DIGITAL GLOBES - FROM VIRTUAL TO REAL

Andreas Riedl
Assistant Professor, andreas.riedl@univie.ac.at
Department of Geography and Regional Research, Cartography and Geoinformation,
University of Vienna

1) ABSTRACT

In the past years the development that took place in the information technologies area led to a significant expansion of the diversity of digital globes. The spectrum stretches from common products (primarily virtual hyperglobes) over unique copies (primarily tactile hyperglobes) to those digital globes that exist until now mainly as concepts (hologlobes).

2) INTRODUCTION

Technological development at the end of the 20th Century opened a new gate for globes. In addition to the traditional analogue physical globes their digital counterparts evolved. Both globe representations are based on a three-dimensional model of the real world.
Because of increasing availability of global data visualization on a global level gains more significance. Therefore many software developers use the globe as an "interface" to large-scale data. The visualization of global data however is enormously dependent on the technological development - both, on the software as on the hardware side. Triggered by the recent years progress in this area the realization of all categories of digital globes are within reach. So far some have only been theoretical.

3) TYPES OF DIGITAL GLOBES

"A globe is a scale-bound, structured model of a celestial body (respectively firmament) presented in its undistorted three-dimensional wholeness" [RIE-00]. This definition applies in the same way to traditional analogue globes and digital globes. Furthermore this implies also for digital globes a three-dimensional model as a basic requirement.

All variants of digital globes are linked together by their digital visualization. Significant distinctions can be made regarding the globes body or the kind of space, in which the globe is visualized.

Regarding their representation following categories of digital globes can be classified [RIE-00]:

- **Virtual hyperglobes**: Visualization of the digital image on a virtual globe body in virtual space.
- **Tactile hyperglobes (material hyperglobes):** Visualization of the digital image on a physical (touch-sensitive) globe body in real space.
- **Hologlobes:** Visualization of the digital image on a virtual globe body in real space.

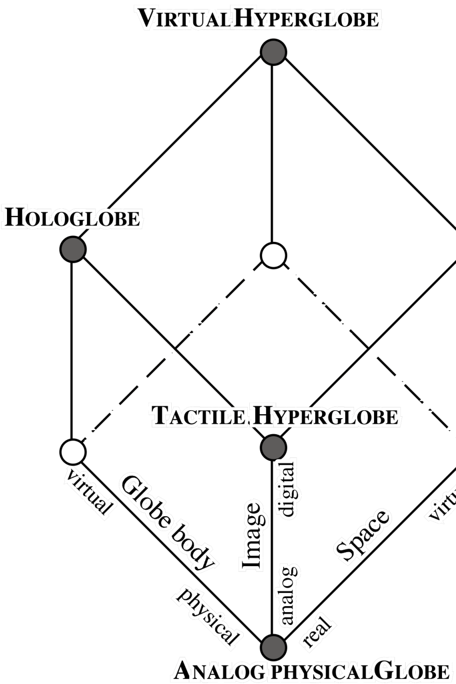

Figure 1: Categories of digital globes.

According to their "reality degree" virtual hyperglobes can be assigned either to the DesktopVR (DTVR) or the Immersive (Semi Immersive) Reality (IR) variant. Whereby it has to be distinguished whether the three-dimensional model is recognized by the viewer as realistic three-dimensional (spatially) or as "projection" on a two-dimensional (screen-) plane (which is the case for instance with DTVR). Still the latter is nearly the exclusive presentation form of digital globes. It requires new display technologies, in order to create a convincing optical depth - perceptible for everyone. Actually new directions are gone and developments are already on the way.

4) TECHNOLOGICAL FRAMEWORK

Its undistorted three-dimensional wholeness constitutes the nature of a globe. The usual procedure is that a digital globe was generated as digital 3D-model, however visualized on a two-dimensional display and only two-dimensionally perceptible. In order to be able to notice optical depth also on digital globes, it requires appropriate display devices.

Display devices which allow 3D-perceptible visualization, can be categorized according to their functionality as following [SCH-05]:

- **Virtual-three-dimensional systems (pixel-based systems)**
  The spatial image appears exclusively as a **three-dimensional illusion**.
    - Spectacles-and-screen systems (e.g. anaglyph method, systems working with shutter glasses)
    - Head-mounted displays (HMDs)
    - Autostereoscopic displays (e.g. lenticular displays, parallax-barrier displays)
    - Quasi-holographic displays
- **Real-three-dimensional systems (basically voxel-based systems)**
  Real-three-dimensional systems don't require any kind of additional 3D-glasses or other wearable equipment. A tree-dimensional projection is being created as a quasi-real existing body of light; that is to say the three-dimensional expansion of the visualization is indeed being carried out in real space.
    - Volumetric displays
    - Electro-holographic displays
    - Special cases like spherical displays

Because of their usability display devices like shutter glasses or HMDs are less interesting than those without any need for additional special glasses like autosteroscopic and real-3D-systems. In 2004 the segment of autostereoscopic displays in particular has been characterized by a significant product range expansion. Almost all well-known display producers introduced an autostereoscopic display. This generation of display devices provides a possibility to easily transform already existing virtual hyperglobes into a 3D-perceptible version. Companies like "Opticality Technologies" announced “OpenGL Enhancer” which allows existing 3D-applications, (using the OpenGL graphics protocol) to output to Opticality displays with no further effort.

In the case of digital globes a special form of the display device is of significant importance. That display’s particular characteristic is its spherical surface, hence its name “spherical display”. Such display devices are a prerequisition for the development of tactile hyperglobes. With tactile hyperglobes the 3D-perception of the globe is retrieved from the display’s geometry and not from an visual illusion based on stereo images. With tactile hyperglobes the display device is globe body and display device at the same time - similar to traditional analogue physical globes.

Among the first prototypes of a spherical display is the so called "Cybersphere". Cybersphere is an immersive reality system and was developed for overcoming limited freedom of movement (e.g. range of a head tracking system). Core of this spherical display device is a hollow translucent sphere (diameter 3.5 m) on which a virtual world can be projected. The installation of the ball enables the sphere to rotate freely in any direction. The user enters the sphere via closeable hatch. Rotation takes place by the users walking movements within the ball.

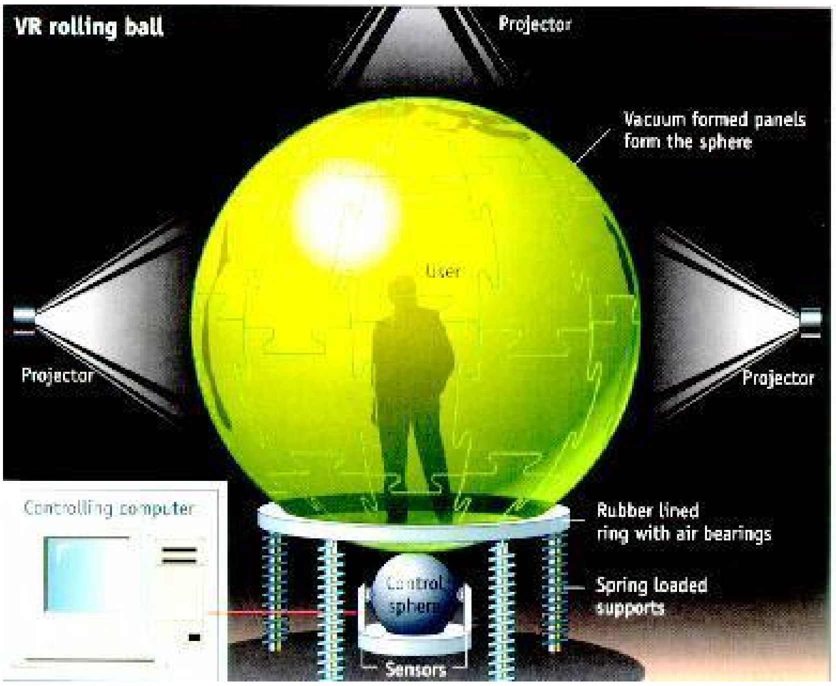

Figure 2: Cybersphere - Spärisches Display for Immersive Reality Systems (www.vr-systems.ndtilda.co.uk)

Cybersphere as control and viewing device could be the base for a digital “georama”. According to Meyers encyclopedia a georama is a hollow globe where one could enter the globe and see an image of the earth. This brings into mind the description of the Cybersphere on the Gottorfer giant globe (diameter 2,85m; Adam Olearis around 1660). This giant globe showed the continents and oceans on its outside. A lockable door (in the Indic ocean) allowed visitors to enter the globe. Once inside, the visitor could see a celestial globe where stars and constellations were drawn on the inner side. A gear gave the globe a revolution of 24 hours, enabling the visitor to watch the star rise and star set [DRE-90].

The Cybersphere as „digital Georama“ is so far only a theoretical possibility. In addition lets have a closer look on a quite substantial number of already existing digital globes.

5) SPECIMEN OF DIGITAL GLOBES

5.1) Digital globe illustrations

The simplest and at the same time most frequently found globes on the Internet are rotating globes in the form of GIF animations. Also the first widely used Web Browser (MOSAIC) had already in its 1.0 version (1993) a globe as logo. Strictly spoken those globes are not digital globes in the full sense of the word, but digital illustrations or animations. This is justified due to the fact that those animations consist of several two-dimensional pictures (mostly on basis of azimuthal projections like orthographic projection). It is not possible to create a spatially perceptible globe based on such a "globe model", neither by software nor by special hardware. Because the globe model is not three-dimensional as stated for a digital globes (see above) these are just globe illustrations. An almost unlimited collection of these animated globe illustrations can be found at www.staff.amu.edu.pl/~zbzw/glob/glob1.htm or www.geog.fu berlin.de/globes/index.html.

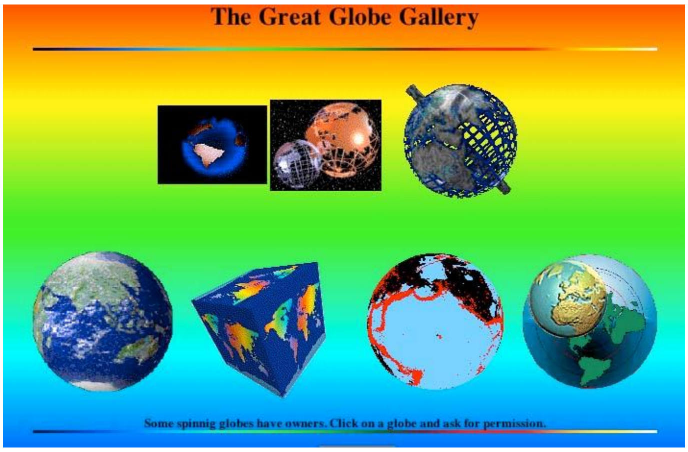

Figure 3: Animated globe illustrations (www.staff.amu.edu.pl/~zbzw/glob/glob461db.htm)

5.2) Virtual hyperglobes

One of the first exponents of digital globes - in the strict sense - can be seen by the digital Behaim globe (generated 1993). It was produced by Hans Klimpfinger [KLI-93] during his diploma thesis. This is the simplest type of a virtual hyperglobe, namely a digital globe rotating around its axis. This digital Behaim globe was actually a by-product of the digitization of the oldest existing earth globe on the occasion of its 500th anniversary. Kraus [KRA-92] states, that the primary goal of the digitization was the production of an undistorted photographic globe image for further reproduction of analog products.

A next innovative step can be seen in the implementation of real time visualization. With this functionality the "EarthBrowser" was among the first. The version 1.0 of the Shareware program was released 1996 and showed a digital globe with the actual weather condition. A global image was retrieved from a meteorological data server. In the meanwhile this virtual hyperglobe visualizes also the day/night shadow on the earth, current earthquakes, volcanic activities and dynamic webcams.

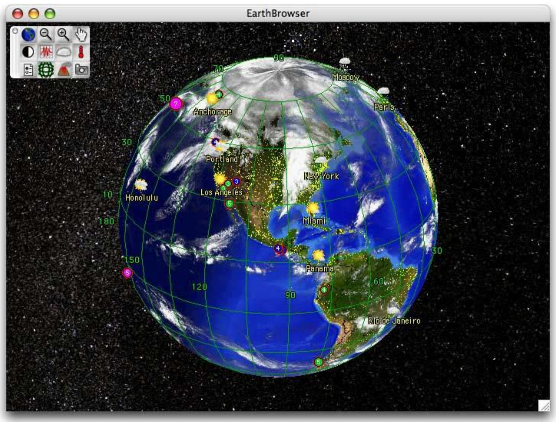

Figure 4: EarthBrowser (www.earthbrowser.com)

The author of this article was among the first who investigated the presentation of spatial aspects in the form of digital globes [RIE-00]. The investigation dealt with an in-depth research regarding how well multimedia is suited for the representation of the world on a virtual globe. It contributes a better understanding about how New Media can free the physical, "desk-bound" globes from their current restrictions and make a primarily carrier of knowledge on global topics. It also provides information how multimedia could be used regarding the elimination (reduction) of existing disadvantages of traditional analogue physical globes, concurrently perpetuating advantages of a globe presentation. Outcomes of the research work resulted in the year 2000 with the development of the "hyperglobe". The hyperglobe offers the potential for providing a tool that could act as knowledge transmitter for anyone, everywhere and at any time. The main advantages of digital globes over physical globes are summarized as being:

- Questions about the earth’s shape are easier to solve (ellipsoid and geoid);
- Questions which can’t be solved with maps can be visualized in an illustrative way (e. g. the earth’s inclination, presenting dynamic phenomena, space travel and satellite-technology);
- Some issues are solved faster (e.g. interactive cartometry);
- New fields of use (investigating historic globes on a virtual model, 3-dimensional geoid visualization, real-time presentations);

At the moment there is a redesign of the Globe Museum in Vienna - the only one of its kind in the world - going on. One aim of the redesign is to broaden the traditional presentation of valuable historic globes with digital methods (e.g. generating a digital facsimile of a globe with interactive tools for investigations undertaken by visitors of the museum) [HRU-05].

Figure 5: Hyperglobe (Riedl, 2000)

At the beginning of the 21th century digital globes became common in electronic atlases. However they functioned primarily as interface element. Thus for instance a software called "The Great Kosmos 3D-Globe 1.0" (United Soft Media publishing house 2001), unveils on a closer look at the product description the true nature of the product: "World Atlas with complete...". Consequently the 3D-globe within the application functions primarily as an interface to large-scale maps. For instance one can freely rotate the globe and perform continuous zooming. The popularity of the three-dimensional representation of the earth led to the fact that 2004 almost each electronic world atlas implemented a virtual hyperglobe as part of the interface. Similar purpose of virtual hyperglobes can be found within GIS software products too, e.g. ESRIs ArcGlobe (first implemented in ArcGIS 9, 2004) or in 3map (3D Metanet Atlas Platform), a free software project with the ambition to generate a digital copy of the earth (scale of the "Virtual Earth" as close as possible to 1 : 1) via distributed geo-servers.

Figure 6: The National Geographic 3D Globe - A virtual hyperglobe functioning primarily as interface element

5.3) Tactile hyperglobes

A special type showing transition between virtual and tactile hyperglobe can be seen in ART+COMs project TerraVision presented 1994. In the project description they say: " TerraVision is a self-contained, virtual reality, 1-to-1 representation of our Earth. By means of a stylized globe users can zoom in on any location in the world and obtain minutely detailed pictures."(see fig.7). The idea of TerraVision was picked up and enhanced by 3map (see above). TerraVision does not use a physical spherical body as display - as it is with tactile hyperglobes - but for navigation purpose. A ball (diameter approximately 50 cm) acts as navigation-device. Movements of the ball are passed on to the digital globe.

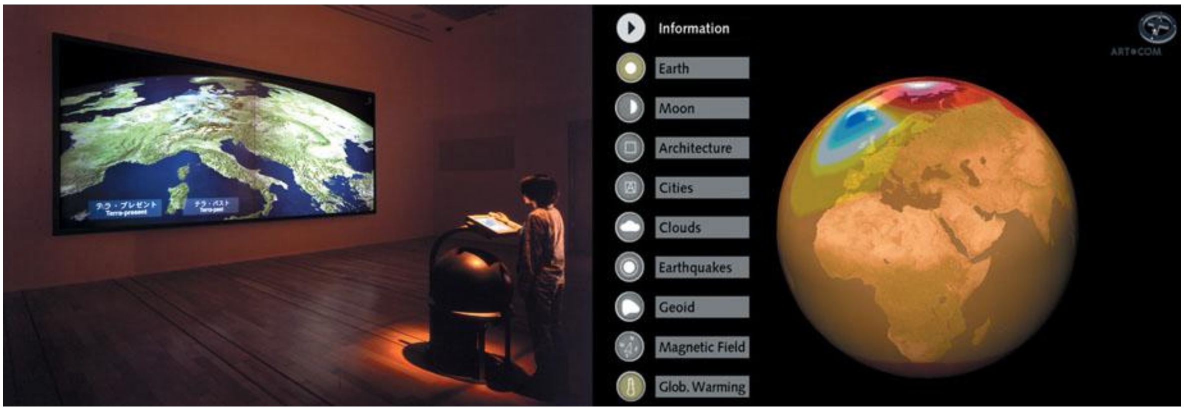

Figure 7: TerraVision - A transitional form between virtual and tactile hyperglobe (www.artcom.de)

Contrary to virtual hyperglobes, tactile hyperglobes have not yet reached the stadium of mass production. A substantial obstacle is probably a feasible spherical projection at reasonable production costs, both installation and maintenance of the complex system.

The first kind of tactile hyperglobes is the "GeoSphere Globe". It has been installed in 1992 at the space research center of Brazil. The globe body consists of an acrylic glass sphere with approximately two meters in diameter. A satellite image is printed onto the translucent sphere. A projection unit inside the globe allows visualization of additional topics. Further installations are at the Toho Gas Exhibition center in Nagoya, Japan, the Vattenfall/Liseberg Theme Park in Gothenburg, Sweden and the Amazonia Gallery in the Smithsonian National Zoological Park in Washington, DC.

Figure 8: GeoSphere - Firts tactile hyperglobe (www.geosphere.com)

A technical unicum of a tactile hyperglobe can be seen at Amadeus Germany (IT service provider for the travel business). Developed and installed by ag4 mediatecture company in the year 2000 in Bad Homburg (Germany). The ag4-globe represents a category on its own. On both the display technology and the registration of user interactions. The display/globe body consists of a glass hemisphere with approximately 1.7 m in diameters. First of all a world map is visualized in the basement on an 11 m^2 LED video wall. From there the projected map is transmitted via 110 000 fiber optic cables onto the globe hemisphere in the foyer. Each fiber optic cable represents a pixel with about 1.5 mm in diameter. For experiencing the "spirit" of Amadeus Germany the world map was divided into 16 climate zones and visualized on the globe. Additionally over 300 destinations (flashing points) are displayed. If one touches a destination on the globe the whole foyer changes dynamically its illumination according to the corresponding climate zone color (e.g. by selecting a destination in the polar region the foyer illuminates in "cool" blue/cyan colors). The interaction between user (hand movement) and globe is controlled video cameras and image recognition. Not via touch screen, as one may assume (such spherical touch screens are not available, yet). The price of the ag4-globe is - as in this segment common - still in the six-digit euro-range.

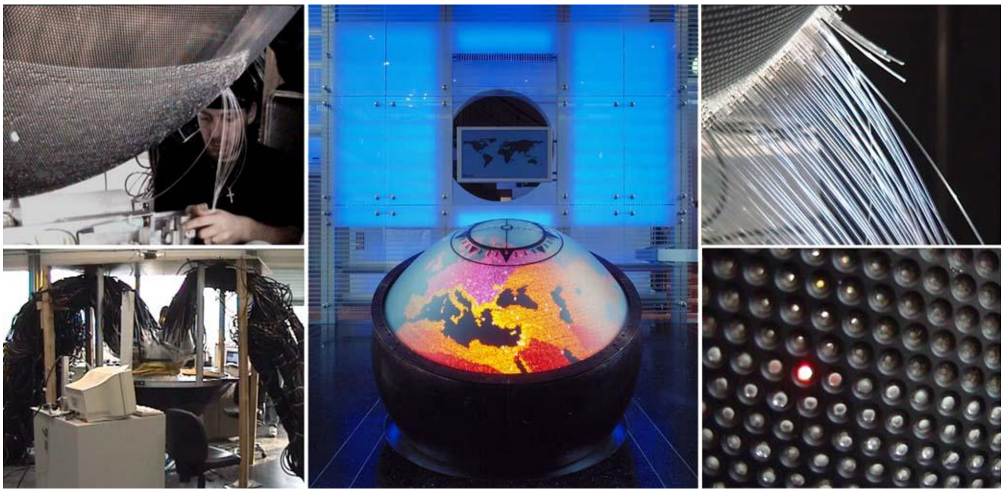

Figure 9: ag4 globe - unicum of a tactile hyperglobe (www.ag4.de)

The youngest representative of tactile hyperglobes comes from the company ARC Science simulation. The company developed a spherical display and holds a patent since 2002. A world map is projected from an LCD projector located in the base through a hole at the sphere's bottom via special convex mirror onto an acrylic glass ball. Therefore a small shadow on the topmost part of the globe can be seen from above. Resolutions up to 1600x1200 pixel (UXGA) are possible for the world map. OmniGlobe spherical displays are currently available in three models: 0.8m, 1.5m and 2m. In May 2002 a 2m OmniGlobe was installed in the Indiana State Museum in Indianapolis. This first installation shows as animation the earth's surface driven by plate tectonics evolving through the last 600 million years. In 2003 OmniGlobe was introduced to the general public at the Siggraph03 exhibition. Starting price of the medium-sized model is about 55 000.- US$.

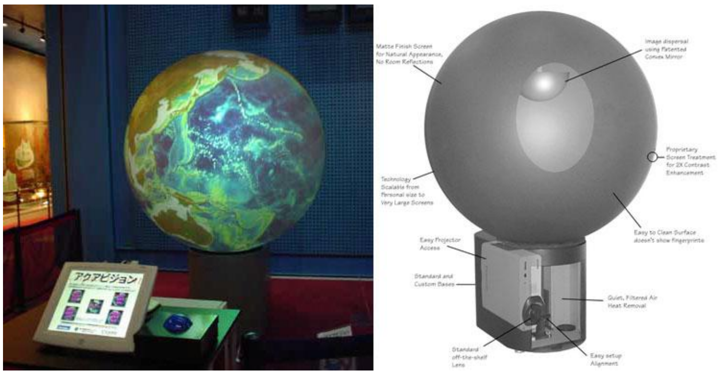

Figure 10: OmniGlobe - most recent version of a tactile hyperglobe (source www.arcscience.com)

5.4) Hologlobes

First approaches for implementing hologlobes are possible since the availability of volumetric displays. This category is still in the early developer stage and a lot of research has to be carried out until a feasible solution will be available. Nevertheless first prototypes are promising as the following example shows.

The company Actuality Systems was founded 1997 with the aim to develop a volumetric display. "Perspecta" the first commercial spatial 3D visualization system has been presented to the public. The resolution of Perspecta (50.8 cm in diameter) is about 100 mega-voxel (volumetric pixels). The company has cited medical, military and geospatial applications as examples. The price of Perspecta is approximately 50,000.- US$.

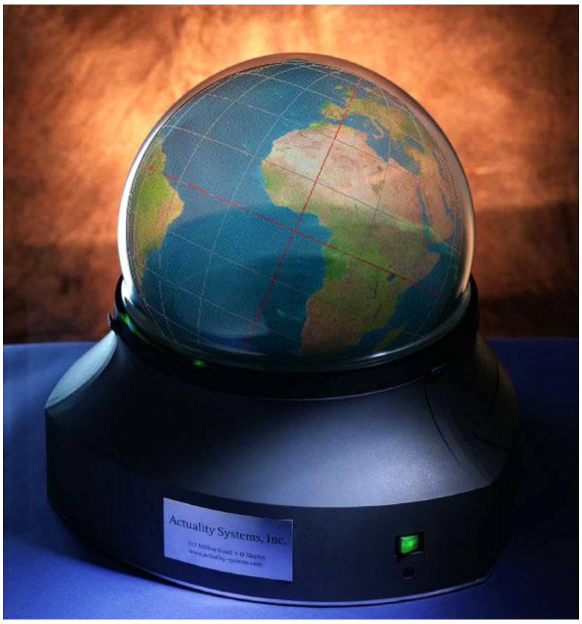

Figure 10: Perspecta - First commercial volumetric display; photomontage (www.actuality-systems.com)

6) CONCLUSION

Actually one of the main functions of digital globes is related to the interaction category “orientation and navigation”. Because they are used often as an interface element, which acts as gateway to comprehensive geo-databases. Also the digital globe and especially the tactile hyperglobe are currently strongly committed to representing tasks. Interestingly it has to be noticed that the number of dynamically visualized topics is more or less the same compared to static presented topics.

It already appears that developments, as pointed out, will lead to a significant variety of digital globes. Research and development of digital globes need a broad interdisciplinary discussion. The Cybersphere for example shows that with new technologies some rejected or almost forgotten ideas of the past do have a second chance of realization. It seems that for globes a new era has begun.

REFERENCES

[DRE-90] Dreyer-Eimbcke, Oswald: Das Schicksal des "Gottorper Globus". In: Der Globusfreund, 38/39. Wien, Internat. Coronelli-Ges. für Globen- u. Instrumentenkunde, 1990. page 77 – 86.

[SCH-05] Hruby F., Plank I., Riedl A.: Potential of Virtual 3D-Facsimiles - Exemplified by the Earth Globe of Gerard Mercator (1541). In: Proceedings, 22. ICA Cartographic Conference, 2005. A Coruña, Spain, 2005.

[KLI-93] Klimpfinger, H.: Visualisierung von Oberflächen und Oberflächenveränderungen mit dem Softwarepaket IDL, Diplomarbeit, Techn. Univ., Wien. 56 pages

[KRA-93] Kraus, K.: Photogrammetrie und Fernerkundung angewandt auf den Behaim-Globus. In: Bott, Gerhard (Ed.): Focus Behaim Globus. Ausstellungskatalog des Germanischen Nationalmuseums. Nürnberg, Germanisches Nationalmuseum, 1992. page 301 – 308.

[RIE-00] Riedl A.: Virtuelle Globen in der Geovisualisierung. Mit einem Nachwort Globenforschung in Österreich von I. Kretschmer. Wien, Institut für Geographie und Regionalforschung der Universität Wien, Ed. by I. Kretschmer and K. Kriz Wien, Institut für Geographie und Regionalforschung der Universität Wien, 2000 (=Wiener Schriften zur Geographie und Kartographie, Volume 13) 158 pages

[RIE-04] Riedl A.: Entwicklung und aktueller Stand digitaler Globen. In: Kainz, W., Kriz, K., Riedl, A. (Ed.): Aspekte der Kartographie im Wandel der Zeit (=Wiener Schriften zur Geographie und Kartographie, Volume 16), Vienna, 2004, page 256 – 263.

[SCH-05] Schratt A., Riedl A. : The Potential of Three-Dimensional Display Technologies for the Visualization of Geo-Virtual Environments. In: Proceedings, 22. ICA Cartographic Conference, 2005. A Coruña, Spain, 2005.

[THO-03] Thorne C., Viveka W. (2003), Earth's Avatar - the Web Augmented Virtual Earth; old.ping.com.au/3map.

Actuality Systems - Perspecta	www.actuality-systems.com
ag4 mediatecture company - ag4-Globus	www.ag4.de
Animated globes	www.geog.fu-berlin.de/globes/index.html
ARC Science Simulations - OmniGlobe	www.arcscience.com
ART+COM - TerraVision	www.artcom.de
ESRI - ArcGlobe	www.esri.com
GeoSphere	www.geosphere.com
Great Globe Gallery	www.staff.amu.edu.pl/~zbzw/glob/glob1.htm
LunarSoft - EarthBrowser	www.lunarsoft.com
Ping broadband - 3map	www.ping.com.au
VR Systems - Cybersphere	www.vr-systems.ndtilda.co.uk

Author:

Andreas Riedl, Mag. Dr.

Assistant professor Dr. Andreas Riedl, born 1965, studied cartography at the University of Vienna, Department of Geography, between 1987 and 1992. Subsequently, he was employed as a research assistant in the cartographic office of the department, and he worked freelance in the field of geoinformation and geovisualization. In addition to that, he carried out research work at the Simon Fraser University in Vancouver, Canada and he participated in the development and programming of courses for multimedia-CBT ("Computer Based Training"), topics GIS and remote sensing, at the ITC (Enschede, Netherlands). Since 1997, he has been assistant professor at the University of Vienna, Department of Geography and Regional Sciences. He finished his dissertation, which has been published 2000 as a book entitled "Virtual globes in geovisualization - Studies in the use of multimedia techniques in geocommunication", after more than two years research work. His scientific priorities are applied geoinformation (GI) and the integration of multimedia techniques (3D-visualization, web-mapping, virtual worlds) into geocommunication. He is board member of the Austrian Geographic Society, responsible for inner affairs of the Austrian Cartographic Commission and corresponding member of the ICA Commission on Visualization and Virtual Environments.
(http://homepage.univie.ac.at/andreas.riedl/)