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DEVELOPMENT OF USE FLOW OF 3D CAD / VR SOFTWARE FOR CITIZENS WHO ARE NON-SPECIALISTS IN CITY DESIGN

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Abstract. The purpose of this study is the development of a tool by which citizens who are non-specialists can design a regional revitalisation project. Therefore, a 3D CAD / VR (3-dimensional computer-aided design / virtual reality) combination system was developed by using SketchUP Pro, GIMP, and UC-win / Road. This system has the advantages of low cost and easy operation. The utility of the system was verified as a result of applying the developed prototype system in the Super Science High School program for high school students created by the Ministry of Education, Culture, Sports, Science and Technology, Japan. It has been used for two years, since 2007. In addition, the characteristics of the VR made by the non-specialists were considered.

Keywords. Urban renewal design; participatory planning; 3D CAD; VR; design by non-specialists.

1. Introduction

Finding people who can undertake the necessary work is indispensable for advancing community building using the new public system. The minimum unit in a community and that undertakes the necessary work in the community is the individual. Individuals, regardless of generation, sex, occupation or nationality, are needed to carry out positive activity for the local community

and to take it forward. In the participatory planning era introduced with the new public system, non-specialist citizens need to take not only a passive role but also a positive role. An example of the passive role is that until now, citizens have proposed designs made by specialists such as entrepreneurs, architects or designers. An example of the positive role is that these non-specialist citizens can propose designs they have made themselves.

When citizens work on a regional revitalisation project, they are not often specialists who are well versed in construction, city planning, engineering works, and the information field. Therefore, when the image of the future in the region is studied, techniques that can be intuitively understood are needed. It is thought that a comprehensible mode of expression in three dimensions is effective for this purpose. 3D CAD and VR are considered as potentially useful techniques for this.

In past research, 3D CAD / VR has been proposed as a tool that can be present a comprehensible representation of the design idea to specialists and non-specialists, and which offers interactive functions (Fukuda et al., 2003; Fukuda and Nagahama, 2007; Kaga et al., 2008; Fukuda et al., 2009). However, the results of this process so far have been produced by specialists who belong to universities and private companies that are well versed in VR technology because the price of 3D CAD / VR is fairly expensive compared to software such as MS Office. Moreover, considerable effort and time are necessary to understand the operation of 3D CAD / VR. It is necessary to create an environment in which not only specialists but also non-specialists can produce 3D CAD / VR so that both can produce design ideas.

Therefore, this study aims to develop a design system connecting 3D CAD and VR in which non-specialists, such as ordinary citizens, can make design ideas. The study also verifies the utility of the system developed, and assesses the characteristics of VR content that non-specialists have made. The computer system supporting design creation has already been reported (Lim et al., 2008). However, the users of this system are specialists, and thus are different to the users assumed in the present study. Moreover, a system that uses VR in a virtual environment is proposed as an environment in which the user can cooperatively participate (Lertlakkhanakul et al., 2008). However, the authors do not target VR in a virtual environment, but target 3D CAD / VR that non-specialists can use as a design tool.

In the research, the best software is identified, considering its functionality and the cost. The data interchangeability flow between software is established, and a 3D CAD / VR system that contributes to the purpose is developed. The prototype system was applied to the Super Science High School program (SSH) in the Ministry of Education, Culture, Sports, Science and Technology

(MEXT), Japan. Its effectiveness was confirmed as a result of applying the system. Finally, to understand the characteristic of VR contents that the non-specialists made, they are compared with VR contents made by a specialist, using a photograph.

2. Developed use flow of 3D CAD / VR software

It is thought that there are few chances for non-specialists to use 3D CAD / VR and to engage in regional reproduction design. On the other hand, it is necessary to execute 3D shape modeling by 3D CAD and creation of texture material with image editing software as preprocessing to make the VR that is the final output. Therefore, when the best software is selected for each work flow, it is necessary to consider the interchangeability of software. As a result, characteristics of the software used should be as follows:

- Operation must be easy.
- Interchangeability between software must be high.
- Software should not be expensive.

Based on these conditions, SketchUP Pro (v. 6.4) was used as 3D shape modeling software, GIMP (v. 2.4.6) was used as the texture material making software, and UC-win / Road (Education v. 1.0001) was used as the VR software.

Next, the software interchangeability was verified. As a result, texture mapping is possible in polygons on both sides in SketchUP Pro. Next, a 3D model with texture made with SketchUP Pro was exported in 3ds format, and the data was imported to UC-WIN / Road. At this time, it became clear that the texture was not being displayed on UC-WIN / Road when texture mapping was done on the back side of the polygon on SketchUP Pro. Therefore, texture mapping should be done on the front side of the polygon using the following procedures.

- After the polygon is selected on SketchUP Pro, entity information is displayed by right-clicking.
- In entity information, texture information on the surface is displayed in the left swatch. Moreover, texture information on the back is displayed in the right swatch.
- Texture mapping is done again as displayed in the left swatch when texture information is displayed in the right swatch.

Figure 1 shows the data creation flow with the 3D CAD / VR system that was developed.

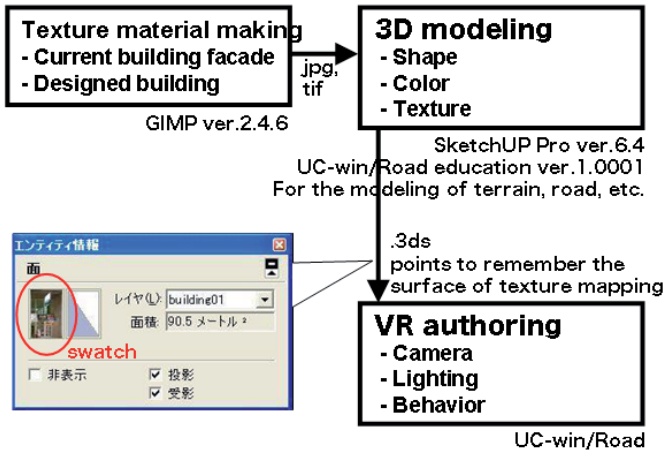

Figure 1. Developed use flow of 3D CAD / VR software.

3. Verification of developed prototype system

3.1. OUTLINE OF CASE STUDY

SSH is a designation awarded by the MEXT to high schools that prioritise science, technology, and mathematics. The program was launched as part of its "Science Literacy Enhancement Initiatives" in 2002. Schools with this status receive increased funding and are encouraged to develop links with universities and other academic institutions. Hyogo Prefectural Kakogawa Higashi High school has been awarded SSH status for five years since 2006. The KAKOGAWA design program applied the developed prototype system in one of the SSH programs in Hyogo Prefectural Kakogawa Higashi High school. This program was executed from October 2007 to February 2009 (Figure 2). Six students participated in this program. The first author is the research adviser. The second author is the teacher in charge. The KAKOGAWA design program was executed by using several PCs. Table 1 shows a PC and the software used.

TABLE 1. PC specification in KAKOGAWA design program.

CPU	Intel(R) Core(tm)2 T5500 1.66GHz
RAM	2.48 GB
VRAM	Intel(R) Calistoga Graphics Controller 128 MB
HDD	40 GB
3D CAD	SketchUP Pro (v. 6.4)
Image edit	GIMP (v. 2.4.6)
VR	UC-win / Road (Education v. 1.0001)

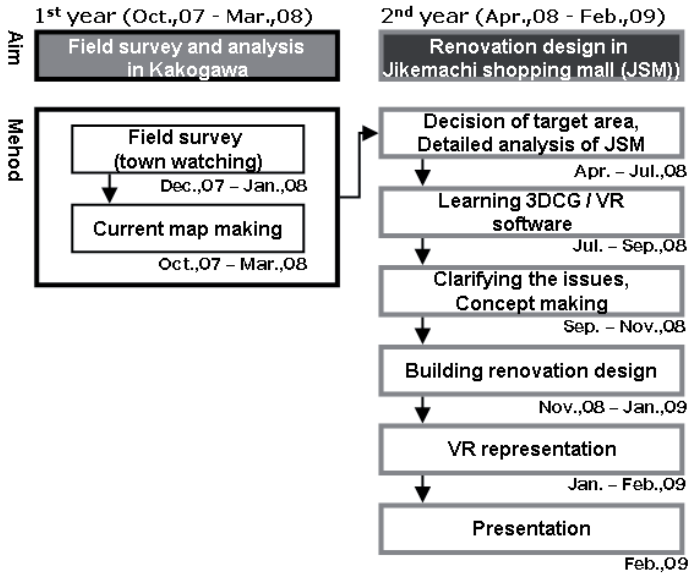

Figure 2. Design process of KAKOGAWA design program.

3.2. KAKOGAWA DESIGN PROGRAM IN THE FIRST YEAR

The KAKOGAWA design program started in October 2007. First, ice breaking was carried out by the six students introducing themselves. Next, field surveys were executed twice, in December 2007 and January 2008, to understand the urban area in Kakogawa City. As a result, the following features were found: 1) completion of elevated railway construction, 2) renewal of central train station in Kakogawa, 3) hollowing of a traditional shopping street located between the station and a high school, and 4) existence of historical construction. These results of the surveys were filled in on a paper map and Google Map, and the current analysis chart of the downtown Kakogawa City area was made. The developed prototype system was not used at this stage.

3.3. KAKOGAWA DESIGN PROGRAM IN THE FINAL FISCAL YEAR

As a result of the examination in the first year, a traditional shopping street located in the downtown area was designed in the final fiscal year (Figure 3 left). This shopping street is experiencing a decline in business, and many stores are closed. Therefore, the project members conceived methods of encouraging citizens to return to this shopping street. First of all, a 1/500 scale map of this shopping street was made. Next, information on the existing building etc. was plotted.

However, when the projects members used 3D CAD / VR technology the final goal was to propose a design for this shopping street. It is impossible to secure much time for 3DCG / VR technical learning in the research program schedule. Additionally, a high specification PC was not available so the lean budget meant an ordinary PC had to be used. Google SketchUP Pro, IMP and UC-win / Road software described in Chapter 2 were used because they satisfied the tight budget conditions and provided the necessary functions for the design. The members learned the operation of each type of software through making a current model of the shopping street (figure 4).

The members continuously enumerated the many problems of the shopping street by the brainstorming method, and classified these according to the KJ method (figure 3 right). Because the members' high school was located near the shopping street, the design concept "Expectations for the shopping street in regard to high school student life" was set. In a six-person group, the project members chose an empty building that existed in the shopping street, and a design to reproduce the building and the shopping street was proposed. Google SketchUP Pro was used to produce the design of individual buildings. Afterwards, the designs were imported to UC-win / Road and these building model data were shown using VR (Figure 5). Finally, a presentation was made three times for high school students and teachers on the study results in February 2009.

Figure 3. Current condition of the shopping mall (left); Sketch UP and UC-win / Road lecture (middle); Design study with project members (right).

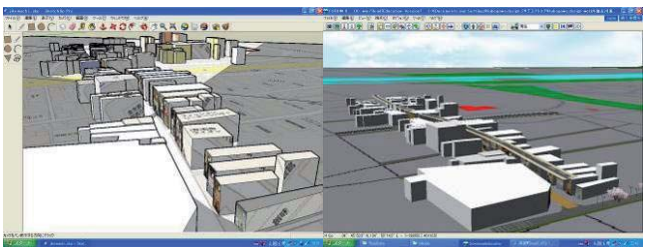

Figure 4. Current model (left: 3DCG, right: VR).

Figure 5. VR screen capture of renewal design.

4. Result

4.1. EVALUATION BY PARTICIPATING MEMBERS

A questionnaire survey on each item of the design process was carried out by the six students who had worked on the KAKOGAWA design. Eight items about the design process were included, namely: “Analyze the present state in Kakogawa City,” “Analyze the present state in the shopping street,” “Acquisition of 3D CAD software,” “Acquisition of VR software,” “Concept examination to solve the problem of the shopping street,” “Building design with 3D CAD software,” “Expression of the shopping street design with the VR software,” and “Presentation of study results.” The members evaluated each item according to four levels: “very easy,” “easy,” “difficult,” and “very difficult.”

The number in the gray circle in figure 6 shows the number of respondents. Moreover, the number beside the black circle shows the mean value by the weighted mean method. The method of calculating the mean value was as follows. “Very easy” was assumed to be one point. “Easy” was assumed to be two points. “Difficult” was assumed to be three points. “Very difficult” was assumed to be four points. In a word, a difficult tendency is shown as the mean value grows.

The lowest the mean value was 2.3 for “Analyze the present state in Kakogawa City” and “Analyze the present state in the shopping street.” Moreover, medians 2.5 were found for two items “Acquisition of 3DCG software” and “Concept plan to solve the problem of the shopping street.” On the other hand, the height of the mean value was 3.7 for “Acquisition of the VR software” and “Expression of the design idea with VR software.” Clearly, the use of VR was rated as “Difficult” while the use of 3D CAD was rated as “Easy.” One of the reasons that VR was considered difficult may be that “The VR software is considerably influenced by the PC specs such as the CPU. Therefore, the performance was bad, and the poor specification PC used with KAKOGAWA design was not easy to use…”

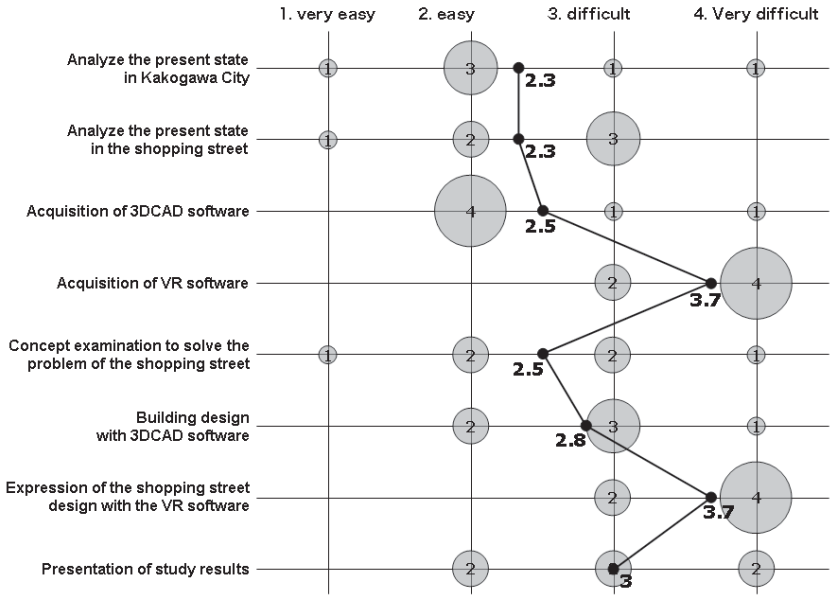

Figure 6. Evaluation by participating members.

4.2. EVALUATION BY CONTENT OF PRODUCTION

The KAKOGAWA design VR that the non-specialists made, VR (other shopping street reproduction projects) that specialists made, and the photograph are compared (figure 7).

4.2.1. Accuracy of expression

There is a blank between the arcade and the building when the KAKOGAWA design VR is observed. Moreover, there is a big blank also between the building and the road. Such a blank is not seen in the VR produced by the specialist or in the current photograph. Thus, a difference was seen in the accuracy of the reproduction of a current shopping street.

4.2.2. Content of expression

There is an assumption that the area was quiet because a signboard set up in the shopping street was not shown in the KAKOGAWA design VR. In the VR and the current photograph that the specialist made, there is a lively impression because the signboard is shown. Thus, a difference was seen in the content showing the current shopping street.

Figure 7. Comparison of VR made by non-specialists (left), current photograph (middle) and VR made by specialists (right).

5. Conclusion and future work

The purpose of the present study was development of a tool by which non-specialist citizens can design a regional reproduction. Therefore, 3D CAD / VR flow was developed by using SketchUP Pro, GIMP, and UC-win / Road. The utility of the system was verified as a result of applying a prototype system that was developed using the KAKOGAWA design program intended for high school students. In addition, the characteristics of the VR that the non-specialists had made were considered. The result of the present study is as follows.

- A 3D CAD / VR system that non-specialist citizens could use was developed by combining 3D CAD software with VR software etc. at low cost. This succeeded in solving the problem of data interchangeability between software.
- The citizens made a regional reproduction design by using the VR system that was developed, and were able to present their study results.
- The participating members felt that the operation of VR was difficult though the operation of 3D CAD was easy as a result of using the authors' developed use flow. One of the reasons why the operation of VR was difficult was the poor VR performance caused by the basic computer specifications.
- The points on which the accuracy of the expression and the content of the expression were different from reality were confirmed with the VR made by non-specialists. When the non-specialist VR was used, various differences with reality were noted.

Future works are described as follows. The system was verified in the present study for the small number people of six people. Moreover, these six people were young people of high school age – a generation who are usually competent at operating computers. The system will be verified for citizens of various ages and occupations, and a larger number of subjects will be used in the future.

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