Geo-contextualised visualisation for teaching and learning in the field

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Introduction

Teaching students themes related to geomorphological processes and landforms requires the integration of knowledge about process working at different scales, the particular processes themselves varying at different times to form unique landscapes. While the generality of individual processes may be understood, unpacking the particular history behind a specific view requires considerable spatial aptitude and imagination of the students, as the teaching vignettes of Figure 1 identify. Geo-contextualised visualisation forms one potential means of tackling this subject-specific communication issue, working alongside more traditional pedagogic approaches. This paper firstly discusses a geo-contextualised mobile PDA application used for teaching students geomorphology, and outlines further development work underway that will allow the progression of these mobile teaching and learning resources within an immersive AR system using a head-mounted display (HMD).

Teaching vignette A

Imagine that you are in the field with students, overlooking a valley that has been shaped by ice glaciers over 15,000 years ago, for example in the Lake District, Cumbria, UK. Having given the students time to explore the landscape and think about its origins, consider how helpful it would be if you could assist the students to visualise how the landscape before them has changed over time using a computer-generated virtual model of the glacier superimposed on the real landscape they are observing in the field.

Teaching vignette B

In the company of 2nd year BSc geography students, you are overlooking a set of river terraces in a landscape shaped by tectonic uplift and consequent river capture, in a zone where there has been maritime incursion twice over the past 6 million years. Unpacking the detailed sequence of processes and landform causality in the area has been the subject of many PhDs. You have 1.5 hours over which to encourage the students to explore landscape and consider how it might have been formed. Could a geo-contextualised landscape evolution model assist you in helping the students unpack the landscape in such a way that they leave the site having a good idea of the principle geographical processes shaping the view before them?

Figure 1 Examples of complex space-time communication issues in a geomorphological teaching context

Method

It has been suggested that AR seems to be an ideal candidate in almost any working context to deliver accurate, useful and up-to-date information (Regenbrecht 2007). In a geographical setting, teaching landscape process in a field context, 'useful' implies the provision of timely geo-contextualised view-related information in a manner that blends and supports traditional pedagogies, using methods that are practical with large student groups and cost-effective. For reasons related both to registration and graphics processing requirements in the context of visualising landscape evolution, and financial cost, we report here on a stepped approach (Figure 2) in which we propose a move from 'light AR' using PDAs in the field to a more immersive approach to visualisation landscape change that has realistic potential in a teaching context in the near future.

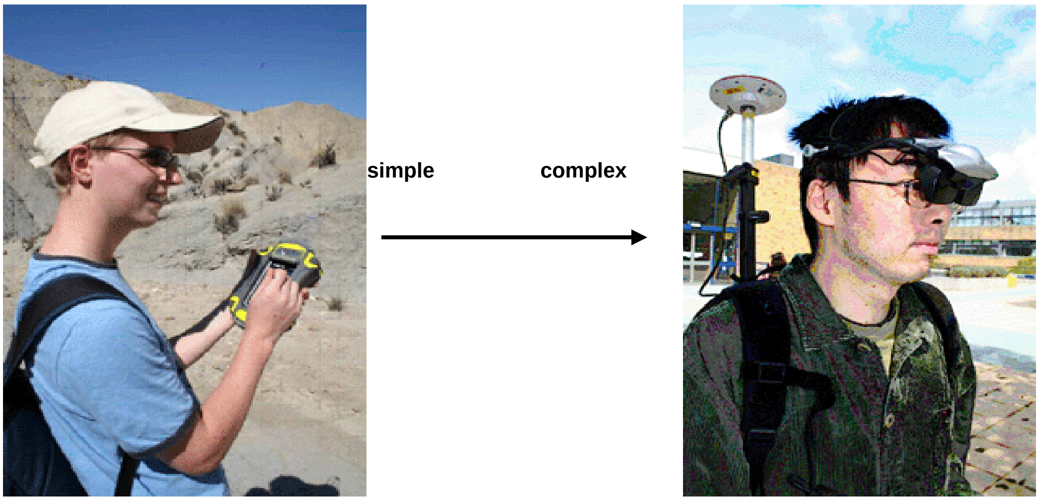


Figure2. Geo-contextualised augmented reality: From simpler GPS-enabled PDA teaching solutions to more complex immersive GPS-inertial tracker developments using laptops & headsets

Geo-contextualised PDA visualisation for learning in physical geography

Landscape visualisation has been used to enhance physical geography fieldwork based in Cumbria, North West England for a number of years. A four day residential year 1 field course included a project to engage students in the landscape history of the area they were staying in, using desktop visualisation of a terrain model to prepare 3D views in the field centre to be used to augment their view of the landscape out in the field. Digital data used included a 5m RADAR-derived Digital Surface Model, aerial photography drapes, geology drapes, and a 3D model reconstructing the retreating glacier in the valley. A general aim of the exercise was to allow students to assess the use of digital terrain modelling and landscape visualisation in recreating real landscapes they could observe at first hand and to engage them in past landscape processes such as glaciation (Figure 3).

In recent years this idea has been implemented using PDAs (Priestnall & Polmear, 2006) where several waypoint locations are chosen and 3D views prepared in the field centre before going out into the field. In the absence of mobile computing power to drive real-time landscape visualisation in the field, pre-defining viewpoints were used. Although relatively crude, this did require the students to develop a frame of reference for navigating the area to find these views and to understand their landscape context which is often acknowledged as an important aspect of fieldwork (Ishikawa & Kastens, 2005). This technique displayed few of the characteristics of a true Augmented Reality system as described by Piekarski (2006) however it did allow users to augment their view of the real scene with spatially-referenced computer generated images. The lack of automated registration between PDA screen and real scene distinguished this approach from many handheld Augmented Reality approaches such as those described by Wagner& Schmalstieg (2003) where the recognition of patterns placed in the real scene is required to generate the virtual content. Having said this, the ability to reconcile a handheld virtual scene with the real landscape is a common issue faced by recreational phone-based navigation packages such as Viewranger (Augmentra Ltd, 2006) and also studies focussing on spatial awareness in the context of location-based services (Krüger et al 2004).

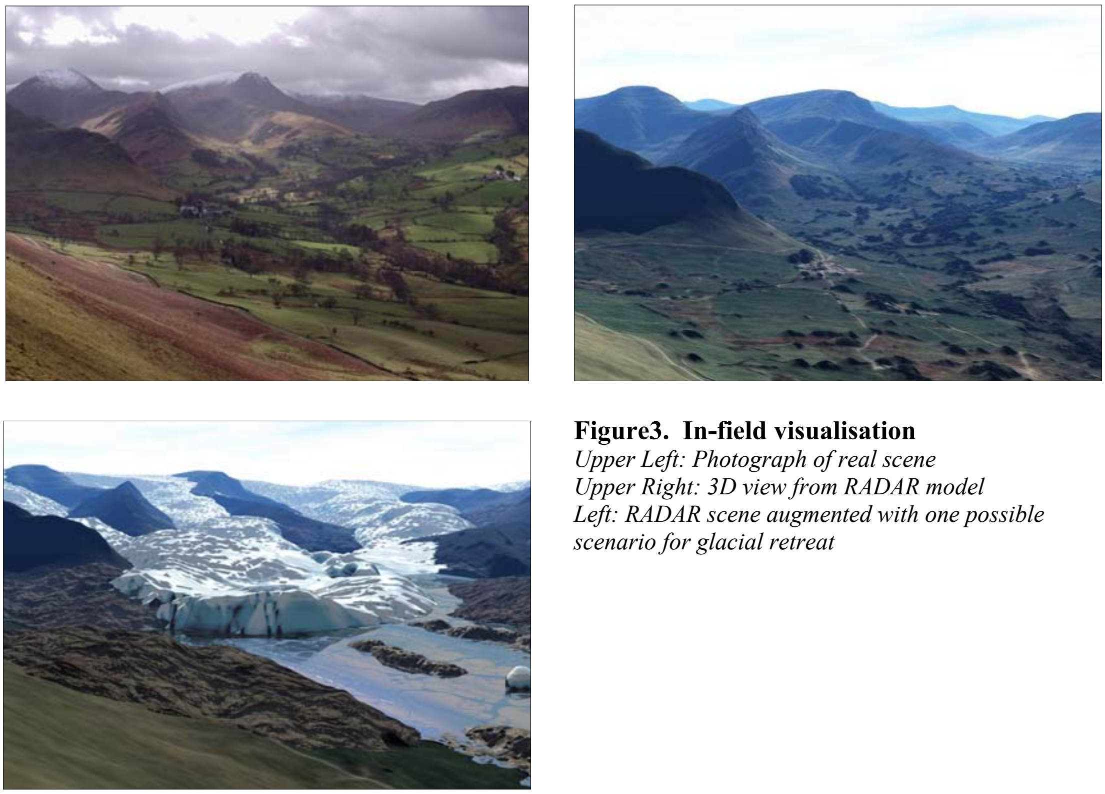


Figure3. In-field visualisation
Upper Left: Photograph of real scene
Upper Right: 3D view from RADAR model
Left: RADAR scene augmented with one possible scenario for glacial retreat

Figure 4 illustrates the stages of the PDA-based field visualisation application. The first stage is to pre-generate images to be used, using the desktop 3D modelling package Bryce, immediately before going out into the field. Students select three viewpoints of interest within the study area. For each viewpoint three views are generated: the 'current' photorealistic virtual model, the 'hidden' landscape represented by the geology map draped over the surface, and the 'past' landscape including the model of retreating glacial ice. The images and details of their viewpoint locations and orientations are uploaded to a GPS-enabled PDA and form a series of waypoint symbols over a map in the navigation screen. In the second stage, out in the field, students use onscreen assistance (current location, distance and direction to the next site), to navigate to the viewpoints in order. As each viewpoint is approached, an image viewer screen is automatically triggered allowing students to compare their computer generated current, past and hidden landscape views with what they can see in the real world. The field sketch function allows them to annotate their images for use in reports that evening. Context-aware audio commentary is also delivered, providing more information about the surrounding landscape. This is based on pre-generated visibility maps indicating the landscape features visible from any given point, in a similar way to Mackaness and Bartie (2005) implemented for an urban environment.

The usability of the application was assessed in part through the use of student video diaries which revealed some subtleties of usage which would not normally be apparent. Battery life and the audibility of commentaries did not prove to be problems and the application generally worked well to engage students in both digital terrain modelling and landscape history. There were problems however relating to screen visibility when facing the sun, the stability of the Bluetooth GPS connectivity, and occasionally the inability to access the chosen viewpoint as placed in the virtual model.

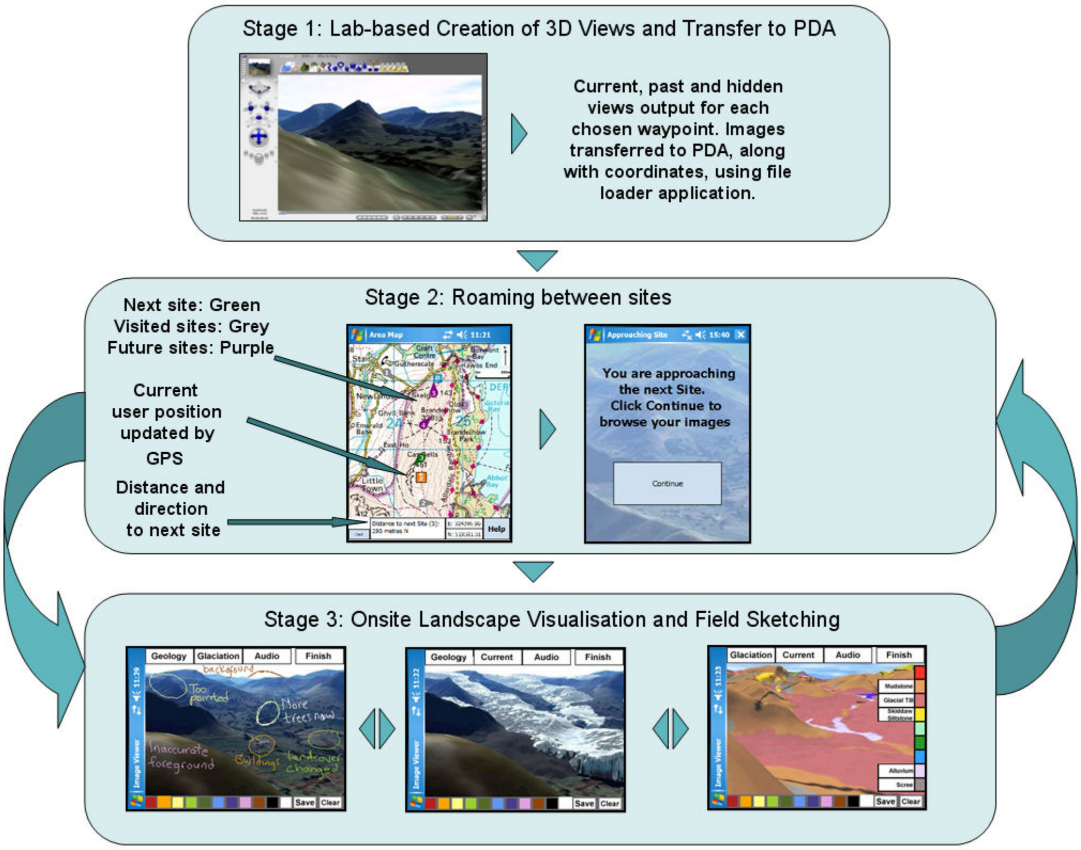


Figure 4: The PDA-based Field Visualisation Application (Kruger et al., 2004)

Geo-contextualised immersive visualisation for learning in physical geography

A logical extension to the fixed-view PDA approach of Section 2.1 is to allow similar views to be generated in the field rather then pre-specify a series of waypoints. Such a facility would allow greater flexibility when used by multiple students at one viewpoint, and offer a wider range of options for field stops. We describe here the hardware and software configuration for such a system that is currently undergoing technical testing, that is being designed firstly to work both on tablet PCs with digital compasses in an analogous manner to the PDA approach and secondly outputting views through an immersive headset linked both to GPS and motion sensors in 3 degrees of freedom as spatial inputs.

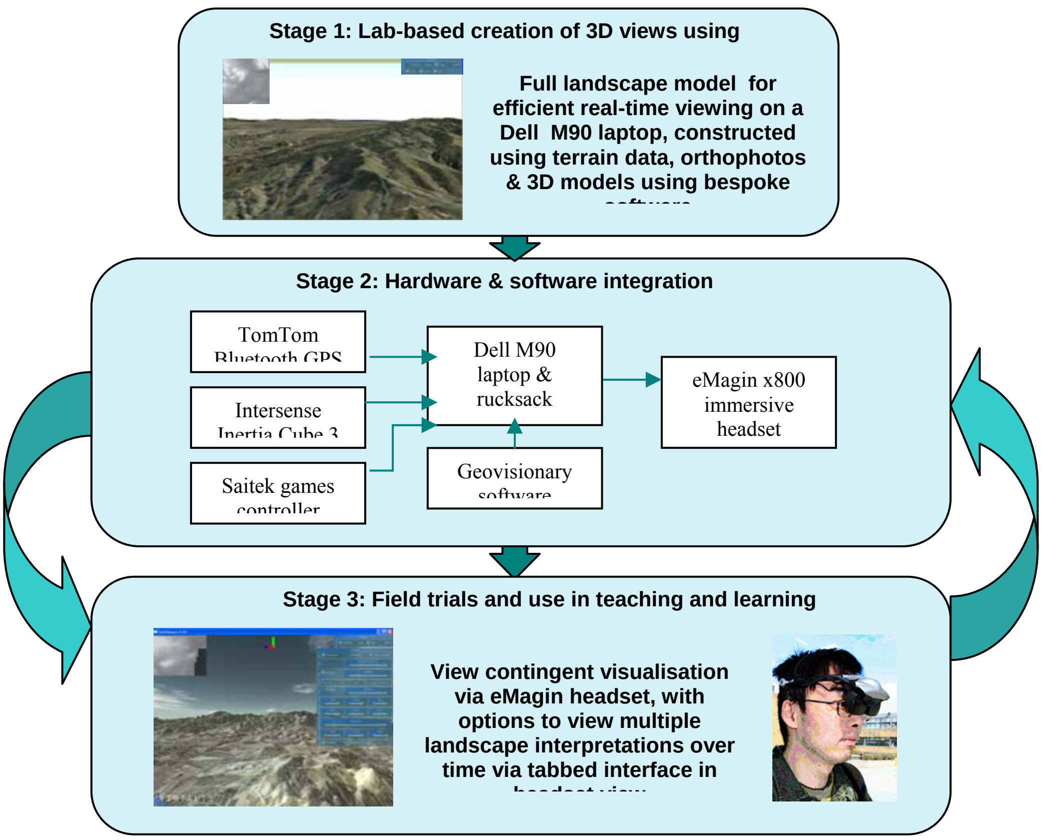
Hardware

Our immersive AR system is composed of an Intersense Cube 3 tracking system, a Bluetooth GPS, a head-mounted opaque display (HMD), a laptop computer and a user-driven input capability in the form of a games controller (Figure 5)

Scaling up to real-time surface visualisation requires mainstream and graphics processing capability, beyond that capable of current PDAs or micro-PCs. In our case, we use the dual-processor Dell M90 with inbuilt NVIDIA Quadro graphics card and 512MB dedicated graphics memory.

This system uses an eMagin x800 headset to provide a broader immersive framework for landscape scale observation than that of a PDA, albeit with a more restricted field of view that the human vision system. Wider contextualisation is important given the scale of processes operating over basin ranges, for example in relation to river capture and tectonic uplift. However, in regard to head tracking, one of the big issues in regard to augmented reality and GIS is that of registration. Typically, a GPS unit, antenna and head tracking mechanism all combine to provide such information but a number of accuracy issues surround this process and despite a considerable volume of work on the subject (e.g. Avery et al., 2005; Kealy and Scott-Young, 2006) the registration issue remains a challenging research subject. Registration accuracies matter, particularly in the context of landscape surface matching, where a student using an AR system must be able to use a system for a reasonable length of time without succumbing to disorientation or motion sickness caused by miss-registration between augmented and actual geographic realities.

Figure5. *Augmented reality system for field teaching based on Geovisionary software*



Thus, at this point in time, we consider that "true" Augmented Reality as described by Piekarski (2006) is both technically and financially prohibitive in the context of fieldwork where several groups of students often undertake the same exercise at the same time. However, a compromise scenario exists in the form of geo-contextualised real-time terrain models offered to the user visually to the user via either through a handheld device or a head-mounted display which *replace* the central portion of the user's field of vision. The latter model is similar to the idea of the 'Augurscope' (Schnädelbach *et al*, 2002) where portable computer, GPS and an Inertial Navigation System (INS) were combined to give offer a window into a virtual historical scene. Using this model a solution using a simpler and thus cheaper headset designed for the mass-market gaming, such as the eMagin x800 becomes financially feasible; slight miss-registration between images are less noticeable since actual and augmented realities are not overlain digitally but rather displayed at different times but for the same actual view.

Software

The software driving the augmented reality system is based on Virtalis's Geovisionary landscape rendering software, adapted by the University of Leicester (working with Virtalis) to take positional data from a GPS source that is then modified to orientate the view within the headset to that of the user with the assistance of the inertial orientation motion tracking device. The user is able to offset or adjust the position used for them within the renderer to give the best visual image, for example to take into account their particular height and particularly to correct for GPS height value given the use of a Sirf3 Bluetooth GPS within this system. Thus the Geovisionary software allows a user to orientate their model view as seen through the headset to that actually in front of them.

Terrain and orthophoto drapes and clusters of 3D objects are considered as "resources" within the Geovisionary software. These are displayed on the headset as a list; the user can toggle pre-specified individual objects, or groups of objects, on and off using the games controller as input device. Each of the resources has a file associated with it which contains text based information which can be displayed within the headset view as a label associated with an object. The application will allow the user to switch between 3-4 four image drapes; in a geomorphological teaching context, these could for example represent past landscapes at preset time periods. In other contexts, such resources could include historical mapping or alternative cartographic perspectives.

Conclusion

The PDA approach demonstrates that students appreciate the power of geo-contextualised visualisation to support their understanding of landscape processes, The immersive development of this core idea moves towards an intermediate AR solution that is practical and relatively cost effective, intended to support student spatial literacy. In addition to the technical aspects of this work we focus upon here, the methods presented will need to be evaluated to examine in what ways they can best be used to help students explore the spatial relationships between past and present landscape features and even the geology under their feet at that point to enhance understanding of a particular geographical system. Quite how best to blend such visualisations within the traditional fieldwork experience in a sensitive manner, such that students remain encouraged to reflect and think for themselves and other staff are comfortable adopting technologies in the field, remain the subjects of further challenge. We also acknowledge that the widespread adoption of landscape-view AR is still in its infancy, both on technical grounds and cost. The latter issue is particularly important in a teaching context, where multiple individual devices are needed. In this sense, this work can be considered “horizon watching” in teaching and learning terms; however, gaming headsets are rapidly reducing in price and high street game-boxes are converging in graphics power on professional VR installations such that the future for AR in an educational context appears inviting.

Acknowledgements

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