A Low-cost Implementation of Lecture Distribution System Utilizing FPGA and Mobile Devices

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***Abstract*—In recent years, projector and the screen is being used by lecturers in the university. The large classrooms might prepare multiple projectors and screens to display the same image of the main screen. But it is high cost. This paper proposes a low-cost implementation of lecture distribution system for classroom. This system detects the laser pointer spot on the main screen and output the slide images with a pointer cursor along with the pointed spot in a mobile device's Web browser.**

Keywords*—*Lecture Destribution; Real time; Laser pointer; FPGA; Ajax

I. INTRODUCTION

In recent years, some lecture rooms are equipped with a projector and a screen to perform efficient presentation using slides or videos from their own lap-top computers. Also large classrooms might prepare multiple projectors and screens to display the same image of the main screen. In order to point out the focus of slide on the main screen, the lecturer may use a *laser* pointer. However, students who sit far from the main screen can't see the pointed laser points as it was not transmitted to the sub-screens.

In order to point out the laser spot through all of the equipped screens, a simple way is overlaying a pointer cursor on the slide image and deliver it to equipped sub-screens. To do this it needs to measure the coordinates of laser spot from slide image projected onto the main screen at *real-time*, namely all processes have to be completed within a video frame rate. In [1]-[3], pointer detection techniques using illuminance and hue of the laser spot are proposed. However Lapointe *et. al.* [1] couldn't guarantee that the detection is done in real-time because they have proposed a software implementation by a personal computer. Dung *et. al.* [2] have proposed a hardware architecture but they show only simulation results by OpenCV [4]. In contrast, in our previous work [3], we have proposed a hardware implementation of both the pointer detection and the pointer overlaying using an FPGA device. This system works completely at real-time under input video frame rate, 30 frame/sec.

On the other hand, there also exists large classroom that is *not* equipped with multiple screens are also exists. It is high cost to install additional projectors, screens, and video distributors in the classroom. Furthermore standard of video signal will be change such as from analogue VGA to digital HDMI, thus it requires replacement cost of out-of-date equipments.

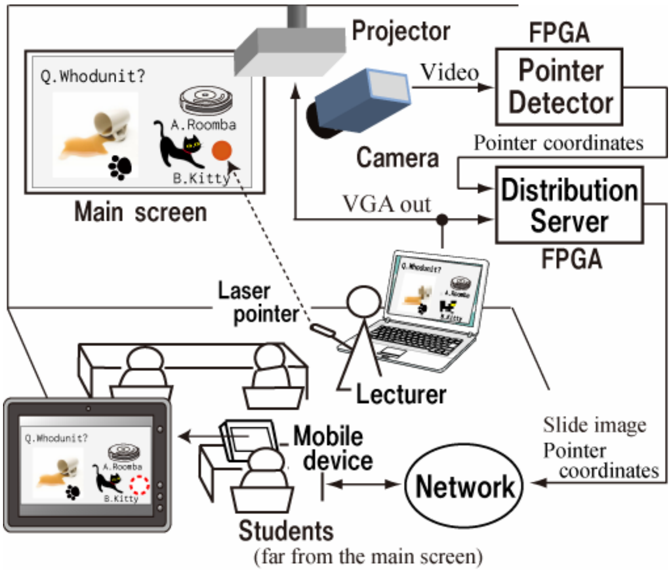

Fig. 1. System concept overview

This paper proposes a low-cost implementation of lecture distribution system for classroom. Proposed system utilizes mobile devices such as tablet PC and smart phone which students may be used widely, instead of additional equipments. The system delivers the pointer coordinates and the slide images to students' mobile devices via a network, and then they display the rendered image. Note that the system is not proposed for distance learning, but it is designed suitable only for a classroom, where the speech of lecture is directly transmitted via an acoustic system.

II. SYSTEM OVERVIEW

Figure 1 is an overview of our system application to a large classroom where a laser pointer, projector and silver screen are installed. The system is composed of two modules; a pointer detector and a distribution server. The pointer detector measures two-dimensional coordinates of the laser spot which the lecturer points out on the main screen (hereinafter referred to as Point of Interest, POI) [3]. The distribution server provides a web service which delivers *independently* the POI coordinates and slide images captured from lecture's laptop to students mobile devices via a network.

The mobile devices overlay a pointer cursor on the slide image using the received coordinates and render main screen image.

The detector is implemented as a hardware using an FPGA board, Atmark-techno SUZAKU SZ410 with A/V extension, based on real-time pointer detection. This board is equipped with Xilinx Virtex-4 fx device and the system clock is 100MHz. The POI detection consists of two steps [3]; a color binarization and a POI coordinate decision. The first step is a preprocessing to distinguish laser color with single-wavelength. It uses a devider-free color binarization technique based a HSV color transform [4] and a decision table. The second step determines the center coordinates of POI by the intersection of peaks of two one-dimensional histograms. The determined coordinates are transmitted into the distribution server via UART. The POI detector proposed in [3] completely works under ITU-656 standard (interlaced, 30frame/sec, and valid pixels 720 × 485).

III. DISTRIBUTION

The distribution server connected to the wireless router with Ethernet. The mobile devices connected to the wireless router. We propose a static image based system which transmitted slide image and POI coordinates as broad bandwidth is needed to transmit every image per frame. And the slide image is expected to be unchanged in each frame generally. We transmit the slide image only when occur scene change. In contrast, POI coordinates must be transmitted to every detection. By doing so, we can cut the required bandwidth by transmitting the only POI coordinates each frame.

We implement the distribution in a simple method, by a web service. A μCLinux OS is installed in the FPGA board and it's able to work *thttpd* as the web service. So we use the FPGA as the distribution server for simplicity. We use JavaScript to display the slide image on the mobile device. We use HTML5 Canvas to overlay a pointer cursor on the slide image on the mobile device. The distribution process is the following: first, the server generates two files, a binary image one and a text one. The image file is a slide image of bitmap format and is captured at a given time period. The text file contains the detected POI coordinates and the file name of corresponding slide image. It is updated when new coordinates are detected. Finally, the mobile devices poll the distribution sever to get the text file. They overlay a pointer cursor on the corresponding slide image. If the image name described in the text file is new, then they request the file from the server and update the slide. It is necessary for the Web browser to display without reloading of entire web contents. We use Ajax technique to realize asynchronous communication to the server and to overlay a pointer cursor on the slide image at the client. Ajax is a method that dynamically rewrites a part of a web page using the asynchronous communication.

IV. EXPERIMENTAL RESULTS

We experimented whether to operate in real time. The FPGA was connected to the wireless router with Ethernet cable. The mobile devices are connected to the FPGA by using Wi-Fi. We use two mobile devices which Windows tablet and Android tablet. As the Web browser we use Google Chrome. The slide image displayed on the mobile devices is the captured image from the camera. Fig.2 shows an image of experiment result. The slide image and the pointer cursor are displayed on a Web browser. We compared the coordinates received by communication of HTTP with detected coordinates by the FPGA. As a result, the coordinates received by communication of HTTP has occurred 2 – 5 frame latency. It can be considered various factors such as the wireless router' transfer speed and FPGA server performance. We need to design and external server.

V. CONCLUSIONS

This paper proposed and implemented a system which camera and FPGA are used to detect pointer cursor pointed by a lecturer, proposed system delivers the POI coordinates and slide images independently to students' mobile devices. The purpose was a low-cost implementation of lecture distribution system for large classroom. This system was which detects the laser pointer spot by using HSV color space, then, which asynchronously overwrites a pointer cursor on the uploaded lecture's slide image in a Web browser using Ajax. As a result from the experiment, there are some issues such as latency. It is necessary to evaluate the environment of multiple mobile devices connection.

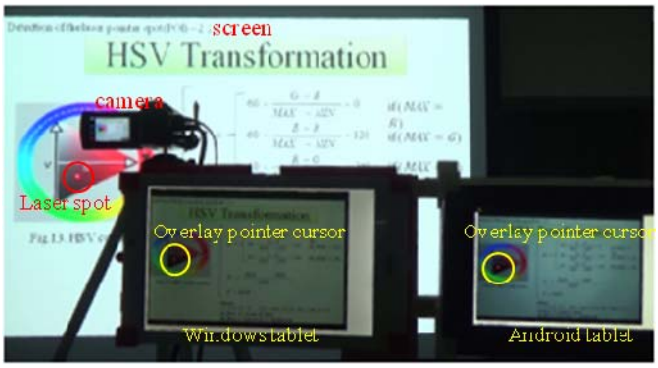

Fig.2. Experiment result

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