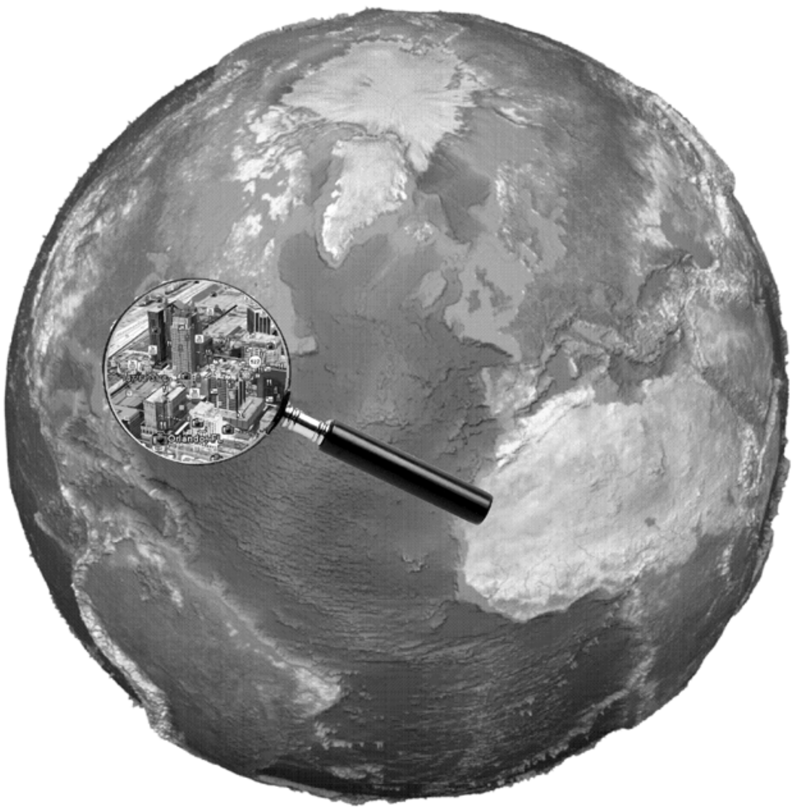
Position papers on

# Virtual Globes or Virtual Geographical Reality: How much detail does a digital earth require?



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**Workshop organizers:**

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Position papers. Proceedings of the ASPRS/CaGIS Workshop on Virtual Globes or Virtual Geographical Reality: How much detail does a digital earth require? Orlando, FL, 11/16/2010

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Cover image:

Created using the earth image released at the URL http://www.texscience.org/earth/earth-3d.gif and a screenshot of Google Earth downtown Orlando.

# *Preface*

*This booklet presents a collection of **position papers** submitted to a workshop that was held in November 2010 in Orlando, Florida in a symposium jointly sponsored by The Cartography and Geographic Information Society (CaGIS)'s AutoCarto conference series and by the International Society of Photogrammetry and Remote Sensing (ISPRS) Technical Commission IV. The conference theme was "Geospatial Data and Geovisualization: Environment, Security, and Society" and the workshop topic was "Virtual Globes or Virtual Geographical Reality: How much detail does a digital earth require?". The workshop was the first of its type for AutoCarto, and was delivered in a format that involved two lectures and a discussion session.*

*The workshop centred on the interdisciplinary issue of geo-virtual environments from a level of detail management approach. We find the topic relevant to all communities working with geographic data, as we observe that more and more data are being collected, yet we need ways to handle, filter, process the data to deliver it to audiences in accessible and intelligible forms. The workshop covered technological and human factors in managing the level of detail, drawing parallels to the cartographic generalization methods. The position papers presented here are short 'opinion' papers rather than regular scientific contributions. The contributions cover technical, political and scientific discussions related to the theme.*

*We hope this modest collection offers some stimulation and inspiration to our readers, and begins an ongoing discussion on the topic.*

*Arzu Çöltekin & Keith C. Clarke*
*February 2011*

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# A representation of everything

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## Introduction

The vision of a "digital earth" has captured the imagination of those involved with geospatial information since a now-famous speech by Al Gore at the California Science Center in 1998. His idea inspired a government initiative, a conference series and an international journal (*The International Journal of Digital Earth*), each with the long term goal of achieving the vision described in the speech. Gore's speech presented the perspective of a child during her interaction with a 'mirror world' – a digital copy of everything there is and has been, immersed in a virtual environment (Gore 1998). The child's geographical exploration experience required no prior training or education, but did involve the VR technology of 1998. Given technological developments since, the current and future benefits of a digital earth not just for education but also for the geo-spatial analyst are self evident.

Since 1998, impressive progress has been made towards a digital earth. Starting with NASA's World Wind (2004), many open source, freeware or commercial virtual globes and their portal managers or geobrowsers, have come into existence, and their impact has been to revolutionize our view of our planet. The early geobrowser Keyhole was purchased by Google and released as Google Earth in 2005 and reached 400 million downloads by 2008, ten years after the Gore speech (Jones 2008). Geobrowsers as entry points into virtual globes are increasingly popular, and have become increasingly more "crowded" with cartographic and multimedia detail, especially when it is user-contributed. Not only can high resolution graphic data and geocodes be produced more easily today than ever before, the emergence of Web 2.0 (including Volunteered Geographic Information) feeds virtual globes with rich information from the bottom-up, including images, videos, sounds and written content.

These developments have been mostly positive, however, side effects such as visual clutter (a form of this is popularly referred to as "red dot fever"), lags in data loading times, information overload, and steep learning curves for interaction hinder the power and efficiency of these candidate digital earths.

## Virtual Globes or Virtual Geographical Reality

Virtual globes and their portals (the geobrowsers) have proven highly popular and they represent great progress especially in public acceptance of mapping. Nevertheless, they suffer from a few drawbacks, and, in terms of content and scope, virtual globes are a simplification and only an approximation of the digital earth. Most operate in a distributed networked environment, and so face bandwidth limitations that impede the immediate access to the extreme levels of detail required for a true "mirror world" (a prior vision of the digital earth concept). A proper mirror world should mimic tangible reality as closely as possible; indeed the experience of the Digital Earth or Earth 2.0 should be exactly that of Earth 1.0. However, the visual quality (resolution, granularity and image depth) of present day geovisualization is limited by bandwidth instead of the abilities of the human visual system and interactions are even more constrained. Given that virtual environments can range from fully immersive true 3D experiences to 3D projections onto 2D web page renderings, current virtual globes are commonly viewed in 2.5D as opposed to the more experiential natural 3D view of the world. Disregarding bandwidth limitations, with current computational resources (equipped with inexpensive fast and high capacity graphics processing units) and high-tech displays, we can already handle finer resolutions than those used with today's online virtual globes.

A setup that brings the latest technology for advanced visualization and analysis is a 'virtual environment' (VE). An immersive and interactive environment where high levels of information intensity can be linked to intelligent objects has been termed a geographical virtual environment (GeoVE) (MacEachren et al. 1999). A true virtual environment should fully immerse the user by stimulating all five senses--sight, touch, sound, smell and taste. Visual stimulation is most obvious, since more than 40% of the human brain is dedicated to processing visual information (Hoffman 2000, Ware 2008) and it is safe to say that currently visualization is the most advanced component of a multi-sensory VE. Audio is also well studied; spatial hearing leads to a more precise navigation within a virtual environment (Klatzky et al. 2006). Haptic (touch) has some promise based on hand tracking and data gloves, however it is still cumbersome and expensive, or limited to one dimension (e.g. texture) (Marsten et al. 2007). Smell printers and virtual taste experiments exist but are in nascent stages compared to the stimulation of the other senses.

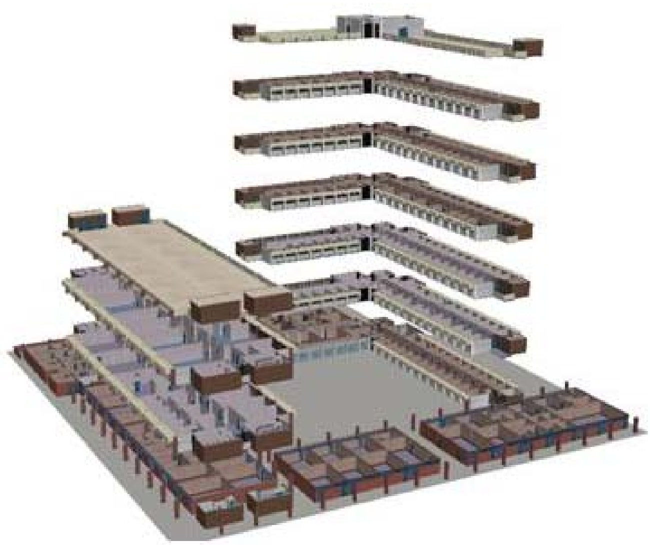

Figure 1. An architectural representation which would require multiple levels of detail to represent the information as the scale changes. Image from UCSB Geography 176C project, Spring 2008, images by Cheyne Hadley, Doug Carreiro, Scott Prindle, and Paul Muse.

In short, a good GeoVE implementation would provide the best digital earth approximation possible at present. Ideally the Digital Earth GeoVE should host unlimited multi-sensory multimedia detail and allow for interaction as if it were the real world, with added analytical possibilities. At present, this would come through links to the current World Wide Web, such as geographic place to Wiki page linkages. Links to video, sound, etc. and place-to-place links on the digital earth would require adding further information into the system and advanced research in technology and human computer interaction, e.g. better algorithms to handle large amounts of scale-dependent data, on-the-fly data fusion (multiple sources and scales) and level of detail management (Figure 1).

As the Digital Earth content grows, new visual analytic and display methods and theory will be necessary to link the extraordinarily dense information primitives together in currently unimaginable ways. Inclusion of deep and historical time, the oceans, the earth interior, a network of things, and human culture will challenge the next generation of geographers and cartographers.

## Level of detail (LOD) management

One of the continuous challenges in dealing with rich geographic datasets has been about controlling the level of detail. How much (visual) detail does a digital earth require, then? Intuitively, one can answer this question with “as much detail as there is in the real world and more.” After all, we want to create a VE in which we can go back or forward in time, explore even the vaguest of spatial links (all places mentioned in Shakespeare’s plays, every place associated with the evolution of the horse), run spatio-temporal analyses or simply enjoy spatio-temporal virtual tourism. As usual, however, the question is intractable without putting it in the right context. Contexts of *capturing* (data collection), *processing* and *visualization* will yield different answers. That is, we want to capture high detail where possible but selectively process and visualize the information specific to the task. This should sound familiar to cartographers, as they have been managing level of detail (LOD) quite intelligently for many centuries using map generalization approaches. LOD management is essential, among other things, to prevent waiting for data to ‘load’ (latency), for helping humans reason better with the available information without extreme cognitive load and to avoid visual clutter.

## Biomimicry and level of detail

The capture-process-visualize stages for controlling the level of detail for geospatial data have parallels in how human senses operate. We are psychophysically wired for a certain level of sensory input at the 'capture' stage (it is perhaps interesting to note that we do not always see or 'hear' as well as our machines, that is, we can record things that are outside our sensory spectrum). Next we selectively process and select the relevant information for the task at hand. Humans do this in real time and remarkably seamlessly. For example, we can 'channel' our hearing to listen to one person speaking in a noisy room even with many people speaking at the same time.

Some LOD management approaches are based on the limits of human perception and information processing, while others make high resolution display computationally tractable. In capturing the data (unless there is a financial or another practical reason), it is invariably best to collect the highest possible resolution. Similarly, a digital earth will require imaging across the spectrum and extensive image archiving. Then at the visualization stage, it makes perfect sense to show only the level of detail that humans can in fact perceive and process.

In terms of visual perception, the human visual system has a certain acuity and the spatial organization of the photoreceptors (rods and cones) on the fovea provides us with a non-uniform visual field, centered on our focus of attention. Our color perception is vulnerable to surrounding colors and simultaneous contrast. Some of the behavioral imperatives make us look at salient objects involuntarily, e.g. objects approaching us rapidly. Peripheral vision is more sensitive to motion. Stereopsis provides us with fine depth discrimination at a certain depth range. The properties of our visual systems can provide us with clues and lead us to find potentially better ways to design our GeoVEs, possibly avoiding visual clutter by managing the perceptual level of detail. Additionally, simulating certain features of the human visual system (e.g. simulating depth of field) might have benefits for stereoscopic displays, which are used in almost all existing VEs.

Cognitive load is yet another issue. Most geospatial data is multivariate and it is tempting to display as many of these variables as possible, especially if the analyst wants to see the spatio-temporal relationships among them. However, humans are said to be able to keep three objects at one time in their visual working memory (Ware 2008) – this number is seven at best (Miller 1956). Awareness of these and other human factors in designing GeoVEs is essential for finding and displaying the right level of detail for the task and for the audience.

## Earth 2.0

As Ribarsky (2005) said, we are dealing with "[…] models of unprecedented scale and detail. Successfully integrating these models into a comprehensive, integrated virtual GIS remains a major challenge" (Ribarsky 2005, p.451). Since 2005, the first generation of geobrowsers has made remarkable progress, but they are merely shadows of the potential systems to come. Furthermore, the scope and content of a digital earth that is now limited to existing imagery and geospatial data has been transformed by the Internet and systems for collecting user contributed content, indeed the citizen science and volunteered information already present is also just a shadow of what the future will deliver. With such a vision as digital earth deliverable within a decade perhaps, or at least a career, one wonders what new knowledge and wisdom about the world will be revealed to the young girl in Gore's speech during her lifetime. With luck, perhaps Earth 2.0 will be the savior of Earth 1.0.

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# Some thoughts on Geovirtual environments

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## Background

A virtual globe is a data repository providing masses of digital geographical information in the form of a globe, generally over the Internet, with the best-known example being Google Earth (Google 2010a). Typically, a virtual globe uses imagery (from satellite- or aircraft-based cameras) for the backdrop, overlaid with various vector data sets (often from official mapping agencies) and then with the capability of users to add their own data (such as volunteered geographical information (VGI)) on top, or create customized views of the data available. Users can contribute their data using a mark-up language (e.g. KML for Google Earth), by geocoding data in other services (e.g. articles in Wikipedia (Wikimedia 2010) or photographs in Panoramio (Google 2010b)), or submitting data according to a protocol (e.g. NaturalWorld 2010).

Needless to say, because of the masses of data, a virtual globe is a resource hog in terms of storage, processing power and bandwidth. From the user's perspective, the latter is the most important. In many areas in many countries, users could be forgiven for having the perception that the available bandwidth is approaching infinity and the cost thereof is approaching zero! Unfortunately, the developers of virtual globes and other online repositories of data tend to come from such well-resourced environments and to develop their products for such environments, though some have sophisticated data management algorithms to load the processing on the server side and to limit the data that need to be transmitted, such as Google Earth and World Wind (NASA 2010).

However, in many parts of the world, assuming a potential user has access to electricity and a computer, for many their Internet access is very slow, very expensive and unreliable. For example, because of the poor service offered for land lines in South Africa, many users have wireless access at home as their primary means of access, which typically yields less than 5Mb/s (MyBroadband 2010). Statistics from the International Telecommunication Union (ITU) (ITU 2010) confirm this. Despite the strong growth in fixed (wired) broadband subscriptions, penetration levels in developing countries remain low at 4.4 subscriptions per 100 people compared to 24.6 in developed countries. Africa lags behind considerably with a penetration rate of less than 1%.

Nevertheless, mobile growth in developing countries provides an opportunity for all kinds of online information and applications, including geovirtual environments. Access to mobile networks is now available to 90% of the world's population and even to 80% of the population living in rural areas. There is also a rapid move from 2G to 3G platforms, in both developed and developing countries. In 2010, 143 countries were offering 3G services commercially (including most of sub-Saharan Africa), compared to 95 in 2007.

The average price for a fixed broadband subscription in developing countries is at least six times as high as that for mobile subscription. Naturally, this is reflected in the respective penetration levels: 4.4% for fixed broadband and 68% for mobile (41% in Africa). Many (but not all) 3G systems provide mobile broadband access, but there is sometimes a premium that one pays for 3G access, which then renders it more expensive than fixed broadband.

## Research issues

We have identified a number of research issues for geovirtual environments.

*2.1: research and innovation is required to develop novel ways of representing geovirtual environments on small mobile phone information displays that require limited bandwidth.*

Even though mobile access in developing countries is higher than fixed broadband access, there is often a premium to pay for 3G mobile access. Similar innovations for text-only mobile services have been highly successful. For example, Vodacom's 'Please Call Me' service is free for prepaid customers who are able to receive incoming calls, but have run out of airtime to make a call themselves. The service allows them to send an SMS requesting the recipient to "Please Call Me". An advertisement is displayed on the receiver's phone together with the message, thus generating income for the network provider (Vodacom 2010). Another example is the highly successful MXiT service that allows users to send and receive very cheaply, text and multimedia messages to and from other users, as well as in general chat rooms. It also supports gateways to other instant messaging platforms. MXit does not charge for one-on-one messages, though mobile operators may charge for data usage (MXiT 2010). *The challenge is to develop novel ways to deliver geovirtual environments and VGI very cheaply on mobile phones.*

*2.2: research is required to improve our understanding of how geovirtual environments can assist people develop an understanding of their spatial surroundings and how our actions can affect others.*

Overall, what is needed is an understanding that the world is bigger than one little village or suburb and that environmental protection is therefore required. A simple zoom-out could convey this message. In other words, how can geovirtual environments be used to educate both literate and illiterate people on issues such as environmental protection? An example would be illustrating how a river still has to support communities downstream, whether one is in an urban or a rural environment, and hence that it is important not to pollute the water passing through one's community.

*2.3: research is required on how virtual globes can be used for all types of education, and not just environmental education.*

Clearly, with the volume and diversity of data they offer, as well as being a platform for disseminating VGI, virtual globes can make a significant impact on supporting education. Other than the access issues outlined above, other issues to be researched include the ownership of the data, quality assurance (particularly of the VGI), anonymous contributions, the political and other agendas embedded in the data, and facilitating or denying access to the data.

*2.4: research is required on the impact geovirtual environments can have on the digital divide – and vice versa.*

"In many parts of the developing world, poverty is exacerbated by information poverty. In poor or deprived communities access to information is limited or non-existent" (Pandor 2010). Can virtual globes and geovirtual environments address information poverty, or are they only for the well resourced? Do virtual globes entrench the digital divide, because the better resourced are able to provide more data about their home turf? Does the bandwidth available in better resourced areas encourage the people there to contribute more VGI? There are more articles in Wikipedia about fictional places such as Middle Earth and Discworld, than there are about many real countries (Graham 2009). However, it must be borne in mind that access to a geovirtual environment is not limited to the Internet: those with access to one can select and process the data to package products that can be made available to those with access to the geovirtual environment, such as print outs.

Does too much bandwidth actually result in lower-quality VGI, effectively quantity vs quality? In other words, if it is expensive for someone to contribute VGI, do they pay extra care to the quality of their VGI?

*2.5: research is required on determining what should be displayed in a geovirtual environment.*

How does a virtual globe decide how to prioritize the data that can be displayed? While the virtual globe might have sophisticated algorithms to enable rapid zooming in and out of the background imagery, the selection of which details to display to reduce visual clutter and their priority when on top of one another is not a neutral process, because of the political and other implications.

The data shown might also be dependent on transient details in the background imagery and might lose its context when the imagery is updated (this is the classic problem of the incremental updating and versioning of base spatial data sets (Peled and Cooper 2004). An example is the VGI on Google Earth, showing what was claimed to be pirate boats on the beach at Eyl in Somalia ("expedition" 2009) – the boats might then be at sea when the updated image is loaded on Google Earth and the KML would then point to an empty beach (Cooper et al. 2010).

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# Geo-cybernetic framework and Digital Earth vision

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## Introduction

Recent advances in 3D modeling have improved accuracy, detail and immersion in spatial reality representations. Emerging out of the interaction between realistic 3D models and people -with their mental maps- is the *self-recognition* in these digital spaces, and the possibility of changing everyday spatial reality through an exposure to them. This paper describes the contributions by the geo-cybernetic approach to the Digital Earth vision (and vice versa), providing an opportunity to construct geospatial knowledge through the mutual development of research and models.

In 1997, Fraser Taylor proposed the term Cybercartography to refer to *"the organization, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest and use to society in an interactive, dynamic, multimedia, multisensory and multidisciplinary format"* (2005, 3); This approach recognizes the importance of the user's mental map in geospatial knowledge construction, an aspect not frequently considered by traditional cartography (Taylor 2005, Taylor and Pyne 2010). Two years later, the Mexican research center CentroGeo, developed the "*Chapala Lake Cybernetic Atlas*," a cybercartographic artifact that facilitated decision-making by local actors (Reyes and Martínez 2005). Over time, advances in research showed that the notion of Cybercartography was not enough to understand the complexity of social and spatial processes emerging from these artifacts; as a result, the notion of Geo-cybernetics was proposed in the field of Geomatics (Reyes et al. 2006). This concept will be introduced in the next section.

Additionally, in 1998 U.S. Vice President Al Gore delivered a visionary speech that described a scenario of a girl interacting with 3D Digital Earth representation and asking questions about the planet and its inhabitants (Gore 1998). Gore's vision influenced the launching of the Digital Earth vision movement in the U.S. Government's NASA program, as well as in the commercial sector (for instance, Google Maps and Bing Maps) and in academia. It led to the emergence of the International Society for Digital Earth, which organizes the *International Symposia on Digital Earth* and the publication of the *International Journal of Digital Earth*.

## Geo-cybernetics

**Geo-cybernetics** is proposed as *"the abstract science that studies the agents (analysts and people) who perceive, recognize, understand and interpret the geographical space processed and represented through digital geospatial models, enabling them to generate and validate geospatial knowledge and actions"*, (Real 2010, p. 26). Geo-cybernetics has three theoretical building blocks: *cybernetics, complex systems* approach and *digital geospatial modeling* (Reyes 2005). **Cybernetics** *(kubernetes, conduction or direction)* studies the abstract organizational and operational principles of complex systems, which includes Wiener's theory of communication, feedback and control mechanisms (Wiener 1948) and the sociocybernetic approach of self-referential systems (Geyer 1995).

Both types of cybernetics consider the observer's. The **complex systems** approach studies the complexity of the space-time reality, especially the systemic interaction among environmental and social issues. Finally, **digital geospatial modeling** -also known as Geomatics- integrates quantitative (remote sensing, photogrammetry, geographic information systems, geodesy) and qualitative frameworks (social sciences) to develop conceptual, technical and methodological processes to represent and analyze geospatial reality.

## Digital Earth, Geo-cybernetics and society

The Digital Earth vision integrates, utilizes and shares geospatial information tools (geobrowsers) that help people acquire knowledge and make decisions, in this topic, the geo-cybernetic approach can enrich the digital earth vision in two ways:

a) First, by considering geospatial technologies and their representations as social spaces, rather than merely informational spaces: According to Echeverría (2002, p. 117), we think about and conceive of digital spaces as *"informational space and not as a space of action... ...We have been educated to express plausibly in the first and second stages of environment* [natural and built]… *...but not in the new third space* [digital]*"*. The artifacts, tools, information and models that integrate Digital Earth are social spaces that allow people to change their reality through a cybernetic cycle of feedback, communication, direction and control.

b) Second, by recognizing the importance of regarding people as *spatial constructors* through said digital social spaces: This approach views people not as merely passive users of geotools but rather as active actors who are constantly building their mental maps, digital spaces and real spaces. The relation between Geo-cybernetics and Digital Earth visions can help transition people's geospatial knowledge from that which is tacit to one which is explicit, a process that provides feedback within the digital social space, as described by Heylighen's Collective Mental Map (Heylighen 1999).[1]

The last two points are exemplified in Al Gore's speech: first, the young girl -as an active actor with a mental map- interacts with a 3D digital

[1] Tacit knowledge, also known as "mental map" or "tacit internal model" is an *"internal representation of reality that a person continually constructs to anticipate or adapt to a changing environment"* (Holland, 1995, p. 31). A Collective Mental Map (CMM) emerges from interaction, cooperation, exchange and consensus in a group that facilitate the solution of complex problems (Heylighen, 1999).

social space (geobrowser) which provides feedback for knowledge and for changing her mental map and her everyday reality through personal actions. Through these digital social space interactions emerges the notion of "self-reference", that is, the capacity of a system to recognize, understand and differentiate it from the environment and to cope with its complexity (Varela and Maturana 1980, p. 57; Luhmann 1995, p. 444). This interaction provokes in the girl questions (self-reflection) of her location and actions in local or global problems.

To study the person's interpretation and action through digital spaces like the girl scenario, is important to consider the Digital Earth research topics: 1. Multiple Digital Earth for different audiences; 2. Problem oriented; 3. Searching similar/analogous situations in time/space with data from sensors and humans; 4. Identification of change and anomalies in space; 5. Future scenarios and forecasts; 6. Visualization of abstract concepts; 7. Open access, participation and multiple platforms and media; and 8. Laboratory for learning and multidisciplinary education and science (Craglia et al. 2008). These topics should be gathered with the last geo-cybernetic conceptualizations to achieve a future common agenda.

## Conclusions

The Digital Earth vision that emerged from Gore's visionary speech and the geo-cybernetic approach that evolved from Taylor's theoretical proposal are needed to continue to build practical and conceptual scientific knowledge through 3D models in order to cope with societal and environmental threats. To achieve these goals, it is necessary to rely on models that consider social spaces and take the user as active actors in the construction of their reality into account, bringing about a sense of self-reference and self-reflection. If the geospatial specialist does not consider such relevance, their models will fail to represent and respond to critical challenges. Therefore, it is essential to approach the Digital Earth vision and Geo-cybernetics through a context that includes new research agendas for education and the development of technological devices and conceptual frameworks. In turn, these conceptual approaches will improve the construction of scientific and social knowledge, especially in terms of addressing social and environmental problems.

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# Proposing a redefinition of the social geographic information domain -- Why perpetuating the use of "VGI" will lead to misconceptions and information clutter

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## Introduction

The World-Wide Web became a public resource not even twenty years ago. However, the vision of making our collective knowledge available to each individual (Berners-Lee et al. 1992) did not become a reality right away. After a period of relatively rapid growth (Gray 1996) the Web had become a largely unidirectional information source. Before 2005, the number of citizens connected to the World Wide Web grew considerably faster than the number of registered internet domains (Internet Systems Consortium 2010, Global Village Online 2010). Taking the number of domains as an indicator for the number of information publishers on the web, we can see that the World Wide Web information landscape of before 2005 was mimicking the division of roles in the traditional, offline information landscape. Production of information remained in the hands of a small group, consisting mainly of professionals and academics, who had the necessary tools, knowledge and access to publish information on this novel medium. The traditional information consumers also stuck to their role and remained on their end of the information divide, with only a few crossing over and becoming publishers themselves.

Only with the advent of the Social Web or Web 2.0 (O'Reilly 2005) did the promise of the World Wide Web as a global democratic information interchange start to come true. A number of coinciding developments can be attributed to have created the climate in which this new generation of the web could flourish. Firstly, an increased body of technology has become available, both in the domain of devices (e.g. hand-held devices with 3G and Wi-Fi connections) used to interact with web-based information, and also in the domain of publishing information in a compelling and interactive way. Secondly, internet access has become faster and more ubiquitous, allowing more people to be connected to the web in more spatial contexts. Lastly, the web has secured its well-defined place in the information society. People have started to use it as a primary resource, not only for access to information, but also to reach out to and expand their social networks.

The channels over which e-citizens can exchange information, share thoughts and ideas, images, sentiments, knowledge, have greatly expanded in the last four years. In 2006, Twitter did not exist, Facebook was a small operation running on a few U.S. university networks, and OpenStreetMap (openstreetmap.org 2010) was all but nonexistent outside of the U.K., where the community mapping project was founded. Four years later, Twitter has 175 million users emitting 95 million tweets – 140-character messages – a day (Twitter.com 2010). Facebook's web site is visited 6 million times every minute (sic) by its user base of over half a billion (Facebook.com 2010). Even OpenStreetMap, tiny by comparison, has started to attract significant attention in the domain of geographic information, showing an information richness and topicality in selected areas that surpasses commissioned sources.

This explosion of social information could, and to a large extent still can, be considered the white background noise of the internet. We know it is there, we know there is a lot of it and that it holds a lot of information. Its geographic dimension, named VGI or Volunteered Geographic Information (Goodchild 2007) is exposed through the Geoweb (Craglia et al. 2008) and as such increasingly available to Digital Globe platforms. What we don't know however is how to appreciate this information, how to uncover it, classify it and use it, leading to issues of information trust (Flanagin and Metzger 2008) in analysis and commercial applications, and to information clutter in visualization environments such as Digital Globe applications.

The term "VGI" attempts to provide an overall definition for an expanding geospatial information domain, and as such has played a significant role in focusing emerging research efforts in the fields of GIScience as well as Geography and Sociology (Elwood 2008a, Elwood 2008b, Tulloch 2008). By its very nature however, the term "VGI" also obfuscates the increasing complexity of that information domain. Only when we succeed to appreciate this complexity can we adequately classify what has coalesced into the blanket descriptor “VGI” but what is really a rich domain of information from disparate sources generated with different intents for a wide range of purposes that is expanding fast both in terms of information volume as well as in breadth of subject matter. The ability to effectively classify information is of paramount importance in dealing with an emerging information domain on every level, from structured analysis to visualization, where preventing visual clutter is key to conveying the information content and enabling the consumer to see beyond the white noise.

We thus propose to move towards a more apt definition of the domain of “social information with spatial dimension”, for want of a better term for the time being. We set out to do this by breaking down the de facto definition, Volunteered Geographic Information, into its comprising parts, aiming to uncover its shortcomings in describing the domain and provide insights towards a richer descriptive context.

## Volunteered

Volunteering is the act of consciously and freely offering to do something. In the context of geographic information, this definition covers traditional (sic) community mapping platforms like OpenStreetMap, whose users clearly are volunteering their local knowledge through the editing tools made available to them; all contributions are conscious acts of transferring information from the individual to the collective information platform and thus can actually be considered volunteered geographic information.

There are other platforms collecting, aggregating and publishing geographic information from a user community for which this is not as clear-cut. Waze is an emerging social navigation and traffic platform. The Waze application can be run on popular smart phone platforms. It looks and behaves like a traditional turn-by-turn navigation application for the most part. What sets it apart is a very tight integration with and reliance on information contributed by its users. This contributed information has two dimensions. Firstly, users can actively and consciously report traffic conditions, such as road maintenance works and temporary speed restrictions that will be shared with other users. Secondly, the running Waze application will periodically transmit the user’s position without the user’s intervention. The Waze platform uses the aggregated position updates from all its users to derive live traffic information and corrections to the road network.

While Waze users make a conscious decision to take part in a social information platform when they decide to start using the application, the location updates they continuously send from then on to improve the Waze platform can hardly be called volunteered as they lack the component of a conscious act. At the very least, the 'volunteered' in the term VGI starts to cause confusion.

This confusion becomes greater still when we consider a more closed variety of the same 'social traffic' idea: TomTom MapShare. MapShare has a similar proposition to Waze, collecting positional updates continuously and feeding those updates back to the MapShare platform. Rather than using a live feedback loop, MapShare uses the location updates – more than three trillion of them so far (TomTom.com 2010) – to flag potential map errors. This helps TomTom to update their maps faster and more reliably and offer those paid map updates to those very same users that shared their location updates for free. This puts the question of whether or not the users volunteer geographic information into yet another perspective. Volunteering implies some degree of mutual benefit, or at least contributing to a societal or communal benefit. When that benefit can only be enjoyed at an additional cost, is volunteering still an appropriate term?

## Geographic

The previous examples; OpenStreetMap, Waze, TomTom MapShare all deal with contributions that are unambiguously geographic. The contributions users make to those platforms, volunteered or not, explicitly contain geographic coordinates. In the larger domain of social information live many instances of citizen-contributed information that was most likely not consciously intended to be geographically interpreted – but it gets used as such. E.g., when a user shares a tweet like "Just landed #SFO", spatial information is implicit rather than explicit: the information does not include an explicit, structured geographic reference in terms of geographic coordinates. Still, the massive volume of information shared though this social platform, combined with a certain degree of predictability of human behavior, can be leveraged to visualize worldwide air travel patterns with relatively little effort (Thorp 2009).

Even more implicitly, geographic information is contained in most generic unstructured text (Jones et al. 2008), such as the millions of updates and stories shared through blogging platforms like Blogger, WordPress and Tumblr. A number of tools allow for Geographic Information Retrieval or GIR (Anastácio et al. 2009) and while there are many language-specific challenges and conducting a well-executed geoparsing is far from straightforward, we can establish that there is a lot of information shared through social platforms that is not explicitly geographic, but still can be interpreted as such and thus is part of "VGI".

## Information

Whereas the data collected in the social web does undoubtedly constitute information, from an individual citizen's perspective things are not so clear cut. While a contribution to OpenStreetMap is, from the citizen's perspective, an explicit act of contributing to a body of information that he knows can be used by others for their own purposes, sharing an update through Twitter or Facebook is much less clearly thus and so. For all intents and purposes Twitter is a platform of transient messages, and when a user posts an update, he perceives it as such, not consciously thinking about the Library of Congress archiving every single tweet for future reference (Raymond 2010). It is quite likely that Twitter users do not even know to what extent their tweets are archived and the information content re-used.

Things become even less clear when we consider passively and/or unconsciously shared information. Consider a car driving over an induction loop in the road or being recorded by one of millions of traffic and security cameras – all instances of geographic information collected through the Sensor Web (Botts et al. 2008) and "the Internet of Things" (Gershenfeld et al. 2004). Consider any credit card payment a citizen makes – even every Google search he performs. The citizen engages in a infinitesimal transaction of mutual benefits and (geographic) information flows. The nature of this transaction, let alone the flows of information involved, are usually not explicitly exposed to the citizen. Not only is he not voluntarily contributing to a body of information, it is not clear to him what bodies of information he is contributing to, and what information content his contribution entails.

## Intent and Spatiality

All (potentially) geospatial data that is collected through "VGI" platforms can be (re-)used for many different purposes: research, spatial planning, policy making, art. To make a good assessment of what data holds the right information content for those different purposes, we have to consider the intent – or lack thereof – with which that data was collected. VGI, as a blanket description of this rich domain, does not allow us to do that. We need a descriptive context of spatially interpretable crowd-sourced data that exposes the diversity of this domain. We propose a definition along sliding scales of *Intent* and *Spatiality* (see Figure 1).

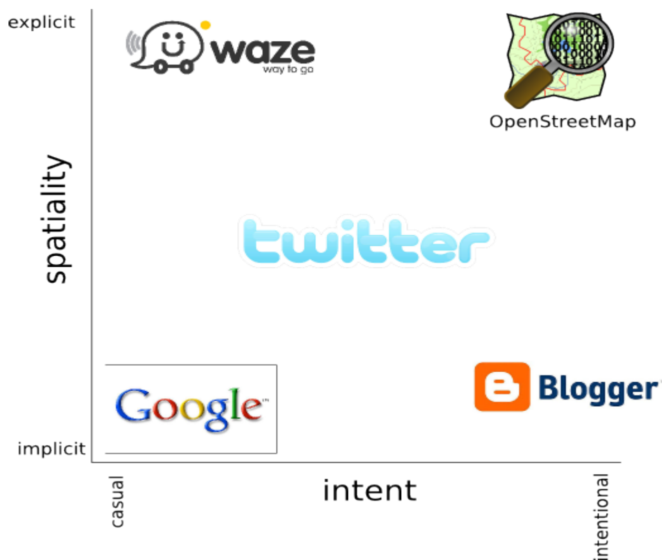


Figure 1. A conceptual visualization of the domain of VGI along the axes of spatiality – in how far are the contributions explicitly spatial? – and intent – to what extent are contributions made consciously?

Using a planar definition of the domain along these axes of Spatiality and Intent, it becomes immediately clear that not all social geographic information was created the same. It rids us of the misconception that all data in this domain is volunteered, explicitly geographic, or even explicitly information and thus helps us focus our efforts better, be they in research, in open data propagation or in visualization. The domain of crowd-sourced geospatial information is rich; new applications for it emerge every day, as the user-generated information current of the social web continues to gain momentum and grows into a torrent in which it becomes exceedingly hard to make out which is which.

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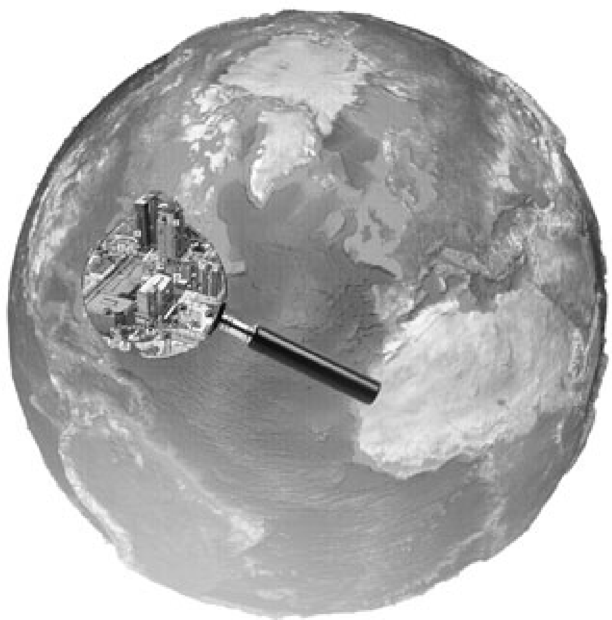



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