Cypher: Cyber Photographer in Wonder Space

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ABSTRACT

In order to make it possible for us to easily create a virtual world simply by using our imagination with building blocks and to take photographs of ourselves traveling in the wonder space with a beautiful composition, we have developed a system called "Cypher (Cyber Photographer in Wonder Space)". With this system, users can blend the real world with a virtual world by using their aesthetic sense. This system is expected to be applied not only to the amusement field but also to support tools for city planning or layout simulations involving furniture and so on.

Keywords

building blocks, fusion system, virtual world, 3D objects, CG, VRML, pose recognition, P type Fourier descriptors, circumference curve, physical image, compositional knowledge

1. INTRODUCTION

Is it possible to create a virtual world easily without special technical knowledge simply by using our imagination with wooden blocks (i.e., the same building blocks that children play with) and to take photographs of ourselves traveling in the wonder space with a beautiful composition? In order to realize such a dream, we have developed a system called "Cypher (Cyber Photographer in Wonder Space)". Cypher is a fusion system that consists of virtual worlds and photographs of the real world.

2. OUTLINE OF THE SYSTEM

Figure 1 shows the appearance of the Cypher system and Figure 2 shows the outline of the system. This system has four kinds of virtual worlds as shown in Figure 3. They include 1) the Japanese world in the Edo period, 2) a rabbit world, 3) a cosmic world, and 4) a haunted world.

When using the system, a user first chooses a favorite world, and then arranges crystal blocks on an exclusive table. Each crystal block contains a model of a building or tree, etc., and each model is assigned to a virtual object. There are eight crystal blocks in total. They include one human figure (assigned to the user himself/herself), two vehicles, three buildings, and two trees. Multiple users can participate in this system at the same time, and try their own arrangements. The situation of each arrangement on the table is reflected on the screen in front of the table in real time. These virtual objects are arranged in the virtual world according to the positions and the directions of the corresponding crystal blocks. The user can proceed with manipulating the arrangement while confirming the quality of the arrangement. After the virtual world is constructed, the user then places a human figure block where he/she wants to appear in the virtual world and instructs the system to take a picture of him/her. Then, the system extracts the image of the user from the picture, and analyzes the physical pose of the user. This system maintains a database of about 200 painting masterpieces and also the physical poses of the main figures contained in these masterpieces. From this database, the system selects the masterpiece containing the nearest physical pose to the user's, and synthesizes a photograph by placing the user's image at the position of the human figure block in the virtual world based on

Figure 1. Appearance of Cypher

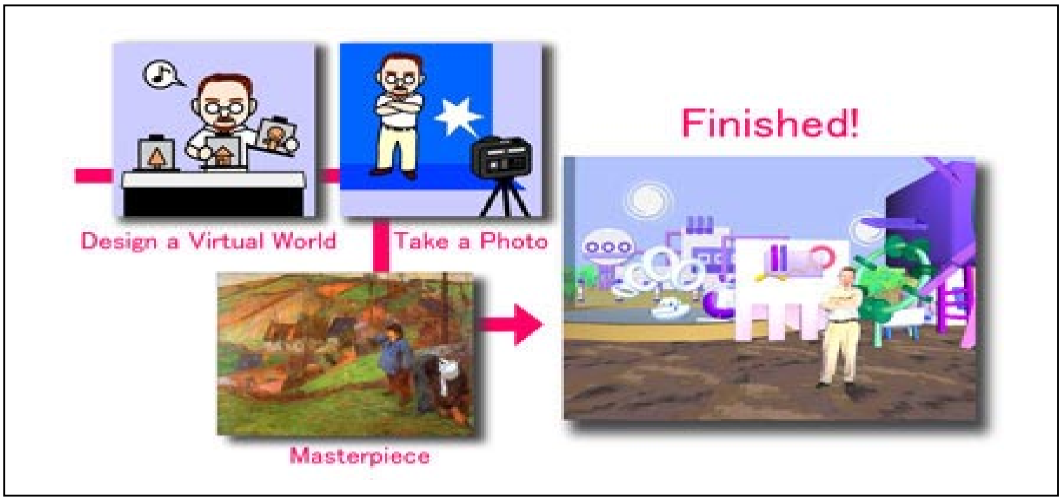

Figure 2. Outline of Cypher

The Japanese world in the Edo period | **A rabbit world** | **A cosmic world** | **A haunted world**

Figure 3. The Four Kinds of Virtual Worlds in Cypher

the compositional knowledge of the selected masterpiece. The resulting photo is printed out and presented to the user.

3. CONSTRUCTION OF THE VIRTUAL WORLD

As is shown in Figure 1, this system has an exclusive table of about 95cm in height at the center, and the top surface of the table is made of a transparent square glass plate about 110cm on one side. The eight crystal blocks, each about 10cm on one side, can be arranged on this table. In the following, how a virtual world can be constructed is explained.

3.1 Measurement of the 3D Position of Each Block

Figure 4 shows how the 3D position of each block is measured. Each block has an ultrasonic oscillator at the center of the top surface, and each oscillator has a different ID code. Four ultrasonic sensors are installed on the ceiling at the position of each apex of the square room; the diagonal is about 130cm. From these sensors, eight different ID codes are sent sequentially by infrared rays. Then, the ultrasonic oscillator that has the same ID code sends back an ultrasonic pulse. Each ultrasonic sensor receives the pulse, and knows the distance from the oscillator by the corresponding delay time. The 3D position of the ultrasonic oscillator is determined based on the principal of three-point measurements. Therefore, the 3D position of each ultrasonic oscillator is determined. In these measurements, it is possible to determine all 3D positions only with three ultrasonic sensors. In this case, however, there is the possibility that one direction might be cut off since all users place only the blocks in their hands. This is why we use four ultrasonic sensors. When an ultrasonic pulse reaches all four sensors, we can select the three sensors that make the error minimum, so that the precision of the measurement can become higher.

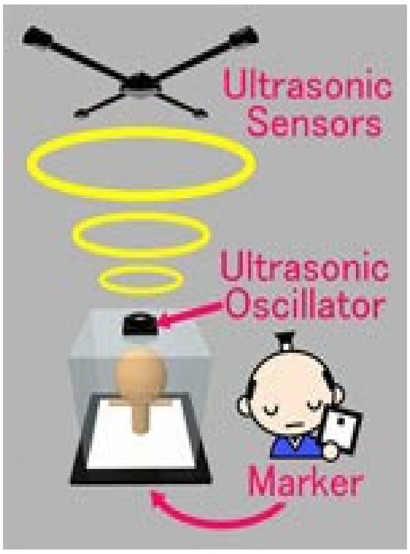

Figure 4. Measurement Method of a Block's Position

3.2 Measurement of the Direction of Each Block

As shown in Figure 5, a square fluorescent substance that shines palely when responding to an ultraviolet ray is stuck at the bottom of each block. On this square surface, a black square marker of about 1.3cm on one side is also stuck on the surface at a position that deviates about 2cm from the center of the square surface towards the front of the block. On the other hand, at the inside bottom of the exclusive table, a camera is installed that takes a picture of the current image on the upper glass as well as black lights that emit ultraviolet light. The picture taken by this camera contains eight white squares and black markers clearly as shown in Figure 5.

The system extracts each white square that contains a black marker from the picture taken by the camera. In this process, these extracted white squares' edges have many irregularities because of noise. Accordingly, we find the straight edge lines of the white squares using Hough transforms. Then, the four intersection points of the four straight lines are identified as the apexes of each extracted white square.

Next, the system performs pattern matching between each extracted square and the patterns rotated around the z-axis as shown in Figure 5. The rotation angle that gives the best matching determines the direction of the front of the block.

3.3 Generation of Objects

Based on the positions and the directions measured by the above methods, 3D objects corresponding to the individual blocks are generated by CG, and are arranged into the selected virtual world. In the generation of the CG, VRML is employed because of the ease it allows in CG development. Four different types of objects have been prepared according to the four virtual worlds. For example, a vehicle block corresponds to a horse or a large two-wheeled cart in the Edo period world, but it corresponds to a flying car in the cosmic world.

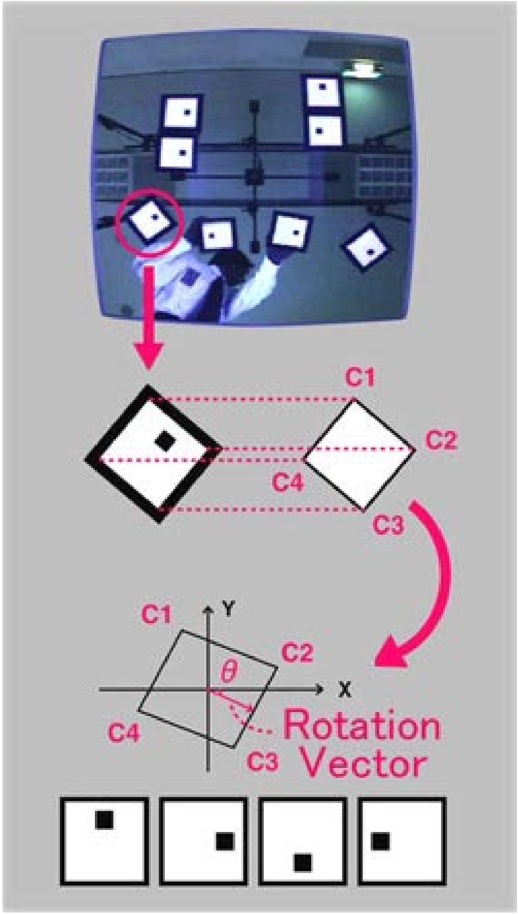

Figure 5. Measurement Method of a Block's Direction

Moreover, because the complete lack of movement in the constructed virtual world can create boredom, we give some objects some movements or we add some additional moving objects. For example, in the case of a vehicle object, we make it move around the center of the block, or in the case of a building object, we make a little girl walk around the building or make the door open and close. By these movements, even after the layout of all objects is fixed, many movements exist in the displayed virtual world, and we can look at it without losing interest.

4. PUTTING THE USER'S IMAGE INTO THE WONDER SPACE

With the method mentioned above, a virtual world can be constructed easily according to the user's imagination. But the interaction between the user and virtual world is slightly poor. Therefore, we add a function to this system to take a souvenir photo of the user traveling in the wonder space with a beautiful composition. With this function, a model of a beautiful composition is taken from a database of compositions of about 200 ancient and modern famous painting masterpieces. Using this database, the user can obtain a souvenir photo with a beautiful composition, even if he/she has no knowledge about the compositions of paintings or photos. In the following, this process is explained.

The basic system of this process is “The Cyber Photographer” [1], which has become a part of the system through name association. This is a technique that extracts the main objects from a picture panoramically taken with a beautiful composition. At this time, the main object is restricted to the user’s figure. Therefore, we do not need to take a picture panoramically expressly, and can simplify the extraction process.

As mentioned above, after placing a human figure block where he/she wants to appear in the virtual world, first, the user takes a picture of himself/herself in front of a blue background. Then, the system extracts only the image of the user by a simple chroma key process.

Next, the system performs a pose recognition process about the physical image of the user. For this pose recognition, the figure of a circumference curve of the physical image is used. This closed circumference curve is described by P type Fourier descriptors [2].

The descriptors are obtained as follows. First, the closed circumference curve is divided into N segments. Next, the lines of each segment are normalized to vectors of length 1, and placed on a complex plane. Then, this sequence of complex numbers is Fourier transformed. These numbers in the frequency domain come to be the P type Fourier descriptors. By using these descriptors, we can describe the figure independent of the size, and make the position of the terminal of the reconstructed curve coincide with the position of the original curve. Moreover, we can reconstruct a smooth circumference curve while well preserving the rough figure by taking out the lower frequency components up to n ($<N$). Here, we use $N=512$, $n=40$.

On the other hand, for the circumference curves of the main figures of the approximately 200 masterpieces, P type Fourier descriptors of $N=512$, $n=40$ are stored as a database. By calculating the summation of the square errors between these P type Fourier descriptors, the figure in the database that gives the smallest summation value is selected as the pose nearest to the user’s.

In the database, the area ratio of the human figure to the entire screen and the position of the center of gravity of the figure are also preserved. In order to make this information coincide, the size and the position of the user’s image are converted. During the conversion, the camera is assumed to be on the normal line of the human figure block, in order to minimize the number of variable parameters of the camera. Accordingly, the conversion is carried out by the change of the distance to the virtual camera and horizontal pan and vertical tilt.

Figure 6 is an example of a souvenir photograph.

Figure 6. Example of a Work

5. CONCLUSION

This system “Cypher” makes it possible for a user to create a virtual world simply through his/her imagination with toy building blocks, and to take a souvenir photograph of himself/herself traveling in the virtual world with a beautiful composition. With this system, the user can blend the real world with the virtual world using his/her aesthetic sense.

This system can be applied not only to the amusement field but also to support tools for layout simulations of rooms in a virtual house, or for layout simulations of buildings and so on in city planning, by replacing the background images and objects.

From now on, we plan to increase the kinds of contents and improve the quality of the contents. We also want to increase the picture quality of souvenir photographs.

6. REFERENCES

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