Generation of Integral Photography Images Using Light Wave 3D™

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Abstract

Integral photography (IP) is an ideal 3D image display system because observers can see realistic 3D images from arbitrary directions without wearing special glasses. In addition, IP is excellent since both pinhole arrays and IP images can be manufactured by printing special patterns on transparent sheets. This paper proposes a new method of synthesizing an IP image by using LightWave 3D, which is commercially available 3D software commonly used worldwide. A series of still images, each of which is taken from a different camera position are required. In order to automate it, the animation function of the software is utilized. Namely, a camera position corresponds to a key frame, and all the key frames are generated at a time by using an LScript, which is a script language developed for LightWave 3D. Under such a condition, still images taken from different camera positions can be acquired as sequentially numbered bmp images. The still images are synthesized by our original software to get an IP image. By experiments it was confirmed that proper 3D images can be observed with the proposed method.

Introduction

Various factors of the human binocular vision are known. Among them, the most important factor which gives the strongest sense of depth in a usual environment is the binocular parallax. By 3D image displays using the binocular parallax, users can easily recognize the shape of 3D objects, and experience high reality. Therefore a various 3D display methods[1] have actively been studied so far. Among them, integral photography (Hereafter, it is called IP) is one of the ideal methods, because users can see realistic 3D images without wearing special glasses. In addition, proper 3D images can be observed even if the observer's eye moves not only horizontally but also vertically. In this respect, IP has excellent properties that are similar to the holography. Moreover, IP has an advantage that it does not require laser technology.

The history of IP is old. In 1908 it was proposed by M.G. Lippmann in France. An initial experiment was conducted by using a pinhole array which is equivalent to fly's eye lens by A.P.Sokolov of the Moscow university. A fly's eye lens is an array of a lot of minute convex lenses. It looks like insect's compound eye. A metal mold is usually necessary for manufacturing fly's eye lens, but it is a problem that the metal mold is usually very expensive. If a pinhole array is used instead of the fly's eye lens, the initial manufacturing cost can be greatly decreased. Although the brightness of the 3D image is also decreased, it can be supplemented with a stronger backlight.

Moreover the recent advancement of printing technology is marvelous, and very high quality images can be output even with inkjet printers for consuming public, so that both a pinhole array and an IP image can be easily printed on transparent sheets. Here an IP image is an image into which hundreds of pictures taken from different angles are integrated. We are entering the age of desktop 3D printing.

In general, there are two methods of making an IP image. One is CG[2-3] and the other is photography.[4] As for CG, the authors' group has already proposed a method of synthesizing an IP image with Shade™, which is commercially available CG software developed in Japan. This paper proposes a method of making an IP image by using LightWave 3D™. It is a product of NewTek Co.,Ltd. in USA, and it seems to be one of the most popular 3D CG software in the world.

Integral Photography Using Printing Technology

In this paper, integral photography in which both a pinhole array and an IP image are made with a printer as shown in Figure 1 is mainly assumed. The pinhole array is printed in an upper transparent sheet and the IP image is printed in a lower transparent sheet respectively beforehand. To keep the distance between the two transparent sheets constant, a transparent board is inserted between them. Moreover, a backlight is set up under them to shine on the IP image.

In this case, the observer's right eye cannot distinguish which of Q or S is the true light source. In the same way, the observer's left eye cannot distinguish which of R or S is the true light source. Therefore the observer feels as if the light were emitted from S according to the binocular parallax, and perceives the existence of an object at S.

LightWave 3D

LightWave 3D is a renowned CG application being widely used by many people including specialists of CG. It was originally developed for the personal computer named Amiga that appeared in around 1985, but it is mainly for Windows and for Mac OS now. LightWave 3D for Windows was used in this research. LightWave 3D can be used to produce not only still CG images but also animations. LightWave 3D is composed of two parts, the Modeler and the Layout, as shown in Figure 2.

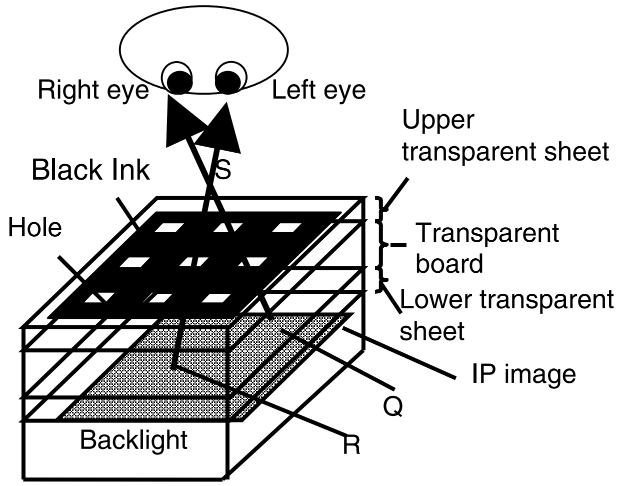

Figure 1. Principle of 3D display system assumed in this paper

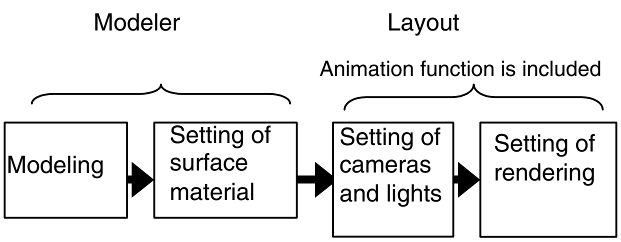

Figure 2. Modeler and Layout

The Modeler is an application that makes various objects such as characters and backgrounds that appear in animation. First, basic solids such as boxes and balls, etc. are combined mutually and a polygonal object is made. Next, the shape of the object is gradually formed, and complex shape such as people and still lifes is made. The surface material is set if necessary. During this procedure, the operator can adjust the viewing angle freely. Moreover, convenient functions such as layer function and sub-patch function are provided.

The Layout is an application that moves the object little by little, and makes animation, after the objects made by the Modeler are arranged with the cameras and the light in the 3D space. Various functions are installed to move the object automatically. Moreover, various functions such as the setting of the cameras and the lights, the editing of the color and the material of the objects, the rendering in which a moving picture file is created, are provided.

Procedure of IP Image Making

The Entire Flow

Figure 3 shows the procedure of the IP image making. The procedure is basically same as the case of usual CG. First each object is made with the Modeler, and the object is arranged in a 3D space with the Layout. A scene is made in this way. If the display is not stereoscopic, rendering from one camera position is sufficient. On the other hand, rendering must be done from multiple camera positions corresponding to the number of viewpoints, if some interpolation technique is not used. Since the number of viewpoints is n×n in integral photography, the camera position should change into n steps both vertically and horizontally. For example, in the case of n=32, the number of the necessary camera positions becomes 1,024. Though it is not impossible to set the camera position one by one by manual operation from a screen of LightWave 3D, the operator have to endure the tension and endurance for a long time.

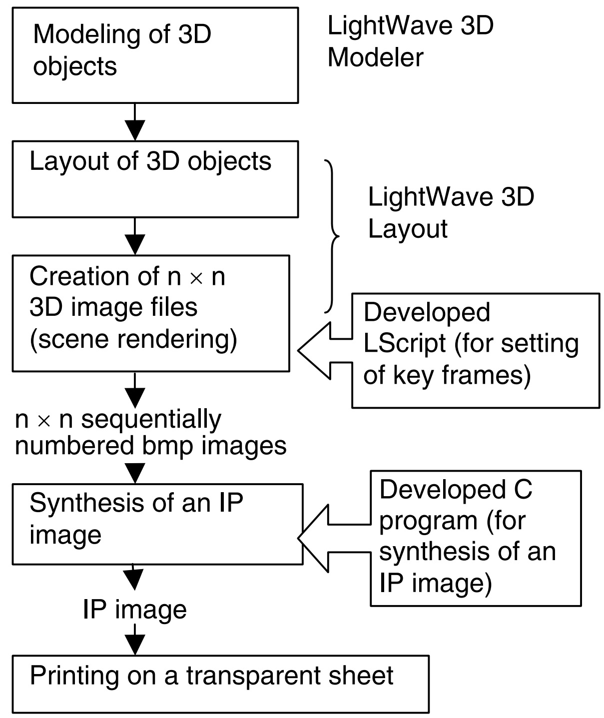

Figure 3. Procedure of IP image making

The key frame function is used to solve this problem as described as follows.

Camera Position Setting Using Key Frames

Originally, the "key frame" is a term used in the production of cartoon films, and the meaning is "an important frame corresponding to a turning point of movement." If a designer must draw all frames, the load is very heavy. Therefore it is usual that the designer draw the key frames only and other frames are automatically interpolated by computers. The key frame function is prepared in LightWave 3D. In this research, the function is used for another purpose, which is the setting of different camera positions. Because the number of viewpoints necessary for making an IP image is n × n (n = 32 for example,) key frames of the same number as the camera positions are made, and each camera position is assigned to each key frame.

The initial camera position is located at the position of frame 0 as shown in Figure 4, and the first key frame is placed there. Then the camera moves only a certain distance horizontally, and the next key frame is put there. The same procedure is repeated until the frame number becomes n-1, then the camera moves back to the initial position of the horizontal path, and the camera moves a certain distance vertically, and the next horizontal scan begins. This procedure is repeated until all the n×n key frames are set.

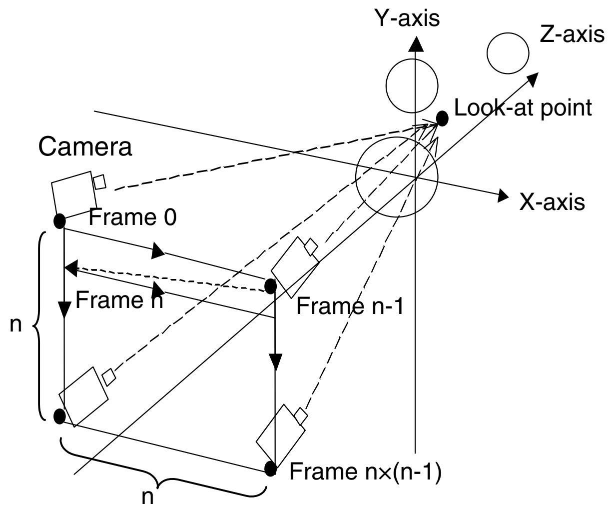

Figure 4. Motion of virtual camera

By this procedure a scene whose viewpoint changes n × n times is produced. When the scene is rendered, the n × n frames with different viewpoints are stored on the disk at a time as sequential number bmp images.

Use of LScript

As already described, the movement of the camera is automated by using the key frame and the labor saving becomes possible. However a very annoying and severe work for a long time is needed if the key frame is made by the hand work. Therefore the authors programmed the making procedure of the key frames with LScript which was a simple programming language LightWave 3D was able to interpret. By the execution of the LScript n × n key frames were made at a time. In this research, LScript of the form that was called “generic” in the Layout was used. In this case, the control is completely passed to LScript, it is executed only once, and the control returns to the Layout when ending.

Synthesis of IP image

Figure 5 shows the principle of the technique for making one IP image from n×n sequentially numbered bmp images. This is basically the same as the method which the authors already presented.[3]

Experimental Result

The shape data (dinosaur) used in the experiment was made by one of the authors. The number of pixels of element images corresponding to one pinhole is 32 × 32 (n = 32), and the number of pinholes is 180 × 180. Therefore the total number of pixels of an IP image is 5760 × 5760. The IP image was printed on a transparent sheet with an inkjet printer, whose resolution was 720 dpi. Therefore the size of the IP image was 203.2 × 203.2 mm. The IP image was used for the experiment as shown in Figure 1. It was confirmed that binocular vision is possible as shown in Figure 6.

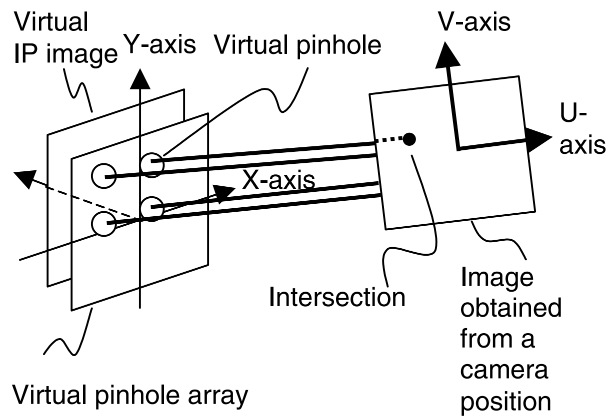

Figure 5. Synthesis of IP image

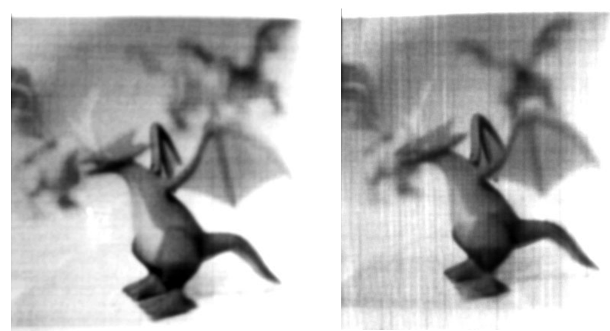

Figure 6. 3D images observed from different viewpoints

Conclusion

This paper proposed an efficient and convenient method to generate IP images with LightWace 3D, which is one of the most popular 3D CG software being used worldwide. It is necessary to take pictures of a scene from a lot of different camera positions for the synthesis of an IP image. By using the key frame function, which is originally prepared for animation, it was made possible that all the n × n images are rendered at a time. Moreover, LScript, which is a simple programming language developed for LightWave 3D, was used to automate the setting of the key frame. As a result, the operator's load has been greatly reduced. It was confirmed that the binocular vision was possible by experiments.

The method of making IP images described in this paper can be applied to the cases in which a fly’s eye lens is used, because a pinhole and a convex lens are known to be functionally equivalent. If the result of this research is used, everyone can easily enjoy 3D display objects made with LightWave3D. Only a personal computer, a printer, and software are necessary. Therefore the application field of 3D display can be extended further. The principle of the IP image generation technique proposed in this paper can be applied also to other CG software that has the similar animation function.

References

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Author Biographies

Kazuhisa Yanaka received his BE, ME and Dr.Eng. degrees from the University of Tokyo in 1977, 1979, and 1982 respectively. He joined Electrical Communication Laboratories of NTT in 1982 and he was engaged in the research and development of videotex terminals, teleconferencing systems, and image coding algorithms. He moved to Kanagawa Institute of Technology,Japan, in 1997. He is currently a professor of the Institute. Email:yanaka@ ic.kanagawa-it.ac.jp

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