Mobile Interaction with the ‘Real World’

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ABSTRACT

Real-world objects (and the world) are usually not flat. It is unfortunate, then, that mobile augmented reality (AR) applications often concentrate on the interaction with 2D objects. Typically, 2D markers are required to track mobile devices relative to the real-world objects to be augmented, and the interaction with these objects is normally limited to the fixed plane in which these markers are located. Using platonic solids, we show how to easily extend the interaction space to tangible 3D models. In particular, we present a proof-of-concept example in which users interact with a 3D paper globe using a mobile device that augments the globe with additional information. (In other words, mobile interaction with the “real world”.) We believe that this particular 3D interaction with a paper globe can be very helpful in educational settings, as it allows pupils to explore our planet in an easy and intuitive way. An important aspect is that using the real shape of the world can help to correct many common geographic misconceptions that result from the projection of the earth’s surface onto a 2D plane.

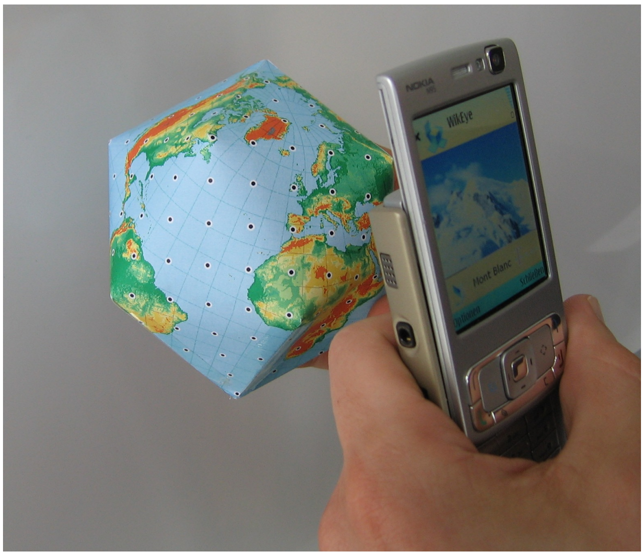

Figure 1: Mobile Interaction with the “Real World”: Interaction with a 3D Paper Globe.

Categories and Subject Descriptors

H.5.1 [**Multimedia Information Systems**]: Artificial, augmented, and virtual realities, hypertext navigation and maps

Keywords

Maps, Mobile Camera Devices, 3D Objects, Platonic Solids, Mobile Interaction with the Real World, Map Projections, Geographic Misconceptions

1. INTRODUCTION & MOTIVATION

Which mountain do I have to climb to stick my nose as far as possible into outer space? Most people instantly answer “*Mount Everest*”. However, it is surprising that several other points on our planet arguably poke much farther into space than *Mount Everest* (8,848 meters). The answer to this “trick” question is not clear because one can define *Mauna Kea*, Hawaii, which rises 10,203 meters from its base on the floor of the Pacific Ocean as the highest mountain on Earth. A third way to determine the world’s highest mountain is to measure the distance from the Earth’s center of mass to the peak. Using this method, *Chimborazo* in the Andes triumphs. Although it stands “just” 6,267 meters above sea level, its peak is the farthest from the mass center. We think that teaching basic geographic and statistical facts about the world, e.g. the locations of the highest peaks, can be effectively supported by the playful kind of exploration that our approach allows.

Two-dimensional map representations of the earth often cause geographic misconceptions that are much more common than the one described above. For instance, “The southernmost part of Florida has a subtropical climate”, “Greenland is larger than South America”, and “Vienna lies south of Munich”. More information about common misconceptions are available online [2, 8] and gender-related knowledge variations within geography are investigated by Henrie et al. [10].

In fact, real world objects (and the world) are usually not flat. It is unfortunate then that mobile augmented reality application often concentrate on the interaction with 2D objects, such as paper documents [1], posters [17], situated

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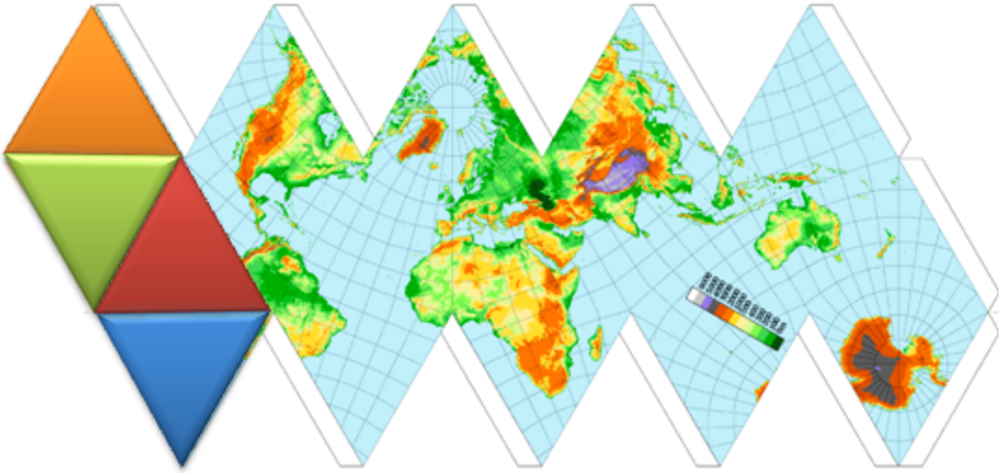

Figure 2: World map on a regular icosahedron (20 equilateral triangles): Gnomonic projection, poles on faces, color-coded topography, original elevation data by USGS's EROS Data Center. ©2004 by Furuti.

displays [4] or paper maps [11, 16].

Interaction concepts for toolglasses or magic lenses [3] with these objects are well studied [6, 12, 14]. In our approach we provide video see-through augmentation of the paper globe with a camera-equipped handheld device. The user's view is mediated by the device and combined with overlay graphics on the display. The user acts on two layers of information the "transparent" device screen in the focus and the paper globe in the visual context. The camera display unit acts as a movable window into a computer augmented view of the physical paper globe. Of course the image of the 3D paper globe is limited to a 2D plane on the mobile devices screen, but the user can still interact with the 3D paper globe with his non dominant hand. Several solutions exist to track the mobile device relative to the object to be augmented on the video screen. When pixel-precise augmentation is needed, usually visual markers are used. If this precision is not needed, other techniques like RFID or NFC are often used [6, 11] to establish the physical hyperlink from the object to the associated data. All these approaches have the problem that the marker only defines an interaction space in a 2D plane. We show how to extend the interaction space to 3D objects by only slightly magnifying an existing tracking technique. This has the advantage that no computationally intensive AR techniques are needed to downscale a tracking algorithm on a mobile device, allowing researchers to concentrate on the HCI issues of such applications. Of course, AR researchers have proposed more accurate and reliable tracking methods, but with the drawback that these techniques cannot be run on today's mobile devices. With a modified version of the tracking toolkit by Rohs et al. [13] we now can test the extension of the interaction space from 2D planes to 3D objects. In this paper, we present an application in which pupils can playfully build their own paper globe and explore the seven highest summits of the world by requesting basic information about the summits. This mobile interaction with the "real" world could train the pupils to learn the location and topology of these objects better than doing the same with a flat paper map, which necessarily introduces some distortion, and hopefully such an application can help to avoid or clarify geographic misconceptions. The remainder of this paper is structured as follows. Section two briefly describes the related work focusing on mobile interaction with paper maps, of which the more fundamental material was covered above. Next, the paper summarizes the interaction concepts with 3D paper objects. The current implementation is outlined in Section 4. Its limitations in realizing the proposed approach and remaining technical challenges are discussed in Section 5. Finally, Section 6 provides some concluding remarks.

2. RELATED WORK

The "magic lens" interaction of mobile camera device with paper maps was introduced by Schöning et al. in 2006 using optical barcodes [16]. Many different applications exist that implement the map magic lens interaction principle [9, 15] and the interaction concepts are well studied [14]. Rohs et al. [13] presented a tracking technique that only requires an unobtrusive grid of small dots overlaid onto the map. Using a modified version of this tracking technique it is now possible to easily apply the magic lens principle to 3D objects that can be freely moved and oriented by the user. Some remaining technical challenges are described in Section 5).

3. INTERACTION WITH A PAPER GLOBE

The basic interaction pattern is that of sweeping the camera device over the globe (as shown in Figure 1). Moving the camera towards or away from the globe will lead to a smaller or greater portion of the globe being visible on the display. The mountain nearest to the cross-hair in the centre of the screen is highlighted as shown in Figure 3 (left). In combination with keystrokes (joystick button click) on the selected feature, additional information – elevation, date and name of the first ascent, etc. – are displayed as shown in Figure 3 (right). We believe that this playful way of interaction can help to teach students a more realistic perspective about the world than using books in combination with maps. However, de did not run formal user studies yet to document possible pedagogical effects.

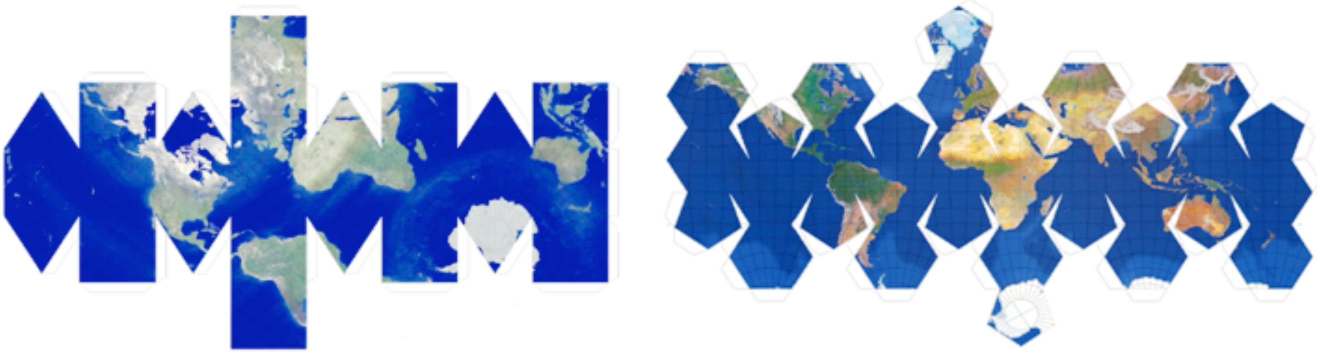

Figure 4: Gnomonic projection on a rhombicuboctahedron, poles centered on opposite triangular faces. Original satellite imagery: AVHRR Pathfinder, by Dave Pape (resumbrae.com) (left). Gnomonic projection on a truncated icosahedron, poles on pentagonal faces, texture-mapped (right) both images. ©2004 by Furuti.

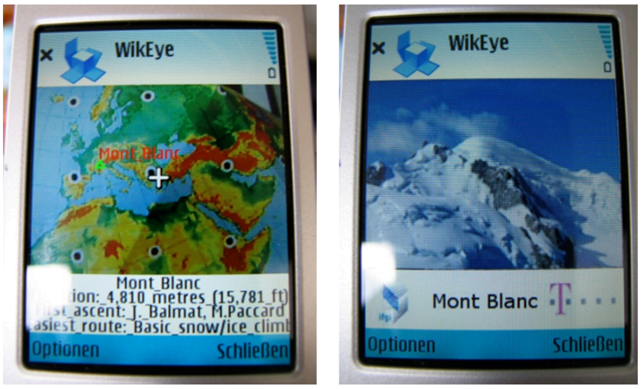

Figure 3: User is exploring the highest summits of the world and acquiring more information about *Mont Blanc* in France.

4. IMPLEMENTATION

The paper globe application is implemented for Nokia mobile camera phones (S60 3rd edition). We use the tracking toolkit by Rohs [13] to track the mobile device in real time relative to the paper globe (6 DoF). In the original dot grid tracking the edge classification implies that the camera cannot be rotated by more than 45° clockwise or counterclockwise from the upright direction. We dropped this limitation by storing the map correlation patches $\pm 90°$ and 180° rotated in addition to upright. In addition, only a window of 5×5 patches around the previous position is considered for correlation in order to increase performance. The actual prototype is implemented on a Nokia N95 mobile phone. For building the paper globe we used paper globes templates from Furuti [7] and integrated them in our MapGridTracking Framework, which allows for the easy creation of interactive paper documents that can be tracked using the grid-dot technique. We intend to make this framework available soon. A video of the application can be found here: `http://www.youtube.com/watch?v=pTt6qNHmCFw`.

5. TECHNICAL CHALLENGES

The original dot–grid technique was designed for flat 2D surfaces. The platonic solids consist of multiple planar surfaces, which can be tracked individually. However, tracking beyond a segment boundary becomes problematic when individual map patches are distorted too much. Another factor is the widely varying illumination conditions that are caused by different orientations between adjacent segments. We are currently working on solving these issues and developing a method that reliably works on a multi-faceted 3D object. Such a method should then also work with other solids like the ones shown in Figure 4 or in Figure 5. A system that tracks the pose of a sphere relative to a fixed camera is presented in [5]. However, the sphere only contains marker points and does not show any useful information to the user. Beyond the tracking system itself we are interested in novel visualization techniques that support navigation on the sphere or that show overlays that are adapted to the spherical nature of the surface. An example of the former would be an extension of the well-known Halo technique to spheres (note that the halo of the off-screen object could be shown in any direction on the sphere). An example for the latter would be curved lines showing flight routes between continents. These could be shown as 3D overlays that adapt to the viewing direction (relative pose of mobile device to sphere).

6. CONCLUSIONS

In this paper we showed how a paper globe can be augmented by additional information using the magic lens approach. There are endless possibilities in mapping "global" information to locations on the earth. In addition to geographic information, all kinds of statistical data about countries, economies, flows of trade, flight routes, the weather, the environment, news events, etc., can be visualized on a global scale. This versatility makes our approach very attractive for educational scenarios. The system we propose engages both hands at once and thus allows for rich tangible input and "projects" the augmented information onto the real shape of the world. We made a first step towards allowing magic lens interaction with complex 3D objects and showed a few possible application scenarios. Of course paper

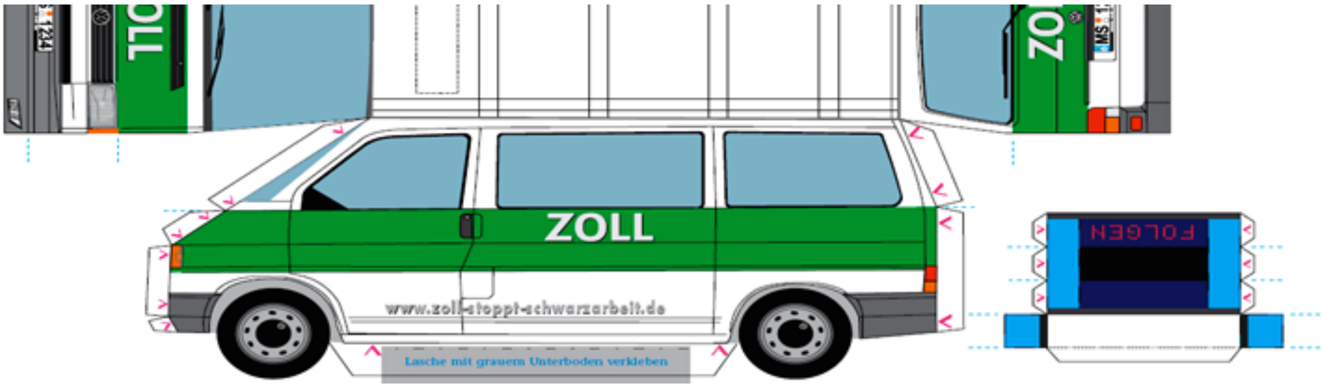

Figure 5: Cutout of a German customs special car. ©2005 Bundesministerium der Finanzen.

globes are just one example for 3D objects. We think that other many other kinds of objects have a large potential for the use in educational and other scenarios. We are planning to bring the paper globe interaction into schools and run user tests with primary school kids in cooperation with the Gi@School initiative `http://www.gi-at-school.de/`.

7. ACKNOWLEDGMENTS

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