User Interface for Creating Traditional Chinese Architecture

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Abstract— *We present an interface for users to conveniently and quickly create a settlement with various standard structures in traditional Chinese architecture. The main page of the interface is a top-down map view of the canvas which allows users to place different structures, such as pavilions, pagodas, halls, houses, gates, moon-gates and bridges onto the scene. Then, the user can custom-design each structure. Because traditional Chinese architecture has a standard form, we simplify the design of a building into a few parameters which users can edit, such as roof curvature and roof height. This allows the user to design the building according to their preference and still adhere to the traditional Chinese architecture form.*

Keywords: computer graphics, procedural modeling, architecture, culture, user interface, 3D models

1. Introduction

3D models of buildings and other structures in traditional Chinese architecture are popular because of their beauty and because of the evocative environment they create in CGI movies and video games. In 2008, for example, DreamWorks Animation's feature film Kung Fu Panda won the Academy Award for Best Animated Feature, and was followed by a sequel in 2011.

In this paper, we describe our work in creating an interface for users to conveniently and quickly create 3D models of a variety of structures in traditional Chinese architecture. The structure of traditional Chinese architecture follows strict rules, therefore it is suitable for computer-aided design, however, some structures, such as the roof, are also very complex, and therefore require computer-aided design for users to create quickly.

Our program is able to create some main structures found in a traditional Chinese settlement, including pagodas, pavilions, halls, houses, bridges, platforms, fortified walls, garden walls, gates, moon-gates, and ceremonial arches. We provide a convenient interface for the user to place structures on the map, and therefore create a traditional Chinese settlement. We also provide the user with the interface to custom-design each structure created.

Because traditional Chinese architecture has a standard form, we simplify the design of a building into a few parameters which users can edit, such as roof curvature and roof height. This allows the user to design the building according to their preference and still adhere to the traditional Chinese architecture form.

2. Related Works

Our work uses procedural modeling to create and describe building structures. Birch et al. [1] introduced one of the earlier works on procedural modeling of architectural structures. They make use of a large library of prototypes to create 3D models of buildings. They have windowsplitting and curve-generation components, and their program can add the 3D models into a scene-graph.

Wonka et al. [9] described a method for modeling architecture using split grammars to generate non-trivial volumetric shapes. They created a large database of rules from which they modeled different designs. With a parameter-matching system, users can specify high-level design parameters to influence the output. They also introduce control grammars, which grow buildings according to architectural principles. Lipp et al. [5] later extended this work to create user-friendly interactive tools so that the user can interactively edit and control the output of the grammar-based procedural architecture system.

CGA Shape [7] is a shape grammar introduced by Muller et al. It has production rules that iteratively generates building models with increasing detail, such as window facades and roof surfaces. This powerful grammar can describe complex building models not restricted to axis-aligned shapes. They are able to create buildings and entire with buildings of varied designs and styles of significant complexity and realism, from medieval towns to futuristic skyscrapers. A user interface lets the user control parameters to determine the appearance of the automatically-generate buildings. CGA Shape is now available in a commercial package called CityEngine.

Several previous works specifically create buildings in traditional Chinese architecture. For example, Chan et al. [2] modeled the Temple of Heaven in Beijing, as part of the effort to preserve historical architectural knowledge, using photographs of perpendicular elevations of the buildings.

Liu et al. [6] built 3D models of vernacular houses in the Southeast China style. They model the vernacular house to significant detail, with elements like roofs, windows, and various types of walls.

Liu et al. [4] introduced a procedural modeling technique based on Chinese Ancient Architecture design theory. They formalized the design patterns into a set of Constructive Grammar rules.

Teoh [8] formulated a description for traditional East Asian architecture using procedural modeling. Noticing that

the structure of traditional Chinese, Korean and Japanese architecture all follow a similar design, but with different parameters, Teoh developed a procedural model for halls and pagoda towers, and by changing parameters such as the number of sides of a pagoda, or the curvature and height of the roof, the user can create structures of different styles.

Hou et al. [3] presented a modeling framework for building 3D models of traditional Chinese architecture from elevation drawings. They use automatic drawing recognition to extract production rules from elevation drawings. They cluster repetitive horizontal regions from the drawings to form architectural components, which serve as elements for 3D model generation. Then, these components are structured into a shape tree and organized hierarchically using Markov Random Fields. Finally, shape grammar rules are derived to construct the 3D semantic model and variations.

3. Interface for creating Chinese architecture

There are two steps in the creation of a traditional Chinese settlement. On the first page of the interface, we allow the user to drag and drop various types of traditional Chinese structures, such as halls and pagodas. The second step is to allow the user to click on one structure to edit. The interface will then focus on the selected structure, providing a user-friendly interface for the user to adjust various parameters associated with the structure type, to custom-design the structure.

3.1 Creating a Settlement

The main page contains a simple interface for the user to create a settlement. On the left is a canvas for the user to drag and drop various structures. On the right is a control panel for the user to choose which structure to create, by clicking on the representative icon. The structures available are: Hall (or House), Pagoda, Pavilion, Platform, Staircase, Corridor, Gate (Ceremonial Arch or Moon-Gate), Wall, Bridge (Wood or Stone Arch) and Tree. The user simply chooses the desired structure, then clicks on empty space on the canvas, and a new structure of the selected type will be created and placed on the canvas. An example is shown in Figure 1.

The control panel also contains icons for manipulating the structures, such as rotate, translate and scale. The user clicks on the desired action, then clicks on the structure to move, and holds down the mouse button while moving the mouse, and the selected structure will transform accordingly.

Structure such as platforms, halls and pagodas are simply placed on the map with a single mouse click. However, other structures such as Bridge and Gate are placed with two mouse clicks, one on each end-point of the bridge or gate. After placing the bridge or gate on the map, the user can move it by right-clicking on one endpoint and dragging it.

To the best of our knowledge, this is the first program that enables users to drag and drop structures to create a settlement in traditional Chinese architecture. This allows artists to conveniently design a settlement. The top-down map view gives the user an overview of the settlement.

3.2 Designing a building

The user can rotate, translate and scale a structure from the main canvas. However, to custom-design a building, the user has to click on the building, and select the "Edit building" mode. The program will then switch to the Edit Building interface. An example of the interface is shown in Figure 2, which shows how a user can edit a Hall structure.

The Figure shows the parameters that can be controlled by the user. For example, the user can click on the control point to adjust the Roof Height, or the Ceiling Height. The user can also adjust how far the pillars and the walls recede from the ceiling edge. The user can also adjust the curvature of the eaves and roof by moving the control points. Other parameters such as wall texture and number of storeys are entered in the adjacent control panel.

In the control panel, the user can also toggle between Hall type and House type. The difference is that the Hall type has eaves on all four sides, while the House type has solid wall on the sides all the way to the top. Examples of houses are shown in Figure 3. The tip of the roof can also be toggled between Rounded style and Pointed style. This Figure shows the difference between the two types of roofs.

The most elaborate part of traditional Chinese architecture is the roof. Roofs are found in different structures: Houses, Halls, Pavilions, Pagodas and Corridors. To structure the roof, our program separates a roof into three parts: (1) the Main Roof, (2) the upper eave, which is above and inside the ceiling line, and (3) the lower eave, which is below and outside the ceiling line.

For a Hall, which has eaves on all four sides, the Main Roof is a prism shape with triangles on the sides, and a single plane on the front and back of the Hall. The user-controlled parameters are: Width, Height and Curvature of the Main Roof. Upper and lower eaves exist for every storey of a House, Hall and Pagoda. The user-controlled parameters are: Width, Height and Curvature of the eaves. By controlling these parameters, the user is able to create structures with different styles. For example, the Tang style tends to have straighter roofs, while the more recent styles have curved roofs for Halls. Houses also tend to have straight roofs, and some also have rounded instead of pointed roof-tops.

The bracket (dougong) system used in the construction of traditional Chinese buildings is also very complex. They are difficult to model for the average user, but they are a distinctive part of traditional Chinese architecture, so they are essential. Our system automatically generates these bracket systems. The bracket structure holds beams which hold up the roof, which can be very heavy. In our program,
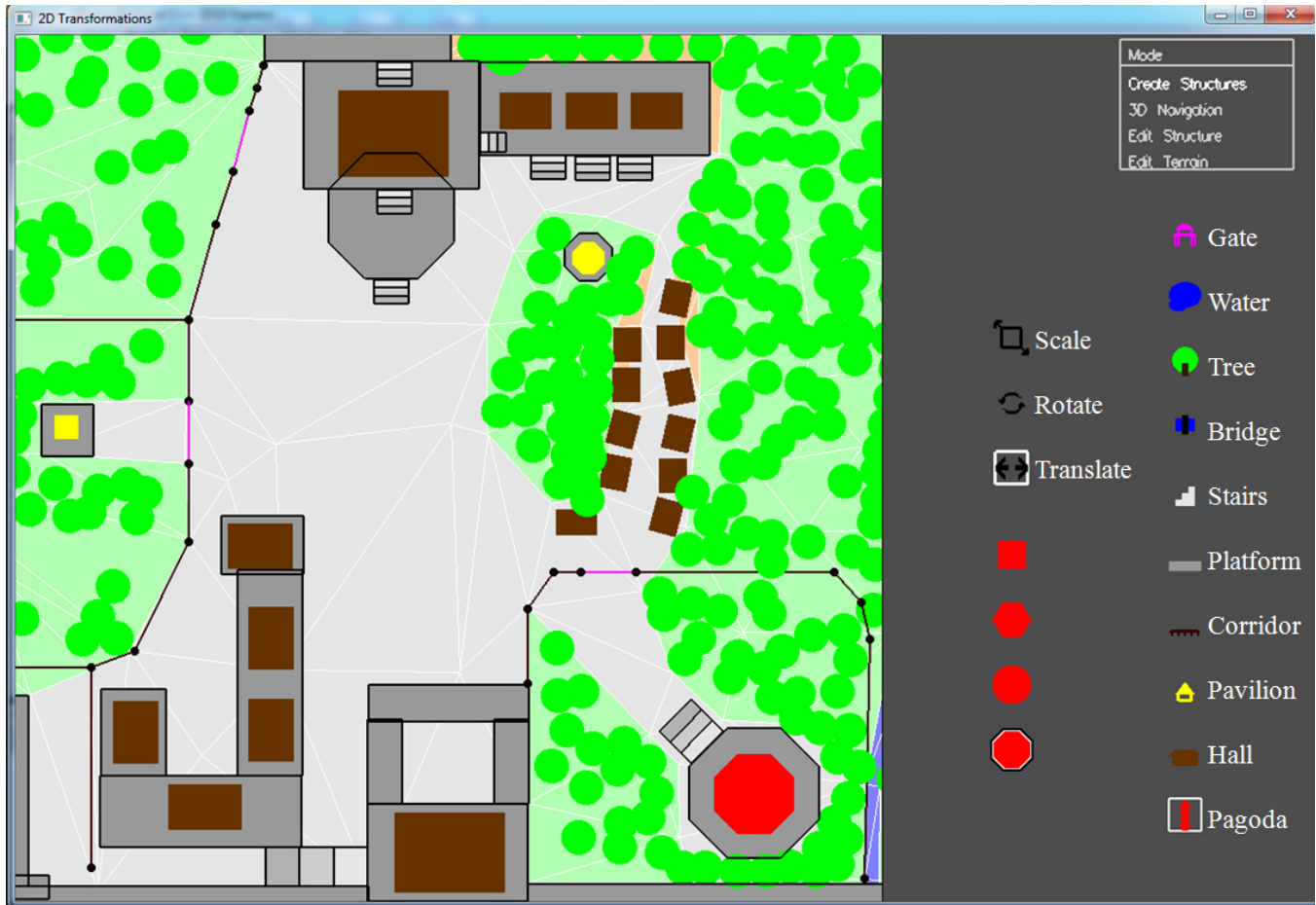
Fig. 1: Interface for creation of structures. Right: Control panel to select structure and interaction. Left: Canvas map to place the structures.

we allow the user to specify the number of pillars on each side of the building. Then, for each pillar, the program automatically creates brackets at the top of the pillar to support the roof. Taking into consideration outer-eave height and width, and pillar offset from the ceiling line, the program calculates the dimensions of the brackets and beams and automatically creates the brackets. An example is shown in Figure 4.

Another structure we allow the user to create is the Gate. There are two types of gates supported: (1) the Moon Gate, and (2) the Ornamental Gate ("Pailou" or "Paifang"). Both are characteristic of traditional Chinese architecture. An example of the Moon Gate is shown in Figure 5 and an example of an Ornamental Gate is shown in Figure 6.

The user creates a gate on the map by clicking on two endpoints of the gate on the map. When a gate is selected, we allow the user to toggle between Moon Gate and Ornamental Gate types. The Moon Gate is an essential part of a Chinese garden, and is connected to a garden wall, as shown in the

example. The Moon Gate contains a circular opening. Like the garden wall, the Moon Gate also has an ornamental tiled roof.

The Ornamental Gate ("Pailou" or "Paifang") is typically a free standing structure. There are two main styles, both of which are shown in Figure 6. The user is allowed to toggle a selected Ornamental Gate between the two different styles. The gate in the foreground has three sections, with smaller boards between each section. The gate in the background has three tiers with no boards between the tiers. The Ornamental Gate uses the same roof structure and bracket structure found in a Hall. The roofs and brackets are complicated structures and are automatically created.

The Bridge is another common characteristic feature of a traditional Chinese settlement. There are two types of bridges, which the user can choose. First is the Arch Bridge, which is typically made of stone. The Arch Bridge has arches below the bridge. The user-controlled parameters for an Arch Bridge are: width, height, height offset of arches, number of
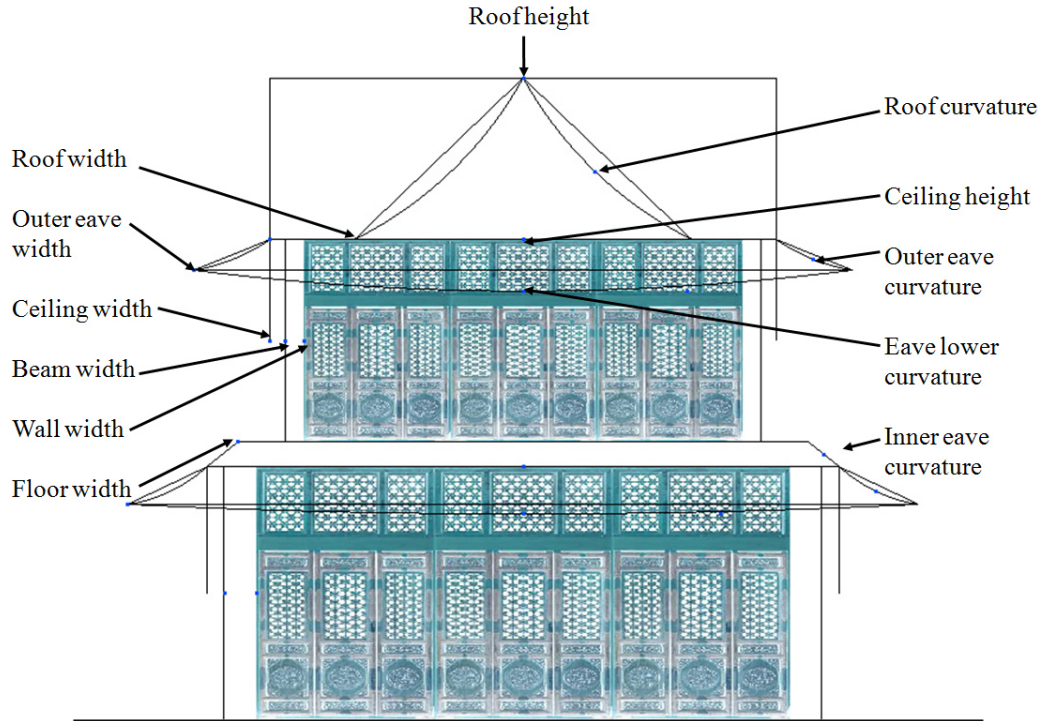
Fig. 2: Interface for the user to edit a Hall. The parameters controlled by the user are labelled. The user controls the parameters by clicking on the appropriate control points and moving the mouse. Other parameters such as wall texture and number of storeys are entered in the adjacent control panel.

arches, width of each arch, height of each arch, and curvature of the top of the bridge. Except for the number of arches, all the other parameters are controlled by the mouse in the edit mode for the Arch Bridge. The number of arches is controlled by the control panel. An example is shown in Figure 7.

The other bridge type is the Wood Bridge. This is a simple arc, supported by stilts. An example is shown in Figure 8. Wood bridges are typically small and found in gardens. By contrast, the Arch Bridge are much more massive and are found in palaces and are meant for transport of cavalry.

Figure 7 also shows an example of Platforms. Platforms are blocks of stone. They can be used to make fortified walls by making the shape thin. Any The Figure shows a Hall on top of a Platform. When the user places a building on top of a Platform, the program automatically sets the base height of the building to the height of the Platform. The user can put multiple layers of platforms on top of one another. In addition, via a check-box in the control panel, the user can also create an arched entrance at the bottom of a platform block. This creates a city gate, an example of which is shown in Figure 7.

Figure 8 also shows an example of a Pagoda, which is one of the largest, tallest and most visible structures in traditional Chinese architecture. The user can set the height of the pagoda, and also the width of each storey, and the curvatures of the roof and the eaves at each storey, as well as the height of the roof.

Figure 8 also shows an example of the garden wall. A garden wall is constructed just like a Corridor, which is shown in Figure 9. The user selects the GardenWall/Corridor icon and clicks on the map canvas. The user can then toggle between these two types. Note that the user can connect multiple corridors to a single control point. In this way, branches can be made to create a corridor network. The user can click on a button to synchronize the height of all corridors connected by the network. The program automatically creates a corridor that is joined properly at the intersections.

4. Conclusions

We have described our work in creating an interface for users to conveniently and quickly create 3D models of a variety of structures in traditional Chinese architecture. Our program is able to create some main structures found in a traditional Chinese settlement, including pagodas, pavilions, halls, houses, bridges, platforms, fortified walls, garden walls, gates, moon-gates, and ceremonial arches. We provide a convenient interface for the user to place structures on the map, and therefore create a traditional Chinese settlement.
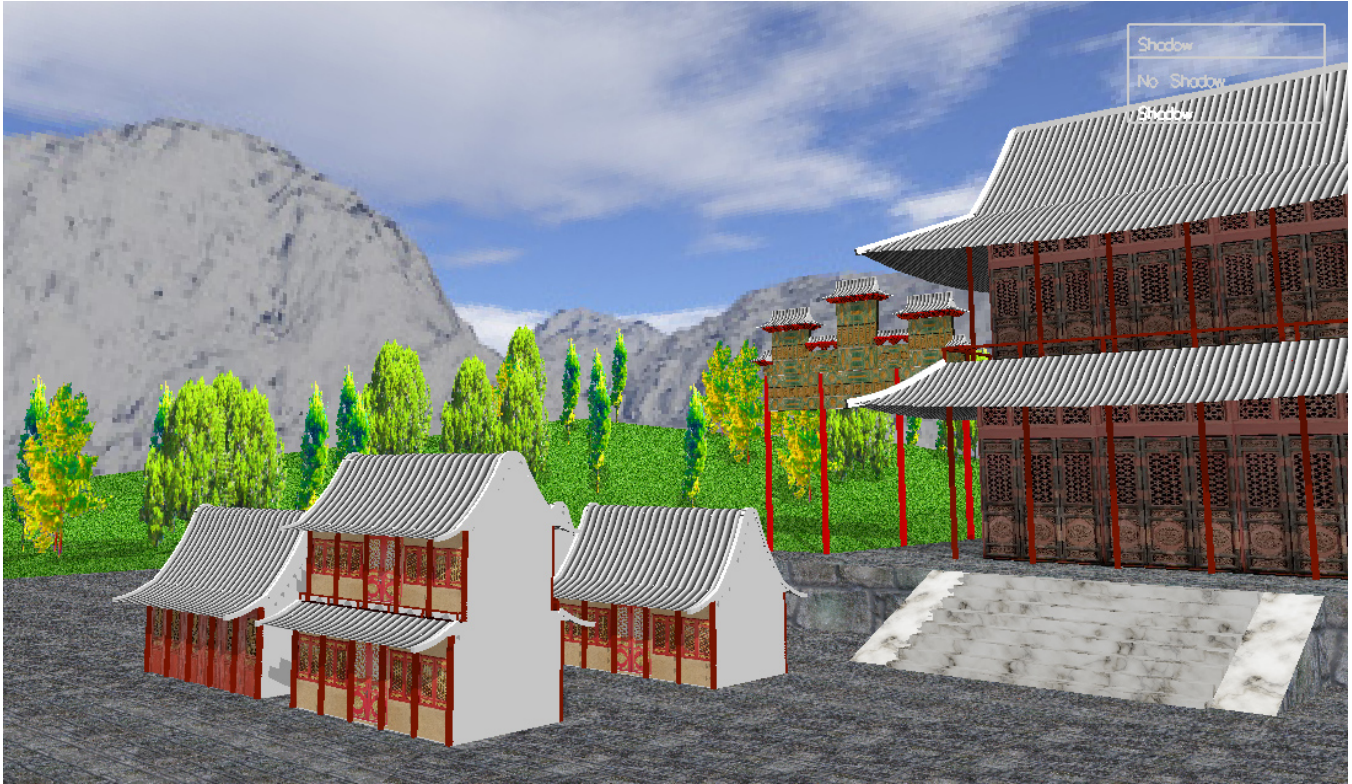
Fig. 3: Example with houses with different number of storeys and with pointed and rounded roof types. Also in the scene is a hall, rock platform and marble stairs.
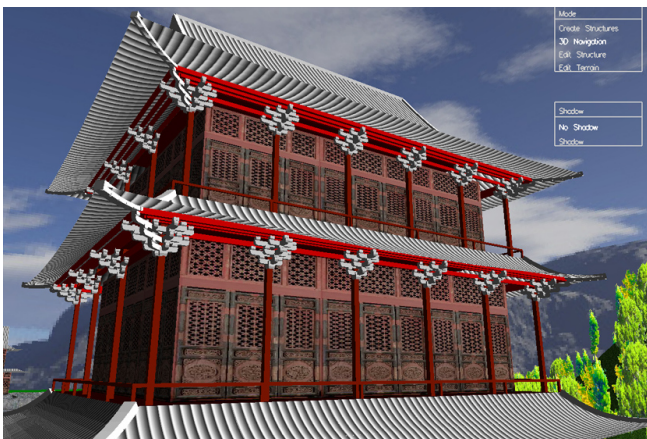

Fig. 4: View of a Hall showing automatically created brackets at the top of every pillar. The bracket structure holds beams which hold up the roof.
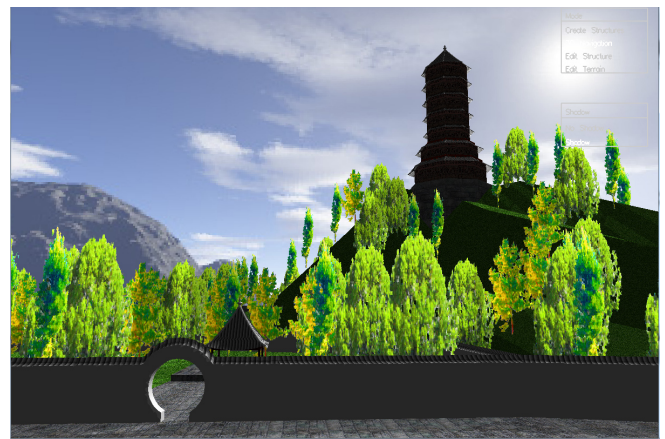

Fig. 5: Scene with Garden Wall, Moon Gate, Pagoda and Pavilion

We also provide the user with the interface to custom-design each structure created.

Because traditional Chinese architecture has a standard form, we simplify the design of a building into a few parameters which users can edit, such as roof curvature and roof height. This allows the user to design the building according to their preference and still adhere to the traditional Chinese architecture form. Our program automatically creates complex structure such as the roof and the bracket and beam system.
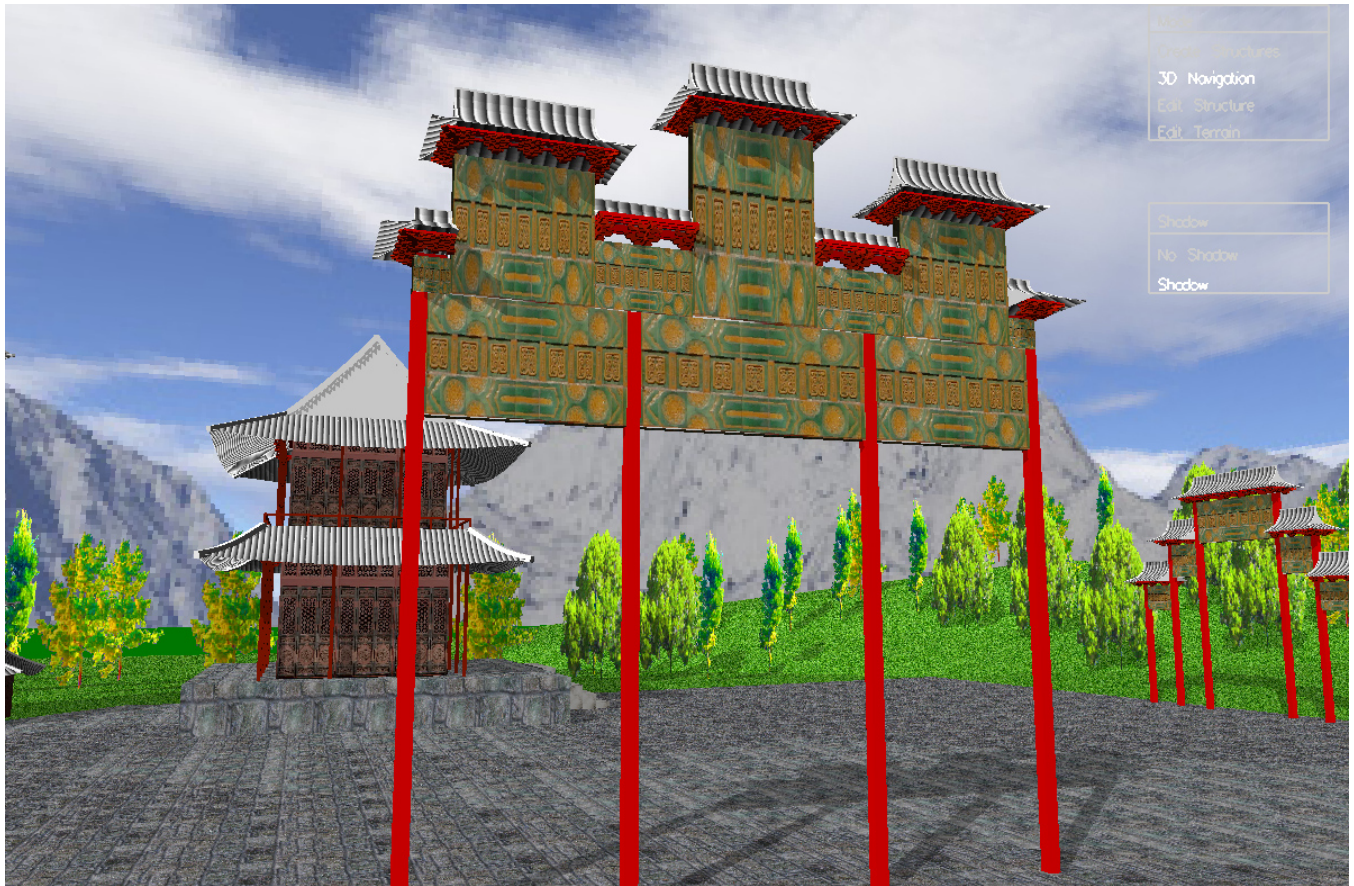
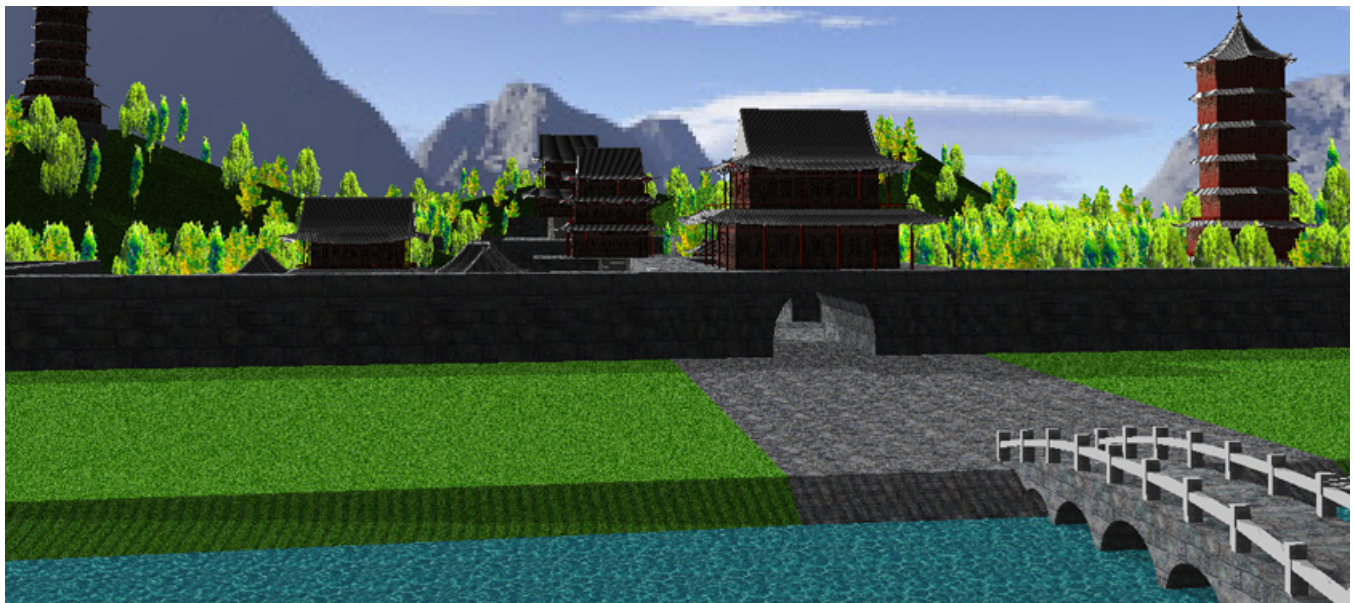Fig. 6: Scene with two Ornamental Gates ("Pailou" or "Paifang")

Fig. 7: Scene with Marble Arch Bridge, Stone Fortified Gate, and Stone Fortified Wall
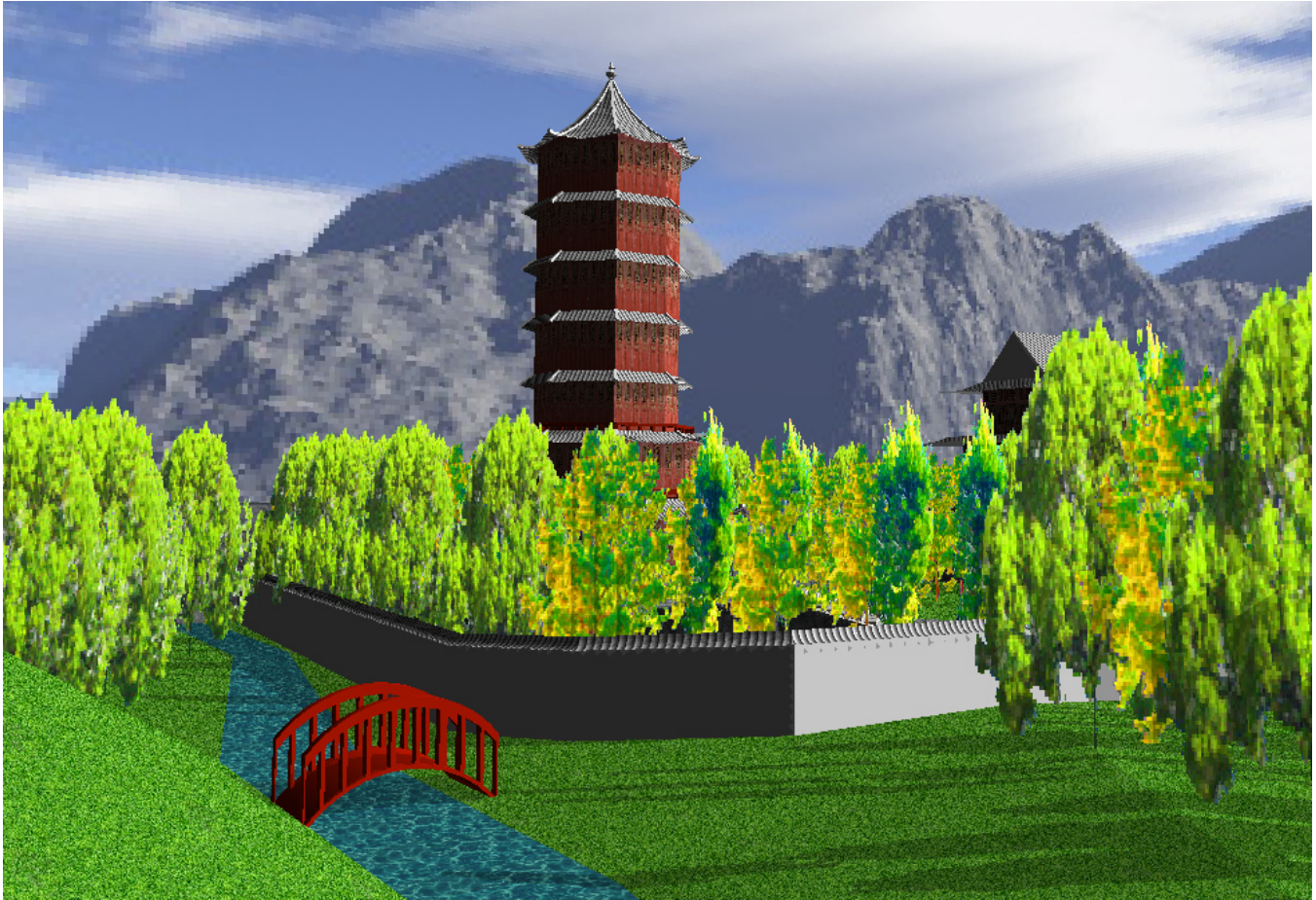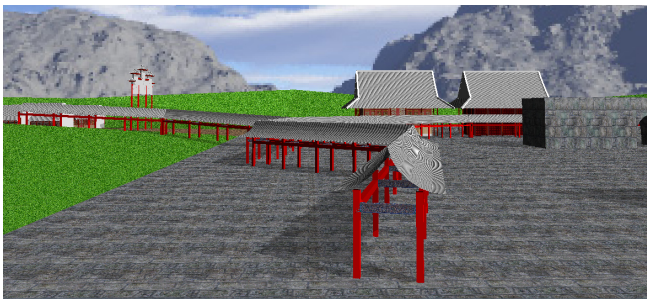
Fig. 8: Scene with Wood Bridge and Pagoda

Fig. 9: Scene with a long Corridor

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