AUGMENTED REALITY FOR ASSESSING FUTURE LANDSCAPES

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Abstract: *A research project is currently underway that is investigating the applicability of augmented reality (AR) for investigating future landscape scenarios and communicating modelled outputs. Currently, landscape scenarios are generated using complex, integrated models requiring substantial input from a range of professionals. The result of this is that the interpretation of the resulting scenarios is typically done by the modeller, resulting in skepticism amongst land managers. The concept being developed, and subsequently evaluated by this project is to make the scenarios more accessible to land mangers by disseminating the results through an interactive augmented reality system. It is envisaged that the system will comprise a processing engine, multiple head-mounted displays for visualization of the scenarios and a single input device to interact with the system. All of the components will be wirelessly connected enabling freedom to move around. This paper provides an outline of the theoretical underpinning of the 'proof-of-concept' product design. The paper describes a proposed scenario and outlines the architecture of the prototype system that will accommodate the scenario.*

INTRODUCTION

Many government departments are undertaking projects looking at the trade-offs between social, economic and environmental factors. This approach, recognised across Australia as Integrated Catchment Management (ICM) (Murray-Darling Basin Commission, 2004; The State of Victoria, 1999), is essential to the long-term sustainability of a region (Bryan, 2003; The State of Victoria, DSE Annual Report 2004, 2004).

Most natural resource projects are now heavily reliant on complex computer-based models that generate large numbers of scenarios. Although these integrated modelling frameworks are robust, outputs from many of these modelling frameworks have been disseminated using static, thematic maps and require further explanation by modelling experts to be understood by stakeholders, resulting in scepticism about the land practice changes recommended.

Methods of visualizing model outputs, and particularly the applicability of utilising Augmented Reality (AR) as an interface between complex modelled data and stakeholders, is the focus of this research. The research is focussing on the human-computer interface and the best methods of communicating complex scientific outputs in AR environments. In order to assess the various interfaces a realistic and useable AR system will need to be built.

Typical Mobile Augmented Reality Systems (MARS), including ARQuake (Piekarski and Thomas, 2003) and the 'Touring Machine' (Feiner et al., 1997), are designed for a single user and require all the necessary hardware to be carried by the person. The proposed system described below is different as it provides an environment in which several users can see the visualization. Each user carries a Head-Mounted Display (HMD) along with position and orientation sensors. One user has access to a Personal Digital Assistant (PDA) allowing them to interact with and interrogate the data.

The first section of this paper paints a theoretical scenario about how such a system would operate. This has been done so that the concepts developed later in the paper (theoretically) can be linked to the proposed practical application of the proof-of-concept prototype, once built, tested, refined and delivered. The second section describes the proposed AR system. The third, and final section of the paper provides information about the current status of the research and development associated with the AR system, and provides information about future development plans.

THE SCENARIO

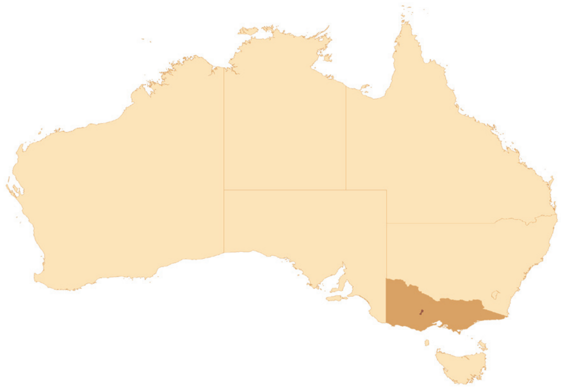

Figure 1: Location of Bet Bet Catchment within Australia

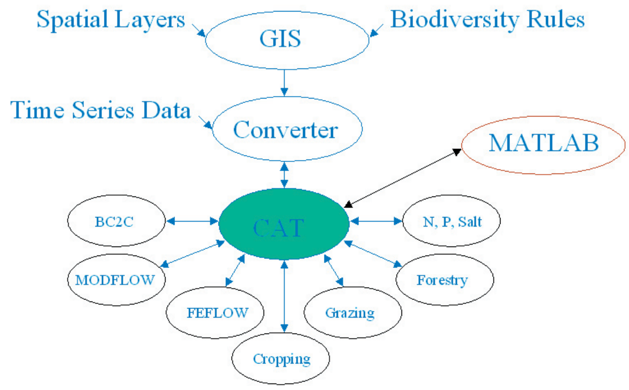

Figure 2: Generalised CAT modelling framework

A model demonstrating the interaction between rainfall, landuse and groundwater levels has been applied to the Bet Bet Catchment in central Victoria, Australia (Figure 1). This model, known as the Catchment Assessment Tool (CAT), integrates several existing models into a robust framework (Figure 2). The CAT relies on many spatial layers, including current and modelled landuse, Digital Elevation Models (DEM), proximity to weather stations, groundwater bore locations and extents of groundwater aquifers. These spatial layers are ‘informed’ by large volumes of temporal data relating to groundwater depth and climate (typically daily). Historic data is used to calibrate the groundwater model (MODFLOW). The calibrated model is audited against a set of control bores not used in the calibration. This calibrated groundwater model forms the basis for the CAT model.

The CAT has been applied across several catchments to determine whether land practice change suggested by policy will have the presumed effect. For each catchment, thousands of iterations (on a user specified time step ranging from daily) are carried out to determine the future impact of landscape change on salinity and water quality.

After many months of refining and checking the model the modellers need to show their findings to all interested stakeholders. The stakeholders involved in this project include people from;

- The Department of Sustainability and Environment (DSE) – Victoria’s leading government agency responsible for promoting and managing the sustainability of the natural and built environment (The State of Victoria, DSE Annual Report 2004, 2004)
- The Department of Primary Industries (DPI) – responsible for the sustainable development of primary industries through strong economic activity, high quality natural resource base for the long term and resilient industries and communities (The State of Victoria, DPI Annual Report 2003-2004, 2004)
- Catchment Management Authorities (CMA) – responsible for implementing the Catchment Management Framework, which involves the sustainable use and management of land and water resources at a catchment level (The State of Victoria, 2003)
- Landholders – People responsible for managing the land in accordance with the above policies for future generations.

In the past outputs from the model would be shown through the use of a Microsoft® PowerPoint presentation comprised of static thematic maps, along with explanatory text, graphs (Figure 3) and complicated mathematical equations justifying the results. Although effective with scientists, this format was found to be less beneficial for landholders and catchment managers whose interest is focussed on the impact of the scenarios on their current land management practices.

This time the results are being shown through an Augmented Reality (AR) system, with the meeting being organised at a property in the catchment where the modelling was undertaken. All the stakeholders who have had input into the development of the model will be in attendance.

The meeting is held outdoors in a paddock that has a good outlook across the catchment. It begins with a brief introduction by a CMA representative who describes the general topography of the catchment and the main issues

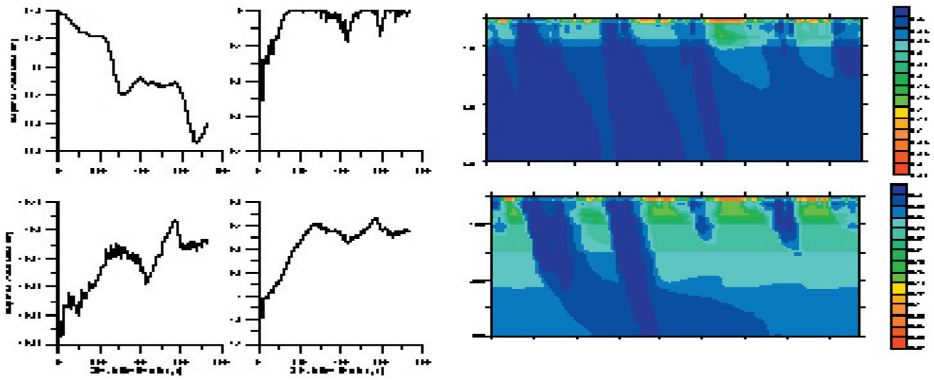

Figure 3: Example output from CAT shown to stakeholders

currently affecting the catchment. An explanation of the AR system to be used to disseminate the results at today's presentation is given by the system developer.

Each stakeholder present at the meeting is provided with the chance to interact with the model and its outputs through the PDA interface. This 'hands-on' approach, in the 'real world' provides the user with an experience not possible in a meeting room. This interactive approach allows the users to visualize the interactions and dependencies amongst the various spatial layers. The other advantage of the system is its ability to store the user-generated scenarios allowing catchment managers and modellers to gain an understanding of how the landholders see their area in the future. These scenarios can be modelled at a finer resolution to determine whether they provide a plausible solution.

EXISTING AUGMENTED REALITY SYSTEMS

A number of Mobile Augmented Reality Systems (MARS) have been created for a variety of different purposes. These include ARQuake and Touring machine systems.

ARQuake

The ARQuake project has taken the familiar first-person shoot-em game and translated it into an mobile Augmented Reality environment (Piekarski and Thomas, 2003). This system relies on the user carrying a lightweight, polycarbonate backpack upon which all the necessary components are attached. The system used one of two see-through Head-Mounted Display (HMD) units, which the manufacturers have now ceased production. A differential GPS is used to capture the users location to an accuracy of 50cm. A hybrid orientation sensor is used to determine the orientation of the users head. A small camera is used to capture video at 15fps. A Pentium-III 1.2GHz processor is used to process the various data and render the relevant graphics to the HMD. A 12V battery provides enough power for approximately 2 hours and the whole backpack weighs approximately 16 kilograms (Piekarski and Thomas, 2003).

The ARQuake system has been designed to emulate a first-person shoot-em game that requires only simple input from the user including moving around and pointing and shooting the enemy. This requires only a single input device. The system is relatively light and transportable but uses expensive hardware, including the GPS, which makes it the 'most expensive gaming system' available (Piekarski and Thomas, 2003).

Touring Machine

This system has been created to provide users with information relating to the buildings on a university campus (Feiner et al., 1997). The system was created in 1997 using commonly available hardware at the time. A typical computer (of the time) was the core of the system. This system made use of a hand-held computer for user input. Virtual I/O I-Glasses see-through HMD, with in-built orientation device, were used to view the augmented overlays. A differential GPS was used to collect location information. An early form of wireless networking was used to provide communication between all the components. Rechargeable NiCad batteries were used for power.

The advantage of this system is that it uses off-the-shelf hardware, but this results in heavier and bulkier components and a system that weighs 18+ kilograms. The weight and cost of the system would be substantially lower if components commonly available today were to be used. Another short-coming of the system is the loss of GPS signal when in close proximity to tall structures resulting in the system ceasing to update the HMD.

THE PROPOSED AUGMENTED REALITY SYSTEM

The proposed Mobile Augmented Reality System (MARS) will allow users to experience and explore the modelling results, in the real world, by allowing them to view abstract, thematic layers through Head-Mounted Displays (HMD).

The requirements for an AR system are (Azuma, 1997);

- Graphics/processing engine – used to generate the appropriate overlays. The complexity of the graphics is minimal due to the graphics only augmenting the reality that already exists. The processor also handles the input from the tracking device(s).
- Display – a head-mounted display (HMD) allows the generated graphics to be displayed to the user. The resolution of such devices can be relatively low as a result of the simple graphics being displayed and the closeness of the display to the eye.
- Tracking – complex tracking devices are required in order to ensure that the graphics are correctly registered with the real world environment. Tracking can be done in one of two ways depending on the application. In a manufacturing environment markers can be used to provide the necessary information. In a natural environment it is necessary to use a range of sensors to determine the users location and viewing direction/angle.

It is envisaged that the MARS will comprise a processing engine, multiple head-mounted displays for visualization of the scenarios and a single input device to interact with the system. All of the components will be wirelessly connected enabling freedom to move around. The five key components are described below and illustrated in Figure 4.

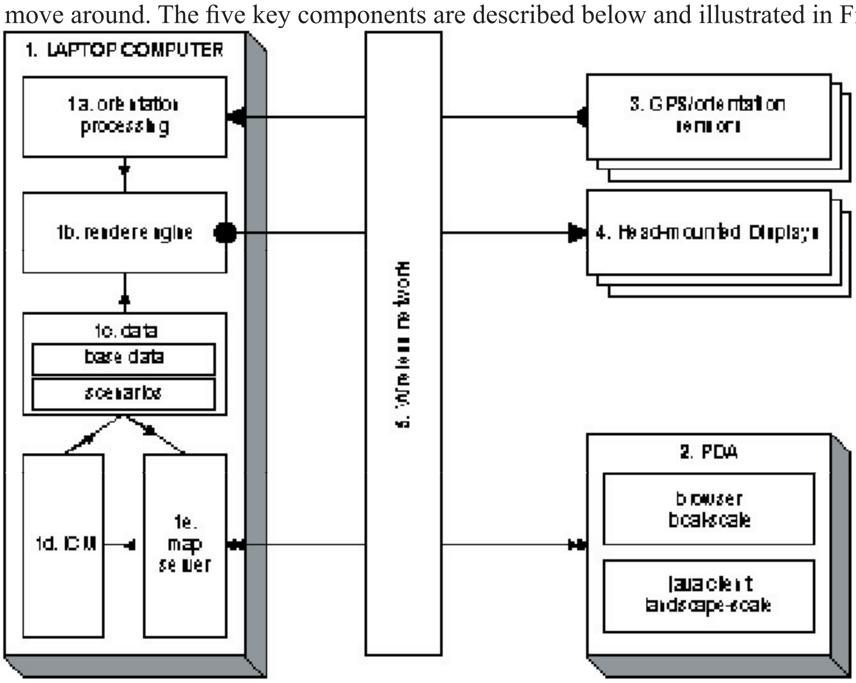

Figure 4: Diagram of proposed AR system

Laptop computer (1)

All the base data (1c) (including Digital Elevation Model (DEM), extents of groundwater aquifers, hydrological data, current land use, modelled land use scenarios and associated water use parameters) used to calibrate the model, along with the generated scenarios will be stored on the laptop. The laptop also provides the computational power to process the parameters being supplied by the GPS and orientation sensors (3) to accurately determine the position of each user to render the appropriate graphics. The system will be capable of generating graphics for several Head Mounted Displays (HMD) (4) simultaneously thereby creating a collaborative environment.

Personal Digital Assistant (PDA) (2)

The PDA will provide the means for the user to interact with the data and scenarios through a small client application. This client could be written in java or utilise a Web browser to interact with the data being served from the laptop to the PDA by means of the wireless network. The client will allow the user to interact with the spatial data library to determine what layer(s) to display in the HMD (4) and provide a means of generating further scenarios by interacting with the ICM (1d) through the map server (1e). The interface will be intuitive and guide the user through the process of altering data to generate different scenarios. One user has access to the PDA and ultimately controls what the other users are viewing in their HMD (3).

GPS and orientation sensors (3)

These sensors, carried by each user, provide accurate user location to the system. The GPS provides positional information (X,Y,Z) while the orientation sensors provide accurate information relating to the direction (heading) and tilt parameters (azimuth) of the users head. The user of the PDA (2) will be shown this information on screen using a small graphic. The option to view the location/direction information for other users will also be provided.

Head-Mounted Display (HMD) (4)

The data and generated scenarios are processed by the laptop and transmitted via the wireless network to be viewed through a see-through HMD. This system will allow users to roam and view any part of the surrounding landscape augmented with the modelled landscape scenario and/or base spatial layers. The number of see-through HMD available has reduced since the late nineties. This may result in a video see-through HMD being adopted, although more research is required.

Wireless network (5)

The wireless network, utilising either Bluetooth© or 801.11g protocols, will link all components, allowing users flexibility to explore the area to view and interrogate scenarios. The distance users can move will be determined by the protocol chosen and will vary from approximately 10m for Bluetooth© and up to 60m for 801.11g.

DISCUSSION

The research is broken into five key phases;

- Researching available AR systems – Focussed on reviewing the literature to determine the commercial and research-based AR systems currently in existence. The underlying features of these systems are being documented to determine the ‘generic’ capabilities present in order to make the research outcome widely applicable.
- Development of a prototype AR system – An AR system utilising commonly available hardware is being created. The system will be based on open source software, where appropriate, and allow for multiple users viewing data in an augmented environment. This stage is yet to commence, but has been developed conceptually. This aspect has been covered in this paper.
- Preparation of the interface framework – Refining and developing current model interfaces to work within the prototype. These interfaces will be implemented by means of a PDA thereby providing a familiar environment for users to interact with the models and spatial data.
- Preparation and loading of the data – In conjunction with the development of the interface, the formatting and loading of source data will be necessary. The software selected as the map server will determine the format of data. Depending on the processing capabilities available, the data may need to be generalised. Rather than accommodating an infinite number of scenarios, some pre-determined scenarios will be used to demonstrate the system at the landscape-scale. It is envisaged that the local-scale interface will allow for any number of scenarios.

- System testing and interface evaluation – The system will be tested using evaluation techniques that are to be developed as part of the research.

The literature review is currently being written. The next important stage, which is just beginning, is the development of the prototype. Sourcing and loading of the base data sets along with the loading of the necessary software can begin, however the HMD and location sensors are yet to be sourced.

CONCLUSION

It could be argued that the system described above is not a Mobile Augmented Reality System (MARS) but rather a portable AR system due to the fact that much of the hardware is in a fixed location with the users 'roaming' around. The proposed system provides users with flexibility unlike that of typical MARS that require all components to be carried by the user.

This paper began by introducing the concept of Integrated Catchment Models (ICM) and the rudimentary ways in which their outputs are visualized. A hypothetical scenario was given, highlighting the potential benefits of using a Augmented Reality (AR) to visualize model output. Existing AR systems were reviewed with particular reference to their strengths and weaknesses. From this, a proof-of-concept Augmented Reality system was outlined followed by a discussion on the future direction of the study.

Augmented Reality has the potential to provide an appropriate interface for interacting with ICM. The development and evaluation of the proposed system will provide users with a unique method to interact with model outputs and support decision making for a range of stakeholders.

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