Townscaping: A Report on an Initial Development of Dynamic Virtual City Augmented 3D Sketch Design Tools on the Basis of SUCoD

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Abstract: The paper presents the development of an experimental Web-based design environment called Townscaping to be used at the conceptual stage of architectural and urban design. Inspired by Gordon Cullen's seminal work on Townscape (1960's-1970's), the idea of Townscaping is to explore how 3D digital sketch design tools could be developed to operate in connection with a dynamic virtual city system under a user's direct control. A prototype of Townscaping has been designed and implemented on the basis of an existing dynamic virtual city system. In Townscaping, a set of tools is provided for users to create and edit 3D graphic elements to be positioned directly onto the user-specified virtual city models. One of the key features of Townscaping is to enable sketching while navigation: designers can perform sketch design and gain immediate visual feedback while navigating the 3D virtual city models to any viewpoint at any moment. The current study suggests that it is feasible for virtual city models to serve as interactive urban contexts for 3D sketch design. Townscaping is considered primarily a research platform with which we are interested in investigating if designers’ engaging in 3D space conceptions may be enhanced through interacting and sketching with virtual townscapes.

1 INTRODUCTION

Digital 3D sketch design has been an active area of research and development in various domains of design such as architecture, industrial design, engineering design etc. With different choices of operating platforms, novel tools have been built to explore interesting issues concerning how the experiences and processes of intuitive (freehand) drawing or sketching can be recreated through digital means. This paper reports on our current research that explores the potential of linking 3D sketch design to interactive urban visualisation modelling. The research hypothesis to be tested is twofold: (1) New possibilities of engaging in 3D sketch design can be identified if the sketching tools can be enacted within contexts of designing; (2) Architectural and urban design at the inception stage could be better supported and to some extent enhanced by sketch design tools augmented by 3D interactive urban contextual visualisation modelling.

The Townscaping project started with the idea of bringing two common practices closer to one another: on one hand, 3D graphic modelling of urban context, and on the other hand, sketch design in architecture and urban design. For various purposes, there is a growing interest in the construction of 3D models of urban and built environment for which a wide array of digital modelling and
rendering techniques have been developed (see, for instance, Pietsch et al. 2001; Shiode 2001). In architecture and urban design, sketch design remains an essential process in which strategic and schematic ideas are played out by designers in an episodic manner (Rowe 1987). Given that these are two commonly seen activities, it seems reasonable to ask if we could consider 3D urban models as a kind of backdrop or canvas for digital sketch design to take place directly within it.

Using any conventional CAD package such as AutoCAD or MicroStation, one can build a 3D urban site and use it as a basis to develop 3D designs. Yet, most designers would consider site modelling and actual designing two separate activities; designs are mostly developed on their own and then tried to 'fit' or 'import' into the site model. In setting up the Townscaping experiment, we have worked the other way around. An interactive urban visualisation system together with information content about a real historical city were first developed, allowing users to select and retrieve any area of 3D urban models in the VRML format. A set of tools for spawning and manipulating 3D basic graphic elements was then built into the urban visualisation system. In Townscaping, users (designers) can therefore activate the tools at anytime to perform sketch design while navigating the 3D virtual urban site. At the end of a sketch design session, the result can be saved and then imported to a CAD system for further design elaboration if the designer so wishes.

Townscaping is considered primarily a research prototype with which we are particularly interested in investigating if designers’ engaging in space conceptions may be enhanced through virtual city augmented 3D sketch design. The remainder of the paper is organised as follows. In Section 2, the SUCoD platform developed through previous research is introduced briefly as the basis for developing the Townscaping environment. Section 3 describes the six key component functions that constitute the present design of Townscaping. More technical details of the current implementation of Townscaping together with a worked example of using the sketch design tools are presented in Section 4. Finally, in Section 5, an initial evaluation of the usability of Townscaping is reported, pointing to a number of issues to be further explored in building the next version of Townscaping.

2 SUCOD: A WEB-BASED PLATFORM FOR GENERATING USER-DEFINED 3D CITY MODELS

The Sheffield Urban Contextual Databank (SUCoD) system was developed through previous research that looked into how the usability and reusability of urban models and associated datasets could be significantly improved by adopting a Web-based multi-tiered framework (Peng et al. 2001, 2002). Central to the design of SUCoD is a set of facilities for allowing users to freely retrieve 3D city models (in VRML 2), images of historical maps, and web links to other associated urban resources according to user-specified spatial-temporal attributes. In so doing, the restriction on end-user retrieval as pre-determined by how the urban models and other datasets were built in the first place by the model developers can be removed.

Figure 1 shows a snap shot of current implementation of SUCoD (accessible online http://sucod.shef.ac.uk). Based on ILOG JViews, a Java applet was built to display an interactive city map of historical Sheffield containing multiple layers of selectable graphic objects that depict the city's terrain, streets and buildings etc. Secondly, extra functions were built into the applet for users to perform resource retrievals including Get Historical Map for
retrieving scanned historical maps, and Get VRML for retrieving user-specifiable city model sets in the VRML 2 format. These two retrieval functions were designed to communicate with corresponding CGI Perl scripts over HTTP. Intended as intelligent agents operating on the middle tier, the Perl scripts were designed to accomplish a number of tasks in real-time: processing user selections, accessing relevant urban data repository stored on the back-end tier, and constructing well-formed maps, models and other associated datasets ready for user browsing.

Another two user interaction functions were also attempted. Upload VRML was designed to allow users to submit their own VRML worlds that can be further combined with the city models they retrieve from SUCoD. List VRML was designed for the user to generate an on-demand HTML table that lists the history of city model retrieval and/or user model upload. List VRML can be invoked at anytime during a single live session, and the history of user interaction is formatted as a simple HTML form page containing checkboxes for all VRML worlds registered through either Get VRML or Upload VRML. With records generated by the listing function, users can go on selecting any of the VRML worlds from the list and creating their own personal virtual worlds, which may well be syntheses of urban contexts and user proposed designs.

The SUCoD prototype has been developed to explore how 3D city modelling might shift from developer-centered to user-driven. We have learned that the usability of 3D city models could not be significantly improved if users of the city models were not allowed to perform interactions at a higher level leading to the generation of personal virtual worlds pertinent to their own purposes. We have since considered SUCoD an open extensible platform for experimenting further interactive functions beyond those of retrieving, uploading and listing. In the next section, I describe our development of the Townscaping 3D sketch design tools on the basis of SUCoD.

3 TOWNSCAPING: DYNAMIC VIRTUAL CITY AUGMENTED 3D SKETCH DESIGN

Townscaping was developed along Cullen's principle of sketching while navigation to provide designers with an intuitive 3D contextual sketch design environment. Sketching while navigation allows users to freely navigate to any position in a virtual city model and to perform 3D sketch design activities. Unlike conventional CAD systems, switching between navigation and sketch design in Townscaping is easier without users going through complicated
mode change on the user interface. The Townscaping environment is envisaged to support early conceptual design by (a) aiding visual understanding of the design context, (b) making a set of 3D graphic editing tools applicable directly onto the design context as represented by a VR model, and (c) enabling immediate feedback on sketch design via VR-enabled navigation. Conceptually, the current design of Townscaping is composed of the following component functions.

Select, Access and Define. As seen in SUCoD, interactive maps of a city are provided for users to select an area of interest and access the VR models of that area. Users define 3D city contexts in terms of spatial boundary and information content that they consider appropriate to their tasks at hand.

Navigation. Once a 3D urban context is defined and generated as a virtual world, the user can freely navigate the world through various modes such as Walk, Fly Through, Pan, Look etc. as commonly seen in VR-based viewers.

Viewpoints. Similar to book marking Web pages when people find their favourite websites, viewpoints can be set up by users freely during navigation. These may be the viewing points where the users consider the scenes captured are of special interests or importance that can be quickly revisited if needed.

Generation. Instances from a range of 3D graphic elements can be specified and generated into the virtual city model. Depending on the computer graphic language chosen in the implementation, the types of graphic elements and the scopes of their attributes may vary from one language to another.

3D Editing. Graphic objects generated in the VR model can be manipulated individually (or, as a group defined by the users) to enable changes in spatial positions, dimensions, appearances, or even behaviours.

World Save. At any one time, users may decide to leave Townscaping and save whatever has been produced during the session including the urban contexts specified. Users can reload their saved worlds later to resume design editing.

4 CURRENT IMPLEMENTATION AND A WORKED EXAMPLE

The current Townscaping prototype is implemented as a Java™ Web Start application that can be accessed directly from the existing SUCoD web server (http://sucod.shef.ac.uk/townscaping). Once set up, it can be launched from a user's desktop shortcut. Java, Java3D and Perl were used to implement the key functionalities for accessing urban contextual models and sketching while navigation. The VRML97Loader class in Java3D was used to load the original Sheffield urban model datasets in VRML 2, and this opens up the use of a great deal of Java3D capabilities in Townscaping such as allowing users’ adding new viewpoints into the contextual models. Several panels were built for users to access various tools and functions such as Navigation, Views, Buildings, Designer (see Figure 4). In addition, a collection of CGI scripts written in Perl is deployed on the server to process user requests for selected urban contextual resources such as maps and models. Finally, when leaving Townscaping, users can save locally their sketch design results as XML files, containing both the city contextual models and their sketch designs which can be reloaded at later sessions.
When accessing Townscaping, the city’s index map is first displayed for the user to specify a general area of interest by selecting one or more 200m square tiles, and then the Get IVL Map for Townscaping function can be activated for building the final 3D urban context (see Figure 2). The green-shaded area on the index map indicates the current scope of 3D VR models currently available from the SUCoD server, which will be extended as more contextual datasets are built into the system.

As soon as the Get IVL Map for Townscaping function is activated, the user is shown another interactive city map in a separate window (Figure 3). Created in ILOG’s IVL format, this is a much more detailed map containing 20 layers that depict the 2D layouts of urban features gathered through an urban study survey. With this interactive map, the user can further define a more exact area of interest by fine tuning the content selection down to individual buildings and street blocks if considered appropriate.
containing all the viewpoints preset by the urban model developers. On the Navigation panel, the user can move around the model via MOVE, PAN or LOOK with Align to reset the sky-ground of the city model into horizontal. Direction of navigation or where to look is controlled by the user’s moving and pressing the mouse cursor into a position relative to the centre of the field of vision. As mentioned earlier, the user can add new viewpoints at anytime by navigating to the intended locations, adjusting the views and then entering names of the new viewpoints through the Views panel (Figure 5). The marking up of new viewpoints can be a valuable exercise in setting up how a sketch design may be approached.

Figure 4   A 3D city model is generated following user selection on the IVL map and the Townscaping toolset is provided on the left.

Figure 5   Adding a new viewpoint “My ViewQ” into the city context model.

On the Designer panel, the user is provided with a set of graphic elements including Cube, Cone, Cylinder and Sphere. This should be seen as the initial toolset, which will be extended to afford other types of 3D elements/tools. Selecting the Cube tool, for instance, a Cube-Properties pad is shown prompting the designer to enter the name, dimensions and colours of a cube element (see Figure 6). As the Apply button is pressed, an instance of Cube is generated into the virtual world at a preset location and orientation. The cube object can then be manipulated through the ten spatial operations on the Buildings panel until a desirable status is reached.
As a worked example to illustrate Townscaping (Figures 6-8), a hypothetic street performance stage is conceived in relation to a city monument site, the Jubilee Monument in Barkers Pool back in 1900. Instances of Cube and Cylinder of various properties were generated and manipulated into the intended positions and orientations. It is worth mentioning that defining new viewpoints can play a very useful role in the process of sketch design because it allows the designer to move around those bookmarked views quickly while deliberating the design composition.
5 INITIAL FEEDBACK ON TOWNSCAPING AND TOPICS FOR FURTHER RESEARCH

A group of architect students were invited to use Townscaping soon after the first prototype was deployed and tested on SUCoD. During the evaluation, no specific design tasks were given, but each student was asked to complete a simple questionnaire regarding their experiences, impressions and suggestions of the sketch design tools. Although the initial feedback received was generally positive and encouraging, there remain usability issues to be further resolved:

1) Manipulating a cylinder element is particularly problematic as it can be difficult for users to predict the net effect of combined move, rotate and tilt. The current spatial operations are command-driven and can be fine tuned with a sensitivity sliding bar. However, the lack of direct manipulation such as "point-and-drag" can often hinder the flow of fluency in sketch design.

2) The current range of 3D graphic tools is limited and, strictly speaking, they are not really for 'sketching' as in freehand sketch but more for 3D conceptual design. More work is needed to incorporate perhaps some of the features seen in HoloSketch (Deering 1996), FreeDrawer (Wesche and Seidel 2001) and Space Pen (Jung et al. 2002). But Townscaping is open to experimenting with novel 3D graphic constructs, free-form or otherwise, as potential catalysts for space conception in architectural and urban design.

3) It was suggested that users should have the option to save their sketch design results into files containing only their design schemes that can be further imported into a CAD system for further design development. More work is needed to enable further processing of the current saved world in XML into a CAD-compatible format such as the DXF.

4) The current urban contextual models retrieved from SUCoD do not contain aspects of urban landscapes other than buildings and streets. Some kind of urban design props could be introduced as auxiliary resources for sketch design. Especially, user placement of 3D human figures in virtual urban spaces could perhaps help engender a sense of human proportion.
The Townscaping environment is presented as a follow-up development of SUCoD. It shows that the urban contextual resources developed for a city can be exploited to realise dynamic virtual city augmented 3D sketch design tools. The development of the Townscaping toolset is still at an early stage, but we believe that the underlying principle and methodology as demonstrated through SUCoD-Townscaping can be applicable to other cities and towns.

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REFERENCES