GENERATING VIRTUAL ARCHITECTURE WITH STYLE

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Abstract: Virtual architecture is a networked spatial environment designed using the metaphor of physical architecture[1], from which virtual architecture inherits many visual and spatial characteristics. However, in order to further explore its potential, virtual architecture need to go beyond its physical metaphor to develop its own theories and styles. One important step of this process is to establish a formal foundation for designing virtual architecture. This paper discusses styles of virtual architecture by analysing various design examples. The findings contribute to the development of design formalisms for virtual architecture.

1. INTRODUCTION: VIRTUAL ARCHITECTURE

Designing Internet environments as architecture considers forms and functions of these networked environments as an alternative kind of architectural design. The design and implementation resultant from this concept is called virtual architecture. According to Maher et al (2000), the phenomenon of virtual architecture can have two purposes: a simulation of physical architecture or a functional virtual place. As a simulation of physical architecture, virtual architecture mimics its physical counterpart using various digital media. As a functional virtual place, virtual architecture supports an extended range of online activities. Virtual architecture can inherit characteristics of being a place, from physical architecture, and the concept of place provides a way to organise our experience of the world. Therefore, this world now has at least two layers of meaning: the physical world that we are relatively familiar with and the virtual world comprised of bits.

1.1 Virtual Worlds Design Platforms

Designing virtual architecture has accommodated many different technologies like MUD, MOO and various 3D virtual world design platforms, supporting multi-user text-based, 2D graphical and 3D virtual worlds, as illustrated in Figures 1 and 2.

The multi-user text-based approach relies purely on the use of linguistic references to the architectural metaphor. The 2D graphical approach is more intuitive by applying the architectural metaphor from a graphical perspective via the use of digital images. Recently, 3D virtual worlds have become more common. These worlds use 3D models for representing places. A person appears as an avatar (an animated character) which locates the view of the world and provides a sense of awareness of others in the world. Examples of 3D virtual worlds are among those designs implemented with Active Worlds, Adobe Atmosphere[2], Virtools and others.

1.2. Static and Dynamic Virtual Architecture

From a structural perspective, virtual architecture can be seen as a composition of architectural metaphor and computing entities. By alternating the focus between these two aspects, we design static or dynamic virtual architecture.

Current examples of virtual architecture are largely static. The definition of virtual architecture indicates the use of metaphor. Through the use of metaphor, concepts in one domain can be expressed in terms of another (Lakoff and Johnson, 1980). The architectural metaphor refers designing virtual architecture to designing physical architecture: a relatively more familiar area. This connection forms a consistent base for adapting design knowledge

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[1] To avoid confusion, architecture as it is conventionally understood and practised, is referred to the term: physical architecture in this paper.
[2] http://www.adobe.com/atmosphere

from physical architecture for designing virtual architecture. In virtual architecture, one recognisable effect of the architecture metaphor is the formation of its spatial infrastructure. As a result in most cases, this spatial infrastructure is an assembly of architectural or architecture-like models. Typical implementation of virtual architecture such as object-oriented virtual worlds is based on placement and configuration of objects. Each object has an appearance of a 3D model in the virtual world, and together they define the spatial infrastructure of virtual architecture. These objects then can be configured or programmed to have certain behaviours that allow the occupants to interact. Similar to physical architecture, such designs are pre-defined prior to their use. The resultant environment serves certain purposes but does not take into consideration the possible changes of the purposes during its use, and these changes often occur when the occupants interact and collaborate with each other. The modification of the environment can be made by the designers but is rarely accessible to its occupants.

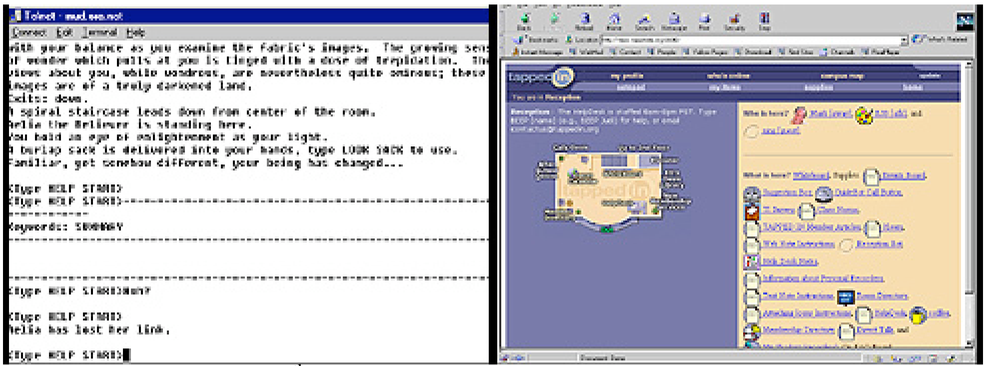

Figure 1. Left: 7th Circle (telnet://mud.oro.net:4000), a text-based MUD;
Right: Tappedin (http://www.tappedin.org:8000), a 2D graphical MOO.

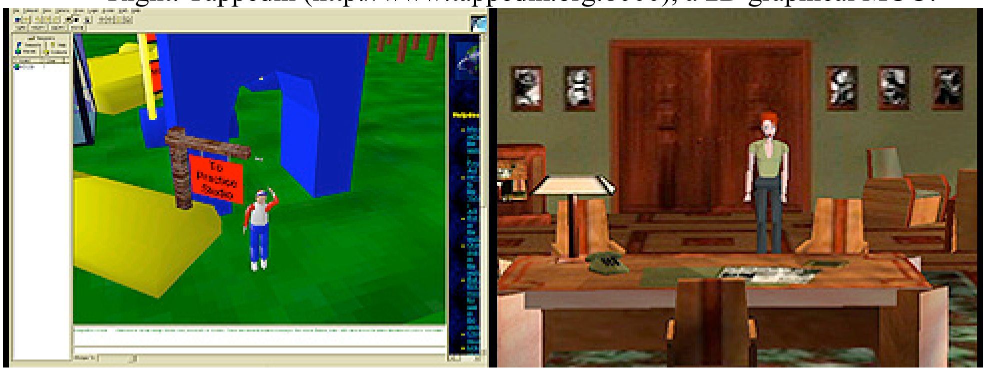

Figure 2. Two examples of 3D virtual worlds implemented with (left to right):
Active Worlds (http://www.activeworlds.com) and Virtools (http://www.virtools.com).

However, virtual architecture does not have to be static. It can be highly interactive and dynamically designed as needed (Gu and Maher, 2003, Maher and Gu, 2003). Except for the input and output devices, virtual architecture is implemented entirely in a computer environment. Therefore, virtual architecture is basically an assembly of computing entities, which can be flexibly programmed and configured. This flexibility makes it possible to consider designing virtual architecture in terms of dynamics and autonomy.

The development of the two compositional aspects of virtual architecture has not been well balanced. Issues that are related to defining spatial infrastructure, such as metaphorical design, visualisation and visual optimisation, have been always the foci of designing virtual architecture. It is not until very recently that we witness some progress being made in the development of computing entities for dynamic and interactive virtual environments.

2. FORMALISING VIRTUAL ARCHITECTURE STYLES

In physical architecture, a specific style is exemplified when several designs "each create a similar impression". The study of style is mainly about characterising the basis for this similarity (Stiny and Mitchell, 1978). In the same paper, Stiny and Mitchell further specify the three main purposes of this characterisation as "(1) it should clarify the underlying commonality of structure and appearance manifest for the building in the corpus; (2) it should supply the conventions and criteria necessary to determine whether any other building not in the original corpus is an instance of the style; and (3) it should provide the compositional machinery needed to design new buildings that are instances of the style". These concepts establish a basis for studying styles of virtual architecture.

Unlike physical architecture, virtual architecture has fewer design cases and less-developed design theories, as the history of virtual architecture can only trace back to about two decades' ago. In the following sections, we apply our design experience and understanding to analyse styles of virtual architecture.

2.1 Styles of Static Virtual Architecture

Like physical architecture, static virtual architecture has a persistent infrastructure that is pre-defined by its designers. Our understanding of virtual architecture as a functional place that supports professional activities provides a common ground for designing virtual architecture. This common ground highlights two key issues: activities and metaphor. Firstly, virtual architecture exists for certain purposes supporting various online activities. Secondly, virtual architecture applies the metaphor of physical architecture. This metaphor provides a consistent context for occupants to inhabit the environment and to interact with each other. Based on this understanding, designing virtual architecture can be divided into the following four phases:

- To layout space for designated activities: the space has a volume that corresponds to certain online activities.
- To configure the space: the space then is configured with certain spatial infrastructure, which provides spatial boundary and visual cues for supporting the designated activities.
- To define navigation: navigation in virtual architecture can be facilitated to consider the use of way finding aids, the hyper connectivity among different sub-spaces, and so on.
- To specify interaction: in general this is a process of ascribing behaviours to certain visual objects, so that the occupants can interact with objects and each other.

Therefore, styles of static virtual architecture can be considered in terms of visualisation (layout and visual forms of spatial infrastructure), navigation and interaction. They are three inseparable parts for providing an integral "impression" of virtual architecture.

2.1.1 Styles of Visualisation

The visual styles of virtual architecture vary when using different design platforms, especially when the platforms are developed for different digital media types. For example, Figure 1 and 2 illustrated in section 1.1 presents four different designs of virtual architecture using four different design platforms.

Even when the designs are implemented using the same platform, the visual styles of virtual architecture can still differ by applying the architectural metaphor differently. For example, the left hand side of Figure 3 shows a virtual campus design in Active Worlds that strictly applys an architectural metaphor, where visitors can find familiar elements based on their experiences in the physical world. The right hand side of Figure 3 is a virtual museum design in Active Worlds that introduces some abstract visual elements in addition to the conventional architectural element. Visitors in this environment need to explore and learn about the semantics of the abstract metaphor based on their own virtual experiences.

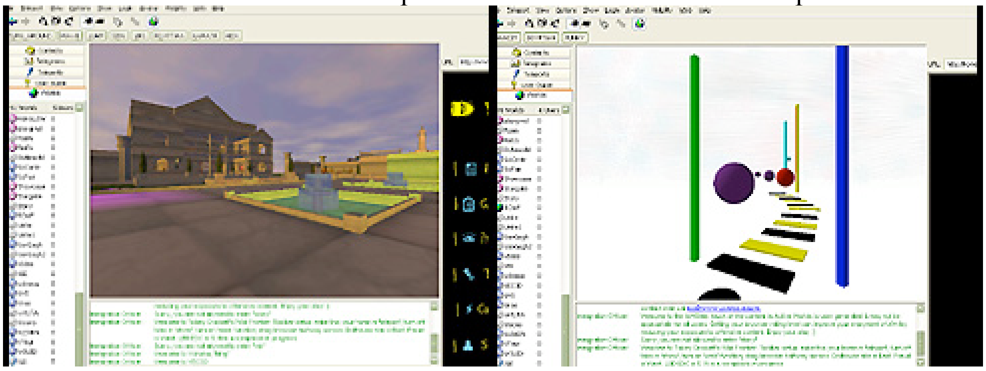

Figure 3. Two examples from Active Worlds educational universe (left to right): Wec3D virtual campus and TCWF virtual museum.

The visual styles of virtual architecture can also change if the architectural metaphor is applied with different styles. The left hand side of Figure 4 is the reconstruction of a village based on Van Gogh's paintings. The right hand of Figure 4 is a rather modern building with the use of contrasting colours and transparent materials.

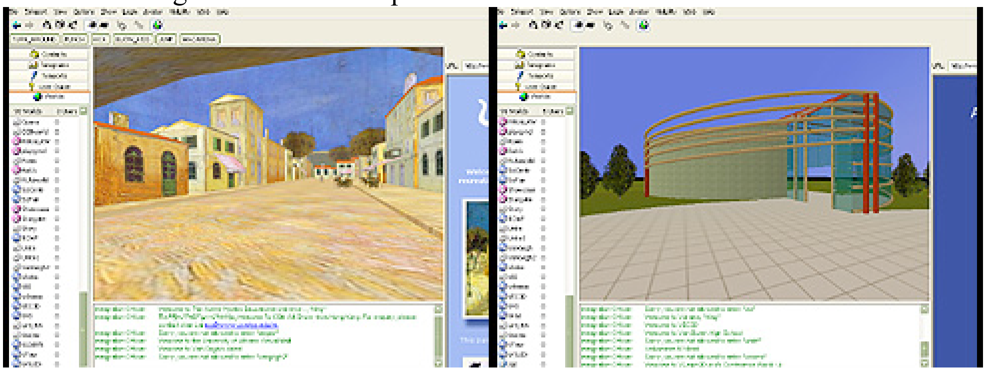

Figure 4. Two examples from Active Worlds educational universe (left to right): Van Gogh world and VLearn online learning environment.

Finally, different uses of layout and forms can as well result in different visual styles. For example, the left hand side of Figure 5 uses the rectangle, one of the primitive geometric shapes as the basic design element, while on the right hand side the design has a rather organic form. In Figure 6, the design on the left extends vertically, following a spiral-like curve, while the one on the right extends horizontally along a floating path.

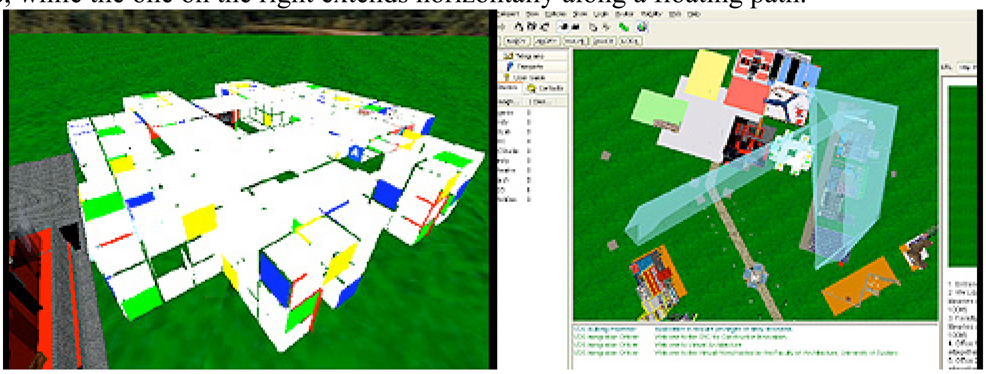

Figure 5. Two Active Worlds examples by students at the University of Sydney (left to right): a virtual gallery and an information centre.

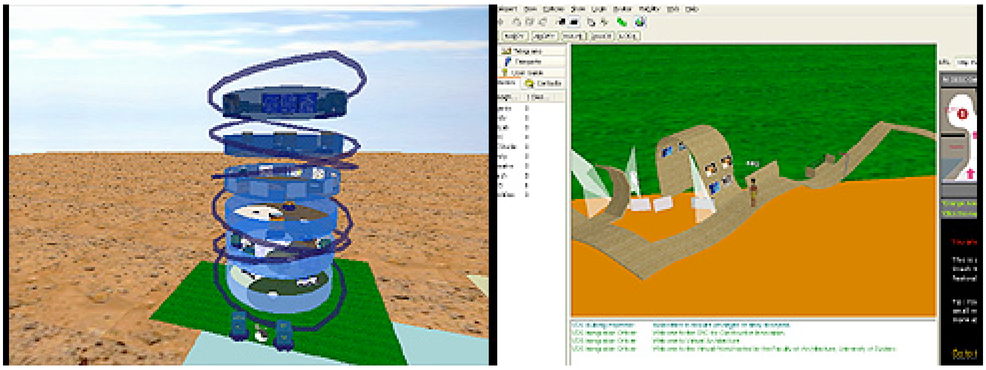

Figure 6. Two Active Worlds examples by students at the University of Sydney (left to right): a virtual studio and a virtual gallery.

2.1.2 Styles of Navigation

Navigation in virtual architecture relies on the use of way finding aids such as environmental image (Lynch, 1960) or hyper links. Way finding in virtual architecture has been studied with direct references to way finding in the physical world (Darken and Silbert, 1996, 1993, Vinson, 1999). In summary, various way finding aids can be borrowed from the physical worl, such as:

- Spatial elements: paths, openings, hallways, stairs, intersections, landmarks, maps, signs and etc.
- Social element: help from tour guide (conversational softbot) or other occupants.

Besides the above references from way finding aids in the physical world, virtual architecture has its unique ways of navigating as virtual places are hyper-linked. Therefore most virtual world platforms such as Active Worlds also provide the following two kinds of navigation methods. They can be classified as semantic elements, which have an origin in navigation of hypertext system (Dourish, 1999).

- Teleport portal: a hyper link that takes avatars from one location to another location without transition.
- Warp portal: a hyper link that takes avatars from one location to another location with transition.

For example, in Figure 7, the design on the left has its areas spatially adjacent to each other. Therefore, visitors can travel from one area to another by following the path, signs and openings. The image at the middle is an interactive map for a virtual gallery. This map appears at several key locations of the gallery and tells the visitor his/her current position. Visitors can mouse-click on areas that are marked with numbers to teleport directly to the relevant locations in the virtual gallery. The image on the right captures a snapshot of a conversational softbot in Active Worlds. This softbot responds to people in the virtual world by matching keywords in their chats.

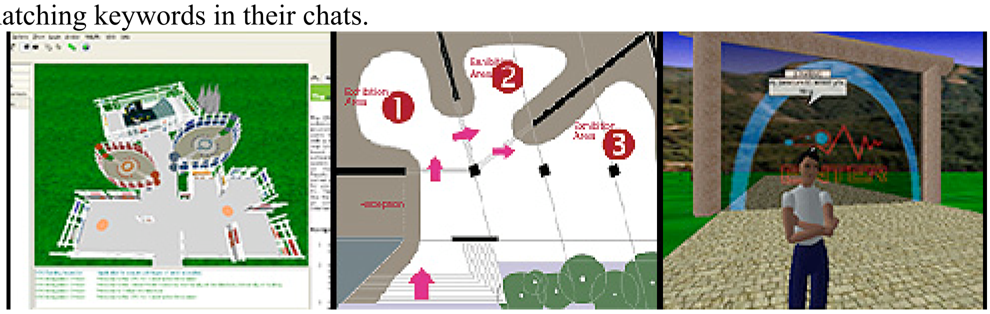

Figure 7. Left: A bird view of CRC world implemented using Active Worlds; Middle: an interactive map used in a virtual gallery designed by students at the University of Sydney; Right: a snapshot of a conversational softbot in Active Worlds.

In many design platforms, for example Active Worlds, hyper links are integrated with visual cues as part of the design. They are called portals. For example, the left hand side of Figure 8 shows two sets of sculptures along a path. Each of them can be mouse-clicked to teleport to a different place. In some designs, the visual cues of portals are hidden. For example, the image at the middle shows a tunnel in a maze design. There are hidden panels placed in the tunnel, when a visitor bumps into these panels, it warps the visitor to the end of the tunnel and transfers to the destination. In other platforms, hyper links are not connected to the visual representation of the objects in the design. For example, in the virtual museum implemented using Virtools shown on the right, visitors can choose to visit the four different sections of the exhibition by pressing different keys on their keyboards.

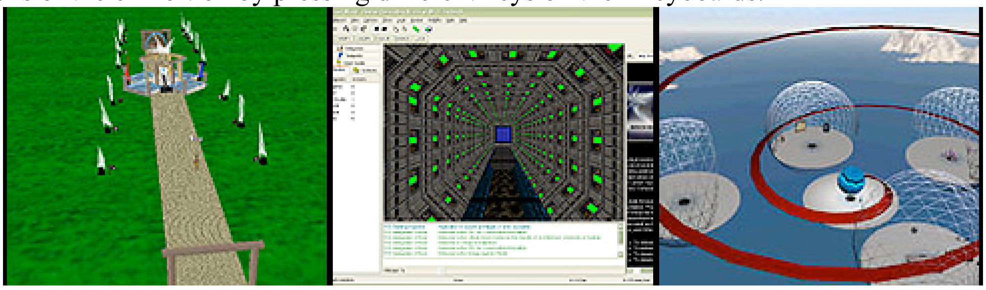

Figure 8. Left: the sculptures are used as portals in VDS world designed by students at the University of Sydney; middle: a tunnel with hidden portals designed by students at the University of Sydney; Right: a virtual museum designed using Virtools.

2.1.3 Style of Interaction

Many current designs of virtual architecture have their foci on visualisation. In these environments, occupants can interact with simple mouse-click actions on some objects or bump into other objects to have those pre-defined behaviours activated. Such behaviours are opening a web page or changing the appearances of the associated object. There is an essential difference between interactions activated by mouse-click actions and those activated when visitors bump into objects:

- When an occupant intentionally performs a mouse-click action, he/she is expecting some consequences. Therefore the designers of the environment allow its occupant to have certain degrees of control over the interactions with the environment.
- When an occupant accidentally bumps into some objects (especially the hidden objects) and activates their behaviours, he/she encounters the interactions unexpectedly. In this way, the designers are able to express their design intentions more assertively.

Some interactive designs carefully combine objects with different behaviours in an environment. Therefore, one interaction between the occupants and the environment can activate other subsequent interactions. Therefore it creates the illusion that the environment actively interacts with the occupants. For example, Figure 9 illustrates three different states of a virtual studio, showing how the studio can respond differently to the existence of its occupants.

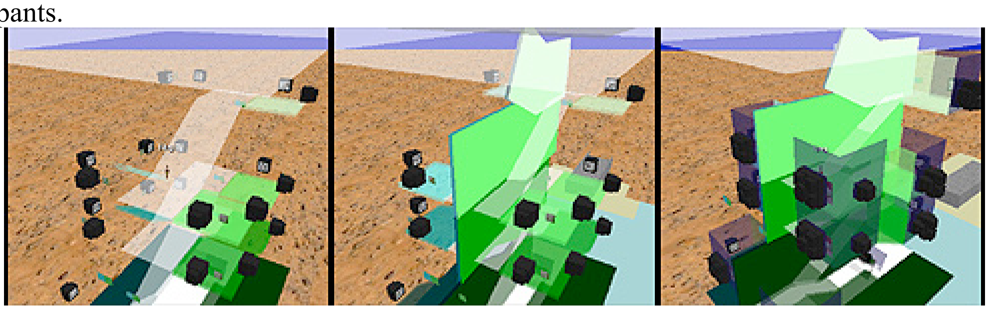

Figure 9. A virtual studio designed by students at the University of Sydney.

Recently, like the gaming industry, a more advanced approach is to combine AI with the development of virtual architecture. For example, Maher et al (2003, 2003) apply a rational agent model for designing and representing 3D virtual worlds. Each element in the 3D virtual world can become an agent. The agent has its belief, can sense and interpret the environment, hypotheses goals and seek to achieve these goals by making suggestions to the occupants or simply act on his/her behalf. In this manner, virtual architecture can be proactive.

2.2 Styles of Dynamic Virtual Architecture

Dynamic virtual architecture shares all the stylistic characterisations of static virtual architecture discussed above. However, unlike static virtual architecture which requires designers to pre-define the detail of each individual design for different uses, dynamic virtual architecture is only designed when it is needed, without the legacy of persistent infrastructure. Therefore, dynamic virtual architecture has a so called generative style. The development of dynamic virtual architecture consists of two main components (Gu and Maher, 2003, Maher and Gu, 2003):

- A reasoning mechanism that allows design and other domain knowledge to be integrated: therefore virtual architecture can observe its occupants, interpret their needs and hypotheses goals in order to match the interpreted needs.
- A design formalism that serves as the generative component for dynamic design of virtual architecture: therefore designers define a design formalism that produces a certain design language of virtual architecture, rather than pre-define detail for a specific design. The application of this formalism is directed based on the interpreted needs from the reasoning mechanism. By applying this design formalism, virtual architecture is self generated, manipulated and ceased as required. The use of this formalism also largely simplifies or even automates the design and implementation process of virtual architecture.

Our current research is to develop a Generative Design Agent (GDA) model for dynamic design of virtual architecture. Adapted from the agent model for 3D virtual worlds (Maher and Gero, 2003), a GDA model is specifically proposed for designing dynamic virtual architecture. The five computational processes of a GDA model are sensation, interpretation, hypothesising, designing and action activation. Through this design agent framework, a GDA is capable of representing a person in the virtual world to sense, interpret, hypothesise, design and act on his/her behalf.

The central part of a GDA's design process is the application of a design grammar. This design grammar is developed based on the notion of shape grammars (Stiny and Gips, 1972). The application of the grammar is directed to dynamically generate designs of virtual architecture, in order to satisfy the current needs of the occupants interpreted by the GDA. The above analysis on styles of virtual architecture is used when developing a design grammar for dynamic virtual architecture. The structure of the design grammar consists of four sets of design rules: layout rules, spatial infrastructure rules, navigation rules and interaction rules, which reflect different stylistic aspects of virtual architecture.

The completed design of dynamic virtual architecture is due to implemented, the current development of dynamic virtual architecture remains in the prototyping stage. Figure 10 simulates two generative styles of dynamic virtual architecture. The image of the left shows an architect's studio. Rooms are placed on different levels and linked via a lift at the centre. The studio can be dynamically expanded by adding or subtracting fixed sized rooms along the lift as needed. The image on the right shows a large-scaled showroom whose interior can be dynamically arranged and configured to suit different purposes. Besides these two, another generative style of dynamic virtual architecture can be incrementally or decrementally resized for a single-use space to address the crowd circulation or for other purposes.

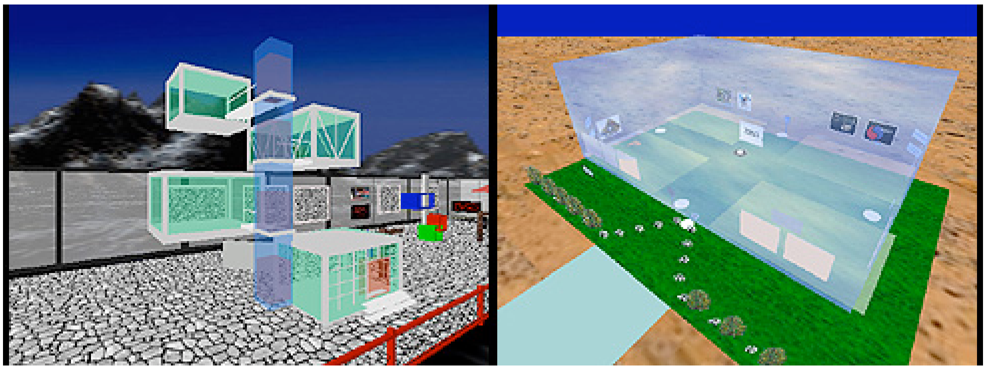

Figure 10. Two generative styles of dynamic virtual architecture
(images taken from student designs at the University of Sydney).

3. DISCUSSION AND APPLICATION

The analysis on styles of virtual architecture and their examples can serve as guidelines for the development of design principles for individual designs of virtual architecture. When designing static virtual architecture, designers can directly apply these principles in individual design case. When designing dynamic virtual architecture, these principles are used to develop a design formalism, for example, a design grammar. Therefore a specific style of virtual architecture is defined, and it can be applied to generate designs to satisfy different needs.

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