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Blurring Boundaries Between Real and Digital/Virtual Globes – Creating virtual globes from real ones and vica versa

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Abstract

The recently opened Virtual Globes Museum publishes three dimensional virtual models of old globes on the Internet. The main purpose of the museum is to preserve these artifacts of old cartographers and at the same time to make them available for anyone who wants to study their content without the risk of making any harm to them.

In this project, the authors established a bi-directional passageway between the world of virtual/digital and real globes. The developed technologies enable the easy creation of digital globes from handmade originals as well as the reverse process: the (re)creation of handmade globes from digital ones.

The “heart” of the system is the Virtual Globes Museum, in which the globes are stored in an appropriate digital format. The images of the globe surface are archived in Platte-Carée, while those of the polar regions are archived in azimuthal equidistant maps.

This “globe database” is fed from various input channels. The sources can be photo sets of globes or scanned images of printed segments transformed into a uniform image. This transforming process – especially when dealing with photographs – involves the problem of georeferencing, for which a special program was developed. This program calculates the projection parameters of a globe photo using control points marked on it.

Another possible source is a newly compiled globe, when the globe map is created in the format that will be stored in the Museum, i.e. in Platte-Carée and azimuthal equidistant projection. This means that no further

projection transformation is necessary. A current research project is trying to define the major guidelines of editing a globe map of this type.

The possible output channels are the various digital visualizing forms of the globes: VRML models or KML globe layers for Google Earth, and a “down-to-earth” version: handmade globes based on the material stored in the museum.

This latter procedure makes it possible to produce “facsimile” versions of old globes even without any original printed material by using a photo series of the globe.

This paper intends to show a total cross-sectional view of globe digitizing by presenting examples of each procedure: digital globes made from photos or prints; globes designed to be virtual ones; and facsimile reproduction of the processed globes.

Keywords

virtual globes, VRML, KML, facsimile globes

Introduction

Terrestrial and celestial globes are peculiar products of cartography in many aspects. First of all, unlike traditional maps, globes nowadays are rather ornaments than navigational aids. Their creation is much more difficult as manufacturers also have to produce the bearer sphere and its frame.

Archiving these objects was a hard task until the recent times. The revolutionary increase of computers’ power however, finally made it possible to digitise globes and visualize them on the computer’s screen also. And if a globe is somehow feeded into the computer, there is the opportunity to recreate a new copy of it, a facsimile globe.

Several projects deal with globe digitising. Florian Hruby, Irmgard Plank and Andreas Riedl created the digital copy of Mercator’s globe using photographs and original prints ([Hruby et al 2006](#)). Andrea Adami and Francesco Guerra created Coronelli’s globe from its printed sheets (Adami & Guerra 2008).

The Virtual Globes Museum is a little bit different from these projects. Its primary purpose is to form a virtual exhibition of the globes related to Hungary. At the same time it wants to serve as a digital archive of these globes. Using its background database it’s also possible to create facsimile globes.

The Museum

The central object of the project is the „Virtual Globes Museum”. It’s a web page with a background database. Its name can be interpreted two ways: a „virtual museum” of globes or a museum of „virtual globes”. It forms an on-line exhibition of three-dimensional globe models somehow related to Hungary.

The website is trilingual: the user can choose between Hungarian, English and German. A simple search engine helps to browse among the daily growing number of globes (Figure 1). Two different types of 3D models are stored in the museum: VRML globes, viewable either by an appropriate VRML player plug-in or by a Java applet; and KML „globe layers” for Google Earth.

The background database stores the images and additional data about each globe. A few words are written about every globe’s history, technology, content and other important or interesting issues. All these data and the available portraits or other photos can be examined on the globes’ detailed data sheets.



Fig. 1. The Virtual Globes Museum web site (<http://vgm.elte.hu>)

The globes' equatorial areas are stored in Plate-Carée while the polar regions in Azimuthal Equidistant projection. The reasons of this choice are simple: the Plate-Carée is the easiest option when we have to assemble many smaller areas to a big map image as geographic quadrangles are rectangles in this projection. The azimuthal projection is used because of the VRML models as the poles have their own textures there.

Input possibilities

If there are unmounted printed gores of a globe available (Figure 2), the easiest option is to scan those prints and process them to create the virtual globe. This process involves the georeferencing of the gores, which requires the determination of their projection.

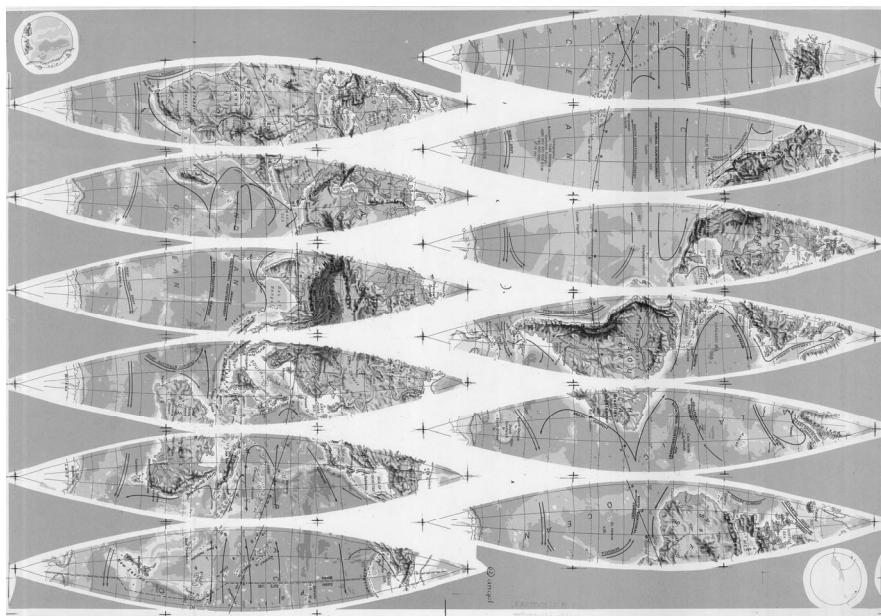


Fig. 2. Printed gore set

Although the gores of old globes didn't have an exact projectional background, the Cassini projection fits adequately. Using as many control points as possible (the intersections of the geographic grid are used) method the results are good. Other projections may also be appropriate, but comparing a 30-degrees wide segment's image in a few selected projections (Transverse Mercator and Polyconic besides Cassini) the

differences seem to be less than the unavoidable distortions due to paper deformations.

If the prints include polar caps, they also have to be georeferenced. These caps were usually drawn in Azimuthal Equidistant projection.

When printed gores are unavailable, a photo series has to be taken. The projection of such globe photographs are the same as the one of a photo of the Earth's surface taken from the space. It is called Tilted Perspective Projection and it is a rather general projection with several parameters. As unfortunately it is not known by any of the popular GIS programs by this time, it is advisable to find a way to use another projection. The easiest solution is to make the optical axis of the camera intersect the centre of the globe. In this case the projection simplifies to the Vertical Near-Side Perspective (Snyder, 1987). An example of georeferenced photo can be seen on Figure 3.

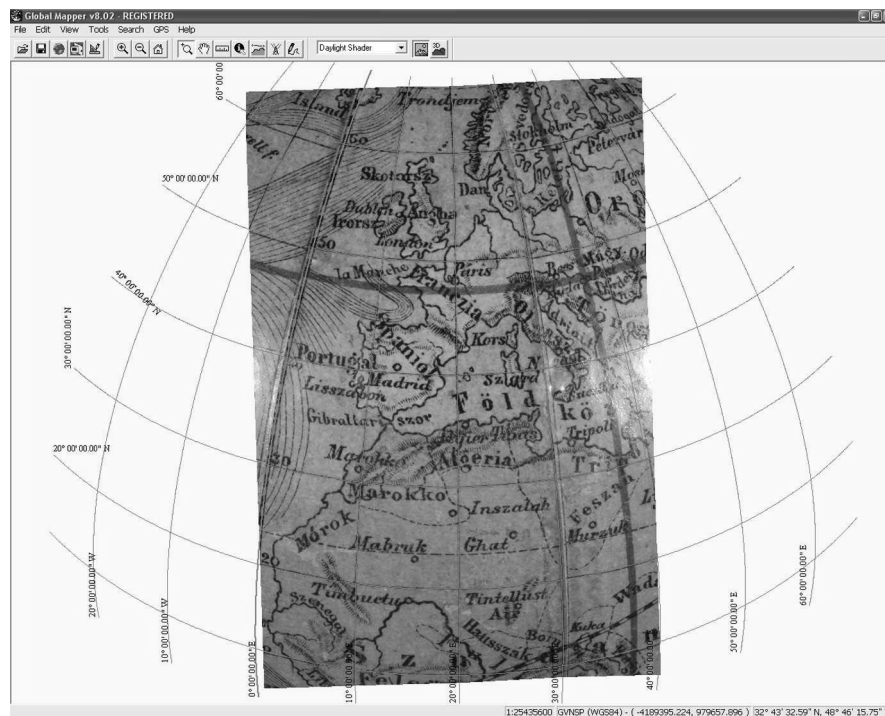


Fig. 3. A georeferenced globe photograph

This projection has three parameters: the latitude and longitude of the projection centre and the height of the perspective point. A useful program was developed to calculate these parameters from an appropriate set of

control points using the Nelder–Mead Downhill Simplex Method ([Nelder & Mead, 1965](#)) to find the optimum values. (Gede, 2009)

Whether we used gores or photos, the next step is assembling the pieces into one large image (Figure 4). The georeferenced images are transformed to Plate-Carée because in this projection globe segments, polar caps and any other geographic quadrangles become rectangular areas so they can be fitted together easily.



Fig. 4. An assembled globe map in Plate-Carée

If we want to compile a virtual globe with brand new content rather than representing an old one, we should create three images: a Plate-Carée map for equatorial regions between $\pm 50^\circ$ latitudes and two polar caps in Azimuthal Equidistant. Hargitai used this solution to create the virtual globes of Moon and Mars and other planets. (Hargitai, 2009)

There is an important issue in this method which must be taken in count: projecting the images to the sphere will distort their content so all the text should be placed after applying an inverse distortion which will ensure their normal appearance on the globe.

Output possibilities

The most obvious format for a 3D object is a VRML (Virtual Reality Modeling Language) model. Although this language has a built-in sphere object, it is advisable to define a special object for globes. It is better to split the surface to more sub-surfaces because the computer graphic cards prefer more small textures than one large image.

A sphere built up of six sub-surfaces were developed for the Virtual Globes Museum. The equatorial areas are divided into four parts and each polar region is separated (Figure 5, 6). The boundary latitudes vary due to the globe's content. Mathematically, the best option would be to use the 45° latitudes, but most globes have a grid system with ten-degree intervals. Therefore, the usual boundary is 50° . There are globes however, with boundaries at $\pm 70^\circ$. This solution was used for smaller globes having polar caps with a radius of 20 degrees which means that the original polar caps are the same as the ones in the VRML model.

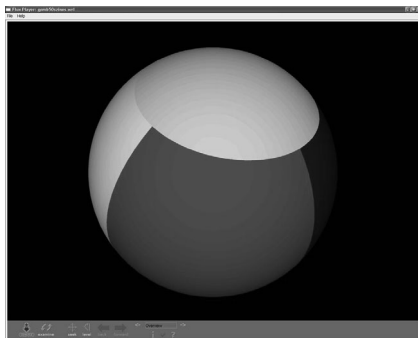


Fig. 5. The VRML sphere built up of six surfaces

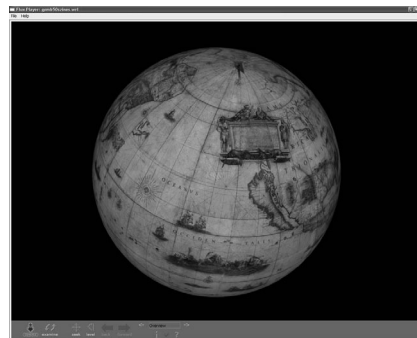


Fig. 6. A VRML virtual globe

VRML models can be viewed by an appropriate player software. Usually it is a free-downloadable browser plug-in. For those who do not want or cannot install plug-ins on their computers but have Java installed, the museum provides a VRML player Java applet.

Another possibility is the using of KML language instead of VRML. KML (Keyhole Markup Language) is a format which can be interpreted by Google Earth and other virtual earth programs (Google, 2009). These KML globe models become a new layer once they are loaded into Google Earth and therefore the content of old globes can be examined and analysed together with other contents like current political boundaries or coastlines etc. (Figure 7)

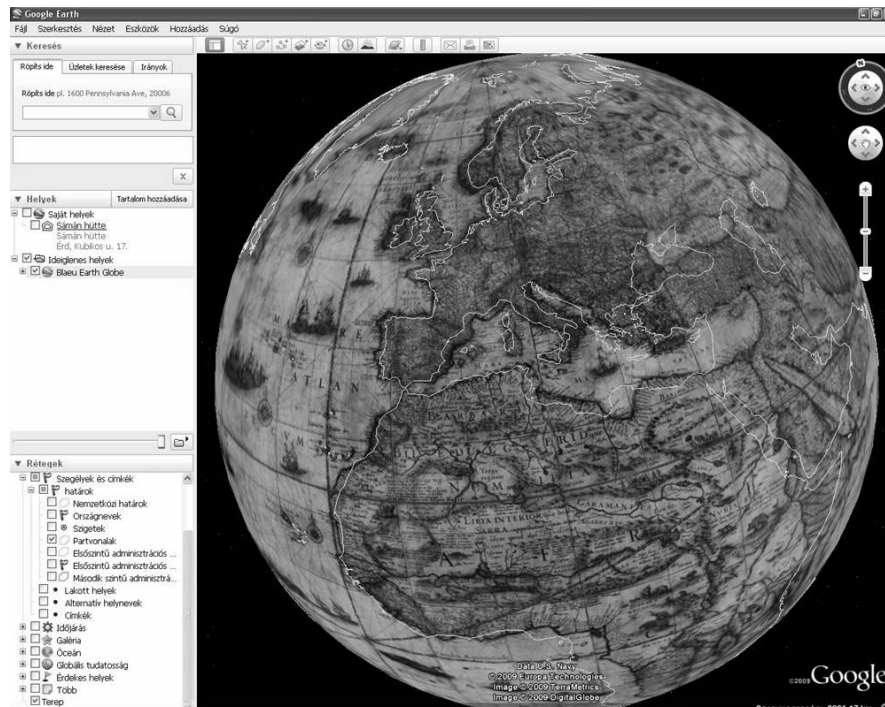


Fig. 7. A KML globe in Google Earth

Creating a facsimile globe

Once a globe, even an unique, manuscript one, is digitised, it is possible to recreate it as a facsimile. It is something like „reverse engineering”, as the set of gores is produced using the processed photo series of the globe. To obtain the gores, the large Plate-Carée map of the globe is divided to usually 12 parts (30-degrees wide each) with some overlap at the edges. At the second step these segments are converted to Cassini projection. Two polar caps in Azimuthal Equidistant projection also have to be created.

After scaling these images due to the mounting sphere’s diameter, they can be printed by a color laserjet. The last step is the mounting of the gores and polar caps to the sphere. This is the hardest task as it needs some hand skill. (Figure 8)



Fig. 8. Homemade facsimile globe

There are other possible solutions. Instead of 12 gores and two polar caps, two petal-shaped prints also can be created (Figure 9). The projection background of these petals are the same as in the previous solution; but the gores are split at the Equator and they are mounted to the polar caps. The

authors developed a little program which produces these petals automatically from the Plate-Carée images.

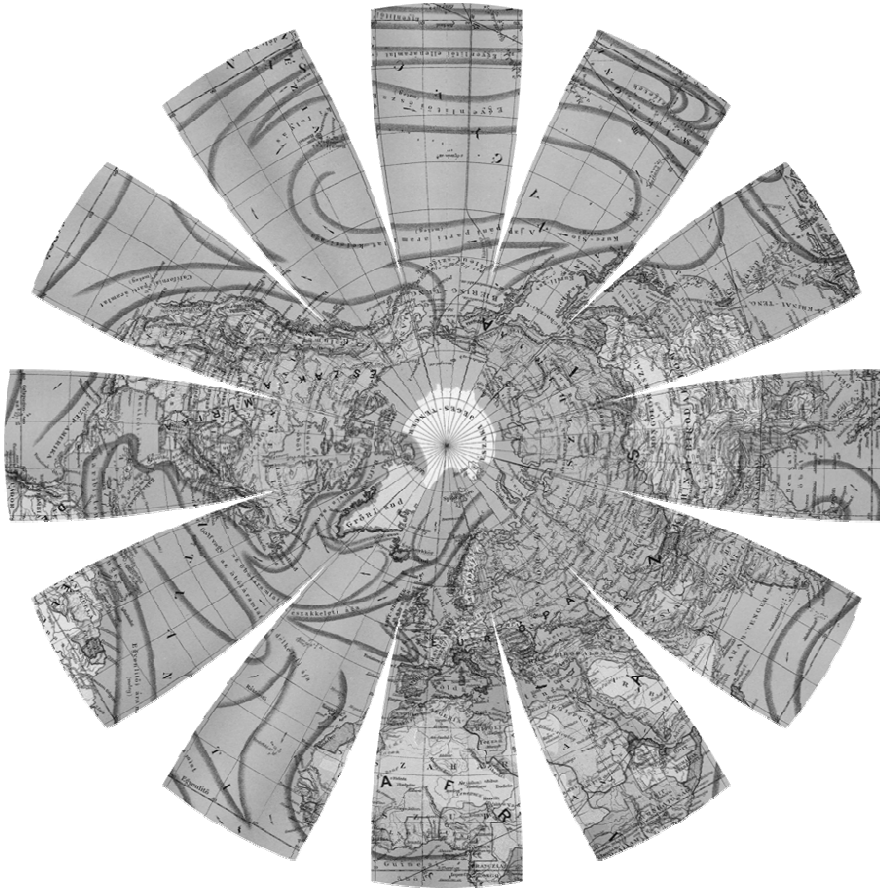


Fig. 9. Petal-shaped globe print

Another option could be the production of a plastic globe with the content of an old one. It needs however, a co-operation with globe manufacturer companies as the production of such plastic globes cannot be done without special machines.

Conclusions, discussion

The globe digitising method described above is usable for most of the globes. There are, however, cases when some difficulties occur.

Celestial globes sometimes don't have a proper geographic grid. Blaeu, for example, had drawn only a few lines to his sky-globe: the Equator, the tropics of Cancer and Capricorn, the polar circles, and the Ecliptica. Additional lines are the edges of gores which are perpendicular to the Ecliptica. The intersections of these lines were the most important GCPs for georeferencing. In areas where the number of those points were insufficient, some stars also were used.

Sometimes the gores were improperly mounted to the globe. These faults can be mended on the virtual globe if the adjacent gores are georeferenced separately.

When photographing a globe, the hardest challenge is to ensure homogenous lighting conditions for each photo. The best solution is to fix the camera, and only rotate the sphere around its centre. Some globes however, cannot be handled this way, because there is no possibility to take them out from their holder. In this case it is almost impossible to make all the photos homogenous in lightness and contrast.

If we want to create a facsimile globe, the first task is to find a proper base sphere. Polystirol spheres (usually available in hobby-art shops) are a good option for smaller globes.

Before printing, the gores have to be scaled to fit the base sphere. A trial mounting of a piece of paper can help to determine how the paper behave i.e. how much it will stretch for example.

The glue shouldn't dissolve the ink or the material of the sphere. The authors used decoupage glue.

To facilitate the proper mounting, it is advisable to draw the place of the gores in advance.

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