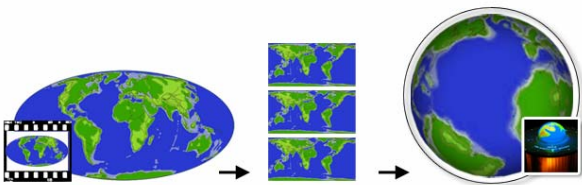
The use of a video projector for the projection on the sphere has two advantages. First, it enables the user to walk around the globe without affecting the projection. Second, any image can be projected onto the spherical surface. Albeit currently the Earth serves as the main projection, it is possible to switch to other images, like stars, planets, satellites or any other spherical object.

The 30 cm diameter sphere is made of 3 mm thick acrylic, and is painted white inside. The image is projected through the transparent acrylic layer, and is reflected by the inner white layer. An aesthetic advantage of this design is that the projection seems to come from inside the sphere. A disadvantage is that this slightly lowers the display quality, since the light is broken by the acrylic before it hits the white layer. Also, the acrylic layer itself reflects light, causing artifacts around the sphere.

The rotational input for the image is measured by a trackball, which is mounted underneath the sphere. This form of movement tracking is cheap and easy to use. A disadvantage is that when the sphere is rotated along an axis normal to the contact point between the trackball and the sphere, this point acts as the centre of rotation, causing the trackball to slip. Solutions to this problem are given in [5].

An external ring is mounted around the sphere which can be rotated to scroll through time in the projected data images. The ring is connected to an axis which rotates around a fixed pole that supports both the ring and the sphere. To this pole a mouse is fitted, whereby its scroll wheel is in contact with the rotating axis. Thus, when this ring is rotated, the axis rotates along with it, causing the scroll wheel to rotate (in opposite direction).

The software created for Globe4D was written in C++ and uses OpenGL for handling user input and rendering three dimensional animations supplied by the data layer. This data layer was written in C++ and Processing and provides the textures for the animations on the sphere. It extracts elliptical images from a movie and interpolates these to texture maps for a sphere. It also provides the text projected around the sphere, which is in this case the name of a geological period. A scheme of this procedure is given in figure 2.



**Figure 2:** Scheme of the data layer, which translates elliptical images from a movie to a sphere to be projected on the globe.

### 4. CONCLUSIONS AND FUTURE WORK

Globe4D incorporates the best of both the digital and non-digital worlds. First, it combines the hands-on interactivity of classical globes with the flexibility and versatility that digital techniques supply. Physical input with direct feedback makes interaction with Globe4D very tangible and intuitive to use. Second, the installation is self-explanatory, making it very suitable for educational purposes in geology, history, economics, physics and for expositions in museums. Globe4D is currently in the final stages of development for Naturalis, the museum of natural history in Leiden, The Netherlands.

Globe4D, while already capable of fulfilling its primary function, is continually being improved. One of the future possibilities with this type of display and user feedback could be live weather charts, synchronization with Google Earth, showing and controlling the Coriolis Effect, the Earth's history of earthquakes, ancient world maps, ocean currents, demographical statistics, etc. There is much geographical and historical data available that could be put in a new perspective when applied to Globe4D. A second future possibility would be to implement new types of user input. Particularly technologies such as motion tracking and pressure sensitive surfaces could improve the tactility of Globe4D. A final future possibility would be to use advanced projection techniques, like spherical projection from the inside of the sphere.

The current state and future progress of Globe4D can be found on the internet via [www.globe4d.com](http://www.globe4d.com).

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