Collaborative Decision-Making in an Immersive Environment Built on Online Spatial Data Integrating Environmental Process Models

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EXTENDED ABSTRACT

Land management issues are of public concern and so is the development of policies that deal with such issues. Public access to spatial data is increasing and also the processing power of modern desktop systems. There is an increasing need for tools that can help find consensus and aid good decision-making on land management issues. We are creating a tool that combines the fields of geographic information systems, virtual reality, environmental process models, and decision making. Our tool is a server-client based system that integrates collaborative decision making, access to online spatial data, and a real-time renderer (SIEVE) based on GarageGames' Torque Game Engine.

Users, which can come from different backgrounds, such as farmers, policy makers, and scientists, are able to specify a geographic area within Australia through a thin client running as a web service. Using the same interface, users will be able to select from available 'what if?' scenarios. These scenarios can be future scenarios based on environmental process models, or can be alternative land use scenarios, which are integrated into the available spatial data base. Once a selection is made, the server will generate suitable 3D models using appropriate spatial data, such as elevations, ecological vegetation classes, and process model outcomes. For example, the server could generate 3D plant models for vegetation that typically occurs in the selected area and alter the texturing based on model outputs to visualise the effects that, for example, salinity could have if the selected area was to be inappropriately managed over the next ten years.

The users can then download the model and interactively explore it in SIEVE. If multiple users download the same 3D model onto their local machines, they can create a network and explore the model collectively. Having such a virtual environment can assist in a number of collaborative tasks. For example, policy makers can use such a tool to educate rural communities about land management issues by visualising what could happen if certain policies are not implemented. Another example could be the use of a collective envisioning system, where community members can explore future scenarios and submit, via an online ratings form their opinions on the visualised scenarios.

To build such a collaborative environment, one must know what the users expect of the system and what outcomes they seek. Online environments have existed for several years now, and there are a number of mechanisms that are typically employed. These mostly include text based mechanisms, used in chat forums and discussion boards, but other elements that deal with user representation, navigational issues, and camera control are equally important. However, online environments are not often used for collaboration. In the case of computer games using online technology the main purpose is to compete against each other rather than to collaborate. This raises the question which existing functionality of online environments is useful for collaboration. Geospatial virtual environments that are built for the purposes of online collaboration are beginning to appear, but the challenge with SIEVE lies in building a tool that can be used Australia wide, and at the same time provides a robust interface that allows for collecting and collating peoples opinions, showcasing and educating about relevant land management issues, and providing a robust interface for focussing discussions. At the same time this tool aims to provide relevant mechanisms for finding suitable policies that improve Australia's management of its land.

1. INTRODUCTION

Land management issues and consequences are of interest to all stake-holders and hence there is an increasing desire expressed by communities to become involved in the development of relevant policies. However, policy making is a complex process and one important part in involving communities is to provide tools for aiding understanding and exploring scenarios of change. Well known software packages that provide this functionality are “What If?” (Klosterman, 2001), “INDEX” (Allen, 2001), and “Community Viz” (Kwartler and Bernard, 2001). In Stock and Bishop (2005), we have linked GIS and virtual reality (VR) technologies and introduced an envisioning system (EvS). The aim was to develop a system that involves the general public as a non-specialist audience into landscape planning processes.

As spatial data becomes increasingly available to the general public and, at the same time, real-time graphics hardware becomes more powerful and affordable, more widespread use of systems that integrate GIS and VR for educational and planning purposes will become feasible (e.g., Herwig and Paar, 2002). There are a number of applications being developed that can visualise landscapes based on GIS data in real-time quite realistically (e.g., Paar and Rekittke, 2005), and it is time to review options that integrate these systems with mechanisms that provide multi-user interactions and discussion platforms. While real-time landscape visualisation is already used in public participatory decision making (e.g., Kwartler, 2005; Stock and Bishop, 2005), mostly this still involves workshop or exhibition scenarios which members of the public have to attend to be involved. Another common approach is to display landscape models allowing for remote access but with only limited interaction mechanisms (e.g. screenshots or simple VRML models via the web).

Both approaches have disadvantages. Meetings at which stakeholders have to be physically present may exclude relevant stakeholders that cannot be present for various reasons. On the other hand, the web based approach only provides very limited interaction and therefore can inhibit input of relevant stakeholders. A virtual online meeting space that integrates planning support could solve these problems, as it allows anyone to participate in discussions and also can provide a range of interaction tools and mechanisms for leaving feedback. The development of such a planning environment is considered to be useful by both government planning agencies and commercial consulting firms.

We are developing a new visualisation environment called SIEVE (Stock et al., 2005) which allows users to download landscape models based on spatial data onto their home or work computers. The intended users of this system include members of the general public, but also specialists like scientists and policy makers. SIEVE will provide not only real-time visualisation of landscape scenarios that can be explored by users interactively, but also provide an online meeting place to discuss the landscape changes being presented.

Before such an online environment can be built, the question of what kind of functionality is necessary to provide a useful online environment has to be answered. This raises a number of issues, such as what the users expect of the system, how they interact with it, identifying the best mechanisms for leading discussions and leaving feedback, and how the landscapes be best explored by multiple users? This paper explores some of the mechanisms that other online meeting software provides and their relevance to SIEVE.

The development of collaborative online systems that integrate spatial data and real-time visualisation for planning purposes is still in early and exploratory stages. This paper provides an overview of the work that has been done to provide SIEVE with online planning and collaboration capabilities. We have in parts drawn from our experience of developing a community planning tool (Stock and Bishop, 2005). The next step is to test these tools - how well they work for online collaboration, what features are still needed and which ones can still be improved.

2. THE SIEVE ENVIRONMENT

SIEVE is being built using a commercial low-cost game engine, the Torque Game Engine (TGE) from GarageGames. TGE provides some basic functionality, such as real-time landscape rendering and a client-server networking environment. This engine uses specific data formats that are also used by SIEVE to load landscape models. This section identifies some of the planned functionality of the environment, some of the development that already has been done, and some of the development that is planned over the next year. For a detailed discussion of SIEVE, especially the environmental modelling interface, please refer to O’Connor et al., 2005, this issue.

To get access to a landscape model, users of the system will be able to log onto a map server that hosts GIS data (such as the GEODATA 1:250,000 dataset from Geosciences Australia or the Vicmap 1:25,000 dataset from the Department of Primary Industry, Victoria). Via a thin web client, an area on a 2D digital map can be selected and on the map server a 3D model will be automatically created. Then, the server will send the 3D landscape model of the selected area back to the users. The 3D models can then be explored by a user in SIEVE. Using this set-up, we envision that the system will be able to automatically create 3D models from anywhere in Australia, on demand.

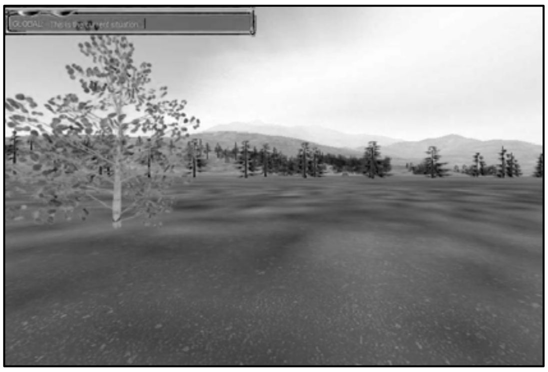

Figure 1. View of an existing landscape

The 3D data conversion on the map server is already implemented using an ESRI ArcObject module in ESRI ArcMap, which is written in Microsoft Visual Basic. This module converts raster layers and shape files into a format that TGE can read. The GIS data is used to generate terrain models including elevation data, roads and rivers, and man-made structures. There is currently some further work being done on the converter. To deal with cases where no mapping information exists (e.g. tree locations), algorithms will be implemented to generate the necessary additional data. For example, in the case of vegetation, the ecological vegetation classes (EVC) will be used to determine the location of individual species (e.g. species A, B, and C are typically found in EVC 1) and spatial species distribution (e.g. species A occurs in clusters and typically together with species B). Furthermore, the system will have access to a vegetation content library based on existing vegetation textures. This library is currently being built and will include all major Australian species. It will also be linked to the EVC classes. Based on the mapping info, the algorithms for generating extra data, and the content library, automatically generated 3D models should reflect the existing conditions as realistically as possible. Figure 1 shows how a landscape model, that has been generated by the current converter, looks like in SIEVE.

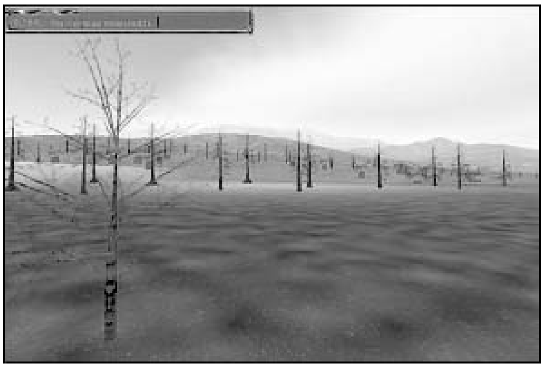

Figure 2. View of a salinity affected area

The aim is for SIEVE to be able to visualise existing landscape conditions, and to import scenarios of landscapes that were generated with the help of scientific environmental process models. The latter can be provided, by experts, as GIS layers that are then used for the building of the 3D models. For example, users can load a scenario that is based on a hypothetical development ten years into the future where the issue of soil salinity has been neglected which manifests itself in soil bleaching and dying vegetation. Another possibility is the building of hypothetical land use models, for example, a production shift from cattle farming to tree plantations and the visual consequences that result. Additionally, land use changes can be combined with environmental process models to show the long terms effects of the land use change. The integration of environmental models into SIEVE is ongoing. SIEVE also provides functionality to visualise underground data, such as water flow, to communicate the interplay of above and below ground effects. These functions allow users to run “what if” scenarios and the resulting models form the basis of the online collaboration. Figure 2 shows how the area shown in Figure 1 could look like if it had been affected by salinity.

Currently, the framework to import environmental models is implemented and over next months this will be tested with actual models. Since the current SIEVE model is tailored for online use, users can only load one model at a time. To compare two different models, users have to load and explore the two models separately and independently. There is no functionality to instantly switch between models. Current desktop hardware is not powerful enough to support such functionality as this requires a lot of system memory.

Once a landscape model is produced, it can be downloaded by multiple users. One user can start a server, and other users are able to join the server and explore the landscape model at the same time. Users can then search for environmental issues that are relevant to them, and discuss their opinions to form strategies for overcoming them.

In the following, we will discuss the collaboration elements in more detail. While we have built a collaborative system that can be used in community workshops (Stock and Bishop, 2005), there are several issues concerning how to best port this functionality into an online collaboration system. In the next section we discuss what online collaboration mechanisms exist in other software, what we already have implemented into SIEVE, and what we are further planning to do.

3. ONLINE COLLABORATIVE VIRTUAL ENVIRONMENTS

The proliferation of the Internet in the 1990s saw the growth of the hypermedia co-operative approach for addressing spatial planning problems (Laurini 2001). The Hypermedia co-operative approach focuses on the use of on-line collaborative virtual environments for involving communities, stakeholders and decision-makers in exploring decision spaces. There are a number of on-line tools available for planners, social scientists and facilitators to elicit local and expert knowledge to make more informed decisions, including chat forums, discussion boards, weblogs, wikis, and geospatial virtual environments (GeoVEs).

3.1 Text-based collaboration

Chat forums enable a number of participants to discuss topics of interest in real-time, typically using text windows, commonly known as chat rooms. Chat forums are a powerful on-line medium for bringing together people located in different geographical locations to meet and discuss common interests and collaborate on particular issues. Having a chat forum moderated by an assigned facilitator can ensure that the discussion remains focused on the designated topic.

Discussion boards enable participants to post comments under particular discussion topics, also known as discussion threads. Discussion boards provide a structured approach for participants to leave postings on areas of interest. Unlike chat forums, interactions between participants does not occur in real-time, with postings usually occurring over a period of days, weeks or months depending on the topic and interest group. One example of where discussion boards have been used to facilitate community involvement in forestry management practices has been reported by Pettit and Nelson (2004).

Weblogs, also known as blogs, are online journals comprised of links and postings in reverse chronological order, where the most recent postings appear towards the top of the page. Blogs are ‘post-centric’ meaning that the key unit of communication is the posting not the web page, as is the case with traditional websites. Blogs typically hyperlink to other websites and blog posting allows many readers to comment on the original posting, thereby encouraging wider audience discussions. Blogs build upon the concept of discussion boards and since the early 21st Century have rapidly grown in use as a collaborative tool.

A Wiki is a piece of server software that allows users to freely create and edit Web page content using any Web browser. Wikis support hyperlinks and have simple text syntax for creating new pages and crosslinks between internal pages on the fly (http://wiki.org/wiki.cgi?WhatIsWiki). Wikis are quite different to other online group communication tools as they allow collaborative ‘self-organisation’, breaking down traditional linear and hierarchical online content structures. The “open editing” paradigm allowing everyday users to create and edit any page in a Wiki website encourages democratic use of the Web and promotes content composition by non-technical users.

3.2 Other collaboration elements

Text-based communication in visualisation software is common in current software applications and works similar to chat forums. Virtual environments are used on some chat servers to offer 3D worlds that chat users can use to meet other people (for chatting), e.g. Adobe Atmosphere - visualisation is only used as a supplement in this form of application. However, interfaces for chatting are common in applications that have visualisation interfaces as their primary function, for example, in computer games. SIEVE fully supports text based communication in a chat window. At this stage, this is our primary interface for users to communicate with each other.

More recently, with the increase in access to fast Internet connections, it has become more common that chat interfaces are supplemented by audio communication interfaces. The standard that has been developed over recent years is the Voice over Internet protocol (VoIP). This allows users to send audio messages over the Internet where they can be listened to at the receiver's end. This technology works similarly to the telephone network, and is increasingly used for long distance calls as a cheap alternative. However, it is also used in visualisation software and especially computer games. Taking audio communication a step further, video conferencing software also allows for sending and receiving video messages over the Internet. However, this is not used to a high degree in current visualisation software. We would like to integrate both audio and video streaming into SIEVE at a later stage as an alternative option for communication. Voice communication feels more natural than text based communication and will make SIEVE more accessible to users.

Communication is not the only desired functionality in building a collaborative environment. It is, for example, desirable to visualise the users in the virtual model also. This functionality is frequently implemented in visualisation software and users are represented in the virtual world as so-called avatars. These avatars can have any shape and look, but often have human form and some applications even allow for customisation of avatars (e.g., body shape or putting a scanned picture of someone's face onto the head). Using avatars in a collaborative environment has several advantages. It makes it easy to recognise other people and gives a feeling of physical presence. During collaborative discussions it may be important to know what features other people are looking at, or even where they are located. This can be especially useful if the meeting is not exclusively virtual, but people with augmented reality sets are located in the actual study area and their avatars reflect their true physical position. Avatars can also be used to, for example, differentiate between lay people and specialists if they look different. Furthermore, avatars can be used for gesturing, for example, using a "look over there" arm gesture. SIEVE supports avatars natively. At this stage their only use is to identify other users' locations and what they are looking at, but other functionality will be explored in the future.

Apart from using avatars to identify users, we have also added an icon based system, that shows users in iconic form in 2D on a sidebar, including the name of the user. With this system, users can readily identify other users that are logged onto the system. In the future more information of the users, such as affiliation, may also be displayed. We are also planning that SIEVE will be able to capture images via a webcam, so that users in front of their PC can be captured in real-time, similar to video conferencing applications. This would work in conjunction with the voice communication discussed above.

It is not necessarily desired to only have the camera views tied to the eyes of the avatars. It may be desirable to leave an avatar behind and view the landscape from a high above ground position or even through the eyes of other avatars. This is particularly useful if one user wants to show all other users a specific location he finds worth discussing, such as a soil erosion spot. We have implemented such functionality into SIEVE. Natively, TGE supports two cameras for each user, one linked to the avatar and one free camera that can be moved anywhere. Users can switch between these two cameras. We have added the functionality of collecting all cameras at one single avatar. The way this works is that a user can press a keystroke and match the camera views of all users to the one of his own avatar, so every user is seeing the same thing. The users can then start a discussion about what they are seeing. If the users find the location interesting, they can press a key and their avatar will be teleported to their current camera view. If they prefer to return to the position of their own avatar they can press a different key. Using SIEVE's camera controls, users can freely navigate the landscape model, search for interesting environmental issues they would like to discuss, and instantly call all users to their location for discussion.

Orientation in a virtual space is another issue. Users can get lost in a virtual model (especially on the ground) if they don't know where exactly they are or which direction they are looking at. In Stock and Bishop (2005) we have provided a virtual compass as a 2D icon in the main view and this has helped audience members significantly to recognise individual features and their location within the model. TGE also provides a small 2D overview map that can be used to plot the position of users onto a 2D terrain map. Both features will be implemented into SIEVE over coming months.

In Stock and Bishop (2005) we have introduced a voting mechanism for collecting feedback from a workshop audience. Upon asking a question, audience members could vote either yes or no, or rate the subject of the question from one to five using handheld devices. Results were displayed when the voting was finished. Online computer games often have yes/no voting mechanisms that could be used for this purpose. SIEVE doesn't support this functionality as yet, but it is planned to integrate voting soon. People can then trigger a vote by keystroke and sending a question, and other users can send back their vote, also using keystrokes.

Collaborative environments are often in need of a moderator. This need arises from the unstructured nature of text and audio communication. Moderators have to, for example, delegate the communication flow, i.e., who should talk next. But other functionality will need to be moderated also, e.g., should someone have control over individual cameras, and if so who? In current online environments, the role of moderators often is limited to removing offending people who abuse their rights from a server, but there are not many applications that allow the delegation of communication and other functions. A more democratic model is one where votes are cast by every user when a decision has to be made. The decision with the most votes will be put into place. This model may be suitable for some tasks, e.g., to decide if a certain issue should be discussed or not. We are planning to implement a vote based model that also allows for nominating a moderator. The moderator will then have limited power to, for example, change camera views or to start a vote.

3.3 Geospatial Virtual Environments (GeoVEs)

Summarised here are some examples of existing collaborative environments other than SIEVE. GeoVEs can represent either fictitious or real geographies where participants can explore virtual terrains. In online GeoVEs participants can interact with other users, and thus online GeoVEs can be used to collaboratively explore virtual decision spaces. Virtual worlds such as Active Worlds http://www.activeworlds.com/ and Cybertown http://www.cybertown.com/ provide examples of fictitious online GeoVEs.

Cybertown is a futuristic online community where users can interact and collaborate with others in either text space or virtual three-dimensional geographical space. Text space interactions are analogous with chat forums. Within the virtual three-dimensional geographical space, users are represented by avatars which can gesture to others and congregate at particular virtual locations such as the Cybertown town hall, plaza (as shown in Figure 3) or at participant's virtual home.

Figure 3. Avatars congregating at the Cybertown Plaza

An example of an online GeoVE created for a real world application is the Jewel Station Neighbourhood situated in the City of Moreland, Greater Melbourne Region, Australia. The Jewel Station Neighbourhood has been constructed by the Community Spatial Scenario Simulation Group, RMIT University (www.c-s3.info) and provides a suite of hypermedia tools for planners and the community to explore existing conditions and potential future development scenarios within the neighbourhood (Pettit et al. 2004).

4. DISCUSSION

We envisage a tool that people from different backgrounds all over Australia can use to discuss land management issues. This tool can be used for several applications, e.g., educating the community about land issues, collaborative land management policy development, and testing scientific environmental models in combination with real-time visualisation.

To give an example of how this application can be used, two people, a scientist and a community member could load a landscape model and view it at the same time. The community member may navigate through the model and familiarise themselves by trying to find local landmarks (e.g., their own house). The scientist may investigate features in the terrain that will give clues about potential land issues. After an initial investigation period, the scientist may decide to run an environmental model that would predict how the landscape may appear in ten years time if certain land management policies were to be put into place. Both users would then load the new model and the community member can explore the changes. The scientist can explain to the community member why these changes exist (e.g., certain farming practices may have caused them). A second scientist may log on and may disagree with some of the changes. The second scientist may decide to run his own environmental model and all three users could load the resulting model afterwards. There may be different changes visible in this predicted model. The community member may have an opinion about which changes are more likely, since he may have some local knowledge which both scientists did not consider in their models. The scientist could then develop a new model based on this input that may more accurately predict future changes.

While we have presented some functionality that SIEVE already provides and what further functionality is planned, systems like this are very young. At this stage, we simply do not know what functionality works best, and how to best implement it. With some basic functionality working, our next step is to install a system and start testing with real people. We anticipate some problems, for example, people may get confused how the camera view works, or may not be able to fully understand the provided navigational help. We need to understand how different people use collaborative systems and what functionality they require to support their virtual presence in such an environment. After testing, we hope to better understand what functionality collaborative systems should provide and how they are best implemented for easy access.

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