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FUTURE USE OF AUGMENTED REALITY FOR ENVIRONMENTAL AND LANDSCAPE PLANNERS

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Introduction

Key to environmental and landscape planning is the visualization of changes to existing features. Current technologies for visualization of such changes include hand-drawn artist renditions, three-dimensional models viewed on standard desktop computers, and three-dimensional models viewed on immersive virtual reality systems. These three technologies all lack the ability to provide the planner with a first person perspective of the changes in situ. In this section we propose the use of augmented reality (AR) as a means of providing the planner with such ability. The AR overlay contains virtual objects such as buildings and trees that appear to exist in the physical world (Azuma, R. 1997; Azuma *et al.* 2001; Azuma, R.T. 1997).

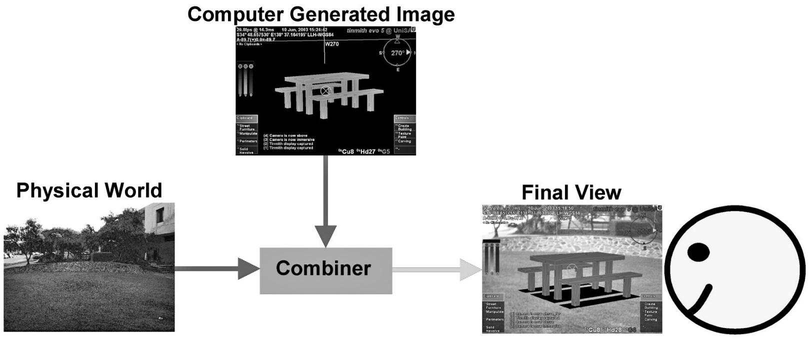
We believe the ability to view design options on site for environmental and landscape planners is a powerful tool. This tool would help the planners to visualize options overlaid upon the physical world, making the impact of the different designs more tangible to the planner. The interplay between each of the options and the existing environment and landscape is much more obvious to the planner when viewed using AR. Some options are difficult to visualize without all the surrounding landscape and environmental features, such as colour or space. The ability to move freely in the environment allows the user to understand sizes and distances in a similar way to perceptions in the physical world. Changing the user's viewpoint is as easy as walking to a new location. The visualization of such models on a traditional workstation using a mouse to change viewpoints does little to help the user understand such concepts. As a second example, imagine that a planner is reviewing the installation of a new walkway, and the walkway intersects a drainage ditch, which is not depicted on the surveyed maps or site drawings. It would be easy for the planner to detect this problem with an AR tool, reducing both costs and time.

This section will first provide a brief introduction to the concept of AR and the required technologies to support AR in an outdoor environment. The section goes on to present two examples of visualization: landscape design and building design. Finally, some concluding remarks are offered on possible future directions of the technology.

Technology

Augmented reality is the registration of projected computer-generated images over a user's view of the physical world. With this extra information presented to the user, the physical world can be enhanced or augmented beyond the user's normal experience. The addition of information that is spatially located relative to the user can help to improve their understanding of size, shape, location and colours of objects such as trees, shrubs, walkways and walls. The schematic diagram in Figure 10.4 depicts how a see-through HMD (used to produce AR images for the user) can be conceptualized.

To provide AR images while the user is mobile, there are a number of technologies that must be integrated. Working first from what the user sees, the AR images are presented through a head-mounted display, as shown in front of the user's eyes in Figure 10.5. We use a Sony Glasstron head-mounted display that is mounted on a helmet with a



10.4 Overview of augmented reality

10.5 Tinmith-Endeavour outdoor augmented reality mobile computing system

FireFly 1394 camera for live video input. To generate virtual images that align with the physical world, the computing system must know the user's position and orientation of view. The technologies we employ are an Intersense IS-300 hybrid magnetic and gyroscopic tracker for orientation sensing, and a Trimble Ag132 GPS with an accuracy of 50 cm for position sensing. This sensor data is processed to render the final view for the head-mounted display. We use a Pentium-III 1.2 GHz laptop with an Nvidia GeForce2 graphics chipset to operate our applications. A single user must be able to carry all this necessary equipment; so a custom backpack computer was designed to support our research, named Tinmith-Endeavour, and is shown in Figure 10.5. The backpack weighs approximately 15 kg and operates for 2 hours. We implemented Tinmith-Endeavour with as many off-the-shelf components as possible, but in the future this could be made smaller and lighter with new technologies and custom-built components.

The techniques discussed in this section have all been implemented and tested in an outdoor environment, unless noted otherwise as future work. We have developed a complete and useable outdoor augmented reality application known as Tinmith-Metro, which allows users to visualize and capture three-dimensional outdoor geometry in the field (Piekarski and Thomas 2001). To implement this application, we use our flexible Tinmith-evo5 software architecture (Piekarski and Thomas 2003), which is a complete toolkit for the development of high performance three-dimensional virtual environment applications.

Landscape design

There are two basic methods of modelling that we have been investigating. The first involves the placement of predefined graphical objects and then modifying their position, scale and rotation transformations. The second is the specification of planar shapes through the placement of vertices using the body.

Placement of predefined graphical objects

The placement of prefabricated objects is performed at the feet of the user as they stand in the environment, such as the table, person and tree shown in Figure 10.6. This method works well when objects that are to be created are known in advance or an approximate graphical model may be used. The physical movement of the user is used to control the object placement. Instantiating objects at the user's feet makes tracking of other body parts such as the hands unnecessary to simplify the equipment required.

Once a predefined graphical object has been placed in the environment, the user can change the object's size, position and orientation.

10.6 Example of a predefined table, person, and tree placed in the environment

Based on some initial inspirations from Bolt (1980) and guidelines by Brooks (1988), the user interface makes use of tracked gloves so the user can point at objects and interact with them. Users may perform selection operations using a single hand with a cursor that is projected onto the three-dimensional environment.

Direct manipulation-based translation operations may be performed by the user with a single hand. At the start of the operation, the user selects an object. As the user's hand moves, this performs translation and maintains the same object to user distance. If the user moves their body during the translation operation then the object will be moved in the same direction as this motion. If the user changes their head direction then the object will rotate around with the user's head.

Scale and rotate operations may be performed more naturally through the use of two-handed input, which was first pioneered by researchers such as Buxton and Myers (1986) and Hinckley (1994). Scaling operations are initiated by selecting an object with the non-dominant hand, and the dominant hand controls the stretching of the object. Rotation operations are performed similarly by selecting an object with the non-dominant hand, with the angle being controlled by the relative position of the dominant hand. Figure 10.7 shows an animation with a sequence of frames of a tree being rotated about the head cursor using two-handed input.

10.7 Rotation operation being performed using two-handed interactions

The user interface has a menuing system designed around an arrangement of finger presses with a special set of gloves. The fingers on the user's gloves map to a set of menu options, and the user can navigate through a hierarchy by pressing their fingers against the thumbs. While each of the previously described transformations use interactive pointing by the user, fixed increments controlled by the menu are also possible. The nudge series of commands can move objects in one metre or other fixed translations, rotate in fixed angles along the axes, and scale in fixed increments. The scale and rotate nudge operations also provide the ability to scale objects away from the user or rotate around the ground plane normal, which is otherwise not possible using image plane based inputs.

Specification of planar shapes

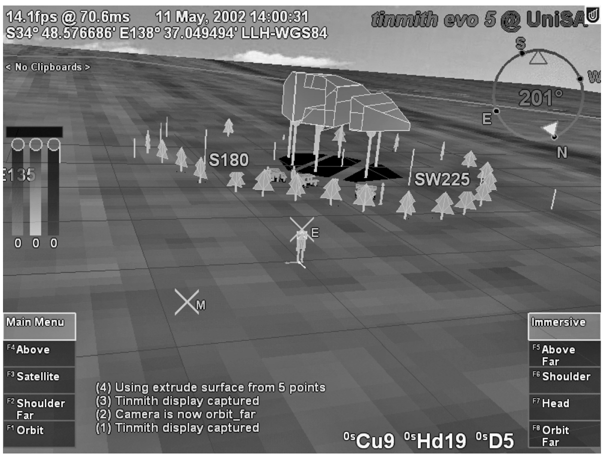
To mark out a region on the ground's surface, the user walks along the perimeter of that region they wish to model and places markers at points of interest under the feet. This is also similar to creating waypoints when using a GPS system while walking. When the user has walked completely around the area they wish to specify, a closed perimeter is formed and converted into a closed graphical region. While the initial perimeter defined is a thin polygon, it can be infinitely extruded up to define a solid building outline, or extruded down to approximate the bottom of a lake or river. This technique has been used to model roads, parking lots, grassy areas and other concave outline style shapes. Paths and navigation routes may also be defined, but treated as a line segment instead of a polygon.

Building design

The ability to define large building structures is also useful in helping planners in the visualization process. This example highlights the modelling techniques with the construction of an abstract building in an outdoor environment. The user walks outside to an empty piece of land and creates a landscape that they would like to preview and perhaps construct in the future. As an added feature, this model may be viewed on an indoor workstation either in real time during construction or at a later time. Applications for creative purposes such as an abstract art or landscape gardening design tools may be brought into operation during this design phase.

Figure 10.8 shows the user's augmented reality view of this example through a see-though head mounted at the end of the construction process, and Figure 10.9 shows the same example as an immersive virtual reality view. The first step in creating this new building is to create the perimeter of the building shape by walking around the building site and placing down markers at key positions of the building, forming a flat outline. Next, the outline is extruded upwards into a solid three-dimensional shape. The user stipulates the shape of the roof by specifying various control points. After the overall roof structure is created, the object is lifted into the air. At this point, the supporting columns, trees, tables and avatar people are created by the placement of prefabricated models at the desired locations. The building is then lowered by visual inspection onto the supporting columns. Next, the user performs further carving and a large hole is created through the centre of the building. After around 10 minutes for this example, the desired model is complete and the user can now move around the environment to preview it from different viewpoints via the see-through head-mounted display.

10.8 Augmented reality view of the new building



10.9 Virtual reality view of the new building

Conclusion

We believe that the use of mobile outdoor augmented reality systems will greatly enhance the ability of a planner to visualize new environmental and landscape designs. Key to helping the planner is the ability to view the designs in the field at the location of the changes. Being able to walk freely around the site allows the planner to *experience* the new designs and to better understand such attributes as colour, size, distances and interplay with existing structures.

This section has presented our existing system Tinmith as a prototype mobile outdoor augmented reality visualization system. The system allows users to place predefined graphical objects at the desired location, define planar regions of interest, and capture and create the shape of buildings. These tools allow the planner to both visualize the designs and modify them in the field to best suit the environment. Future technology advances will enable the construction of mobile AR systems that are lighter and more portable, for use in possible commercial applications.