Active Projector: Image correction for moving image over uneven screens

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INTRODUCTION

Projectors have had a small and light body, bright and fine images and a wireless function. These mobile projectors are often used for large screen presentation at customer's office and the projector and the screen need to be settled in right position to avoid keystone distortion. It is expected to correct the distortion automatically by measuring screen distance and slant. Furthermore, since high performance and mobile projectors can be used at various scenes, it is required to adjust projector parameters such as geometric image correction, color, brightness, zoom and focus corresponding to the environment. We describe a geometric image correction method using screen surface shape data measured by a camera.

ACTIVE PROJECTOR

System Configurations

Active Projector is an image projection system that allows the image to jump to various types of object such as walls, ceilings, floors, or desks. The system consists of a small projector, a pan/tilt rotation table, a PC and a camera. We developed mirror controlled Active Projector for large and heavy projectors [1]. We have improved it for small and light projectors. This system's rotation table specification is shown in Table 1 and the system configuration is shown in Figure 1. The rotation table and the PC are connected via serial ports and the PC controls pan/tilt rotation angles and speeds. The PC corrects contents images and outputs the corrected images to the projector's input. Since the image correction and the image position must be synchronized, the software program adjusts the output time of rotation control signal. The camera is used for screen shape measurement.

Table 1: Rotation table specifications

	Pan	Tilt
Rotation angle	-270 ~ +270 (degree)	-90 ~ +90 (degree)
Rotation speed	37.5 (rpm)	40 (rpm)
Size(H,W,D)	300(mm) x 300(mm) x 300(mm)	

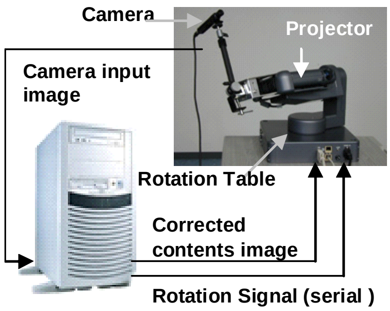

Figure 1: System configuration

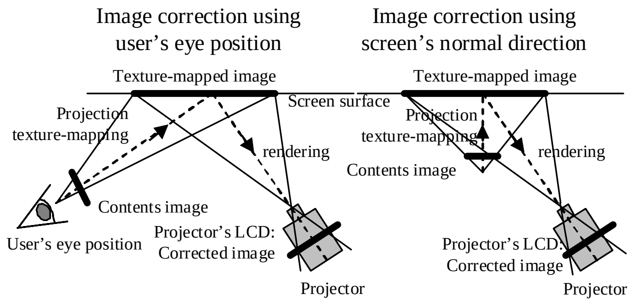

Figure 2: Existing image correction methods

Image Correction

Several methods using 3-D graphics rendering technique are proposed for projector's image correction [2]. We have improved such existing methods for the rotating projector.

Screen Measurement. In a typical measurement method, pattern images are projected on an object, a camera takes the projected scenes, and the object surface coordinates are calculated using the projector and camera coordinates with image processing. In Figure 1, a camera, which is fixed to the rotation table, takes several scenes while the system is rotating with a pattern image projection. The system can acquire the surrounding surface shape data.

Existing methods. As image correction uses 3-D graphics processing, input contents images are texture-mapped on the measured screen surfaces. There are two existing methods; one is based on user's eye position and the other is based on the screen surface normal direction. Both methods have the following problems.

As shown in Figure 2 left, user's eye position is used for the texture-mapping perspective viewpoint. The texture-mapping perspective direction is to the intersection of the projector's lens center and the screen surface. Then, the corrected images are rendered on the virtual projector's LCD screen. When the projector displays the corrected image actually, the user standing on the eye position can see the normal image. However, this method is not appropriate for many users.

As shown in Figure 2 right, the texture-mapping perspective direction is the normal of the screen surface. The projected images will be shown as a poster. However, if the screen surface contains several polygons or the screen surface is uneven, there is a problem how the normal direction is to be determined.

Proposed methods. We propose the following two-step method. First, a polygon reduction is applied to the measured screen surface shape data in order to generate rough shape data. Secondly, image correction is processed with the equal distance surface of the rough shape data.

In the polygon reduction step, as the target shapes are 2-dimentional shapes, the edge points should be weighted not to be eliminated. Users adjust the polygon reduction parameters to reduce as many polygons as possible with keeping shapes features.

In the image correction step, the screen surface normal direction is used for flat screen area. In case that a projection area contains more than one polygon, the texture-mapping perspective viewpoint which has equal distance form these polygons is calculated

Figure 3 shows a simple example. When a projection area overlaps with the corner of a room, **A** is the equal distance from the polygons and it is the texture-mapping perspective viewpoint. **B** is the intersection of the projector's lens center and the screen surface of the rough shape data and vector $\overline{AB}$ is the texture-mapping perspective direction. While the projector is rotating, the texture-mapping perspective viewpoint moves on the bold dotted lines in Figure 3. This line signifies equal distance from the rough screen surfaces.

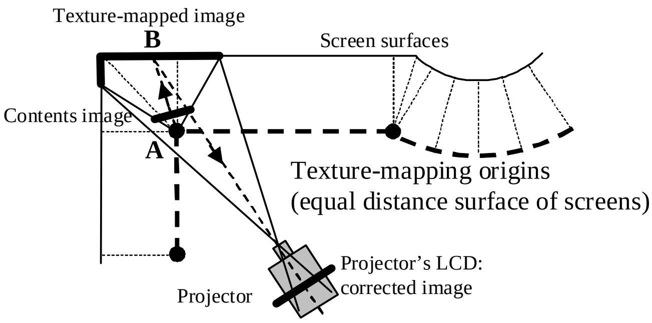

Figure 3: Proposed image correction methods

IMPLEMENTATION

Figure 4 shows that our system displays sample image near the corner As shown in this figure, image distortion is almost corrected and images are displayed like as posters on both flat surface part and corner part. One of our proposed method features is to transform images continuously even though the images move over uneven screen surfaces as shown in Figure 5.

CONCLUSION

We proposed a projector image correction method, which provides continuous transformation even if the projection image moves over uneven surfaces using a rotating projector. The projection system with the proposed method can be applied to various image displays with new image effect and we expect it to be an interactive display or an augmented projector.

REFERENCES

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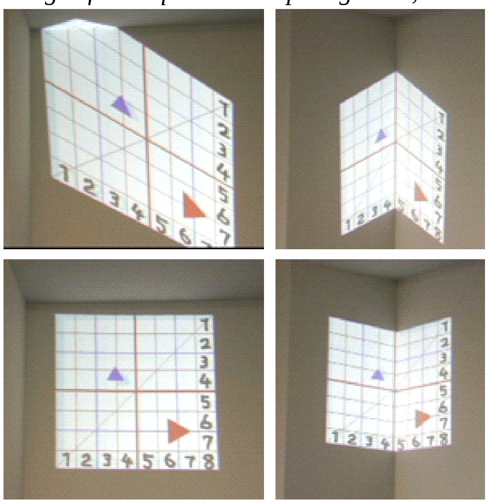
Figure 4: Image projection on a corner.

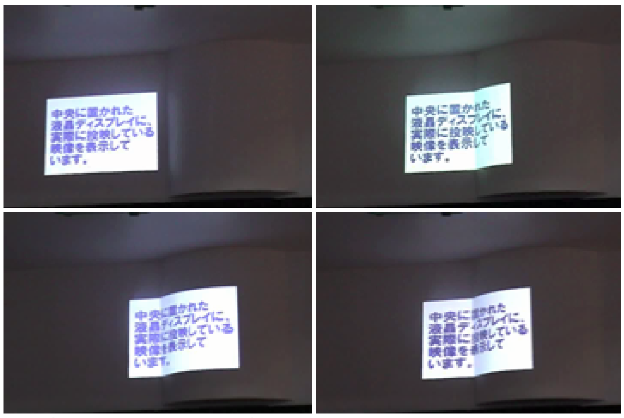
Figure 5: Image moving over uneven surfaces