# 18 Digital Globes

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## 18.1 Introduction

The era of the globe began with the great exploratory expeditions and has lasted for over 500 years. At the beginning of the third Millennium, and especially under the influence of New Media, the methods of visualization on globes require fundamental re-examination. In particular, animation, interactivity and 3d-technology have a potential that is still hard to estimate. 3D-multimedia systems are the key technology for digital globes, giving cartographers the opportunity to implement a globe in a digital 3D environment where the digital globe appears as a real object to the user, just like an analogue/physical globe. It seems that the abundance of possibilities is limited only by the creativity of cartographers.

## 18.2 Categories of Digital Globes

The following definition for globes applies in the same way to both traditional analogue globes and digital globes:

*"A globe is a scale-bound, structured model of a celestial body (respectively firmament) presented in its undistorted three-dimensional wholeness"* (Riedl 2000, p 17).

Furthermore and most importantly, this also applies to digital globes where a three-dimensional model is a fundamental requirement. The term ‘Digital Globe’ should not be confused with the term ‘Digital Earth’ (although a Digital Globe can act as a Digital Earth). Digital Earth is an interface metaphor for accessing/organizing high-resolution global geodatasets. US-Vice President Al Gore coined the term Digital Earth in 1998, when he was Vice-President of the USA during a speech at the California Science Center (USA) (Gore 1998).

In general globes can be distinguished regarding their implementation by three parameters:

- The nature of the cartographic image (analog, digital);
- The character of the globe body (physical, real); and
- The kind of representation space (real, virtual)

If one combines these three parameters this results in eight theoretical possibilities, of which four are realistic. One of the four is the well-known analog physical globe. The remaining three variants represent digital globes which are linked together by their digital visualization techniques. Significant distinctions can be made regarding the actual globe body or the kind of space in which the globe is visualized. Focusing on representation, digital globes can be classified as:

- **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.; and
- **Hologlobes:** Visualization of the digital image on a virtual globe body in real space. (Riedl 2000)

Figure 1 represents this classification graphically.

According to how data is accessed, digital globes can be either online or offline globes, or a combination of both. In fact, there is a strong move from offline globes to online globes. This is related to the broader availability of broadband internet and huge databases providing high resolution geospatial information.

According to their ‘degree of reality, virtual hyperglobes can be further classified as either DesktopVR (DTVR) or Immersive (Semi Immersive) Reality (IR). Here, it needs to be determined whether the three-dimensional model is recognized by the viewer as a realistic three-dimensional object (spatially) or as ‘projection’ onto a two-dimensional (screen) plane, which is the case with DTVR. Until recently the latter was the exclusive presentation form for digital globes. Now display technologies can create a convincing optical depth perception using wide-ranging equipment (Schratt and Riedl 2005).

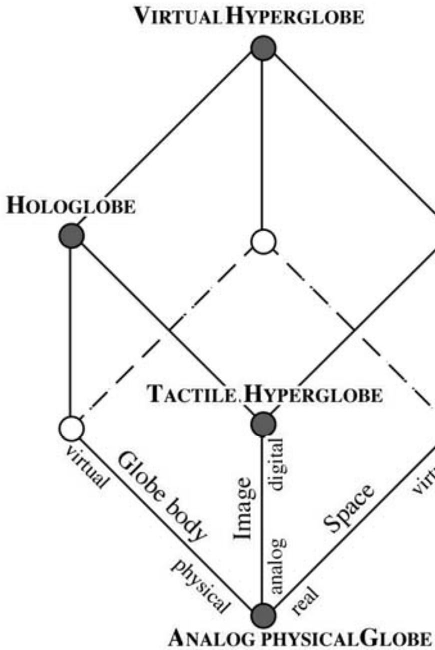


**Fig. 1.** Categories of (digital) globes

## 18.3 What makes Digital Globes superior?

The use of multimedia and hypermedia has had a great impact on the presentation and the distribution of geographic information (Cartwright et al., 1997). When it comes to digital globes there exists a physical independence between the visualization surface (screen) and visualization theme (digital data). This allows cartographers to implement a great number of features that would have been impossible with traditional globes.

The biggest advantage of a globe in general is that it is distortion free and shows spatial relationships found in the real world. There simply does not exist another cartographic product that come as close to a globe from this perspective.

If we compare digital globes with traditional analogue physical globes the advantages of virtual globes become apparent. By generating a digital (virtual) model of a globe we do not only eliminate the disadvantages of traditional physical globes, but also preserve their advantages. Many globe specifying parameters can be significantly improved, the basics being:

- **Transportability**: The cartographic images of digital globes are based on digital data and therefore as easily transportable as any other digital information. Of course some of the drawbacks are similar to tactile hyperglobes.
- **Scalability**: Geospatial information can be viewed on digital globes (with online functionality) at any given scale ranging from 1: 500.000.000 to 1: 10.000 and beyond. Current digital globes can only show the whole globe at large scales. But to view and have access to the whole planet at least a part of the Earth’s (curved) horizon should be visible. Otherwise the ‘three-dimensional wholeness’ would be lost and we would not be dealing with a digital globe in the strictest sense.

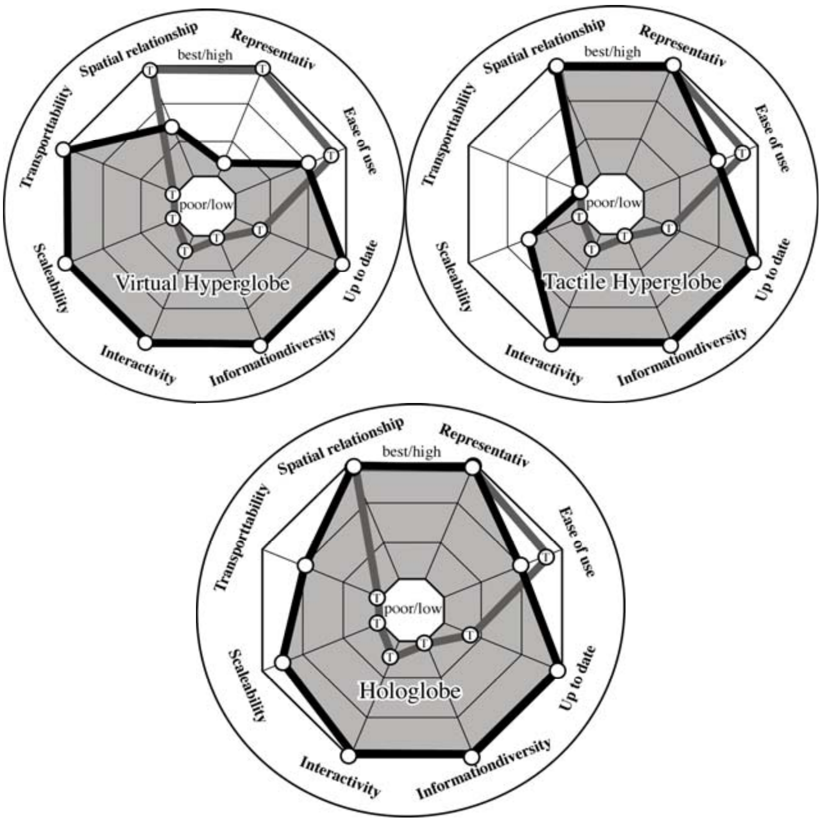


**Fig. 2.** The typification of digital globes vs. traditional globe (T)

- **Interactivity:** Before the digital era, physical globes had the greatest degree of interactivity of all cartographic products.  But the globe's theme was non-changeable. A digital globe has functions that make it possible to receive feedback from the user. This leads to a globe that represents information according to specific user needs. The result is similar to maps-on-demand – a globe on demand (GOD).

- **Choice of topics**: Digital globes do not have the drawback of having to show not more than two different topics as with traditional globes. The 'surface' is able to switch between an almost unlimited numbers of global themes stored in geospatial databases. The 'poor-choice-of-topics' era for globes is passed once and for all. Interestingly it has to be observed that the number of topics dynamically visualized is equal or even greater than those possible with static presented topics. This is especially true with tactile hyperglobes.
- **Currency**: With digital globes the update period can be any given time span. The update period can be reduced or even eliminated in order to visualize global topics in real time (e.g. actual weather condition). Furthermore we can not only present topics at a given time, but also over a given period of time, providing a dynamic or animated image.

## 18.4 How suitable is a theme for a digital globe?

Not every subject is suitable for globe presentation. The evaluation of how appropriate a theme is to be presented on a digital globe could generally be called the theme's 'globe-worthiness'. In view of the possibilities offered by a digital globe, the globe-worthiness of a theme needs to be re-analyzed. The parameters and criteria that can be used to evaluate the globe-worthiness of digital globes (Riedl 2000) are outlined in the following paragraphs:

**Freedom from distortion – relation to the shape (geometry) of the celestial body:** Aurada (1978) points out that the dependency of globe-worthy themes on the shape of the earth must be so high that the disadvantage of representation by a globe, i.e. the loss of complete overview, is counterbalanced. Due to the possibility of observing the digital globe from more than one position at the same time, this problem is of minor importance. Nevertheless, the dependency of the theme or of the question to be solved using the shape of the celestial body is of central importance even for digital globes. The range of applications covers, for example, illustrating the earth's shape, showing the effects of the inclination of the earth's axis, tracing the great circle between two points, or visualizing dynamic phenomena (like climate, ocean-currents, etc.).

**Global availability of data:** The theme to be represented must be a worldwide phenomenon and require a global representation. The global availability of data is a basic condition, but it does not imply that the globe is the best depiction method. Depending on the theme, a ‘worldwide representation’ can, in exceptional cases also be meaningful when the representation is limited to sea areas or landmasses. In order to make causal connection obvious, such topics are usually shown in combination with others. This is expanded upon more in the ‘Capability of combination further section later in the chapter.

**Representation on small scale – possibility of interpretation in spite of a great amount of generalization**: Although digital globes are, in principle, not subject to restrictions regarding the scale, representations at small scale and associated great generalization will nevertheless dominate. The themes shown must retain their impact under these circumstances. It is possible that just by emphasizing single aspects in highly generalized themes that global connections can become visible.

**Capability of combination**: It is possible that a theme is not globe-worthy in isolation, but it may not be apparent in combination with another theme. Thus to a certain extent combination is required. This is particularly true for themes where content is limited either to oceans or to continents. A combined representation makes hidden relationships visible and thus makes them understandable.

## 18.5 Examples of Digital Globes

### 18.5.1 Digital globe illustrations

The simplest and most common globes on the Internet are rotating globes as GIF animations. Due to the fact that those animations consist of several two-dimensional pictures (usually azimuthal projections) and the globe model is not three-dimensional, as needed for digital globes, these globes are not in fact digital globes, but digital globe illustrations or animations.

### 18.5.2 Virtual hyperglobes

At the beginning of the 21st century digital globes have became common in electronic atlases. However they function primarily as an interface element. The popularity of three-dimensional representations of the earth has resulted in the fact that by 2004 almost every electronic world atlas had implemented a virtual hyperglobe as part of the interface. Similar applications of virtual hyperglobes can be found within GIS software products - ESRIs *ArcGlobe* (first implemented in *ArcGIS* 9, 2004 and 9.2, 2006). Actually there is a strong move away from offline virtual hyperglobes to online virtual hyperglobes. This trend was triggered by Google Earth and advanced by the huge demand for real time information and high resolution aerial and satellite images.  A number of examples are illustrated in the following sections.

**Table 1** Pioneers of virtual hyperglobes

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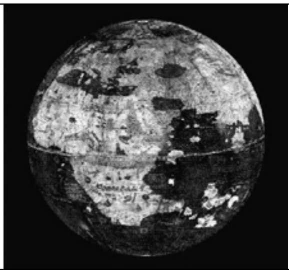
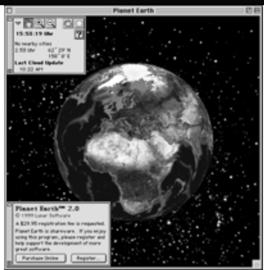
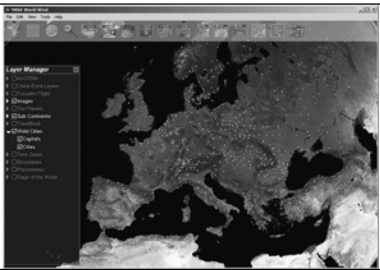
|---|---|
|  | *Digital Behaim Globe* (Hans Klimpfinger, 1993)<br>One of the first exponents of digital globes was actually a by-product of the digitization of the oldest this existing earth globe on the occasion of its $500^{th}$ anniversary.<br>(Klimpfinger 1993) |
|  | *Planet Earth* (Giger, 1996)<br>Among the first with real time visualization. With this functionality *Planet Earth* (now *EarthBrowser*) showed a digital globe with the actual weather conditions shown.<br>www.earthbrowser.com |
|  | The *Hyperglobe* (Riedl, 2000)<br>The *Hyperglobe* is based on an in-depth research that focused on how well multimedia is suited for the representation of the world on a virtual globe.<br>www.hyperglobe.info |

**Table 2** State of the art (online) virtual hyperglobes

| | |
|---|---|
|  | *World Wind* (NASA, 2004)<br>*World Wind* is open source containing freely available add-ons and plug-ins.<br>worldwind.arc.nasa.gov |
|  | *Google Earth* (Google, 2005)<br>Based on Keyhole's .technology and containing the largest global geodatabase (>50Tb). It is freely accessible, including 3D building models of certain cities. *Google Earth* was a breakthrough for virtual hyperglobes, as similar systems existed years before, but remained virtually unknown.<br>earth.google.com |
|  | *Virtual Earth* (Microsoft, 2005)<br>Based on MapPoint technology with much global data. It has a focus on North America.<br>virtualearth.msn.com |

With little effort existing virtual hyperglobes can be transformed into a 3D. The new generation of auto-stereoscopic displays from Companies like Opticality Technologies provides 'OpenGL Enhancer' which allows existing 3D applications, using the OpenGL graphics protocol to output to Opticality's auto-stereoscopic displays with no further effort.

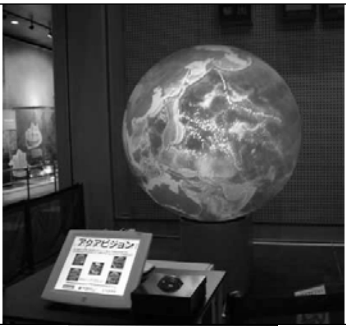
### 18.5.3 Tactile hyperglobes

With tactile hyperglobes the 3D perception of the globe is achieved by the display's geometry and not from a visual illusion based on stereo images. A special form of display device is a prerequisite for developing tactile hyperglobes. Similar to traditional analogue physical globes the display device has to be globe body and display device at the same time. The display's particular characteristic is its spherical surface, hence its name "spherical display". Currently there are three different (patented) versions of spherical displays in use for tactile hyperglobes. The scale in the table below relates to the earth and the diameter of the globe body. The year relates to the first installation.

**Table 3** Pioneers of tactile hyperglobes

| | |
|---|---|
|  | *GeoSphere* (The GeoSphere Project, 1992)<br>*GeoSphere's* globe body consists of an acrylic glass sphere, 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.<br>Scale ca. 1:6 000 000<br>www.geosphere.com |
|  | *TerraVision* (artcom, 1994)<br>This type shows the transition from virtual and tactile hyperglobe. . A 50 cm ball acts as navigation device. Movements of the ball are passed to the digital globe displayed on a wall.<br>www.artcom.de |
|  | *ag4 Globe* (ag4 mediatecture, 2000)<br>The *ag4-Globe* represents the technical pinnacle of tactile hyperglobes. The image is retrieved from a LED video wall and projected via 110 000 fibre optic cables onto the globes hemisphere. The interaction between the user's hand movements and the globe is controlled by video cameras and image recognition software.<br>Scale ca. 1 : 7 500 000<br>www.ag4.de |

**Table 4** State of the art tactile hyperglobes

| | |
|---|---|
|  | *OmniGlobe* (ARC Science Simulation, 2002)<br>With this system a world map is projected from one or two video projectors located in the base through a hole at the sphere's bottom via a special convex mirror onto an acrylic spherical screen.<br>ø 0.8m, ø 1.5m, ø 2m - scale from 1 : 16 000 000 to 1 : 6 000 000<br>www.arcscience.com |
|  | *Magic Planet* (Global Imagination, 2002)<br>*Magic Planet* uses one video projector to display images projected through a hole at the sphere's bottom via special lenses onto an acrylic glass ball.<br>ø 35cm, ø 46cm, 61cm, ø 91cm, ø 1.22m - scale from 1 : 36 000 000 to 1 : 10 000 000<br>www.globalimagination.com |
|  | *SOS - Science on a Sphere* (NOAA, 2002)<br>NOAA's SOS uses video projectors to display images on the outside of a sphere.<br>It uses 4 video projectors, each driven by a computer. A fifth computer is used to control the operation of the display computers.<br>ø 1,8 m - scale 1 : 7 000 000<br>sos.noaa.gov |

## 18.6 Hologlobes

The category of hologlobes is still in the early developer stage and much research needs to be carried out until a feasible solution is available. Nevertheless science-fiction ideas have matured from the first promising prototypes as the following examples show.

**Table 5** Volumetric and free space display

| | |
|---|---|
|  | *Perspecta* (Actuality-Systems, 2002)<br>*Perspecta* is the first commercial spatial 3D visualization system. The image on the left shows a photomontage.<br>ø 50.8 cm<br>www.actuality-systems.com |
|  | *Heliodisplay* (IO2 Technology LLC, 2005)<br>The current version of the first commercial interactive, free-space display (FSD) projects a diagonal image into mid-air, floating above the device. It’s not yet a volumetric display, but a virtual image in real space. It is interactive, like a virtual touch screen.<br>22" to 42" (depending on model)<br>www.io2technology.com |

## 18.7 Conclusion

There are numerous possibilities arising from the potential presented by globes, New Media and display technology. Many scientists and engineers are already involved in the development of digital globes and this illustrates a broad interdisciplinary collaboration. Examples and developments, as illustrated will lead to a significant variety of digital globes never seen or imagined before.

Digital globes are used primarily as an interface that acts as gateway to more comprehensive geospatial information. In the age of globalisation a global point of view is necessary so as to better understand interweaving and interdependences. Digital globes will also help to motivate users to work with globes, and thus encourages the examination of global topics and their possible relationships. A digital globe offers the potential for providing a tool that could act as a geographical knowledge transmitter. It seems that for globes a bright future exists.

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