Eötvös Loránd University

Faculty of Informatics

Department of Cartography and Geoinformatics

Mátyás Gede

Webcartography and Geoinformatics for Protecting Cartographic Heritage

Thesis of PhD dissertation

ELTE Doctorate School of Earth Sciences

Leader: dr. Gábris Gyula

Doctorate Program of Cartography

Leader: dr. Klinghammer István

Consultant:

dr. Györffy János, associate professor

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Aims

The different terrestrial and celestial globes are an important part of the Hungarian cartographic heritage. Archiving, digitising and preserving the current state of these objects, however, is a much more complicated task in comparison with two-dimensional maps that can be easily scanned or photographed.

The aim of my research was to develop easy and safe methods of globe digitising, archiving and presenting to the general public in an internet-based globe museum.

Antecedents

Although there are no other examples of on-line globe exhibitions as the one described in this essay, globe digitising itself is not unprecedenced. There were several projects aiming to create the virtual copy of a globe using various techniques. The following projects are the most important:

- The simplest example of globe archiving is a digitised version of the pair of Mercator's globes on the website of the Harvard College Library. In this case there was no virtual facsimile created, only the photographs of the globes taken from different viewpoints can be viewed by an interactive user interface.

- The researchers of the Technical University of Dresden created a digital facsimile of the 68 cm diameter Blaeu globe. The source was a black and white photo series, which was coloured on the computer screen. A special display is used for presenting the model, which gives the spectator a true three-dimensional view of the globe. The calendar frame is also implemented in the model.

- The virtual Mercator globe can be viewed at the Globe Museum of Wien, next to the original one. This digital facsimile was made by processing a photograph series of the globe where each photo depicts a 10 by 15 degree quadrangle.

- The digitally redrawn version of Waldseemüller's globe was created at the Department of Cartography and Geoinformatics at Eötvös Loránd University as a part of a master thesis in cartography. The digital sphere, which is rotating around its axis, was realized as a Flash animation, and beside the original coastlines the current ones can also be seen. This solution unfortunately lacks any interactivity, even the point of view cannot be selected. The antecedents of this work are the digital globes of Gyula Pápay that present the world of Strabo and Ptolemy.

- Adami and Guerra created a virtual copy of a globe of Coronelli at the IUAV University in Venice. This facsimile globe is based on the original prints.

- The virtual Behaim globe at the Institute of Photogrammetry and Remote Sensing at the Technical University of Vienna. Its peculiarity is that not only the content but also the shape of the globe was determined by photogrammetric means. The results show that the globe was strongly deformed because of its own weight. The virtual globe (which represents the original spherical shape) is a VRML (Virtual Reality Modeling Language) model. The website which introduces the globe unfortunately does not work properly with all browser – VRML player combinations. Another issue is the improper texture mapping at the poles.

- During the restoration of the Karl-Theodor globe in Heidelberg its virtual copy also was created. The VRML globe is based on the scanned gores of the original sphere after applying a special digital filter on the images.

- The models of Giovanni Maria Cassini's terrestrial and celestial globes from 1790 can be seen at the web page of the David Rumsey Map Collection. These globes are visualized using the Google Earth plug-in. According to its description the technology is the same that the one I present in this essay, but using other software. These virtual facsimiles were made later than the first items of the Virtual Globes Museum, but as there are no references to antecedent research in the description, the creators probably invented their method independently.

Methods

Globe Digitising

After analysing the previously mentioned projects I developed two different methods to realize globe digitising:

- If the original prints of the globe are available, the digital material can be produced by scanning and georeferencing these prints. In this case georeferencing is easy as the projection of the gores and polar caps is known (Cassini's and Postel's projections).
- If the print is not available, a series of photographs has to be taken and processed. The georeferencing of these pictures is rather complicated. If the optical axis is crossing the centre of the sphere during the photographing, the projection of the pictures is the Near-Side Vertical Perspective, but the parameters of this projection are unknown.

To solve this problem, I have written a utility program which estimates the missing projection parameters from the data of a set of ground control points, using the Nelder–Mead Downhill Simplex method for the calculation. The input/output format of this software was designed to fit into the georeferencing process: it uses the Global Mapper's control point (*.GCP*) and projection (*.PRJ*) file formats.

Regardless of the source material, the georeferenced maps have to be transformed into Plate-Carée as in this projection it is easy to assemble them into one image.

Visualization

I developed two methods for the visualization of the virtual globes on the computer screen:

1.   A VRML globe model. This model is built up of six sub-surfaces: four 90° wide quadrangles around the equatorial areas between ±50° latitudes and two polar caps. This solution has several advantages:

- The edges of the polyhedrons that are estimating the spherical surface match the ten-degree grid lines. This avoids the unwanted interference between the edges and the grid which often occurs if a globe is visualized on the built-in Sphere object of VRML.
- Each sub-surface is given its own texture, so the size of the textures can be smaller. This is crucial when using lower performance graphic cards (which is very common in notebooks or older desktop configurations), as in this case the maximum size of the textures is limited and this causes insufficient resolution.

- As the textures of the polar caps are in azimuthal projection, the texture mapping problem at the poles of other three-dimensional spherical models does not occur.

Utilising the possibilities of VRML, I also created two special non-spherical model: the digital copy of the 40 cm detachable structural Earth model of Cartographia and the model of a truncated celestial globe from the 19th century.

2. The other visualization method I developed is the usage of the globe maps as a Google Earth layer. This solution helps analysing the globe content together with other data provided by Google.

A KML file has to be generated for this solution, which describes the location of the Plate-Carée map parts on the globe surface. I created a utility program which facilitates the creation of these KML files.

The Virtual Globes Museum web site

I created the Virtual Globes Museum web site (http://vgm.elte.hu), where the three-dimensional, navigable models of the globes are presented as well as the background data relevant to them. The easy usage of the site is helped by an easy search engine, and there is a list of the most important related publications for those who are interested in this theme.

The user interface is currently trilingual (Hungarian, English, German) to help those visitors also who cannot understand Hungarian. The structure of the web site allows easy addition of further languages.

Results

1.

I developed a VRML globe model with positive properties. This model is built up of 6 sub-surfaces: four quadrangles between the ±50° latitudes completed by two polar caps. The textures of the equatorial areas are in Plate-Carée while those of the polar caps are in Azimuthal Equidistant projection. This minimizes the problems of texture mapping.

The VRML globes also can be given different viewpoints, which facilitates the navigation on them. I created a utility program which creates the code of these viewpoints. The use of this software makes it possible to give various sets of viewpoints to globes with different themes.

Utilising the possibilities of VRML, I also solved the problem of visualizing such non-spherical globes as the detachable structural Earth model.

2.

I developed the method of visualizing globes as a Google Earth layer. The advantage of this solution is that the content of the globes can be viewed together with other map data provided by Google, helping, for example, the accuracy analysis of globes.

To facilitate the visualization in Google Earth I created a utility which creates the appropriate KML file for any gridded globe maps. This file projects each part of the gridded map to its proper place on the sphere.

3.

I developed the technology of georeferencing globe photographs. I also created a program which estimetes the projection parameters of a globe photograph, using the data of a set of control points marked on the digital photo. This program made it possible to create high precision models of globes based on a series of photos.

4.

I developed the creation process of globe prints needed for facsimile globe making, based on the digital projection transformation of globe maps created for the virtual models. I also created a raster-based projection converter program which can produce the prints for any globe making technology, using the Plate-Carée map of the globe as source.

The creation of these prints without this program is not posible or only with a plenty of work.

Conclusions

Globe digitising and visualization of virtual models of these spheres on the internet can be a great help for any institute that is preserving globes as these methods provide an easy way of studying the content of the globes without the risk of damaging the original object.

Using the solution of facsimile globe making described in the essay, real, touchable copies can be created, even with different technology and in different size than the original.

It would be useful to carry out virtual restoration on every globe with the method described in the dissertation before starting any physical restoration. The analysis of the results could avoid incidental modifications that can cause the irreversible damage of the globe.

Publications

Book chapter

Gede, M., Márton, M., 2010: Globes on the Web – the Technical Background and the First Items of the Virtual Globes Museum. *In: Cartography in Central and Eastern Europe – Lecture Notes in Geoinformation and Cartography. pp. 279–290. Springer, Berlin, Heidelberg, 2010.*

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