TSUMIKI CASTLE:Interactive VR System Using Toy Blocks

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ABSTRACT

This paper proposes a Virtual Reality application for playing with blocks. Players can create their own decorative castle in a virtual world, by only stacking simple physical blocks in the system.

We designed a tangible interface such that a player can experience seamless interaction between the real world and a virtual world when playing with toy blocks. The system gives players a revolutionarily enjoyable experience where blocks are stack in the real world and blocks stacked in the real world are dynamically transformed into a castle in a virtual world. The system enables players to create a realistic castle that reflects the shape of the blocks. Moreover, the system smoothly connects the physical-world to the virtual-world by means of a tangible interface and real-time computer graphics. The system was exhibited at "Ishikawa Dream Festival" for two days. The evaluation of the system was done survey by a carried out using questionnaire at the event. The evaluation found that the system was easy to play and most of the players enjoyed the system.

Keywords

Virtual Reality, Tangible Interface, Toy Block, Shape Cognition

1. INTRODUCTION

In this chapter, we explain the background of our research, and then some related works are introduced. Finally, we describe the aim and position of our research.

1.1 Back ground

The population of young children playing with a touchable device like an iPad or a smartphone has been increasing in recent years. It is arguable whether it is desirable that young children play with touchable devices at early stage in life. In developmental psychology, it is said that it is very important for children to use the five senses, to contact objects physically and to demonstrate their creativity thorough playing [1]. However, sufficient experience cannot be acquired with touchable devices alone.

The first reason is that these devices have only a display as an interface which does not allow people to feel what is displayed physically. The second reason is that playing contents on those devices is not a creative activity for children because the subject and the goal of a content is already given. It can be said that this is a serious situation in childhood education even if touchable devices are very exciting for children. Therefore, it is necessary to provide children with play that is creative, tangible and more stimulative than touchable devices.

1.2 Related work

There are some related works regarding tangible user interface. For example, "TonTon" is a VR system based on an old Japanese traditional game, about Paper-Sumo wrestling [2]. This is new body-sensory style VR application that is implemented using an intuitive and robust interaction model. An entertainment system that enhances the experience of playing spinning top using AR technology is reported [3]. Video games can provide users with rich interactive experiences. Observing the movement of a spinning top may give support to understand this physical phenomenon. This research proposes a new toy that has both advantages of video games and of traditional toys. A novel device that allows a user to construct a 3D model by using tangible interface [4]. This research uses cubes, called *ActiveCube*, like traditional toy blocks as an interface. *ActiveCube* is equipped with both input and output devices, and this makes the interface intuitive and helps to understand the relationship between the input and the output.

We aim to motivate children to play with toy blocks using tangible user interface and VR application, and hope this system stimulates their creativity.

1.3 Our approach

We focus on toy blocks which are well known in a traditional play encouraging creativity and cognition of children. The toy blocks can easily be used by everyone for playing [5]. When young children make something with toy blocks such as a house, a robot, or a castle they use their imagination. Moreover they can also play

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with the models created using toy blocks. Even though toy blocks are quite simple forms, children assemble and play with them, while at the same time unconsciously learning and enhancing their creativity and imagination [6]. We propose a novel interactive toy for children, maintaining the physical assets of wooden blocks and enhancing them with automation by using special blocks which bridges the gap between cyberspace and the physical environment. The system uses a pattern matching method for changing stacked blocks into 3D CG models in real time. When children make a castle with toy blocks, they imagine a European castle, Asian castle or military castle that has special features as shown in Figure1. If they become an actual model, playing with toy blocks becomes a more exciting game.

This paper proposes a VR toy blocks system named "TSUMIKI CASTLE". "Tsumiki" means toy blocks in Japanese. This system enables you to create a realistic castle by stacking toy blocks. After a player stacks a toy block, toy block model is displayed in a virtual world, therefore the player feels that the real world and the virtual world are seamlessly connected. The stacked toy blocks in the virtual world will change into a decorative castle model in real time. As a result, the player can create an amazing cool castle reflecting his/her image. The transformation of primitive blocks into complex CG model will make children excited. We hope that children can feel more pleasure in the act of creation.

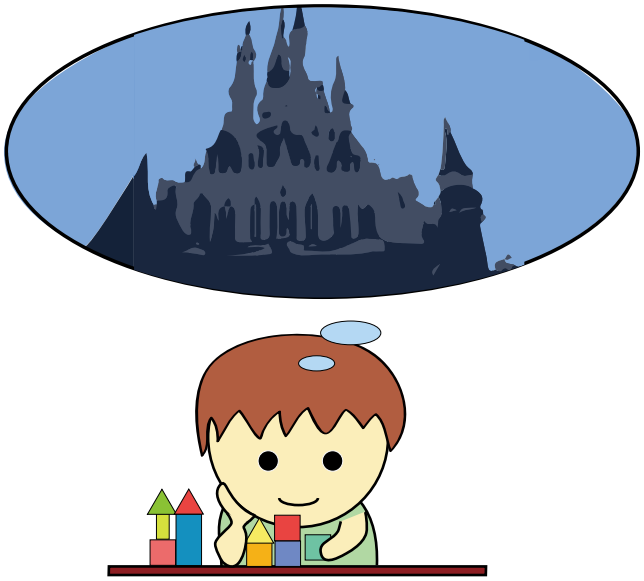

Figure 1. A child is stacking blocks using imagination

2. USER'S EXPERIENCE

Figure 2 shows the flow of user's experience in the system. A player stacks toy blocks freely according to his/her imagination in a tangible interface. S/He can stack four shapes of blocks their choice. The way of stacking blocks is a quite simple action to drop down a toy block into the device. After a block falls into the device, the attractive lighting system illuminates the block from the underneath of the system. After a block is stacked in the system, it is immediately transformed into part of a castle in a virtual world. A block is placed in a virtual world at a relative position to where the real block is stacked. A player can construct a decorative castle model by setting blocks at any position. However, s/he has to stack toy blocks carefully in order to create a desired castle because the block in the device can't be repositioned in once playing. If players consider a balance and feasibility of a target castle while stacking blocks, the castle becomes a realistic one. Otherwise it becomes a funny one, such as a base structure is on a roof structure. After a player completes making a castle, s/he can choose a favorite scene and enjoy the scenery of the castle from a free viewing angle.

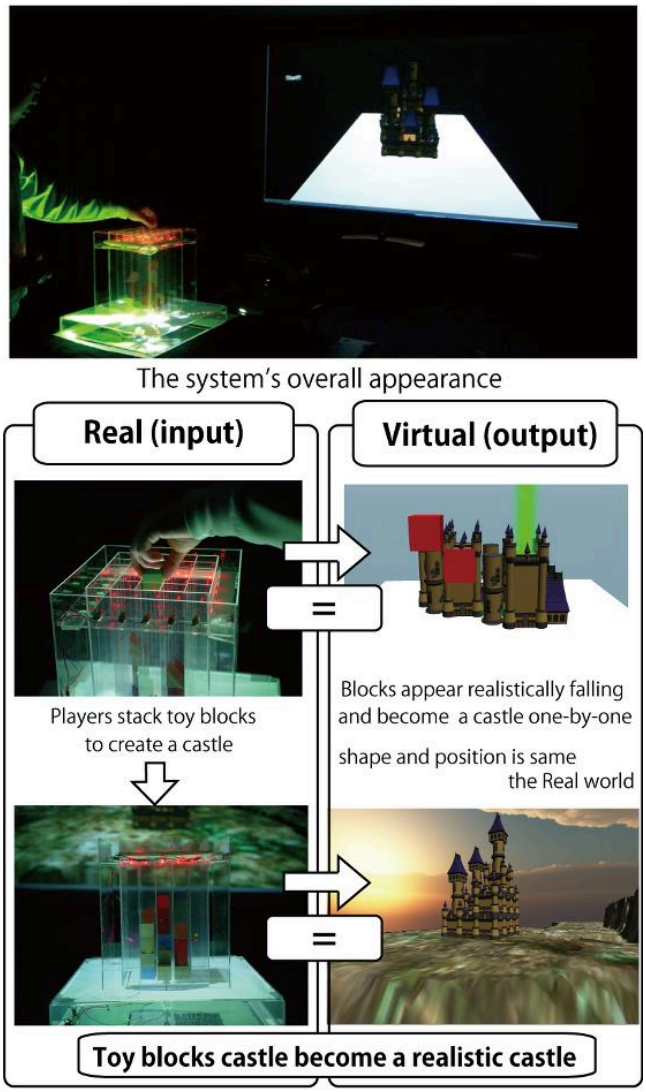

Figure 2. User's experience

3. SYSTEM CONFIGURATION

This chapter explains about the system. The system consists of three modules; (1) Interface module, (2) Sensing module, and (3) Scene creation module.

The interface module, where a player stacks blocks, consists of a transparent acrylic case and a working desk installed with two projectors. The case is partitioned into 5×5 cells to hold stacked blocks, and displays the stacked blocks beautifully. The case is dynamically illuminated from its basement by the projector changing color and brightness.

The sensing module consists of 1) a laser array attached on the top of the case detects the position where a block is inserted to synchronize real world and virtual world, and 2) a digital scale installed beneath the basement of the case identifies a shape of block.

The scene creation module creates an image composed by a castle and a landscape in real-time. We use the game engine "Unity" to implement this module. A player can see the process of a castle is being built in a virtual world while stacking blocks in a real world.

The details of these three modules are described in the following sections.

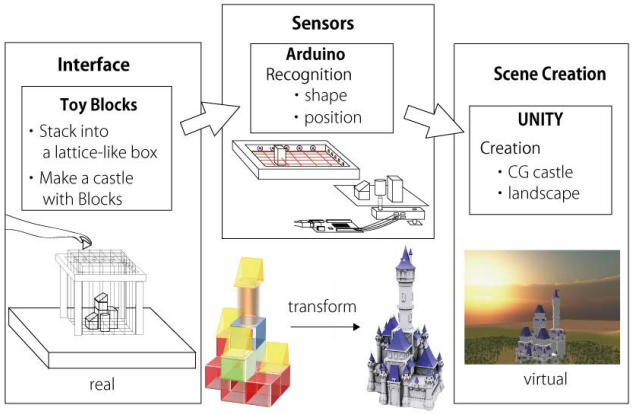

Figure 3. System flow

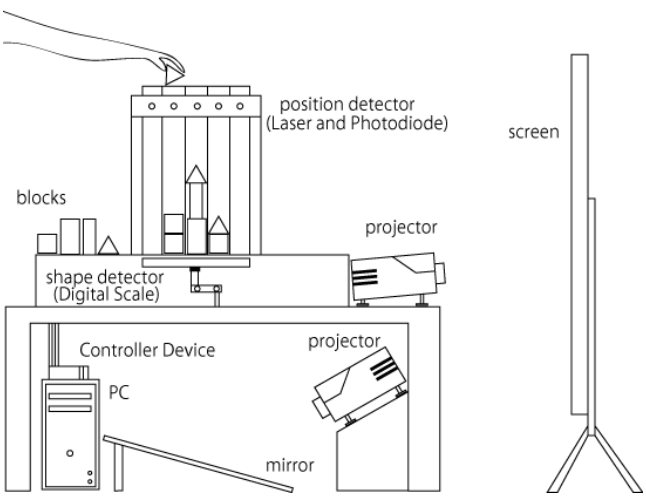

Figure 4. System overview

3.1 Interface

Figure 5 shows the interface, which is the body of the system.

The interface is assembled with transparent acrylic boards (1mm-thick) by crossing pairs to make a lattice for stacking blocks, and a frosted acrylic board (3mm-thick) as a basement. Since this device is transparent, the player can see the stacked blocks are displayed beautifully. A laser array is installed at the top of the case as shown in Figure 6, and a digital scale is attached beneath the basement as shown in Figure 7.

The light from a projector (SANYO PRO-X) illuminates the basement through a hole in the table, to motivate players to stack blocks.

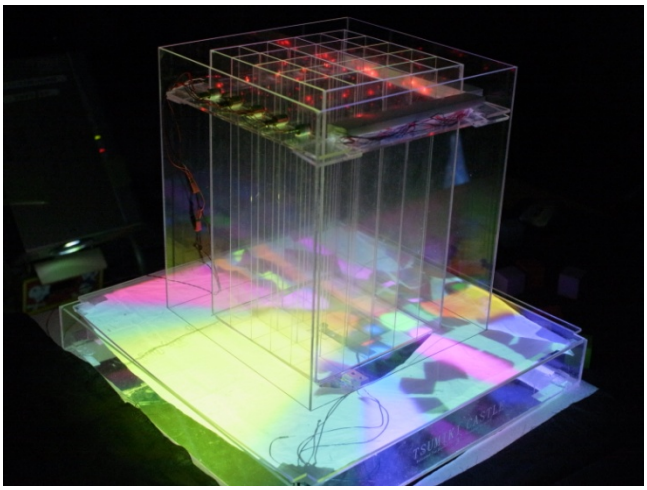

Figure 5. Interface

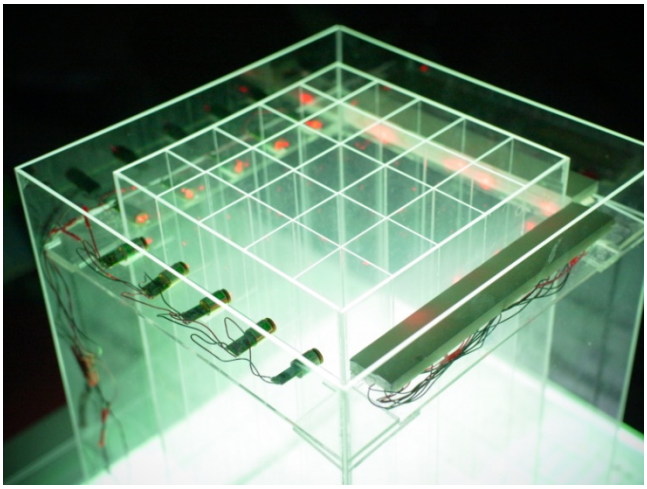

Figure 6. Laser diode and photo diode

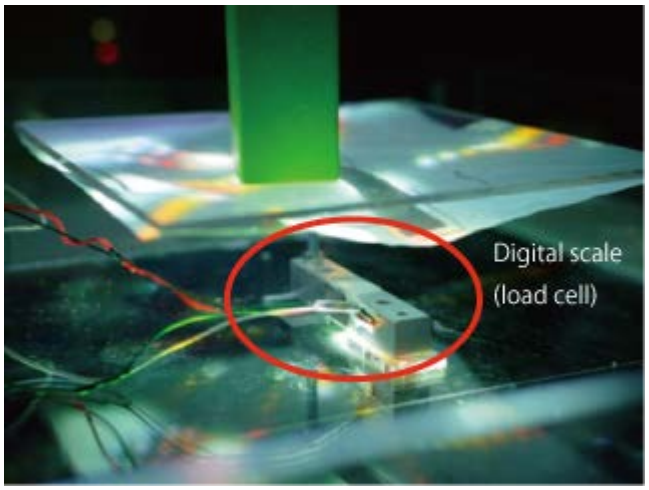

Figure 7. Digital scale

3.2 Sensors

The laser array consists of pairs of a laser-diode (LM-101-A-red) and a photo-diode (HAMAMATSU S7183) as shown in Figure 8. When a block obstructs the laser light, the system detects the position where a block is placed without any physical contact. The detected data is transmitted to the PC through ArduinoUno.

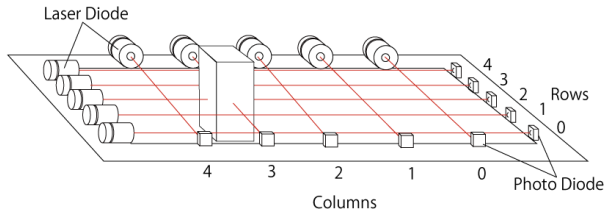

Figure 8. Laser array system

The system uses a load cell (DRETEC KS-209-CR) to identify a shape of block. We set unique weight for each shape of block as shown in Table 1. By this setting, the system can identify an enabled block only by measuring the weight. The load cell outputs the voltage according to the weight, and the voltage amplified through an amplifier (LT-1167) is received by ArduinoUno. The ArudionoUno converts received analog data to digital data by 10-bit A/D convertor for recognizing shapes. Therefore the system can identify the block IDs from data. Finally, the stacking position and block ID are transmitted to the PC as a character string data {Row, Column, Shape}.

Table 1. Setting weight

			
Triangular prism	Cube	Colum	Quadrangular prism
5g	12g	21g	30g

3.3 Scene Creation

A cross-platform game engine, Unity, is used to render a scene in real-time. UNITY receives the character string data transmitted through a serial port from ArduinoUno. Moreover, Unity memorizes these transmitted data in an array in the order of inputting.

Figure 9 shows an initial status of a grid of makers where a block to be stacked on; here the row and column ID are corresponding to the received string data. When the system receives the string data, a corresponding block object falls down in the virtual space that acts in the same way as real situation. The 3D block object transforms into the part of a castle after it collides with a marker and then a colorful shaft of light effect is appeared in a virtual world (Figure 10). After that, the marker will move to on the top of the collided object. Figure 11 shows the correspondence 3DCG models with tsumiki.

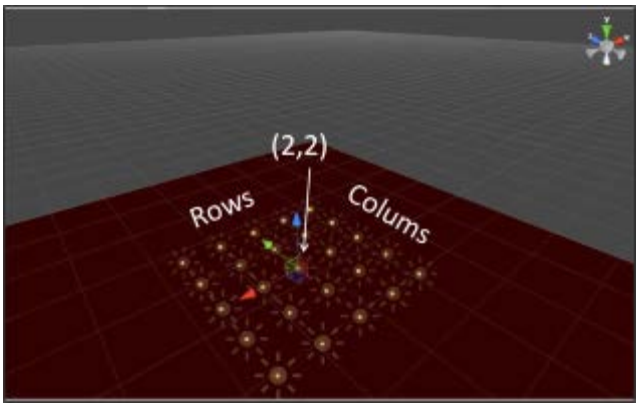

Figure 9. Grid of markers

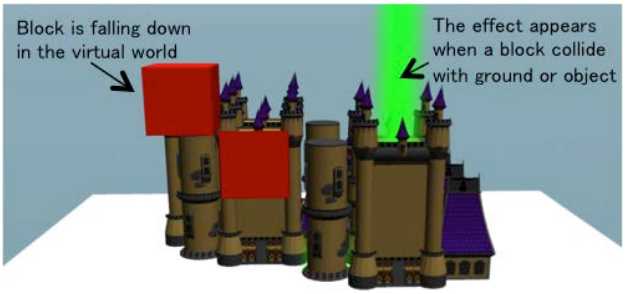

Figure 10. Blocks become the part of a castle

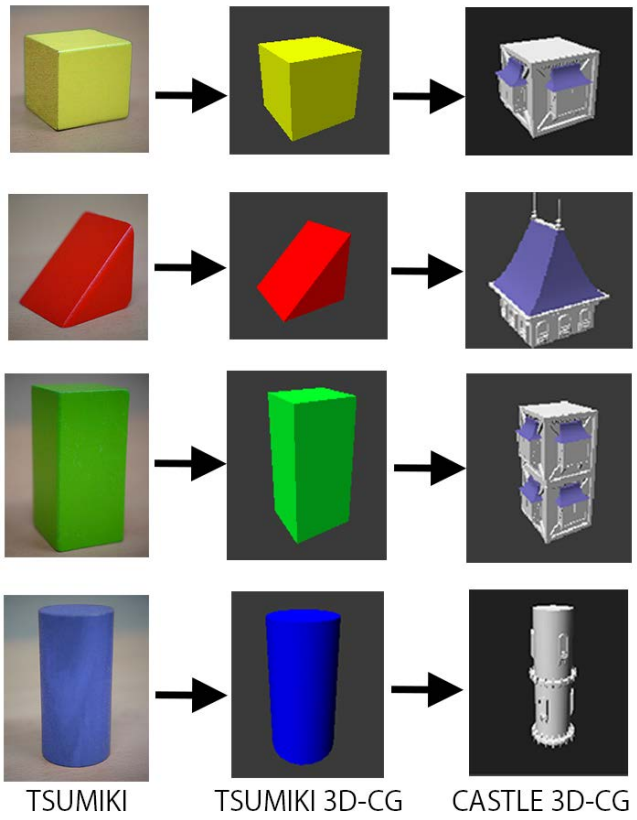

Figure 11. Correspondence of 3DCG models with tsumiki

The shape of a block is changed by a spatial relationship with other blocks. These rules are shown in Figure 12 and Figure 13. A triangular prism will transform into two types of 3D models; when it is placed on a cylinder block, it becomes a conic roof, otherwise it becomes a hipped roof. Figure 13 shows the case of cube and rectangular parallelepiped. When there is nothing on a block, an ornament is added upward. In the other case, if there is nothing horizontally, an ornament is attached to the edge of block. A cylinder always is changed into a turret as shown in Figure 11.

Figure 14 shows the correspondence between a toy block and a part of a castle.

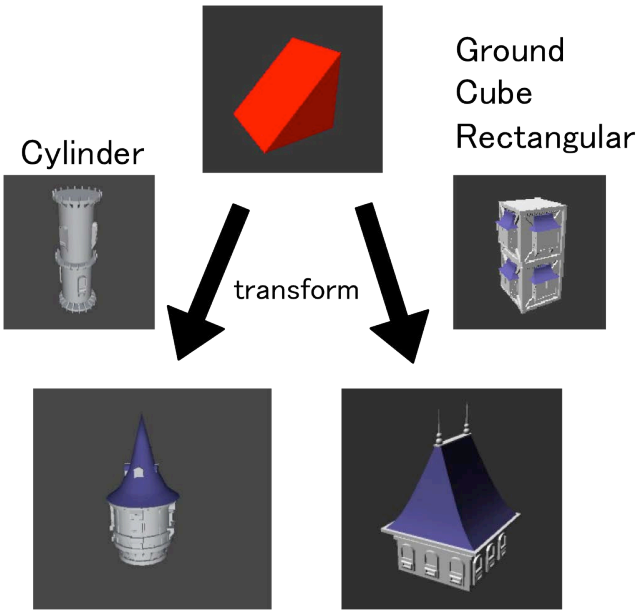

Figure 12. Transformation pattern of triangular prism

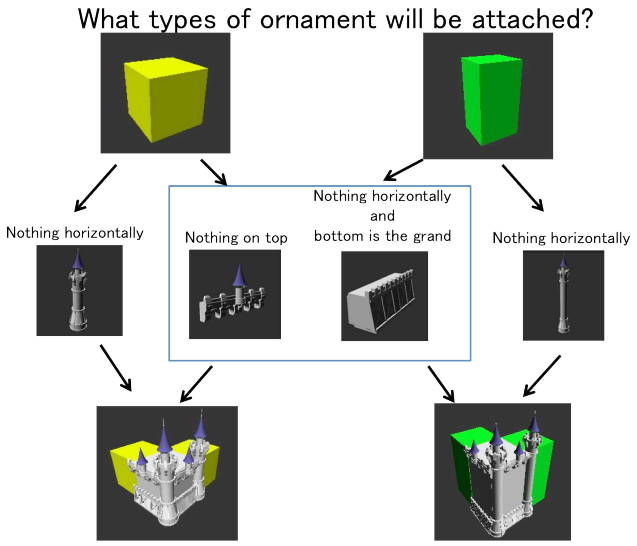

Figure 13. Transformation pattern of cube and rectangular parallelepiped

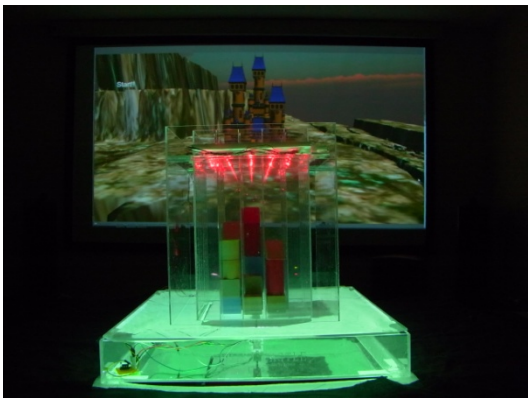

Figure 14. Relation between toy blocks and castle's CG

A scenery image is inserted to a virtual world after creating a castle model. A player can choose favorite scenery according to the castle they made. We use the "Terrain Engine" contained in Unity to create the scenery. The example of created scenery is shown in Figure 15. There are several scenery patterns including grassland, vertical cliff, lakeside, and so on. In addition, we prepare some sky effects using "Skybox tool" to generate a background image of the scene. Therefore players can enjoy a unique combination of scenery and a castle as they like. The example scene is shown in Figure 16.

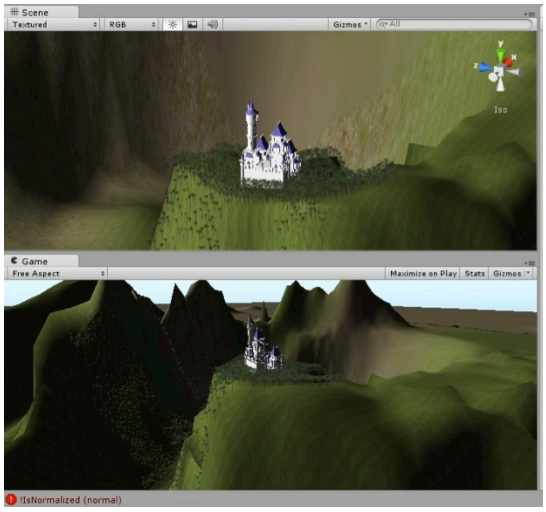

Figure 15. Terrain Engine

Figure 16. Created scene

4. EXHIBITION

The system was exhibited at “Ishikawa Dream Festival” in Ishikawa, Japan on November 10th and 11th. Figure 17 shows the scene of the exhibition. More than 100 people experienced stacking blocks and choosing a landscape to create favorite castle and scenery.

Figure 17. Exhibition at "Ishikawa Dream Festival"

4.1 Reaction

Figure 18 shows an example of castle created at the exhibition. Many children enjoyed creating a castle with their family. During the exhibition, especially young children stacked blocks haphazardly, however children themselves really wondered at the beauty of a generated CG castle. Many children proudly told their parents about their creations. A teenager was enthusiastically checking the position of stacked blocks from all directions to realize his ideal castle. Such situations were often seen except very young children. On the whole, the system received positive approval by players.

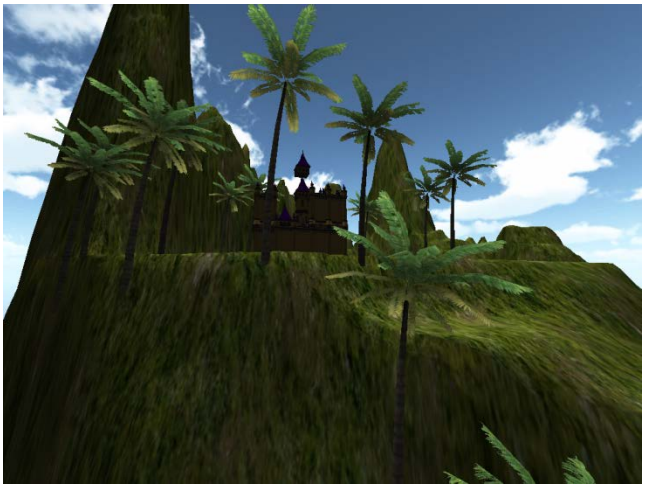

Figure 18 Created castle in exhibition

4.2 Questionnaire

After the experience, we had a questionnaire about the system, and we collected answers from 69 people. The result is shown in Figure 19 - 23. According to Figure 19, under 10-years-old children are accounted for 80 percent of all players. The reason is that “Playing toy blocks” has strong affinity for children. In response to the question “Could you enjoy “TSUMIKI CASTLE”?”, 58 percent players answered “very exciting”, and 41 percent players said “exciting”. Figure 21 shows that not only children but also their parents for exited to play with this system. We prepared a question “Do you want to play again?” to collect more accurate information.

As Figure 22 shows almost all people want to play again. Actually, many children tried to create a castle again. In addition, we asked “How difficult is it?”. a number of people answered “very easy” or “easy” as shown Figure 23 These results show that this system is easy to play and gives enjoyment for everyone. However, 15 percent players said that it was “difficult” or “very difficult”. We guess the reason of this score is that children are unfamiliar with using a keyboard for choosing a scenery, or the position of the case installed is too tall for them. We plan to improve the system reflecting on the obtained evaluations.

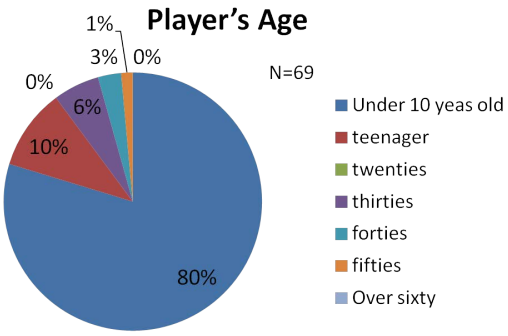

Figure 19.Player's Age

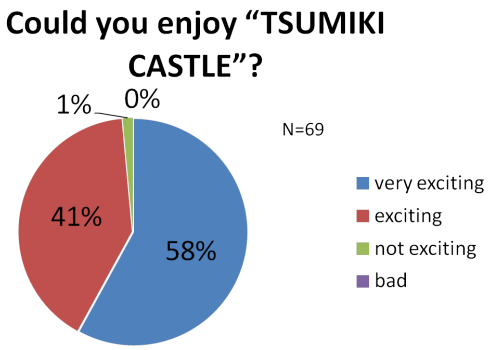

Figure 20. Could you enjoy "TSUMIKI CASTLE"?

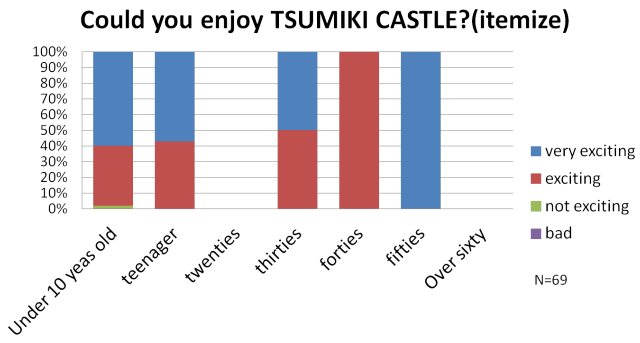

Figure 21. Could you enjoy "TSUMIKI CASTLE"?(itemize)

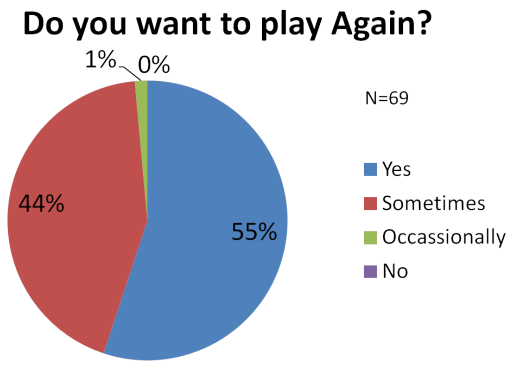

Figure 22. Do you want to play again?

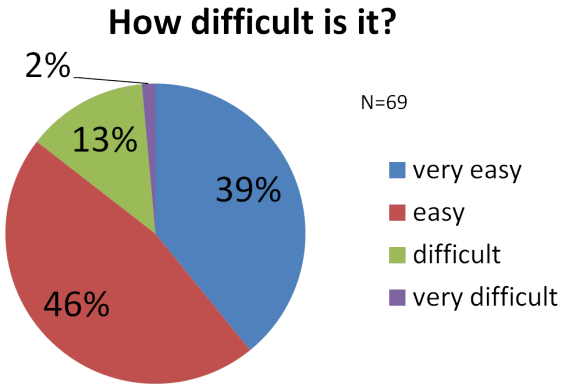

Figure 23. How difficult is it?

5. CONCLUSION

This paper presented a virtual reality application for creating decorative castle by stacking toy blocks. The system converts a stacked block into a part of a castle, and dynamically makes a CG castle. From evaluation at uses, it could be continued that people of any age and both sex can enjoy themselves through the exhibition. We would like to provide more exciting experiences by increasing the variation of CG, and hope that the system stimulates children's creativity.

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