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Printed 3D Multi-View Images

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The technique to produce full-parallax 3D multi-view still pictures is described. The matrix of source views (from 6x6 to 15x15 views) is built from computer-generated images or from the natural images taken by a photo-camera. The matrix is processed in specially designed software and the resulting multi-view picture is generated. To display the large size (up to 0.4 m x 0.6 m) multi-view picture, the crossed lenticular screens of two types were used.

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I. INTRODUCTION

There are a number of methods to display stereoscopic pictures with the lenticular sheet [1,2] applied to the printed picture. The HPO (horizontal parallax only) multi-view pictures can be also displayed with a single lenticular sheet. Additionally, it is possible to display full-parallax pictures by means of the two-layer lenticular screen [3] or the point light source array [4].

In this paper we describe the enhanced way to produce the large size full-parallax multi-view pictures with some additional features. The source image matrix, 3D multi-view picture and its reference point, the lenticular screen layouts, and the sample pictures are described and discussed. The size of the resulting color 3D pictures is increased from 25 cm x 25 cm to 0.4 m x 0.6 m.

II. SOURCE IMAGE MATRIX

The source matrix includes a set of source views, which can be taken, e.g., from a digital photo camera. The source images can be also generated in the computer. The camera array (positions of cameras) is arranged in a square matrix NxN, N = 6, $\cdots$, 15 (Fig. 1).

In practice, instead of the NxN camera array, the single camera could be used. In this case, however, only the static objects might be included in the picture with no changes in their form and position during several minutes, while the camera is moved from its first position to the last (NxN-th) one.

An additional angular camera adjustment could be applied to avoid loosing edges. With no angular adjustment, the images in the upper row of the source matrix include more details above the object while the images in the lower row include more details below it. These details are actually excluded from the common area to be displayed in the resulting multi-view picture. With the additional angular camera adjustment, one could avoid loosing these details. In fact, it means that some point (area) of the object is chosen as a reference point. This point appears in the same area of the screen plane in all views.

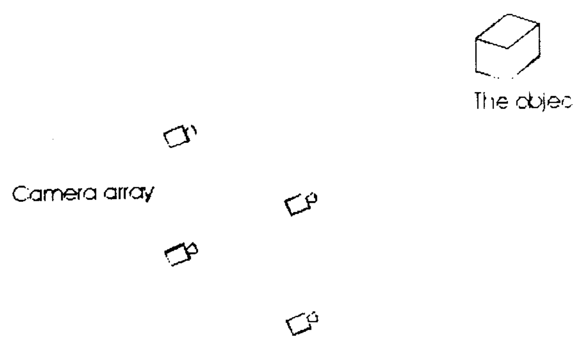

FIG. 1. Camera layout.

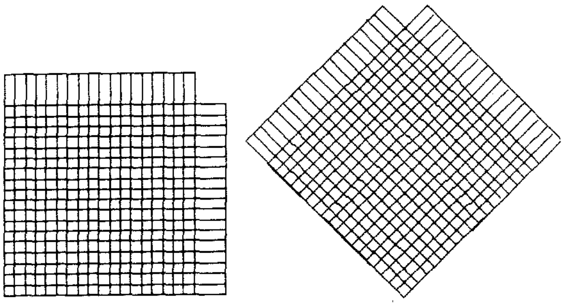

FIG. 2. Lenticular screen layouts. A: square matrix (left), B: 45° diagonal (right).

III. LENTICULAR SCREEN AND THE PICTURE

The multi-image picture includes all the source views arranged in appropriate order. The picture is split in cells which shape depends on the lenticular screen layout currently used (Fig. 2). The basic geometry of multi-view picture is shown in Fig. 3. The lenticular sheet L is applied to the multi-view picture P, the viewing distance is z_v. The cell size a_p depends [3] on the viewing distance z_v and on the lenticular sheet parameters, its focal length F and pitch a_l,

$$\frac{a_p}{a_l} = 1 + \frac{F}{z_v} \tag{1}$$

The pixels of source views are displayed from the pixel cells (Fig. 2) to the viewing zone. For the 2-layer lenticular screen L made of crossed sheets, the viewing zones are multiplied (repeated, e.g., in vertical and horizontal directions for layout Fig. 2A). The shape of the single viewing zone is square-based 4-face pyramid. Its horizontal size (width of its base) was found in [3] for the case of the square layout Fig. 2A,

$$w_v = a_l \cdot \left(1 + \frac{z_v}{F}\right) \tag{2}$$

For the case of diagonal layout Fig. 2B, the horizontal size of the viewing zone is increased in $\sqrt{2}$ times.

To compose the multi-view picture, the special software program was developed. It generates the multi-view picture from the source matrix represented as the set of separate image files. Then, the resulting multi-view picture is printed in the printer.

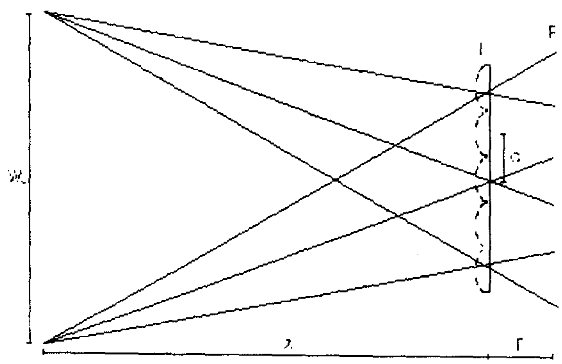

FIG. 3. Basic geometry.

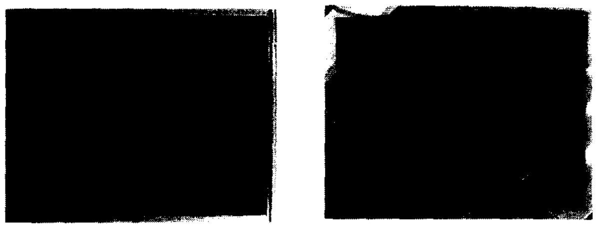

FIG. 4. Computer-generated multi-view pictures, square screen layout (left) vs. diagonal screen layout (right).

IV. DISPLAYING THE PICTURES

The printed multi-view picture is applied to the crossed lenticular screen. The screen and the picture should be mutually aligned to match their axes. We used the lenticular sheets with the pitch values ranged from 0.5 mm to 1.7 mm. The sample photographs (single view only) of resulting pictures are shown in Figs. 4, 5 and 6.

Two different screen layouts (Figs. 2A and 2B) were used, square layout (Figs. 4 left and 5 left) and diagonal layout (Figs. 4 right and 5 right). The 3D pictures of museum objects (Fig. 5) were especially designed

FIG. 5. Multi-view pictures for some antique objects, square screen layout (left), diagonal screen layout (right).

FIG. 6. Multi-view picture with an embedded image in LU corner.

for the backlight illumination while no special lighting was required for other pictures (Figs. 4 and 6).

Sometimes, special images can be artificially embedded in some parts (rows or columns) of the source matrix. These images are visible from corresponding regions of the viewing zone. An example is shown in Fig. 6, a woman face in the left upper (LU) corner of, the picture. Here the image is embedded in the uppermost row of the source matrix. Therefore it appears in the upper part of the viewing zone and disappears in its other areas. At the same time, the stereoscopic perception is not destroyed in any part of the viewing zone.

V. CONCLUSION

The large size multi-view pictures were made with different screen layouts applied. The diagonal layout Fig. 2B seems to provide the better picture appearance (right images in Figs. 4 and 5). In this case, the viewing zone is 40 % wider than that for the square layout Fig. 2A. The embedded image (Fig. 6) can also make the picture more attractive. This feature could be especially useful, e.g., as a special effect in advertising. It is also possible to use different screen layouts, e.g. diagonal screen layout with the angle 30° between the lenticular sheet axes instead of 45° (Fig. 2B). Combined with other features, it might provide the changeable picture appearance and the controlled size of the viewing zone.

The pictures shown in Fig. 5 (and more museum objects) were made for Cheongju International Printing and Publishing Expo 2000, September - October 2000. The size of the printed pictures is increased from 25 cm x 25 cm to 0.4 m x 0.6 m.

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