

# ANALYSIS AND DEVELOPMENT OF REAL-TIME SIMULATION FOR ENVIRONMENTAL DESIGN

YEO WOOKHYUN, MOTOI TOSHIO, FUKUDA TOMOHIRO, KAGA  
ATSUKO

*Department of Environment Engineering, Graduate School of  
Engineering, Osaka University, Japan.*

*yeo@env.eng.osaka-u.ac.jp*

*motoi@env.eng.osaka-u.ac.jp*

*fukuda@env.eng.osaka-u.ac.jp*

*kaga\_atsuko@env.eng.osaka-u.ac.jp*

AND

SASADA TSUYOSHI

*National Institute of Information and  
Communications Technology, Japan.*

*sasada@sasadalab.jp*

**Abstract.** In this study, we introduce the history of adapting real-time simulation to Environmental Design, and develop the study of user interface which we think was needed at this stage. In detail, we developed functions for generalization such as improving manoeuvrability and the enhancement of reusability. And we developed special functions to achieve the goal in the project such as distance measurement function, surplus soil calculation function and section function. These developments made it faster to build up new real-time simulation in another project.

## 1. Background and Purpose

Real-time simulation for environmental design is becoming increasingly widely used. This study presents cases where real-time simulation was used in environmental design projects, and analyzes the flow to date based on those cases. It proposes issues to be resolved in the future and endeavours to find solutions for them.

As a result of this analysis, we found that development of an interface was important because it is interface that connects people with the system.

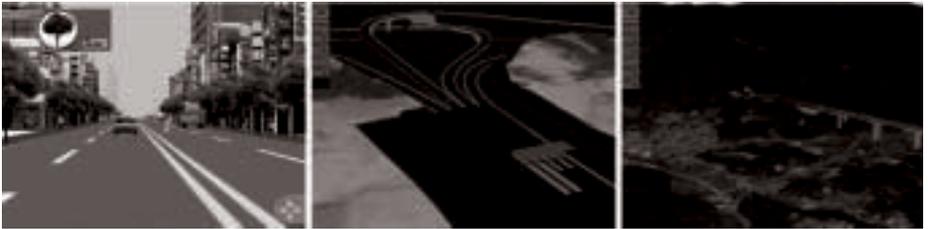
Specifically, a development is initiated for a new interface addressing the issues of conventional real-time simulation. The interface has been made simpler to allow more people to use the current real-time simulation, and by adding a perspective angle and view correcting function equipped with human senses, the effect can be created of real people viewing in an actual space.

## 2. Advancement in Real-time Simulation

At our laboratory, research applying real-time simulation in environmental design projects has been in progress since the year 2000, and this research has completed about 15 projects. Analysis of case studies at our laboratory shows that real-time simulation has developed in the following 3 stages:

### 2.1. THE FIRST STAGE

This was the stage where real-time simulation was first applied to environmental projects. This may be considered an experimental stage addressing how to perform real-time rendering in environmental projects that work with massive quantities of data. In this stage, studies included techniques such as lightweight data, LOD (level of detail), and camera clipping, to render over 10 frames per second in real-time.



*Figure 1.* Example of first stage.

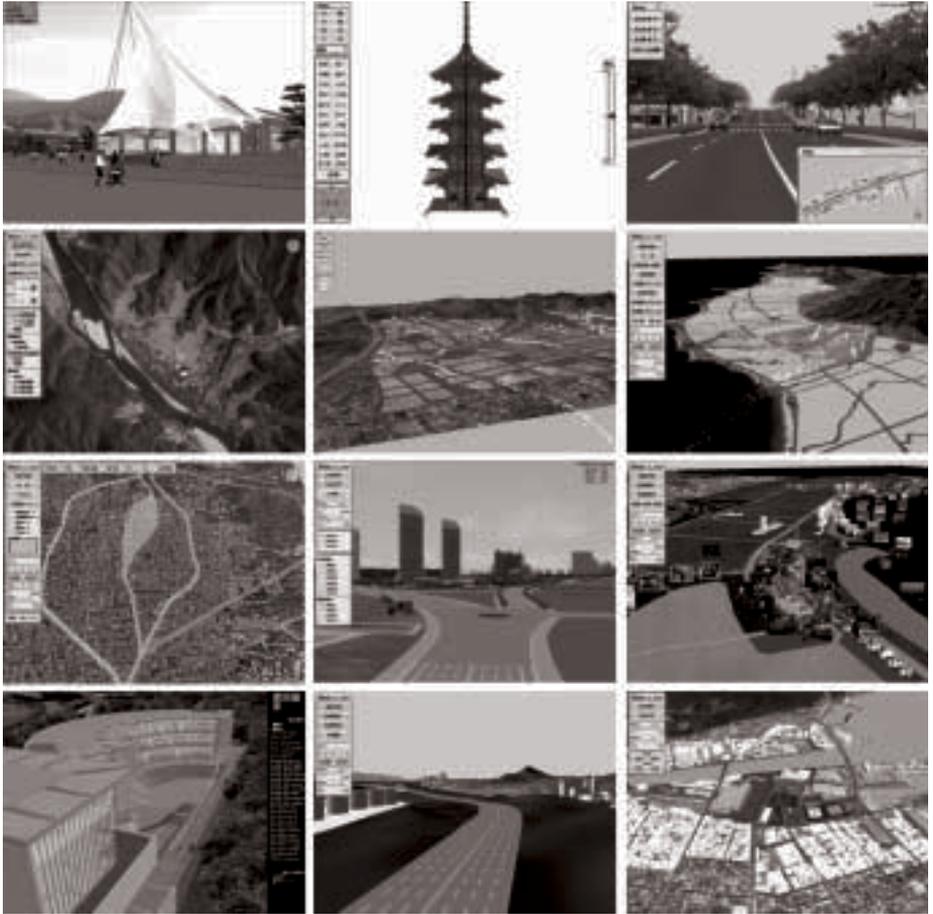
### 2.1. THE SECOND STAGE

Based on the fundamental studies of the first generation, studies were made applying real-time simulation to diverse projects. In this stage, we expanded the scope of real-time simulation while applying existing research findings to various fields. In addition to enlarging the areas of application by using simulation in a variety of areas including road planning, regional planning, and view evaluation, advancement was made to enable its functions and interface development to be used at the presentation stage as well as the stages of design and planning.

### 2.1. THE THIRD STAGE

The research currently in progress is the third stage. Proceeding through the first and second stages, we discovered the possibility of using real-time simulation as a tool for environmental design, and enlarged its target scope.

However, the stages considered so far have focused mostly on developing new functions and applications, without much progress in the research on the interface. At this stage where real-time simulation is fully applied to environmental projects,



*Figure 2.* Example of second stage.

the most necessary development would be an interface that users can operate easily and as actually desired, which enables them to see exactly what they want to see.

### **3. Interface Development**

There are two types of interface; the GUI (Graphical User Interface) and the System Interface. In this study, we developed the GUI and System Interface.

#### **3.1. EXTENDED FUNCTIONS FOR CAMERA OPERATION**

Conventional interfaces are usually categorized into two types, namely, walk-through and fly-through. Walk-through allows changes in the speed of movement

but in terms of changing direction, it only offers the function of moving back and forth.

However, when a real person moves in space, there are many more movements. Functions such as walking sideways with eyes fixed ahead and walking while viewing a certain object would be additional requirements. In this study, an interface enabling such movements was developed.

### 3.2. EXTENDED FUNCTIONS OF FIELD AND ANGLE OF VIEW FOR HUMAN SENSE

When a person sees an object in an actual space, the perspective angle changes depending on the situation. In most cases, when perceiving an object in a wide space, the perspective angle becomes narrow, and in a small space, the human perspective angle tends to become larger. As for sloping surfaces, people look at the slope in the direction of movement. When going up a hill, they raise their heads and look towards the higher part, but when they are going downhill they look towards the lower part.

This study added the functions of automatic change of perspective angle and perspective correction on sloping surface. This provides users with an experience closer to that of being in an actual space.

### 3.3. MODULIZING OF INTERFACE FOR REUSE

The interface and functions that have so far been developed were mostly intended for specific projects. Therefore, we had the inconvenience of having to make new interface for new projects. In this study, a module function was added to enable application to any project. This means it is possible to use existing functions by simply selecting required functions without any further development.

## 4. Application to the real project

In this study, we apply an interface developed for the Kamicho Lavender Park in Hyogo Prefecture, Japan development project. In this section, we will explain developed functions and types of usage through actual cases.

### 4.1. CAMERA OPERATION FUNCTION

We added a parallel walking function, speed change function, etc., in order to raise the flexibility of operation.

In the case of walk-through, we added a parallel walking function to the original functions such as look-up, look-down, rotation, and movement of the camera. Before

this we could only rotate at a given point. With this addition, by moving along the side of buildings we can consider the scenery of the facade, which also made it possible to perform smooth movement during walk-through.

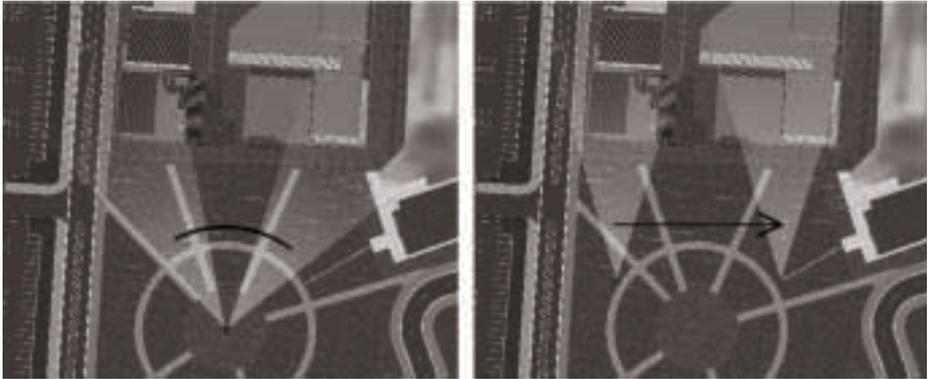


Figure 3. Normal moving(left) and parallel moving(right).

Moreover, in the case of walk-through, by pushing a button, we can easily move back and forth, change direction and change the motion speed when the parallel and normal walk is being carried out. It can be said that this function can satisfy the client's demand to choose what he looks at or to slow down and look around where he pleases. These smooth performances of movement and examination made it comfortable for both operators and audiences to check the plan, and we believe that a smoother presentation will be possible.

#### 4.2. CAMERA COMPENSATION FUNCTION

We put in the viewpoint compensation function and the viewing angle change function in order to adopt a more natural view from a camera.

The viewpoint compensation function involves looking up in accordance with the slope, with the angle changing automatically.

In the existing method, when looking at a plan under which an object area like the lavender garden in the lower picture is a slope, when the direction was changed, we had to look up again, and the angle had to be changed manually and adjusted.

For example, in the case of an uphill slope, if the view angle is always horizontal as you see with the figures on the left in the pictures in Figure 4, it will show only the base of a slope, or in the case of a downhill slope, a scene stretching further ahead than is necessary.

Then, if you consider the figures on the right, after compensation is made, you can see that the view is the same as what a person would actually see in that location.

Even if the angle of a slope changes, by using this function you do not have to adjust the view angle manually at the time. It will be automatically adjusted

which will provide smooth movement in the scene and comfortable examination can be performed.

The adjusted angle of the camera is calculated using two points; the point you are standing at and the point of the ground that you see horizontally. (In short, the angle of the camera is parallel to the ground on which you are standing.) We put in the viewpoint compensation function and the viewing angle change function, in order to adopt a more natural view from a camera.

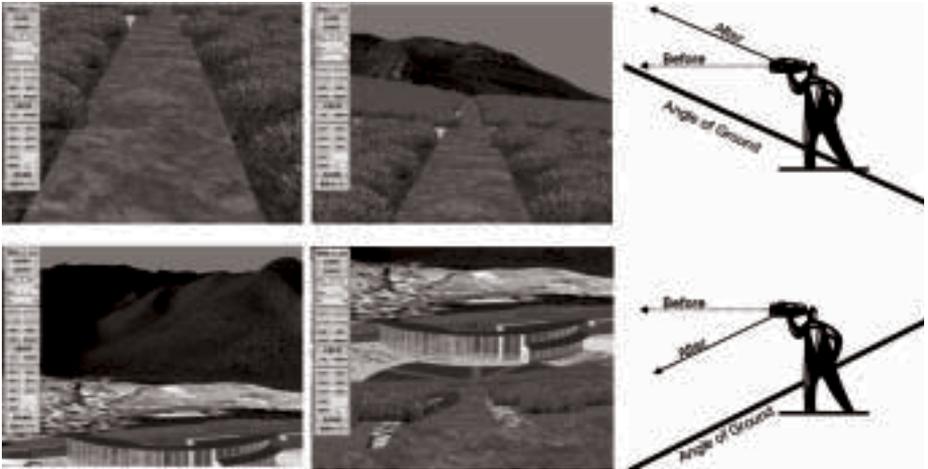


Figure 4. Compensation before (left), after compensation (centre), and Key map (right).

The viewing angle change function can set up the viewing angle of a camera by putting in a number from a direct keyboard.

When using this system for an indoor examination, it is possible to enlarge the viewing angle to enable examination that is suited to the purpose.

### 4.3. MODULIZING OF INTERFACE

Basic operation function, camera operation function, and camera compensation function are commonly used in all projects. Therefore, if the interface is modularized, it is easily recyclable in other projects. In this research, the Behaviour Script is divided according to function and is modularized. It could then be reused simply by saving.

By this, we were able to shorten the time until it corresponded to real time.

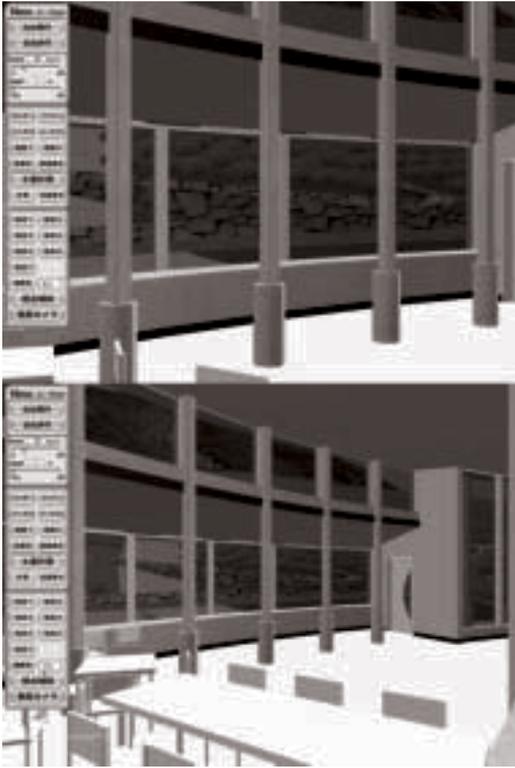


Figure 5. Change of viewing angle (40 degrees (left) and 70 degrees (right)).

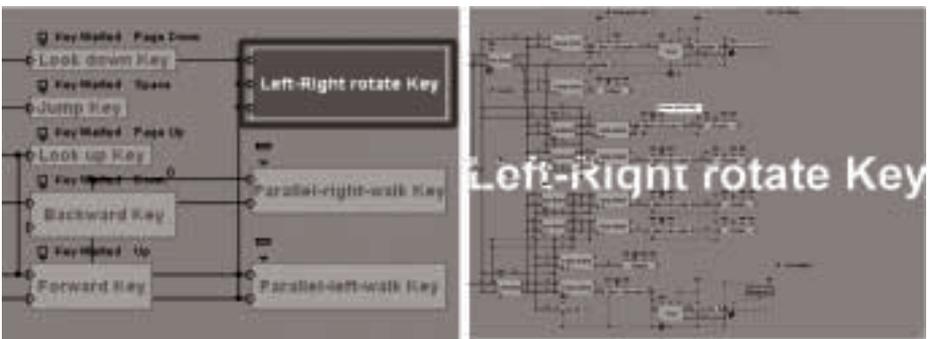


Figure 6. Modulizing (left) and Contents of module (right).

#### 4.4. DISTANCE MEASUREMENT AND SOIL CALCULATION FUNCTION

Sections 4.1 to 4.3 explained the function of using a real-time simulation for general purposes. However, a special edition function for each purpose and to achieve specific

goals is also required for each project. In order to use a real-time simulation in an actual project, you should put in the function to achieve the goal after the function for general purpose use.

We developed a distance measurement function, surplus soil calculation function and section function which were required in order to achieve the objective of this project. These functions are introduced below.

A distance measurement function is one that can measure the height of a certain point, the distance between two points, horizontal distance, perpendicular distance, and the angle of a slope in a free place. Moreover, examination is also possible, always displaying the height of a camera if needed while carrying out the walk-through. During a real-time simulation a user may want to get an impression of the size of a building or a road, of scale, slopes, etc.

Now, information such as length and slope can be measured by this function by anyone, and the coordinated data of a 3D model can be effectively used.

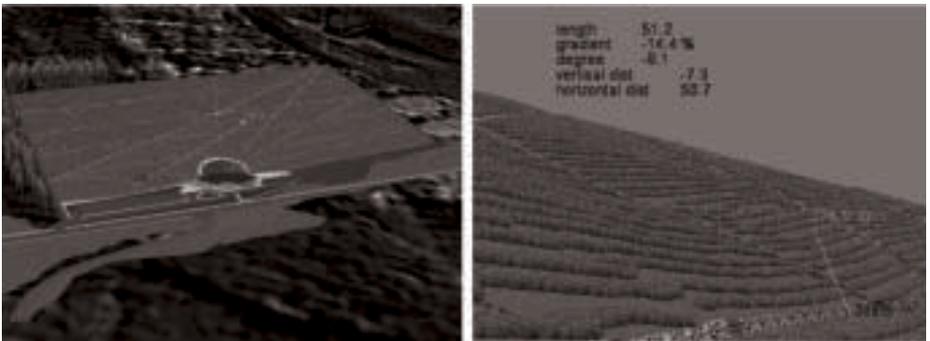


Figure 7. Change of field of view (40 degrees (left) and 70 degrees (right)).

In a surplus soil calculation function, the quantity of the soil cut off, and that of the soil piled on can be calculated (the amount of surplus soil) in real time, and the calculation result can be displayed numerically. Moreover, the accuracy of calculation of the quantity of soil is also changeable by adjusting the size of the mesh data of the ground surface used for calculation.

The calculation method is sectional measurement; first, radiate the rays from a top toward the ground surface at a fixed interval; next, pick the 3D coordinates of the intersection; next, multiply the area by the height, according to interval, and add up the volume of each cube one by one.

We compared the result of the calculation before, and after the plan. By this function, calculation of the quantity of the soil, which took about 8 hours conventionally, was attained in about 10 minutes when calculating an object ground of about 5 hectares in a 4m pitch.



Figure 8. Calculation of the quantity of the ground and graphical display.

A section display function is a function which indicates the section of an original ground surface and the ground surface after implementation of a plan for comparison.

It not only helps in understanding geographical feature but it can assist in understanding the contents of the plan by comparing the section before and after the plan by displaying the section.

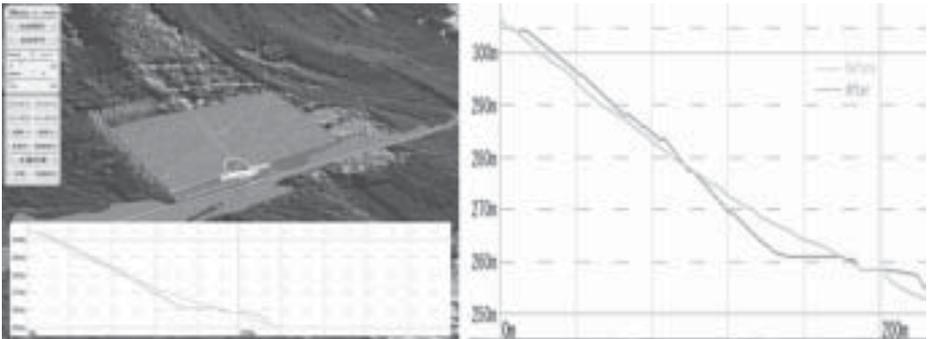


Figure 9. Section display function.

## 5. Conclusion and future study

It was found that real-time simulation had developed largely through 3 stages. In this study, research was done on restructuring of the interface, considered to be an issue in the current third stage. As a result of 3.1 and 3.2, it may be said that advances were made in real-time simulation to make it closer to what people feel in an actual space. Also, as a result of 3.3, by adding the function enabling common usage of the interface, which formerly had to be developed for specific individual projects, the time required for developing the interface was effectively reduced.

In the real-time simulation developed so far, one problem has been that once design changes were made using compiled Play files, the changed data could not

be saved. To resolve this issue, it would be necessary to add a function that preserves people data through linkage with a database. Another need would be the development of a Plug-in function using the database.

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