User Interface for Browsing Geotagged Data – Design and Evaluation

Erika Reponen, Jaakko Keränen, and Viljakaisa Aaltonen

Nokia Research Center,
Visiokatu 1, 33720 Tampere, Finland
{erika.reponen,jaakko.keranen,viljakaisa.aaltonen}@nokia.com

Abstract. The surface of the Earth is getting covered with geotagged data. We describe a mobile application and UI that combines embodied interaction and a dynamic GUI for browsing geotagged data. We present the design process and analyze results from a user study. UI is based on a dynamic grid visualization that shows geotagged content from the places around the world where the user is pointing. It shows a continuous and interactive flow of items, including real-time content such as live videos. The application is aimed for entertaining and serendipitous use. The study results show that usability and intuitiveness were improved by providing an additional, familiar view and controls; showing transitions between view modes; and enhancing the unfamiliar views. Also, the content grid UI was found to be a good way to browse geotagged data.

Keywords: Geotagged data, Embodied interaction, User interface, Augmented reality.

1   Introduction

It has become common to tag data to locations, either manually or automatically based on metadata. This kind of *geotagged data* combines virtual information with physical locations in the real world. Also, mobile devices often are connected to the Internet, so sharing geotagged data is possible. The surface of the Earth is getting covered with geotagged data. The sensors in mobile devices (such as accelerometer, compass, and GPS) enable using the device for pointing based interaction. The device knows its geographic location and can determine its orientation in relation to the Earth's gravity and magnetic field, and this can be used in an application's user interface (UI) to determine which physical places the user is pointing the device at. Specialized graphics processing hardware of modern mobile phones allow the creation of graphically sophisticated user interfaces where techniques like real-time 3D rendering can be used. One challenge in presenting geotagged data in user interfaces is the huge amount of data available from different sources. In user interfaces that are based on a 2D map (e.g., Google Maps), geotagged data items are overlaid on the map as small badges (icons, thumbnails or text labels) [see also 14], many items shown at the same time. High density of geotagged data (e.g., tourist photos) may cause information overload. The badges also hinder the visibility of the

geographic view itself. Another example is to have a row of thumbnails above or below a map or AR view (e.g. Flickr's World Map view). To bring an alternative UI for browsing geospatial data, we developed a novel user interface for browsing geotagged data using a mobile device and created an application called MAA (Finnish word meaning the Earth) with which you can browse geotagged data all over the world by pointing to different directions around [11, 12]. In this paper we present and evaluate the full-featured user interface of MAA. We comment on what kind of an effect the changes applied to the preliminary version had. We first cover the relevant related work, including a brief description of the concept. Then, we describe our user interface design process and the user interface of MAA, followed by a description of the user study and an analysis of its results. In the end, there is some further discussion and conclusion, and the list of references.

2   Related Work

We consider our work to be part of reality-based interaction (RBI) [5], positioned between augmented reality (AR) and map-based interaction. Our work combines a graphical user interface seen on the device screen with pointing based interaction. There are two kinds of common mobile applications that use pointing based user interfaces: 1) AR applications that augment the camera viewfinder with information about nearby geotagged data, and 2) applications that determine the pointing direction of the device and show a view into a virtual world accordingly. Example of the former is Nokia Point and Find [4] which is a system that enables getting information about pointed objects through an AR view and the latter astronomy application Sky Walk [13]. A lot of research exists on augmented reality. Rekimoto et al. [9] have talked about an augmented interaction style that focuses on human-real world interaction and not just human-computer interaction. Also philosophers like John Baudrillard [2] and media artists such as Myron W. Kryeger [7] have been presenting various ideas related to mixing physical and virtual reality. Jorge et al. have published research about whole-body orientation in virtual reality interaction [6]. Content that is created and/or consumed in real-time is becoming more common with social media applications such as Twitter. Users are presented with a continuously updated flow of information. Real-time video connections between places out of viewing distance has been researched first by Kit & Sherrie who arranged a media art experiment "Hole in Space" [3] which is a live video connection between NY and LA, and found surprised and excited reactions. Newer research on the real-time video communication tells that also mobile phone videos can be used in real-time communication [10].

2.1   MAA Concept

MAA is an application that utilizes an embodied interaction method for browsing any geotagged data in an entertaining and captivating way. It is an AR application in the sense that it presents the user with an augmented, first person view of the surrounding physical world. However, while traditional AR deals with things that are physically

visible to the user, MAA is about seeing geotagged data that is hundreds or thousands of kilometers away. Users own location in the application is same as his/hers current location in physical world, and right on the surface of the Earth, not below or above it. By pointing downwards, one can view locations on the other side of the planet, as seen through the Earth (Figure 1). The MAA user interface is based on a 3D model of the planet drawn on the display of a mobile device so that it matches with the physical reality around the user. By pointing with the device to any direction around him or her, the user is able to see geotagged data and places in the pointed direction. Differently to traditional 2D map: the user sees the surface from underground, through the Earth, and due to the curvature of the surface areas near the user appear to be "squished" to the horizon.
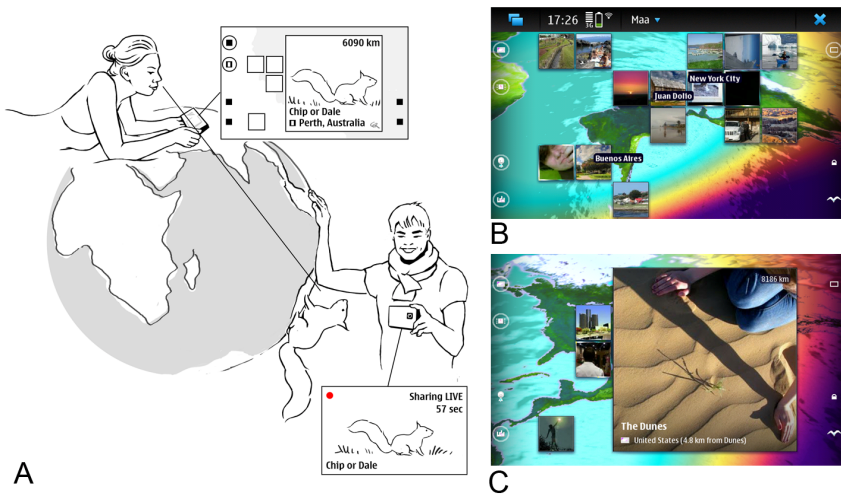
Fig. 1. A: The MAA concept: seeing geotagged data through the Earth, as if the mobile device was a window through the planet, B: MAA user interface, C: Photo preview opened

3   Design Process

Our goal was to make use of an embodied interaction method for browsing geotagged data in a novel and playful way, to allow the user to see the world and geotagged data directly through the Earth, reminding of living on a spherical planet. We were thinking about augmented reality in playful way. We wanted to find a solution that would be able to cope with any amount of content and give easy and direct access to it. The user interface should be simple and elegant, attractive, and easy to use. However, there should always be something new for the user to view. From the beginning, the UI combined embodied interaction with a touch-screen GUI. This combination allowed an interaction style where the user points in the real world and a mobile device acts as a "lens" or "window", showing a view through the Earth.

The first step was UI sketches on paper, but early prototyping was important because from the beginning we wanted to run the UI on real hardware to get a feel of

the interaction. Development work was carried out on a mobile device with a 3.5", 800 x 480 pixel touch screen. The device had accelerometer and compass sensors. We quickly settled on visualization where geotagged content is presented on a 3D globe. We augment reality in such a way that it would allow the user to see the inner surface of a hollow Earth. To keep the design clean and simple we used as few icons and other visual UI controls as possible. The focus should be on the view of the Earth and the geotagged content itself, not generic icons and badges representing the content. One of the biggest challenges in the visualization was to make the Earth look familiar enough to be recognizable, but still avoid the impression that the user's viewpoint is like in maps somewhere above the surface of the planet. As the UI was intended for mobile touch-screen devices and finger-based use, certain restrictions needed to be applied. Thumbnails, text labels, and other content that the user clicks on were designed to be large enough but user interface not get too cluttered with content. Toolbar icons were designed so that the icons are, although small, so far away from each other that they are easy to hit with a finger.

To validate design ideas we first conducted a study on working prototype of the central aspects of the application with the basic features and the preliminary user interface showing placeholder content: a view of the Earth, some city labels, and a set of dummy photographs tagged to arbitrary locations on the planet. The first evaluation [11] focused on the user experience of seeing through the Earth. Results of that study were used to develop a full-featured version of the user interface. Updated prototype was validated in a user study, reported in this paper.

4   User Interface

MAA UI was designed for an enjoyable user experience, showing content as a dynamic flow, which retains the user's interest while preventing information overflow. The user interface (Figure 1) has three layers: 1) The 3D Earth, 2) Content and 3) UI Controls.

The 3D Earth layer fills the whole screen background and shows a view of the planet. It is presented as seen in first person perspective, through the ground on which the user stands. Oceans and continents as well as polar regions are shown in different colors. Water is considered transparent, so that the sky on the other side of the planet is seen through the oceans and lakes. The day and night sides of the planet are visualized using different color schemes. The approximate direction of sunlight is calculated at the time of day according to the clock of the device. For regions on the day side, the colors are light green and turquoise, and on the night side they are dark violet. Day/night boundary is visualized with a colorful gradient that emulates the colors of a sunrise and sunset in a stylized fashion. When viewing the planet in bird view from above the surface (i.e., from space), the color scheme is gray (Figure 2). The intent is to create a contrast between the "inside" and "outside" views.

The Content layer shows geotagged data from places visible on the screen. Videos and photographs are presented as thumbnails on a grid of 7x5 square cells. There is a subtle effect for separating photos and videos: an animated, glittering frame is drawn

around video thumbnails. The grid does not cover the entire screen to leave room for other UI elements. The size of the grid cells is large enough to allow the user to make sense of the thumbnails. Thumbnails appear and disappear constantly with an animation where the thumbnail flies to/from the screen from/to the tagged locations on the Earth. Consequently, only one thumbnail is visible from the area covered by a grid cell. Zooming in is required if the user wishes to see several items from a small region at the same time. Content is animated but never overlapping, and a maximum of 15 grid cells are filled at once (always leaving 20 cells empty while a preview is not shown), preventing a situation where the screen gets covered in thumbnails and no space is left for seeing the Earth model. This way, large amount of data can be viewed on small screen. When the user clicks on a thumbnail, a preview of it is opened. The clicked cell expands with an animation to cover the area of 5x5 cells. The locations of the world's largest cities (e.g., New York, Sidney) are shown as black text labels, located so that the city is in the center of the label. The number of labels shown simultaneously was restricted to three, to prevent the whole display to be filled up with them. As with thumbnails, each label is only shown for a period of time, after which it is hidden and another label is shown elsewhere on the screen.

On the *UI Controls layer* there is a row of toggle buttons on the left and right sides of the screen. The left side buttons are used for selecting the visible content types: photos, videos, friends, and cities. The right side buttons control the view: a fullscreen toggle, bird view and lock mode. Activated buttons are circled. All the icons are mostly white so that it would be easy to see them above the colorful 3D Earth layer and to make sure they are visually distinct from the items on the content layer.

5   User Study

We arranged a user study to evaluate MAA with the completed user interface and see what kind of impact the visualization and user interface improvements had. The study focused on general usability issues and in how easy the "see through" concept was to understand. For the study, the MAA prototype was configured to show content from a number of existing services on the internet. We used photos from Panoramio, videos from Qik, cities from Geonames, and manually placed the information of five people around the world to act as the user's friends. We recruited 12 participants for the study (6 men, 6 women), between 16 – 55 years, mostly in the age group 31-35. They had a mixed background: various professionals such as user experience designers, managers and engineers working in a large technology company, and one participant was a high school student. A test session lasted 45 minutes. The sessions were conducted inside, in a first floor room with a window. We chose this venue instead of a closed-off usability lab so that the participants could see outside through the window. The sessions were organized as semi-structured interviews while the participants were interacting with the device and performing a set of tasks. During the session the participants tried out the application for 30 minutes. We gave them very little information about the application beforehand to get their initial reactions to the concept. As the session progressed we gave them more information and described the

idea of the application. Questions such as: "describe what kind of thoughts this application raises?", "what can you do with this application?", "what kind of content you would like to have in this application?" and "could you show me where London is?" were asked. At the end of the session the participants filled in a questionnaire with free-form answers to 11 questions, including ones such as: "my primary feelings after using the application are __" and "the application made me think that the Earth is __". The users also filled in an AttrakDiff survey [1]. AttrakDiff measures practical quality, hedonic quality identity, attractiveness, and hedonic quality stimulation: it was translated into Finnish for this study (the native language of the participants) but was also available in English. The general structure of the test sessions was similar to the one we had used when evaluating the preliminary version, enabling easy comparison the results. Some additional questions were added about the bird view (seeing from space), viewing near-by content, content grid, and recognizing the type of different content items. Afterwards, all results were combined and analyzed.

6   Study Results and Analysis

The study results and their analysis are divided into two main topics: *Earth navigation* and *the content grid UI*. We summarize the challenges we identified in earlier study [11] and then describe the changes applied to the prototype for current study and analyze their impact. Participants felt that the concept was novel and inspiring. However, they were unfamiliar with the mental model of seeing through the planet. This was not unexpected, as the users had had no prior exposure to the concept. As the AttrakDiff graph (Figure 2) shows, the completed user interface and real world content did not change the overall response and user experience significantly.
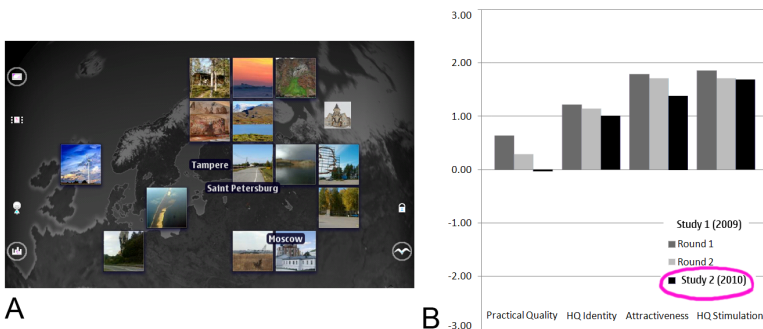
Fig. 2. A: MAA bird view, B: AttrakDiff results: Darkest ones being the ones from the current study, earlier ones from the 2-round study with preliminary UI

6.1   Earth Navigation

Using one's own body in relation to the device and environment is a good way to browse geospatial content. However, users are expecting to also have more control over the UI in addition to using the body and its position. Embodied interaction style

makes exploring the Earth and content around it more captivating and personal, compared to existing solutions, but the visualization we were using in preliminary version was not intuitive enough. When encountering this kind of a view for the first time, the users were a bit perplexed as to what they were seeing on the screen; the participants had not thought this way about the Earth before. The idea of seeing directly through the Earth was new for them and they found the application novel and unprecedented. Difficulty understanding see through idea derives from the users' pre-existing mental models. To address this we must make it more evident that the view is through the Earth, not from an elevated vantage point or simply a mirrored 2D map. We found three ways to improve the user interface for navigating the Earth and understanding the mental model: *A) providing an additional, familiar view and controls, B) transitions between view modes and C) enhancing the see-through view.*

A) Providing an additional, familiar view and controls. In study with preliminary UI traditional map view and possibility of changing one's own location within the application were wished for. Another feature request was the ability to "zoom all the way to the street level", like in Google Street View. Yet another wish for the UI was the possibility to lock or freeze the view to the pointed direction.

To make MAA better, we then added the bird view mode where the Earth is shown as seen in third person, as if you were looking from space (Fig 2). To make the bird view clearly different than the see-though view, the Earth model was visualized in gray scale in the bird view, and water was made opaque in the bird view. We also enabled locking the view. Locking only affects the viewing direction, so the flow of displayed content is unaffected. We replaced the on-screen zoom buttons with hard keys on the device (volume keys) but we did not increase the maximum zoom level.

The bird view was well understood and got a positive response from users. Users intuitively applied the bird view mode for browsing content from nearby areas — a task that was considered difficult in the default see-through view. The challenge in visualizing areas near the viewpoint in the see-through view is that all regions inside a radius of about 1000 km is shown "flattened" near the horizon. Content grid cells at horizon level also cover a larger geographical area than cells below the horizon. The bird view is similar to traditional 2D/3D maps of the Earth, except in our UI the user's own location is always fixed to the center of the device screen — allowing the pointed directions to continue to match between the physical world and the application's virtual representation of it. The gray scale color scheme in the bird view was not appreciated. While users realized it was beneficial to differentiate it from the see-through view, they found it too dark, gray, and unrealistic. Most of the participants wanted to have both the see-through and bird views, as they suited different situations and needs. The lock mode was welcomed. It was found useful when showing the view to others or for keeping the target fixed when observing one location for a longer period of time. It was also considered to be a possible starting point for manually moving the user's own location, by panning with fingers, to see a little bit behind the Earth in the bird view, or to better see the horizon areas in the see-through view.

B) Transitions between view modes were understood better when used manually than when seeing the opening animation. Changing between see-through-mode and

lock-mode manually clearly helped users to understand the difference between the modes and also understand the concept better. Results on the opening animation reveal that users did not realize that they were seeing the inside surface of the Earth after seeing the animation. It was clear that it was showing moving closer to the planet but what happened when the animation ended was misunderstood: "We are moving closer to Finland, surface of the Earth. Ok, and now we are going to China. Wow, really nice." Some commented that typically opening animations are there just to have something to see while the application is being loaded, and therefore they were not really paying attention to what was happening in the animation. Although the users did not quite understand the animation, they thought it was attractive. When seeing the opening animation for the second time, after having heard that the application allows them to see through the Earth, some said: "Right, ok, that's what the text says, but I didn't get it."

C) Enhancing the see-through view. To make the see-through view more intuitive, we made adjustments to the overall visualization of the world. The most significant changes were a more saturated color scheme and animated, rippling water. These were intended to give the view a more real-time, dynamic appearance. A multi-color gradient was added to visualize the areas where the Sun was currently rising or setting. We were aiming for an increase in the visual impression and feeling of seeing the "imaginary inner surface" of the Earth. As a further link to the physical world, we added the Sun to the sky in the correct direction. The Sun was also visible through the oceans if it happened to reside on the other side of the planet. The day/night boundary was too colorful in some participants' opinion. Also, its meaning was not clear to all. Seeing the difference between day and night areas was considered important, though, as it indicated which time of day it was in specific locations. On the whole, the color scheme of the see-through view was liked. Many users wanted to check if the Sun was in fact shown in the correct direction within the application and compared it to what they were seeing outside in the window. The animated water went largely uncommented but some misunderstandings were happening: it was either mistaken for real-time animated clouds from satellite pictures, ocean currents, or wind patterns. Nevertheless, we think that these comments hint at animation in the Earth model enhancing the feeling of liveliness.

6.2   Content Grid UI: Browsing Geotagged Data in Real Time

In the earlier study, featuring only placeholder content it was unclear to the users whether they could trust it was coming from the correct places. It was expected that tapping on a content thumbnail would allow them to see the real photograph or details about the location. Users also wished to see, for example, the locations of their friends and real-time videos from around the world.

In the current full featured UI the users were presented with a dynamic flow of real content from around the world. We also added a visualization for showing friend location on the Earth: pulsating towers of light protruding inwards from the Earth's surface, accompanied by text labels showing the friend's name. Due to a flaw in the implementation the friends were not visible in all test sessions.

Overall, the finished content grid UI was intuitive to the users. They liked watching the dynamic flow of content on top of the Earth model. They found it inspiring and nice that they serendipitously got interesting content from pointed locations without active searching or selecting. The animated transitions for appearing and disappearing real online content made it clear that the content was coming from actual locations on the Earth. Most of the participants liked being able to turn content types on and off by selecting and unselecting the content type icons and thus filtering the contents to be shown. They also liked that they could control the geographic coverage of the grid by zooming. When the preview was open (Figure 1), the UI also showed the geographic location of the content (e.g., country and the nearest city) and how distant the content was from the user in kilometers. This got a lot of attention from the users as it introduced a link to reality in an otherwise unfamiliar user interface. The users found it fun to see how far the locations are. Although mostly liked, a couple of users commented that the dynamic content grid was too busy. Some users commented that interesting content item disappeared before the user had time to tap on it. Some wanted to have a line or dot indicating where the content came from. While the location of friends was important information for the participants, their visualization was insufficient; they were expecting to see friends as photo thumbnails in the grid. Also, the participants had trouble seeing the difference between video and photo thumbnails. The glittering frame animation in the video thumbnails was not clear enough to separate it from photo thumbnails. Either the animation was not noticed at all (too subtle), or the meaning was unknown. Sometimes it was also unclear which of the thumbnails glittered and which did not, when multiple thumbnails were next to each other. Users were expecting to see playing video, at least in the preview if not already within the thumbnails. The participants suggested adding a familiar 'play' triangle symbol on the thumbnails, or using film strip borders. The toolbar icons were considered too small and not easy enough to recognize quickly. However, the users were able to find out what the toolbar icons meant after trying them out. For example, when asked to search for videos, they turned the other content types off and then knew that all they would be seeing was videos.

7   Discussion and Concluding Remarks

Compared to traditional map based user interfaces, we see MAA as a more entertaining and inspiring way to look at the world. It still has a strong basis in the physical reality and makes us pay more attention to the planet below our feet. The kind of user interface we have presented is best suited for exploring content in a serendipitous manner. Only a small number of content items are shown at any given point in time and the user is motivated to keep watching and exploring the content flow. No user actions are required for watching the content flow. MAA gives a user the ability to concentrate on and enjoy the content he or she wants to see, without searching or selecting from the huge amount of available data. However, a search feature would be required for pinpointing the location of specific items of interest. Content is not restricted to the types used in our application, as any kind of geotagged

data could be used with this kind of user interface. Also, the grid UI is suitable for both map based and augmented reality views, as demonstrated in our bird and see-through views. Allowing the user to change his or her location within the application would be interesting because in the see-through view, the Earth looks different depending on where you are watching it. We have presented the design process and analyzed the user study results of the MAA user interface, which is a combination of embodied interaction and a dynamic grid based GUI for browsing geotagged information. User interface shows geotagged data directly through the Earth, in the pointed direction. Additionally, a bird view is provided for focusing on content near the user's current location. Our study results show that providing familiar user interface views in addition to the unfamiliar see-through view, the new application became more usable and understandable. An animated transition between the familiar and unfamiliar views helped the users understand the unfamiliar view. Both see-through and bird views were liked. The see-through view was new, inspiring, and straightforward to use just by pointing, and the bird view was familiar from earlier experience and enabled to see the near-by areas in more detail. Combining old and new was found to be a good solution. UI that combines embodied interaction with a dynamic content grid was considered a good way to browse geotagged data. Together with an Earth model visualization that features day/night colors, the Sun, and animated water, it gives the impression of exploring the world in real-time. Interesting areas for future research include visualization techniques for new kinds of content, techniques for changing the user's location in the see-through view, and even better ways to assist the user understand the mental model of seeing through the Earth.

References

1. AttrakDiff, http://www.attrakdiff.de/en/Home/
2. Baudrillard, J.: Simulacra and Simulation. University of Michigan Press (1994)
3. Galloway, K., Rabinowitz, S.: Hole in space (1980),
   http://www.ecafe.com/getty/HIS/index.html
4. Gao, J., Spasojevic, M., Jacob, M., Setlur, V., Reponen, E., Pulkkinen, M., Schloter, P., Pulli, K.: Intelligent Visual Matching for Providing Context-Aware Information to Mobile Users. In: Supplemental Proc. UbiComp 2007 (2007)
5. Jacob, R.J.K., Girouard, A., Hirshfield, L.M., Horn, M.S., Shaer, O., Solovey, E.T., Zigelbaum, J.: Reality-Based Interaction: A Framework for Post-WIMP Interfaces. In: Proc. CHI 2008, pp. 201–210. ACM Press (2008)
6. Jorge, V.A.M, Ibiapina, J.M.T, Silva, L.F.M.S., Maciel, A., Nedel, L.P.: Using Whole-Body Orientation for Virtual Reality Interaction. In: Proc. SVR 2009, pp. 268–272. Brazilian Computer Society (2009)
7. Krueger, M.W.: Artificial Reality 2. Addison-Wesley Professional (1991)
8. Rekimoto, J., Nagao, K.: The World through the Computer: Computer Augmented Interaction with Real World Environments. In: Proc. UIST 1995. ACM Press, USA (1995)
9. Reponen, E.: Live @ Dublin – Mobile Phone Live Video Group Communication Experiment. In: Tscheligi, M., Obrist, M., Lugmayr, A. (eds.) EuroITV 2008. LNCS, vol. 5066, pp. 133–142. Springer, Heidelberg (2008)

10. Reponen, E., Keränen, J.: Mobile Interaction with Real-Time Geospatial Data by Pointing Through Transparent Earth. In: Proc. NordiCHI 2010. ACM Press (2010)
11. Reponen, E., Keränen, J., Korhonen, H.: World-Wide Access to Geospatial Data by Pointing Through The Earth. In: Extended Abstracts CHI 2010, pp. 3895–3900 (2010)
12. Sky Walk, `http://vitotechnology.com/star-walk.html`
13. Uusitalo, S., Eskolin, P., Belimpasakis, P.: A solution for navigating user-generated content. In: Proc. ISMAR 2009. ACM Press (2009)