Mindstage: towards a functional virtual architecture

RICHENS Paul[1] and NITSCHE Michael[2]
[1] *Digital Research Studio, Department of Architecture, University of Cambridge*
[2]*School for Literature, Communication, and Culture, Georgia Institute for Technology*

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Abstract: *Mindstage* is a multi-user real-time 3D environment in which is embedded a lecture on film design by Christopher Hobbs. The spatial design follows the structure of the lecture, and is richly illustrated with stills and film clips. The environment, implemented in Virtools, proved to be a visually intriguing combination of architectural, filmic and virtual space, though it was found that co-presence induced some problems with the concept of time.

1 INTRODUCTION

It has for some time been possible to make real-time interactive spatial simulations of architecture using the technology of computer games, but the results tend to be bland and un-engaging compared to computer games themselves (eg Richens and Trinder 1999, Moloney and Amor 2003). The three key pleasure of cyberspace have been well described as *immersion* ('the experience of being transported to an elaborately simulated place'), *agency* ('the satisfying power to take meaningful action') and *transformation* ('countless ways of shape-shifting'), all of which are offered by games (Murray 1997). Purely architectural simulations do not go beyond the first. *Mindstage* is a prototype multi-player real-time 3D virtual environment (RT3DVE) which combines practical intent with all three pleasures by the delivery of teaching material with a strong 3d content, in our case Film Design, but it could just as well be architecture, engineering or physical chemistry.

The project develops one aspect of *Cuthbert Hall* (a virtual Cambridge College) which explored how the integration of narrative and architecture can produce dramatic engagement in an RT3DVE (Nitsche and Roudavski 2002, 2003). Places there are considered as spatial structures which offer Gibsonian *affordances* that is, potentials for action or engagement, which are exploited in the unfolding of dramatic events (Gibson 1979). Some were intended for educational activities, and *Mindstage* elaborates these to become a virtual place affording entry and exploration, the delivery of educational material by speech, text, images and movies, the staging of experiments and demonstrations, and social interaction between students.

Educational researchers have defined a Virtual Learning Environment (VLE) as a designed information space in which educational interaction occurs, where the information/social space is explicit, and where students are not only active but actors who co-construct the space (Dillenbourg 2000). A VLE does not have to be a 3DVE, but could well include one: we see *Mindstage* as such a component. It will be treated as a place (not a document) and designed architecturally (Kalay et al 2004). The primary design elements will be layout, surface, navigation and interaction (Gu and Maher 2004).

The subject matter chosen for our prototype is a lecture regularly delivered by Christopher Hobbs to our Master's students studying *Architecture and the Moving Image*. Hobbs is a distinguished production designer whose film credits include *Caravaggio*, *Edward II* (Jarman 1986, 1991), *The Long Day Closes* (Davies 1992), *Velvet Goldmine* (Haynes 1998) and on television *Cold Lazarus*(1994) and *Gormenghast* (2000). His lecture entitled *Film Design: Illusion and Practice* talks about these, and the wide range of precedents (from the *Bride of Frankenstein* to *Blade Runner*) that he admits as influences. The lecture is richly illustrated with film clips and production stills..

The team assembled for the project had skills in architectural design, texturing, modelling and lighting, sound recording and editing, gameplay development and programming. Implementation was through the *Virtools* 3.0 Game Prototyping software, with modelling in *3D Studio Max* and *Maya*. Hobbs was intrigued by prospect of designing virtual space, and assumed the role of Art Director - which proved to be richly rewarding for the rest of the team. At the time of writing, after about one year's effort, we have a playable prototype which implements three-quarters of the spaces, and delivers about half of the lecture. About two-thirds of the time was spent on technical tests and development, and one third on production.

2 DESIGN

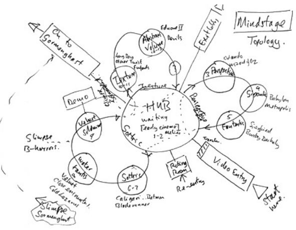
The basic research question to be addressed by *Mindstage*, is whether a RT3DVE can be effective as a learning environment, and if so to develop an approach to the architectural design of virtual space that reinforces that effectiveness, for example by promoting engagement, exploration and memorability. Secondary issues were to find an effective software platform and production workflow, and to locate the boundaries of what is technically possible in a desktop implementation. The starting point was the Hobbs typescript of about 4000 words, which referenced around 40 still images and a similar number of film clips.

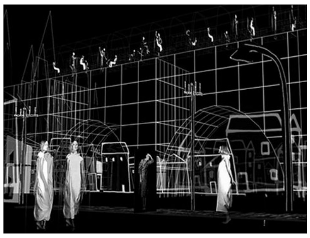
2.1 Spatialisation of knowledge

The first design issue to be confronted was the basic topology of the virtual environment. At one extreme we could make a single space in which the whole action would take place, with all images projected onto a single screen – a virtual lecture hall. At another, we could spread out the material in a linear fashion, with a succession of screens and delivery points to be visited in strict order. If strict sequencing was not required other topologies might be attractive, such as tree, star, ring or grid. Some of these are familiar forms for galleries and exhibitions.

There is a fair amount of architectural theory and precedent that might be considered. Space syntax (Hiller and Hanson 1984) draws attention to the importance of topology, suggesting for instance that public spaces should form a highly interconnected shallow graph, and private ones deep trees. Richard Owen's 1865 concept for the London Natural History Museum spatialised the taxonomy of the animal kingdom (Stearne 1981). Then there is the long tradition known as the *Art of Memory* (Yates 2001). From classical times orators trained themselves to recall an argument by committing to memory a series of *loci* within a building or city, and visualising mnemonic *imagines agentes* within them. Today's virtual space has a definite affinity to these imagined 'palaces of the mind' and might well be designed on similar principles, eg *loci* should be: not too similar, of moderate size, neither brightly lit nor dark, about thirty feet apart, in deserted places.

In the present case we analysed the structure of the lecture and spatialised that. It consisted of an introduction and a series of themes embracing stylistic and technical material - perspective illusion, gigantism, fantasy, gothic tendencies, fog and smoke, painted illusion, texture, abstraction. The themes fell roughly into three groups, each with internal continuity, but the groups themselves were not strongly ordered. This suggested a topology consisting of a central Hub, where the introduction is presented, with exits to three zones of two or three spaces each (Figure 2). Between zones there is a return to the hub; there is a single route through each zone; the order of zones is suggested but not enforced. We called the central space the Hub, and the three loops the Perspective, the Gothic and the Texture Zones. Later we added an entrance called the Robing Room, and an exit (the Gift Shop?).



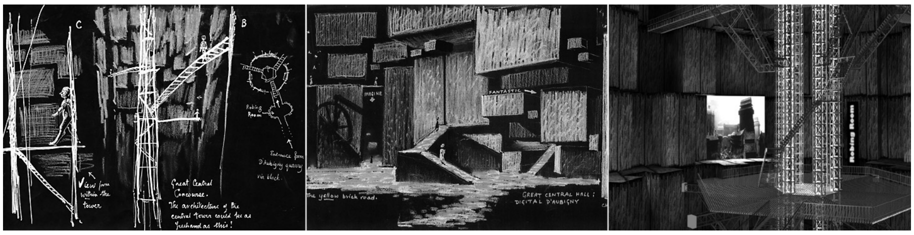
Figures 1-3 Aubigny, Topology, *Jubilee Line*

2.2 Look and feel

Hobbs' script already assumed that it was being delivered in a very special space, an ancient subterranean limestone quarry at Aubigny near Auxerre, France (Figure 1). The network of tunnels and high chambers has a peculiar facetted texture where large blocks of stone have been sawn out. This became a primary visual reference for the project, and an early trial VE was made in *Quake 3 Arena*. The Hub was a deep square pit, approached at a high level: the main route spiralled down around the walls, with the zones being sequences of caves at the corners, but on successively lower levels.

The trial space was found to be unsatisfactory in several respects. It was too small. The descending progress felt wrong – "onward and upward" would be better. The simple geometry and texture mapping were too literal; there was no necessity for our spaces and textures to be architecturally realistic. Virtual space could be more spare, nebulous or graphic: for example the Stargate sequence in *2001*; the PlayStation game *Rez*, or Tim Hope's exquisite short animation *Jubilee Line.* The latter was adopted as a second visual reference, both for architecture and the treatment of characters (Figure 3).

As the technical trials progressed Hobbs contributed a number of sketches, storyboards and renderings, which did in the end determine much of the environment (Figure 4). The Hub became a deep pit containing a flimsy latticed mast bearing several platforms with bridges to the zones (a familiar 'gothic laboratory' motif found everywhere from *Frankenstein* to *Half-Life*, and an oblique reference to Panorama rotunda (Grau 2003)). Its walls are facetted on a large scale like Aubigny, their fine texture is scanned directly from a chalk drawing by Hobbs (Figure 5), and they are dimly lit by radiosity from the scattered projection screens and illuminated signs (Figure 6). The Gothic Zone has an insubstantial white-on-black linear design, with a star-field behind. The Texture Zone uses semi-transparent screens textured with engravings by Gustave Doré of Dickensian London, and leads into a hypostyle hall of Abstract Space with rectangular columns based on Hobbs' design for *Edward II* and textures grabbed from the film itself (Figures 10-12).



Figures 4-5 Hub concept sketches; 6 Hub realisation

2.3 Demonstrations

As well as illustrations, a good lecture will often include demonstrations involving dynamic 3D objects, which in the case of *Mindstage* become interactive simulations affording the pleasures of *agency* and *transformation* (Murray 1997). A reconstruction of the combination of studio set and matte painting used in the *Wizard of Oz* is planned, but not yet executed. The Gothic Zone contains a reconstruction of the skyline models of Los Angeles used in *Blade Runner*, but the most elaborate is a reconstruction of the studio set for the ballroom scene in *Velvet Goldmine*. This was designed by Hobbs in a highly theatrical style – baroque architecture painted onto cut-out flats - and the demonstration has been realised from his original drawings. The student can interactively move the flats and modify the lighting (Figures 7-9).

Figure 7 *Velvet Goldmine* drawings; 8 Studio set; 9 *Mindstage* reconstruction

2.4 Avatars

The central problem for *Mindstage* was how to represent the lecturer. A character was required to lead the students through the spaces, draw their attention to the clips and demonstrations, and deliver the words of the lecture. Current games use detailed body models, skeleton-based animations derived from motion-capture of actors, photorealistic face textures and detailed lip-synch and expression generation. We did not have the resources to emulate these, and looked for less realistic and cheaper alternatives. Video techniques seemed promising – for example a full length or head and shoulders video sprite. We tested a 'cosmic egg' – a luminous ellipsoid with video of a disembodied face texture-mapped to its surface. Hobbs was not comfortable with the idea of video-recording the full lecture, and eventually, at his suggestion, we simplified the character to a floating Aztec mask. This is devoid of all internal expression, but can react gently by rotating and bobbing, and has proved surprisingly effective.

In a multi-player environment like *Mindstage*, it is necessary to provide avatars for the players (the students), so that they can see and recognise each other. As the motion requirements were very simple, we could have used stock game player-character models and animations, differentiated in the usual way by choice of skin texture map. Instead, we opted for a more abstract representation, inspired by Shelley Fox's fashion models in *Jubilee Line*. Each player is represented by a body-sized bounding box, on the surfaces of which are texture-mapped moving images built from the classical sequential photographs made by the 'father of cinematography' (Muybridge 1901) (Figures 10-12).

3 IMPLEMENTATION

Mindstage is implemented in *Virtools 3.0*, a package intended for interactive 3d simulations and game prototyping. An Environment is developed by assembling resources – 3d models, textures, sounds, animations, developed in other software - in the *Virtools* editor and then adding behaviours, that is, real-time programs that make the objects interactive and intelligent. Behaviours can be implemented at three levels: schematics composed in a visual programming language out of several hundred predefined building blocks; additional building blocks programmed in the lightweight *Virtools Scripting Language*; heavyweight additions programmed in C++. *Mindstage* employed all three techniques, though the visual approach predominates. At run-time, *Virtools* provides a render engine which updates the screen image at around 60 frames per second, and a behaviour engine which similarly allows each intelligent object to process its script incrementally once per frame.

3.1 Static objects

The following resources are static in that they require little or no intelligence. They are exported directly from a modelling package:

1) Triangle meshes (with *uv* texture coordinates attached) representing the architectural geometry of the environment.
2) Texture maps, often with alpha masks for holes or partial transparency.
3) Lightmaps, additional textures representing the results of a radiosity lighting calculation. Basic lighting can be done at runtime, but high-quality global illumination needs to be pre-calculated.
4) Collision surfaces: some meshes (not necessarily visible) may be designated as walls or floors to constrain the movement of the player.
5) Lights: as we used pre-lighting the usual computer-graphics lights were not needed, though some objects (signs, screens) were made self-luminous.
6) Ambient sounds: these need simple scripts to ensure that they are only heard by players in the relevant spaces.

3.2 Dynamic objects

These objects involve extensive scripting to develop their interactive behaviour. There is usually a core of static geometry as well. When there are many similar objects (like movie clips or control consoles) they will be created by an initialisation script, usually by copying a common prototype and setting its attributes. Most dynamic objects are also *shared*, meaning that key attributes are automatically synchronized between users of a multi-user environment, so that each user sees the objects in the same position, and performing the same actions.

1) Movie-clip: essentially this is an intelligent texture defined by an *avi* file, with behaviour to start and stop playing itself, and also an associated *wav* file containing the soundtrack. State of play is shared, so each user sees the same frame.

2) Console: each movie screen has an associated control console from which the student can control the display, independently of the lecturer. The script detects the proximity of the student and the use of a *Ctrl* key, then changes colours and activates the film clip.

3) Moving objects such as lifts and the scenery in the *Velvet Goldmine* set require quite elaborate programming. The motion must be shared between users, and transmitted to characters and objects standing on them.

4) Student avatar: each player has control of his own avatar, whose position, orientation and animation state is shared with other players. Four scripts are used: one deals with the animation frame and footfall sounds; one deals with text chat between players; the third detects keyboard and mouse action and uses them to control movement; the fourth prevents collisions with other objects, and makes sure that feet stay on the floor.

5) Lecturer avatar: this has by far the most complicated script, which is driven by a database which associates with each paragraph of speech the place from which it should be delivered and the clips to show. More general behaviour causes the mask to move between positions and to wait for students to be nearby, looking in the right direction, and not chatting among themselves before delivering the next segment. Various ‘cut-away’ remarks have been recorded to help the avatar attract attention and shepherd students through the space.

Figures 10-12 Gothic, Texture and Abstract Space zones with avatars

4 EVALUATION

Evaluation of the overall pedagogical impact will be delayed until completion; meanwhile preliminary play testing has uncovered a few issues to be addressed on the way: the spatial design is overly linear, the soundscape needs attention, interaction with consoles is clumsy, and the demonstration lacks purpose.

At the technical level, we find that *Virtools* has delivered most of what we required. In particular, we have been surprised at how well we can play several high-resolution movie clips in virtual space simultaneously; something difficult or impossible in most game engines. Most of our problems have been to do with sound. Movie clips are textures, and generate no sound; we have to play the soundtrack separately, and it soon goes out of sync. We cannot add reverberation effects at run time, and failed to find a way to implement voice chat with spatialised sound. The hardware resources needed are quite heavy – *Mindstage* so far occupies about 650Mb on disk, and needs a 3GHz machine with 1Gb of memory and a good 64Mb graphics card to play smoothly. Parts of the workflow are quite delicate, particularly baking the lightmaps, where we had to patch some of the macros involved. We found that the *Virtools* visual programming approach encourages its own version of "spaghetti code"; it is not properly object oriented and it is going to take further effort to achieve adequate levels of abstraction, encapsulation, information hiding and inheritance. Shared objects, needed in a multiplayer world, unfortunately have a different programming model to normal ones, and are challenging to test and debug.

At the conceptual level, most of our problems have centred on multi-player issues. In a single-player environment, the player's sense of time is personal. Time can be interrupted by leaving the game and coming back later; and it is quite possible to revert to an earlier saved state of play. But in a multi-player world these thing are not possible. If players are to share the state of the lecture, so that they can interact over its contents, then they must operate in the same time frame. If a player leaves the lecture and returns, he will have missed a segment. If he joins later than the first player, he will miss the start.

It turns out that there is quite a wide range of choice over which dynamic objects are shared. If nothing, then the game provides a single-user experience. If the player avatars and film clips are shared but not the lecture sound track, then each player will have a private experience, like visiting an interactive museum with a personal audio-guide. If everything is shared, then you get a synchronized guided tour running every hour or so, rather than an on-demand private visit.

Our tentative resolution is to divide space and time into three chunks, corresponding to the major zones. Each zone has its own instance of the lecturer, running in its own time frame. This has two beneficial effects; waiting time for a segment to start is reduced to a third, and the segments can be taken in any order. The drawback is that it reduces the unity (in Aristotle's sense) of the lecturer character.

5 CONCLUSION AND FURTHER WORK

Although incomplete, it is clear that *Mindstage* succeeds on several levels. That our initial ambition, to enliven a virtual architectural space by placing meaningful activity in it, has succeeded is rather obvious in its current state of incompletion. Empty unlit spaces, though navigable, are not interesting. With radiosity lighting installed they become visually attractive; with film clips and sound tracks added they invite exploration; and when the lecturer is activated they become intellectually rewarding.

Mindstage is, as intended, visually intriguing, sitting at the boundary between architecture, film and virtual reality. Placing Hobbs's thoughts about Hobbs's films in a Hobbsian space delivers a modern virtual *Gesamtkunstwerk*, especially startling where filmic space of the movie clips achieves a kind of continuity with the virtual architecture on which it is projected (Figure 12).

According to the educationalists, the reason for making a Virtual Learning Environment both spatial and multi-user is that “co-presence promotes shared conversation context, mutual ‘tracing’ supports mutual modelling of knowledge and implicit co-ordination of problem solving strategy” (Dillenbourg 1999). While *Mindstage* offers these affordances the time-frame conflicts we have unearthed show that they come at the expense of on-demand access. In the multi-user case, Gu’s elements of virtual architecture (layout, navigation and interaction) should be expanded to include *characters* and especially *time* (Gu and Maher 2004).

For the future we intend to make some rationalisation of the software structure, and then complete the lecture so that it can be tested on students. Two further lectures – on the filming of *Gormenghast* and the History of Perspective – are being contemplated. Beyond that we intend the software components to contribute to a larger toolkit (the *Cambridge Architectural Game Engine*) which will enable us to implement a wide range of expressive and useful virtual places.

6 ACKNOWLEDGEMENTS

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The *Mindstage* DVD contains many small excerpts from copyright material. Under fair use provisions we may develop it as an academic research project, and show it at academic meetings. We regret that we do not have the resources to obtain the clearances needed for a wider distribution.

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