DEVELOPMENT AND EVALUATION OF A REPRESENTATION METHOD OF 3DCG PRE-RENDERING ANIMATION FOR ENVIRONMENTAL SYMBIOSIS DESIGN

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Abstract. As a method of dissemination of environmental symbiosis design towards environmental problem solutions, 3DCG pre-rendering animation (3DCGPRA) which has a high quality of representation and has a powerful appeal, is expected to be particularly effective. After arranging components required in an environmental symbiosis design, the representation targets which needed to be developed were clarified. In addition, representation methods of shade and shadow, grass, human activity, and symbiosis methods etc. were developed. In a real project, a 7' 3DCGPRA was created applying these new methods, and its validity was evaluated.

Keywords. Environmental design; environmental symbiosis design; 3DCG pre-rendering animation; eco-village; natural elements

1. Introduction

Each human's life is directly connected to the global environmental and social issues. The increasing concern about these issues has led to discussion of how architecture, cities, and human life should be adapted to move towards realization of a sustainable society which curbs greenhouse gas emissions. Some sustainable societies such as "eco-villages" have been built, but these still tend to be special attempts by special people. Dissemination to the world is a very important issue. As a method of dissemination, 3DCG which is a powerful and easy to understand medium (Sasada, 1999) is expected to be particularly effective. 3DCG is classified into still pictures and animations, and animations are further classified into pre-rendering and real-time rendering. In this research, the authors focus on 3DCG pre-rendering animation (3DCGPRA) which has a higher quality of representation and more powerful appeal than real-time rendering.

Compared to live-action film, 3DCGPRA is better for visualizing future spaces and aspects which do not currently exist. And when a future human life is visualized from the first-person point of view using the scenario scripting method (Ying-Hsiu Huang, 2001; Kaga, 2005), audiences feel that what they see is more relevant to their own lives. 3DCGPRA generates still pictures by pre-rendering in the first stage. Then, an animation sequence is created by

combining these pictures. A final version of the animation is created after adding special effects and cutting.

On the other hand, a design which exists symbiotically with its environment is called for, and the representation needs of animation are changing. It is necessary to develop a new representation method for 3DCG animation, such as natural representation. This paper is organized as follows: Section 2 describes considerations of 3DCGPRA representation. Section 3 describes the development of various elements of 3DCGPRA. Section 4 describes the application of 3DCGPRA in a real design project, and its evaluation. Section 5 concludes with the result.

2. Consideration of the representation method of 3DCGPRA

In order for people to take effective action towards the solution of environmental issues, it is necessary not only to stress understanding of the issues, but to stir up sympathy. Therefore, realism is required of the vision presented. Table 1 shows the representation targets of environmental design. An environmental symbiosis design is included in environmental design fields. Care for the natural environment, minimization of adverse effects by development, and social health have been emphasized recently. Therefore, in addition to representation of artificial things, which has been covered quite extensively to date, it is necessary to establish a representation method of human activities or natural elements. In this research, components written in italics in Table 1, such as mechanisms, social activity, sky, terrain, soil, water, plants, animals, weather, shade and shadow, are considered. In particular, the authors pick as especially important some components of shade and shadow, grass, trees, soil, human activity, and symbiosis method.

In the initial stage of an environmental design, the final design is not visualized. In the initial stage, it is necessary to deal flexibly with changes in a plan. Changes of representation accompanying changes in a plan may be repeatedly requested. This is different from the film producing industry. Figure 1 shows the work flow of a general 3DCGPRA image and the definition of turnaround time. An important issue is how turnaround time can be reduced. However, generally, to sustain reality, in order to reproduce a complicated form, the amount of data will be large. Consequently, processing time, such as that required for modelling and lighting, and rendering time will also increase. 3DCGPRA images that have been produced to date are reviewed under such conditions, and the subjects are thrown into relief. Table 2 shows consideration of the differences between goals and present CG methods in the environmental design field.

TABLE 1. Representation targets of environmental design.

Classification	Component	Examples
Social Elements	Social Situation	social structure, establishment, ethnogenesis, language
	Mechanism	circulation, *symbiosis method*
	Social Activity	*human activities (private, business, religion, community)*
	Architecture	residence, office building. station
	Civil Structure	road, footway, bridge, railway, traffic signal, airport, bay
	Transportation	car, bike, bicycle, boat, ship, airplane, train
Natural Elements	*Sky*	*blue sky, night sky, cloud, moon, star*
	Terrain	*mountain, valley, hill*
	Soil	*rock, stone, sand*
	Water	*sea, lake, river, falls, pond*
	Plants	*tree, flowering grasses, grass*
	Animals	*human being, animal, bird*
	Weather	*snow, rain, thunder, wind, fog*
	Shade, Shadow	*sun, artificial lighting, shade, shadow*

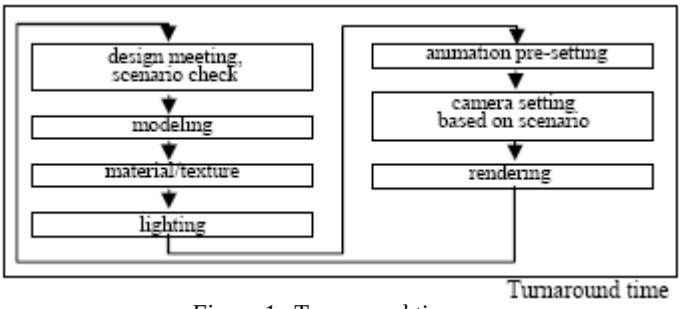

Figure 1. Turnaround time.

TABLE 2. Consideration of the difference between goals and present 3DCGPRA.

Component	Goal (photo)	Present (CG)	Difference
Shade, shadow			Shade and shadow in CG are represented in the same way. In the real world, soft edges appear because of indirect light.
Grass			Hair-like representation of grass is not attained in CG. Grass waving in the wind is also not represented.
Trees			In an ambitious project, 3D representation is not attained. Falling leaves, leaves shaken by the wind, and detailed textures of leaves are not represented.
Soil			Bumpy shapes, different types of soil, and degree of surface roughness are not attained.
Human Activity			A 2D photo-based model is usually used because a 3D human model is not realistic When a CG camera moves around a 2D model, activity is not represented
Symbiosis Method	non-existence		Pattern diagrams are descriptive; photo-realistic representation is needed for empathy.

3. Development of a representation method of 3DCGPRA

3.1. DEVELOPMENT OF EACH COMPONENT

The originality of this research is in improving the quality of representation, which was impossible until now, taking into account the conditions of environmental design. Therefore, component engineering is introduced and the setup of parameters etc. is considered. For example, if the part made using 3DCGPRA is assumed to be 5' of a total 7', the rendering time for one frame and the time for the 5' animation will be as shown in Table 3. If we examine the repetition of the rendering of the whole volume in every design meeting in the case study shown in Chapter 4, the longest turnaround time is three weeks. Therefore, the rendering time was 3' per frame, and an expression technique according to this time was developed.

TABLE 3. Relationship of rendering time between per frame and for 5'.

Rendering time per frame	Rendering time for 5' (30 frames/sec)
1'	150 hours (6 days + 6 hours)
2'	300 hours (12 days + 12 hours)
3'	450 hours (18 days + 18 hours)
4'	600 hours (25 days)

Shade, grass, trees, soil, human activity, and microclimate as elements in a kind of symbiosis method are set as the representation targets developed in this research.

- Shade: Representation of soft shade created by indirect light was enabled by adding the global illumination calculation. This involves the radiosity method, photon mapping method, and light mapping method. The light mapping method is said to be a pseudo-global illumination calculation, but can obtain sufficient quality, can set parameters easily, and calculate fast. "V-ray 1.47 advanced", which is commercial rendering software based on this technique, is applied. Applying the light mapping method, indirect light under the eaves is calculated (Figure 2).
- Grass: 3D representation by the Hair and Fur technique of 3ds MAX was developed. This technique was originally developed for the representation of human or animal hair. Vertices and polygons are not created so that modeling and rendering time does not increase. Simulation of physical conditions such as wind or gravitational forces is possible. In this research this technique was customized for grass representation (Figure 3).
- Tree: "NatFX" which is a commercial 3D tree generating program was applied to show 3D trees fluttering in the wind. A representation technique showing the trees shedding leaves was developed using the particle technique. A representation technique by which individual ivy leaves can be distinguished by the particle technique was also developed (Figure 4).
- Soil: To represent garden plots and farms, displacement mapping and bump mapping techniques were applied. Undulations generally have a complicated shape so that much modeling time is spent on making polygons and a long time is required for rendering. The displacement mapping technique can change the original shape depending on the color value of the mapped texture so that high quality soil representation can be realized while at the same time, modeling and rendering time can be reduced (Figure 5).
- Human activity: Representation of a close-range view which can be recognized as being 3D from all directions was developed using "PRC3.0" based on the IBR (Image Based Rendering) technique. Since it is live-action photo representation, high realism is also obtained in the close-range view (Figure 6).
- Microclimate: Representation in which the incidence angle of sunlight was developed by expressing sunrays using a volume light technique. Volume light for light effects represents rays of light in the atmosphere. The volume light technique, 3D deciduous tree model, and the residence model were used for microclimate representation (Figure 7).

Figure 2. Shade and shadow results using light map technique: (1&3) Before application, (2&4) After application, (5) Parameter window.

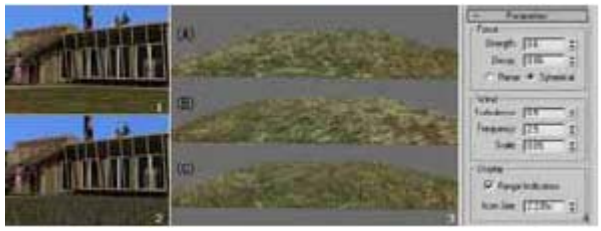

Figure 3. Grass results using the Hair and Fur technique: (1) Before application, (2) After application, (3) Grass waving in the wind, (4) Parameter window.

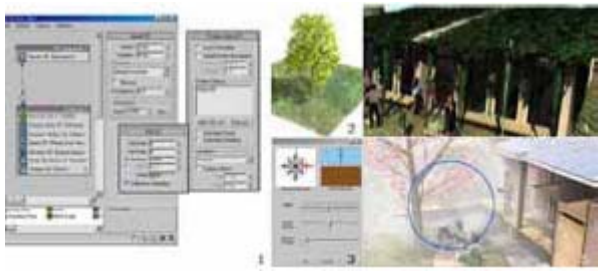

Figure 4. Material, Parameter, and Representation: (1) Parameter setting of particle technique, (2) 3D camphor tree of "NatFAX", (3) Wind setting of "NatFX", (4) Result of ivy using particle, technique (5) Result of 3D trees and falling leaves using particle technique.

Figure 5. Material, and Results of Soil: (1) Original texture, (2) Bump map, (3) Displacement map, (4) Result of undulation using displacement mapping.

Figure 6. 2D Human Activity model for a close-range view: (left) rendering result of RPC3.0, (middle and right) how the activity of people is visibly changes with the movement of a camera.

Figure 7. Microclimate representation: (left) parameter window of volume light, (right) 3DCGPRA images of 4 seasons design by microclimate.

3.2. MEASUREMENT OF RENDERING TIME

In the process of design study, it is sufficient to have image quality of a grade which allows understanding of textures and form. For this reason, finally, although made at the resolution of HDV 720p (1280 x 720 pixels), rendering time was measured as a resolution of 720 x 405 pixels for the purposes of the study. As is shown in Figure 8, all rendering times were between 1’ to 3’, and this corresponds to the rendering time of less than 3’ described in Chapter 3.1. Therefore, these representation methods are suitable for application to an environmental symbiosis type design, and it can be said that this is an advanced representation method compared with what existed formerly.

Figure 8. Rendering time (720 x 480 pixels).

4. Application in the “Kobunaki-eco-village” project, and Evaluation

The “Kobunaki-eco-village” is an environmental symbiosis development project in which 1,200 persons will reside (Fukuda, 2006). In the project, 368 environmental symbiosis residences will be built on a site of about 15 ha. An animation (HDV 720p), 7’20" in length, for the ground-breaking ceremony was created after the sustainable lifestyle design was finished. The developed representation method described in Chapter 3 was applied. Figure 9 shows some cuts of “Kobunaki-eco-village” 3DCGPRA.

Narration and explanations by characters were avoided as much as possible. For example, the design of a home which used a microclimate was represented realistically. Although characters and diagram representation help the audience gain an understanding as Chapter 1 described, satisfaction and empathy are needed, in addition to understanding, for them to take action.

Moreover, a design study using animation is described. Although the bank protection of a balancing reservoir was made of concrete in the original plan proposal, as a result of studying the animation, it was felt that this was not a good design, and the bank protection design was changed to one using natural stone and soil. In an environmental design with a wide range of representation, changes can affect many scenes. Therefore, re-rendering of the whole volume was often necessary. However, since a representation method that used a rendering time of less than 3’ per frame had been developed, the re-rendering of the whole volume could be carried out within three weeks, as described in Chapter 3.1.

5. Conclusion

This research first described an environmental symbiosis type design for solving environmental problems. Then, in order to promote positive action, the importance of 3DCGPRA, which creates a vivid impression and helps observers to identify with the scene, was described. After arranging the

Figure 9. Cuts from “Kobunaki-eco-village” 3DCGPRA.

components required in an environmental symbiosis type design, the representation targets which had to be developed were clarified, leading to the development of shade and shadow, grass, 3D trees, ivy, soil, human activity, and the symbiosis method. This was applied to the “Kobunaki-eco-village” project, and the validity was evaluated. When the animation is observed, it can be said that it provides a more photo-realistic representation compared with before. A questionnaire given to subjects after they had watched the animation indicated they had not only obtained an understanding of the project but also sympathised with its aims. For solution of global environment problems 3DCGPRA can contribute to showing clearly the environmentally-friendly actions that every person should perform. Representation of natural features and physical operations which were not been attained by this research is a problem for future research.

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