Cubes, shadows and comic strips - a.k.a. Interfaces, metaphors and maps?

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EXTENDED ABSTRACT

This paper explores the scope of three specific geovisualisation ideas.

a) The Tangible Augmented Street Map (TASM): the use of a paper cube as a tangible augmented reality (AR) interface to a "book" of digital street maps.

b) A Shadow Metaphor for Multi-temporal viewsheds: the use of differing transparencies to convey the consecutive viewsheds of points along a route.

c) "Cartoography": regarding the map as a caricature or cartoon of real world features; how far can we take this analogy? The map as comic strip is explored here.

These potential areas of research encompass much of the current geovisualisation agenda, as introduced by MacEachren and Kraak (2001). These include interfaces (augmented reality), cognition (use of metaphors, and the assessment of interfaces) and representation (maps as caricatures, viewsheds).

***Keywords and phrases*:** geovisualisation, tangible augmented reality, street maps, viewsheds, caricature, generalisation

1. USING A CUBE AS AN AUGMENTED REALITY INTERFACE TO A DIGITAL STREET MAP

1.1 Developing a Tangible Augmented Street Map (TASM)

Imagine that you are walking around a city for the first time. You have a street map to help you navigate around this unfamiliar environment. The map you have in front of you is actually a "complicated communication mechanism" (Lobben, 2004). For effective navigation, we would have to efficiently perform a mental transformation from the 2D information contained on paper to a 3D impression in our heads (Crampton, 1992), which we then relate to the immediate environment.

The first aim of this proposed project is to develop a *Tangible Augmented Street Map (TASM)*, a portable and intuitive *3D digital map*, theoretically reducing the amount of mental processing needed to effectively read and use a street map. The method to be used is *tangible Augmented Reality (AR)*, the superimposition of digitally generated graphics on top of real world objects in order to enhance a user's experience (using a digital camera, head mounted display fitting directly over the eyes, and a palmtop as computer processing power). The combined use of 'wearable computing' and AR in the spatial domain has been with us since the early 1990's, a GPS-based outdoor system providing navigational audio help for the visually impaired (Loomis, 1993; cited in Clarke, 2004). For a comprehensive overview of mobile AR / GIS systems (mostly involving the registration of graphics with real world *in situ* objects) see Clarke (2004). As an example of a current project, use of augmented reality and mobile devices is also being used in the lbs4all project in the UK, providing Location Based Services for visually impaired and blind people (lbs4all, 2004).

As an example of tangible AR, the type of AR used by TASM, the Magic Book application (Billinghurst et al, 2001) employs the recognition of patterns from the pages of a children's book to generate virtual 3D images that appear to rest on the current page of the book. Figure 1 shows a similar set-up.

Figure 1: *A tangible Augmented Reality set-up, using a book as the tangible object (Source: Mark Billinghurst, HitLabNZ, University of Canterbury, NZ)*

The Augmented Reality software ARToolKit (also used for Magic Book) will be adapted to build the TASM. In a typical tangible AR set-up, the effect experienced by the user is achieved with a Head Mounted Device (HMD), through which the real environment can be seen, but with graphics projected onto the inner surface of what is in effect a pair of customised goggles. The HMD also contains a digital camera, which will pass images of the real environment to a palmtop computer. This computer will use ARToolKit to ascertain whether a pattern contained in an external image matches a stored pattern; if so the palmtop will display a digital object (in this case the map) in the HMD.

The proposed outdoor street map scenario will employ a small cube as the interface to the 3D digital map (the digitised street map draped on an elevation surface). Relating to the example above, the cube assumes the role of the book, with the six faces corresponding to book pages. Apart from using tangible AR to represent spatial data, the novelty of using the cube to navigate digital "pages" of a composite street map lies in:

- the simple rotation of the cube across an edge to pan to an adjacent "page" (more intuitive than an actual street map book) and the ability to keep on rotating in the same direction, generating a different "page" each time (so that a pattern need not always be linked to the same "page")
- the rotation of a face to align the 3D street map with the surrounding reality (reducing the amount of cognitive processing needed to navigate).

Changes will be made to ARToolKit and the hardware set-up, so that representative patterns will be mounted on each face of a cube, with a portion of digital map initially linked to each pattern, to be displayed in the HMD when the pattern is recognised via the camera-palmtop set-up. In this way, data for an entire city can be accessed through the cube. From a start map (the city centre), the user may rotate the cube to the right so that the adjacent face in that direction is shown. Consequently, the map immediately to the west of the start map is displayed. To enable this effect, the ARToolKit will be adapted so that each cube face pattern is linked to the patterns adjacent to it (to the N, S, E and W of it) so that when the cube is rotated the correct 3D map is displayed. Building data will be used to generate representative 3D buildings on the digital map. Finally, elevation data will be used to give the street map geometry a 3D base to be displayed upon, able to be more readily linked with reality.

1.2 Cognitive Assessment

The second aim of this research is to compare the developed TASM with a conventional street map book, testing for affinity with *cognitive* processes. Both qualitative (*cognitive walkthrough*, *think-aloud protocol* to gather data and *emergent themes analysis* for the analysis) and quantitative (task completion times, correctness of navigation) tests will be employed in this phase.

A series of navigation tasks will be set, and a set of users will be assessed both qualitatively and quantitatively:

a) Qualitative
   i. *Cognitive Walkthrough* – a systematic way of reasoning through the interactions with the system
   ii. *Think-Aloud Protocol* (Hackos and Redish, 1998) – having familiarised themselves with the system, users voice aloud their thoughts whilst undergoing set navigation tasks. Followed by an interview consisting of open and closed questions about the tasks performed
   iii. *Emergent Themes Analysis* - "an iterative distillation process" developed to help extract design insights by identifying themes and decision strategies from voluminous interview data from real-time operational

environments (Wong and Blandford, 2002). In this way, the broad usability and cognitive themes will be extracted from the raw data

b) Quantitative
   i. *Task Completion Times* – an indication of navigation efficiency
   ii. *Correctness of Navigation* – proportion of the navigation tasks that the participant performs correctly

2.0 USING SHADOWS AS A METAPHOR FOR MULTITEMPORAL VIEWSHEDS

When an object casts a shadow as a result of light being shined directly upon it, it is commonly observed that the boundaries of the shadow are diffuse. Figure 2a shows this effect, with the area of full shadow (umbra) and the diffuse boundary as an area of partial shadow (penumbra), forming a gradient from full shadow to light (Mischler, 2003).

The shadow effect can be employed as a metaphor for a viewshed, an approximation of the areas that can be seen on a landscape from a given viewpoint, and a common GIS operation. In this case the metaphor links our knowledge of some computer-based phenomenon (the viewshed) to something with which we already have familiarity (shadows) (Petersen, 1995). "Shadow metaphors" have been used in other contexts, such as the use of shadow as a text container on 3D visualisations, seeking to make obvious the text-to-object connection and minimize occlusion of 3D objects (Chigona, 2003).

At the simplest level, a single viewshed can be represented as areas of light, with full shadow being attributed to the terrain not seen. Using a similarly limited take on the shadow metaphor, the penumbra regions are not mapped (refer to Figure 2b).

If a series of viewsheds are calculated from points along a route, then a dataset of *multi-temporal* viewsheds is produced (Wheatley et al [1995] refer to 'cumulative viewsheds'- alternatively 'multiple viewsheds' - Ruggles et al [1994], deriving the summed viewshed of several archaeological monuments at the same time). The full use of the shadow metaphor would represent several consecutive viewsheds in the following way. Assuming that there was a "current" viewpoint, to be represented by light / no shadow, the stages along the route before and after this point could be represented in increasingly darker shades of grey or decreasing transparency. This gradation is represented by the penumbra part of the metaphor (a nominal number of stages before and after the current point would have to be chosen, beyond which full shadow is depicted).

In Figure 3 the current viewshed (with the middle point as viewpoint) is schematically represented by region 1, the adjacent stages on the route (before and after the middle point) are shown as an amalgamated viewshed (region 2), and so on. There is a hierarchy of importance, starting with the current viewshed as the most important, and this is reflected in the gradient into full shadow and the superimposition of the current viewshed on adjacent viewsheds (this effect is propagated forwards and backwards along the route). Variations on this model include separating out the forward and backward elements of the route, perhaps emphasising the route yet to be travelled along with lighter shades of grey or more transparency.

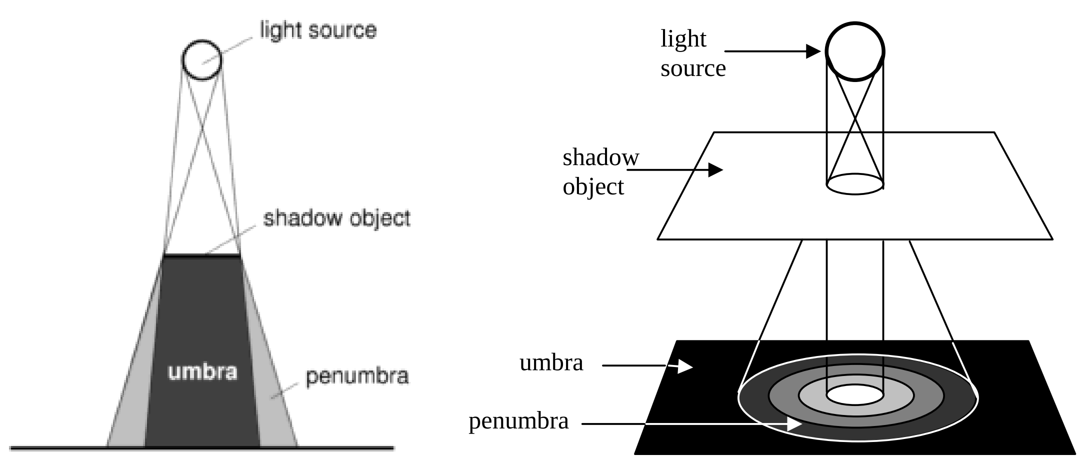

Figure 2: *a) the casting of a shadow, producing umbra and penumbra (from Mischler, 2003). b) the same situation amended for the shadow metaphor for multitemporal viewsheds.*

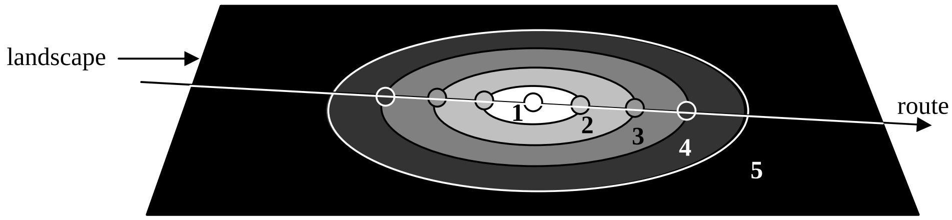

Figure 3: *The multitemporal viewshed on the simulated terrain. Seven consecutive points along a route are shown, with the current point (point 4) producing viewshed 1, and points 3 and 5 (before and after the current point) producing an amalgamated viewshed 2, and so on. In shadow metaphor terms, viewsheds 1-4 form the penumbra; unseen terrain from this route sequence forms the umbra.*

3.0 THE MAP AS COMIC STRIP

Jones (1997) has said “a map is … not simply a collection of facts, rather it is a caricature of these facts”. In making this statement he was referring to the cartographic process of generalisation, which is essential in making the map legible and therefore conveying its message to the user. Under the generalisation umbrella are techniques such as omission (choosing real world objects that are not important to the message of the map and simply choosing not to display them), exaggeration (e.g. enlarging small yet important features so that the map user can see them), line reduction (reducing the complexity of a line to match a given map scale so that it is legible yet still retains the character of the feature the line is supposed to represent) and enhancement (altering a map element so that it more represents its real world counterpart – adding smooth curves to a river feature is an example).

Figure 4: *Shaded elevation model of a 60-square-mile area near Austin, Texas (extract from Sanborn, 2004). What are your first impressions about this map?*

The parallels between maps and caricatures (and by extension cartoons and comic strips) are clear; they both use these techniques – and more – of generalisation. However, the same technique can be used for a different purpose. For example, in caricatures of people, exaggeration is used to make distinguishing features of that person more prominent, therefore making the illustration more recognisable. In this way it is more similar to cartographic enhancement than cartographic exaggeration, which is chiefly used to make a map feature visible.

In this section we explore this link between maps and comic strips in particular. It could be argued that this particular juxtaposition introduces scope for representing spatiotemporal data in particular, adhering to the snapshot model (Langran, 1992), for what is a comic strip if not a series of snapshots. Questions that could be asked include:

- now that a generalisation link has been made from map making to caricature drawing, what representation lessons do caricatures / cartoons / comic strips have to offer cartography? (Putting a bit of "art" back into cartography?)
- for example, does Figure 4 seem cartoon-like to you?

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