# AN AUTOCALIBRATED AND INTERACTIVE TILED DISPLAY SYSTEM FOR IMMERSIVE EDUCATION

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Abstract: A tiled display is one of virtual reality systems which generate high-quality images and guarantee wide view angle using multiple projectors. The virtual reality systems may be used as a new educational tool because a user can be provided immersive sensation as he/she experiences a real object. Previously, we have proposed a tiled display system where a high resolution image is generated by binding multiple images obtained from multiple and low resolution projectors. We have also implemented the educational contents on the proposed tile display system. However, the system does not consider an interaction method which enables an instructor to control educational contents in front of screen. Therefore, this paper suggests realistic educational platform based on the interaction and automatic calibration.

## 1 INTRODUCTION

The emergence of virtual reality technology and its great improvement have brought immersive educational platforms (Hereld, M. et al, 1999), (Yang, R. et al, 2001), (Chen, Y. et al, 2001), (Hereld, M. et al, 2000), (Krishnaprasad, N. K. et al, 2004). Previously, we have proposed a tiled display system which has high resolution screen (its resolution is 4096 x 1536 and its effective resolution is 3200x1200) (Kim, S. Y. et al, 2009). Moreover, we have applied a seamless technique to this system in order to remove joint lines and to improve the quality of images (Kim, S. Y. et al, 2009). Based on the previously developed system, we have implemented education contents for coaching users' study of a CMOS manufacturing process (Kim, S. Y. et al, 2009). However, there are some problems to be solved before accepting educational field. The most critical problem is that the investigation for interaction is not thoroughgoing enough. In the previously system, an instructor controls an authoring tool on a PC monitor with a mouse during a lecture. This interaction method makes the instructor uncomfortable because he/she generally gives a lecture in front of a screen not a PC monitor. Therefore, in this paper we propose interactive education platform where an instructor can move, rotate, and magnify the educational contents in front of a screen by pressing and dragging a screen as if he/she manipulates touch screen. For constructing this interaction system, we develop a hardware which is used for recognizing a constructor's motion and transferring it to a main PC. Furthermore, we also present an automatic calibration method for increasing the quality of educational contents.

## 2 TILED DISPLAY

### 2.1 Previously Proposed Tiled Display

We have already constructed a tiled display system which provides immersive sensation to users (Figure 1). The system was implemented with a single PC and 2000 ANSI DLP projectors whose resolution is 1024 x 768. Two graphic cards were included in the single PC and each graphic card has two graphic output ports. Each graphic output port has a Graphics eXpansion Module (GXM) which can connect two visual displays. Therefore, our system generates high resolution image by connecting eight projection areas with a single PC.



Figure 1: Previously proposed system.

The graphic simulations were carried out by a program written in Visual C++ with direct X. Eight projectors were used for creating huge and high resolution images. To look out for the case where projectors are moved or rotated by a small amount of disturbance (for example, certain vibration, small impact, and/or etc.), we purposely overlapped the portions which the projectors undertook. However, this installation causes an image to distort. For compensating this distortion, we have conducted geometric calibration.

In the previously proposed tiled display system, we have implemented a virtual silicon island (VSI) where users can learn semiconductor manufacturing processes. Users arrived at the VSI and walked in one of the buildings where they can study the semiconductor manufacturing process. We have also developed a VSI authoring tool in order to easily create, edit, and play semiconductor contents. A user

can insert or delete the semiconductor manufacturing components through the VSI authoring tool. For further information, refer to our previous research (Kim, S. Y. et al, 2009).

### 2.2 A Proposed Tiled Display System for Interaction

In the previously proposed system, a user can create, edit and play educational contents. However, for immersive education, students want to investigate a virtual object by magnifying and rotating the object. Because of the limited interaction in the previously developed system, instructors became inconvenience whenever the instructors wanted to rotate, move, and translate the educational contents. Therefore, we developed interaction hardware which recognizes and analyzes a user's motion and transfers it to virtual environment. We attached infrared LEDs to the interaction hardware and mounted a tracker on a PC. When a user grasps the interaction hardware and moves it for transferring his/her command to the PC, the tracker receives signal from the infrared LED and recognizes the user's motion. The signal for moving is transferred to the data receiving part in the PC and is interpreted by the command interpreter. After that, the rendered images are projected on the screen via GXM and projectors. Therefore, the user can experience the virtual images as the virtual images exist in real world. Moreover, a user can rotate a virtual image in our tiled display with the interaction hardware. Figures 2 (a) and 2(b) show the signal flow of previously proposed system and proposed system, respectively.
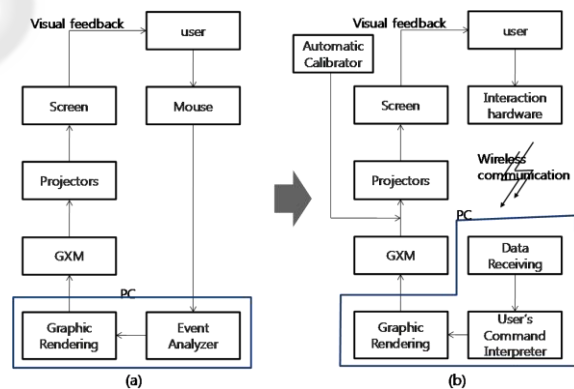


Figure 2: (a): Signal flow of previously proposed system (b): Signal flow of proposed system.

Figure 3 shows the rotated or magnified images. An authoring tool is displayed in the virtual environment. That is, the tool is shown on the screen not a PC monitor. The structure of the authoring tool

is almost same as that of the previously tool except for two parts (interaction and automatic calibration parts). Figure 3(g) shows the authoring tool having slide bars for interaction. There are three slide bars for rotations along the x-direction and the z-direction and for magnifying/minifying the image. If the first slide bar is moved to the right with the interaction hardware, the virtual image is rotated along the x-direction. When a user moves the second slide bar to the right, the image is rotated along the z-direction. The third slide bar is for magnifying/minifying the image. Figures 3(a) and 3(b) show an initial semiconductor image and the rotated image along the x-direction, respectively. Figures 3(c) and 3(d) illustrate the scaled images and Figures 3(e) and 3(f) are the rotated images along the z-direction. Even though the screen does not have any touch sensors, a user can control the authoring tool as the screen has touch sensor array.
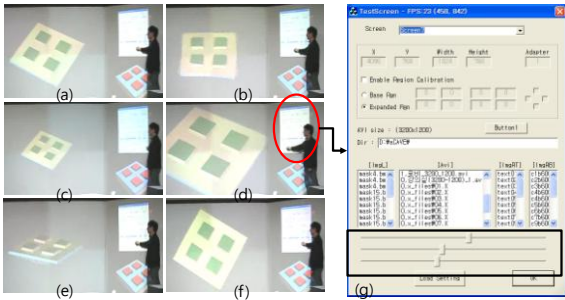


Figure 3: Proposed Interactive and Immersive Platform.

# 3 AUTO CALIBRATION SYSTEM

In the previously research (Kim, S. Y. et al, 2009), we have conducted geometric calibration in order to prevent the distortion of images. We divided original projection portions and the calibrated projection portions into triangles as shown in Figure 4 and then computed transformation matrix. This strategy for adjusting all nodes manually, however, brought a new issue for accurate calibration because a user has to spend a lot of time for calibration process. So, this paper suggests automatic calibration method by detecting projection images and addresses the developed image detector (we call it Wi-gray). Since the sensitivity of a general camera is different from that of a human eye, cameras can hardly tell the difference between the colors or intensities of two images, however human eyes can. Therefore, it is very hard to make each intensity of the projection regions same with a general camera. In order to adjust the intensities of projection regions, we

developed an image detector whose intensity is almost same as human eyes.

The objective of the calibration is to adjust a distorted image (Figure 6 (a)) to a rectangular image (Figure 6(b)). For calibrating each image automatically, we attached the image detectors to the screen and the projected binary code images where black and white patterns cross in x- and y-directions as shown in Figure 7. We narrowed the gap between patterns and accepted the signals from the detectors to understand the projection region and the position of the detectors. As such, we could obtain the relative position between the projection region and the detector by collecting the intensity about the binary coded images.
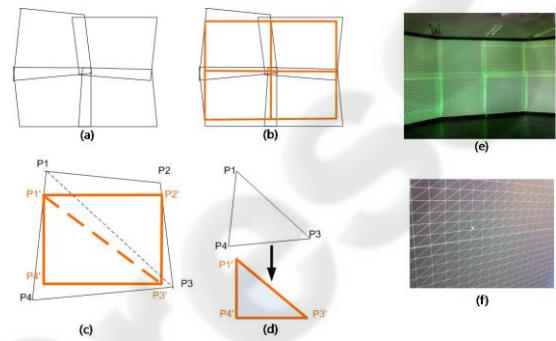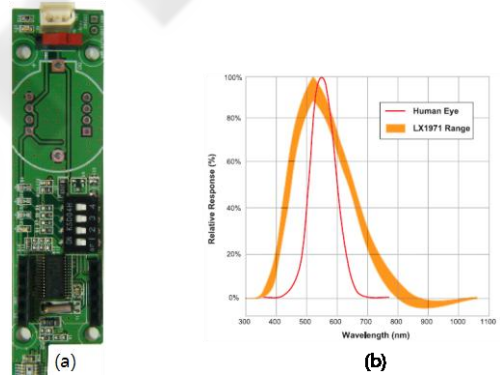


Figure 4: Geometric Calibration.



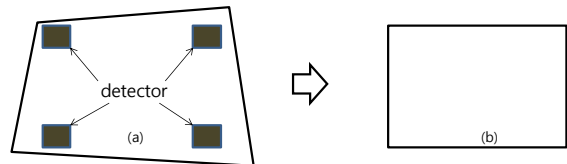Figure 5: (a) Image detector (b) the sensitivity curve of human eyes and the detector.



Figure 6: Calibration of a distorted image (a) to a rectangular image (b).
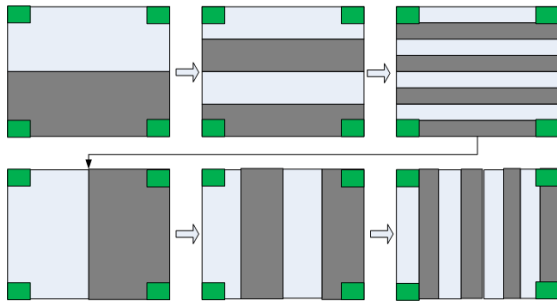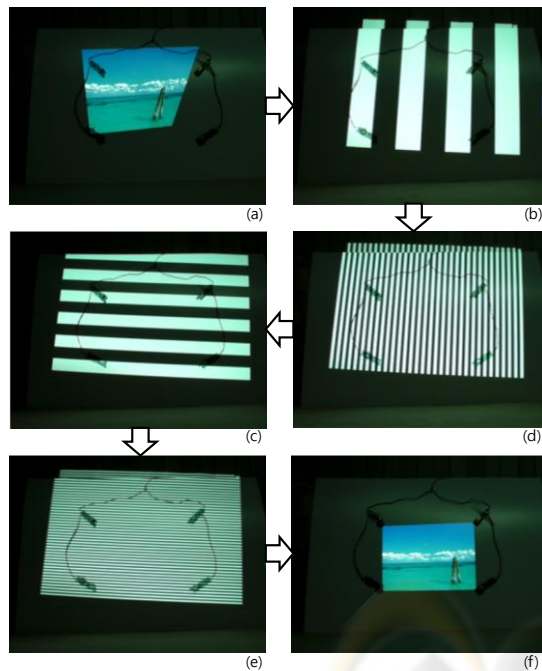
Figure 7: Calibration Process.



Figure 8: The images of before the calibration (a) and after the calibration (f).



Figure 9: Result after finishing calibration process.

Figure 8 shows the calibration process using the developed image detectors and the proposed method. Figure 8 (a) and Figure 8 (f) show the distorted image and the calibrated image, respectively and others show the calibration process. Figures 9 (a) and 9 (b) are the VSI image and semiconductor educational contents after finishing calibration process. From Figure 9, we found out that distortion in educational contents was removed.

## 4 CONCLUSIONS

In this work, we developed the wireless automatic calibration system and conducted automatic calibration process with the system by projecting gray coded images on the screen. We also presented interaction hardware system for effective lecture.

## ACKNOWLEDGEMENTS

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