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Design and Implementation of the 3D Real-Time Monitoring Video System for the Smart Phone

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ABSTRACT

Recently thin computing clients such as smart phones have experienced fast growth in display resolutions and graphics processing power. In this paper, we show how to design and implement the real-time 3D stereoscopic HMD, based on high resolution smart phones, which can be applicable to the remote monitoring such as sightseeing and surveillances. Our HMD prototype is unique in that system is based on real-time, allowing it to be wireless, and convenient to use.

Keywords: *Android, Graphics, HMD, Monitoring, Smart Phone, Stereoscopic*

I. INTRODUCTION

In recent years, many smart phone add-ons have been introduced to enable 3D image display in accordance with the rapid development of smartphone penetration of virtual reality technology. This paper suggest how to design and implement for the case of creating and viewing stereo images from the HMD environment using a smart phone that maximize realism without distortion between the camera and the subject by controlling the movement of the camera and adjusting the depth of distance as the subject changes.

Ivan Sutherland [1] presented a virtual 3D world to users using a vector cathode ray tube (CRT) head mounted display with a set of either mechanical or ultrasonic sensors. A general purpose computer processed the tracking data, while a special purpose graphics processor made the scenic data. Since that time, the graphics processing power has grown rapidly. With the 3D game engines popularities, graphic chipsets are now in smart phones and other thin clients, like tablets.

A head-mounted display (HMD) is a display device, worn on the head or as part of a helmet, that has a small display optic in front of one eye, known as monocular HMD, or each eye, known as binocular HMD. Head-Mounted Displays are considered as personal information-viewing devices that can provide information [2]. However, these devices have not become popular due to the limitations of graphics chipset. These HMDs were typically manufactured in low volumes, and were very expensive. Though virtual reality displays for gaming, such as the Nintendo Virtual Boy, it was commercially unsuccessful. A variety of relatively low cost HMDs have been available in low cost such as Sony Glasstron and Virtual I/O iGlasses.

This paper is organized as follows: Section II gives the previous works of related works including HMDs. Section III proposes our system that enables 3D real-time stereoscopic view. Section IV proposes extensive simulation results. Finally, Section V summarizes and concludes this paper.

IV. RELATED WORKS

The mobile HMDs usually carry a common smart phone as a whole for display and processing of data. They provide a simple casing, which keeps the phone at a specified distance from the lenses. The Google Cardboard6 provide basic interaction equipped with a magnet on the left side of the cardboard. The sensors of the phone detect the magnet motion.

The 3deeShell and 3deeSlide [3] are for the Apple iPhone that create 3D images from interleaved stereo pairs. However, these devices does not provide a wide field of view experience. The My3D clip-on for the iPhone is a two eye-piece device that allows stereo display of image pairs [4] similar to the classic View-Master 3D viewer.

Oculus Rift a virtual reality headset making company has launched a developer kit [5] which is a Virtual Reality (VR) headset which uses proprietary design consists of Organic LED display, head movement tracker and lens holding assembly. Samsung with Oculus provides GearVR7, which has an additional touchpad on the side of the case. Another ergonomic smart phone holder is the Zeiss VR One8 which supports Apple Phones as well as Samsung Phones. Phone specific slide-ins are used to place the mobile devices inside the casing. Zeiss recently also provided a version following the approach chosen by Google VR One GX, which is fully compatible with Cardboard, also features a magnet and has no back strap.

V. OUR PROPOSED SYSTEM

In this section, we describe our system. We explain how our software and hardware are implemented.

3.1. System Organization

Our system consists of three parts: viewing part, pan & tilt part and processing part. Our overall system model and deployment diagram can be drawn as in Fig. 1 and Fig. 2.

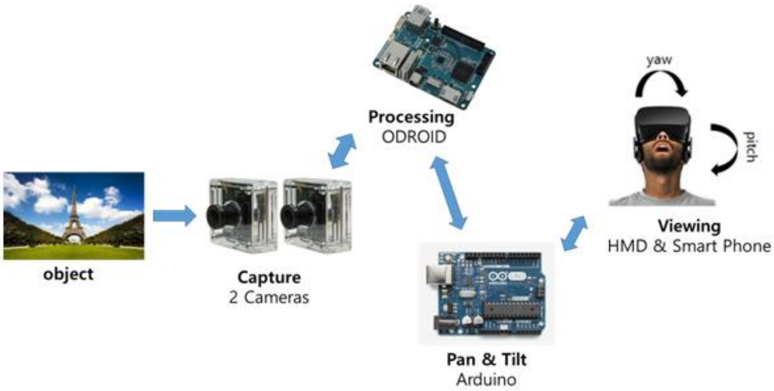

Figure1. Overview of Our Model

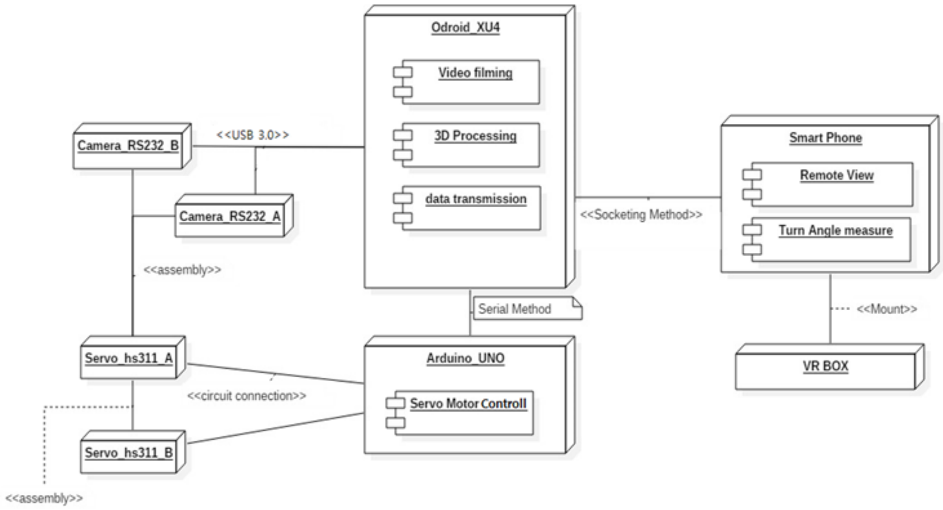

Figure2. System Organization Diagram

Class diagram for the *Processing part* is shown in Fig. 3. Classes in this part are organized as Connection Manager, Task Manager, ThreadPool, Arduino Manager, Android Manager and Image Manager.

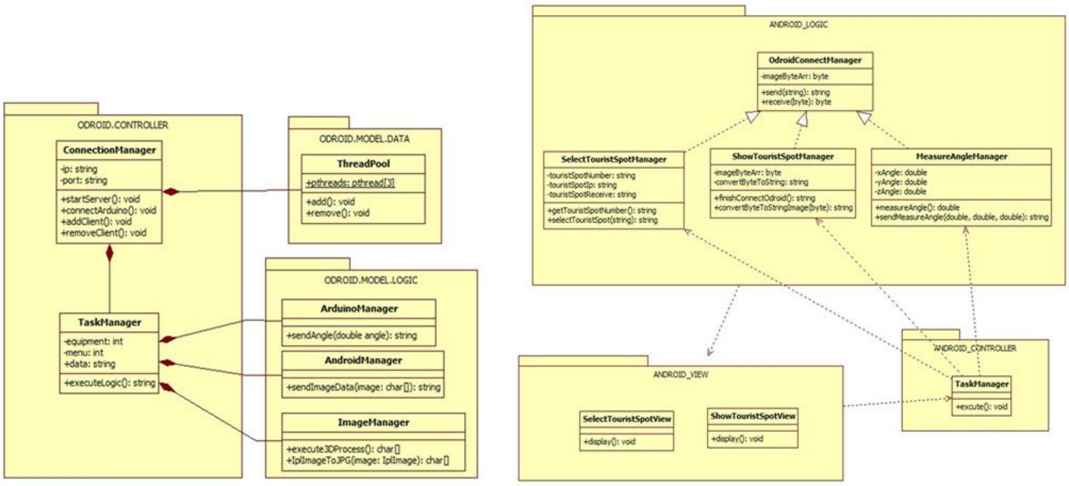

Figure1. UML Diagram of ODROID

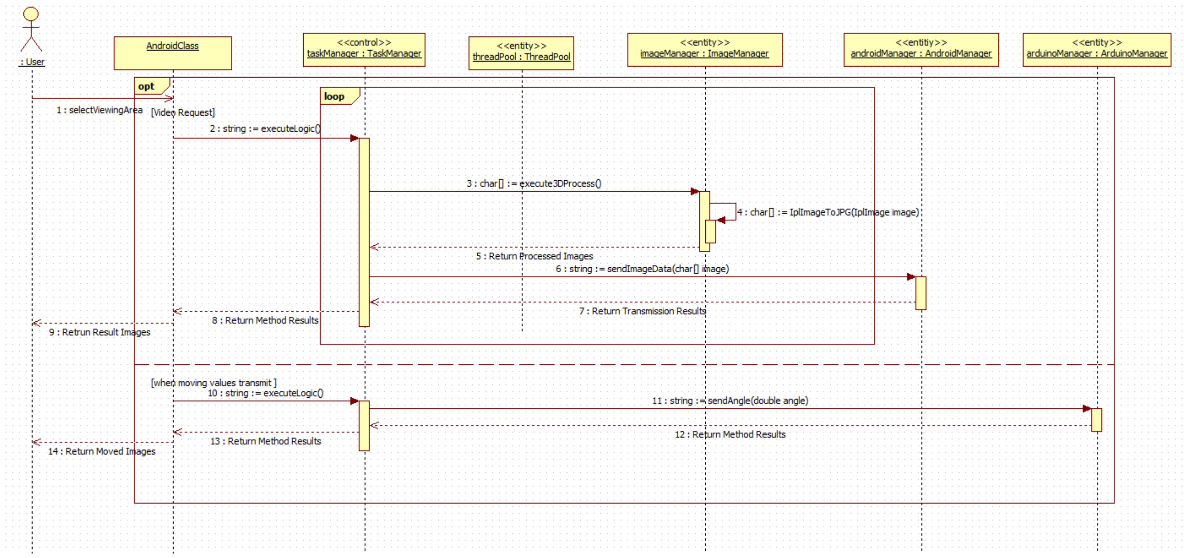

Figure 4. Sequence Diagram of ODROID

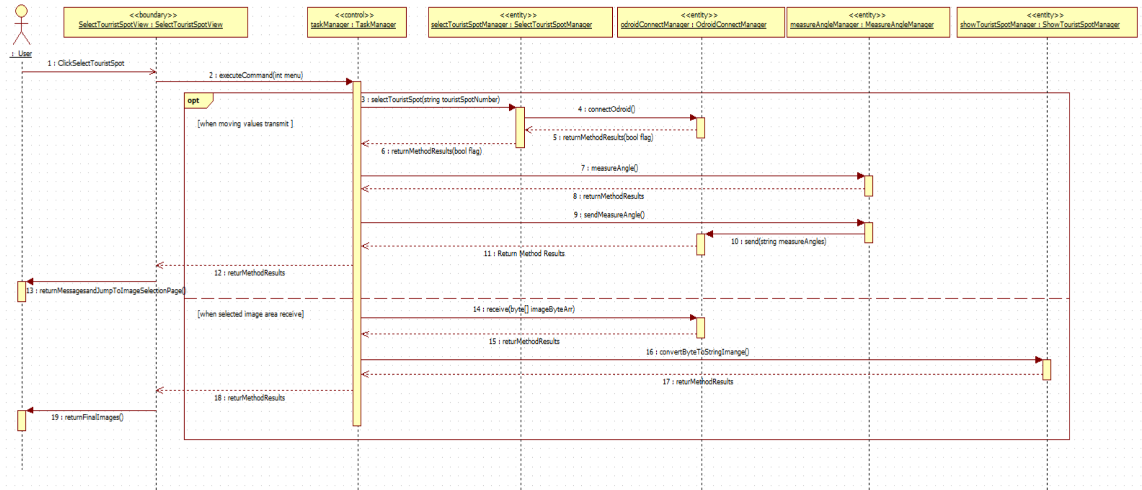

Figure 5. Sequence Diagram of Android Device

3.1. Viewing Part

Viewing part is composed of HMD and smart phones. Combined with smart phone, HMD performs two functions. First, it measures the angle by using the acceleration sensor and a geomagnetic sensor embedded in the smart phone as the user moves freely. We used smart phone running Android. In this Android environment, it is easy to get an acceleration sensor and a geomagnetic sensor values.

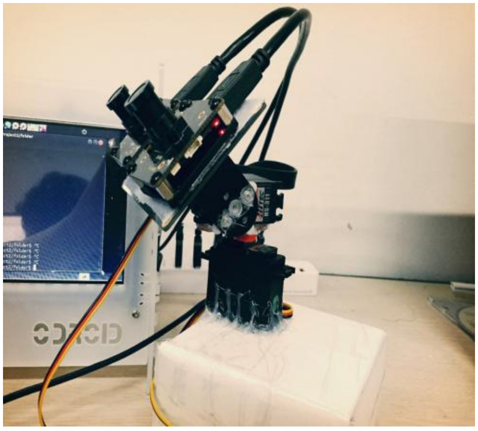

Figure 6. Viewing Part

After measuring the acceleration of gravity of smart phone, the acceleration value of vertical axis of smart phone should be between -9.8m / s² ~ 9.8m / s². Then the upper and lower angle of the user point is calculated. To obtain the right and left angle of the viewing point of user, the acceleration sensor value and the geomagnetic sensor value applied to the horizontal axis of smart phone are used.

The Rotation Matrix can be obtained by calling *getRotationMatrix* method with two values as input parameters in Android smart phone. Left and right angle values can be calculated after converting the *azimuth*(axis:Z) value in the Rotation Matrix into degree. Then Kalman filtering [2] scheme is applied to these values for stability, thus reducing the external noise and interferences.

These processes are performed periodically and the results for the direction of the user are fed to the small dedicated computer, ODROID. Then this small computer sends these results to the Processing Part.

Second, the output is displayed to the user by receiving completed captured images and processing images from the Processing Part. Then left and right images are feed to the smart phone, which can be viewed as a single image through the HMD.

3.2. Pan and Tilt Part

Pan and Tilt Part is composed of two servo motors and Arduino board for motor control. Arduino board controls the pan and tilt of two cameras, which is connected to servo motors for pan and tilt. Arduino board gets real-time transmission of position values measured and processed images from Viewing Part via serial communication. Pan and Tilt are adjusted constantly by controlling the two servo motors with two cameras as the viewer changes user's view point. In front of the pan-tilt part, two cameras are mounted so that the viewer's view point is adjusted to the camera's view point.

3.3. Processing Part

Processing Part is composed of a small dedicated computer and two USB cameras. Main function of this part is to perform remote image capture and processing for the 3D image generation. Serial communication is used for the Pan and Tilt Part, whereas wireless communication for the Viewing Part.

ODROID-XU4, a small dedicated computer, which is used for the remote image processing and eMMC is employed for fast read and write storage devices. Two Ocam boards with USB 3.0 are used for each camera module. Two USB cameras are attached to the front of the case and the pan-tilt camera with 65 mm binocular [3] is placed. To improve the quality of images, fish-eye rendering and contrast correction process are performed on the two images captured. Then these images, which are in BMP format, are converted to JPEG format to improve the transmission rate [6]. The processed images is transferred to the smart phone and visible through the HMD. The images through the convex lenses of HMD are 3D stereoscopic, though the distance between the HMD and eyes are too close. In addition these stereoscopic images are real-time, giving vivid images of target fields.

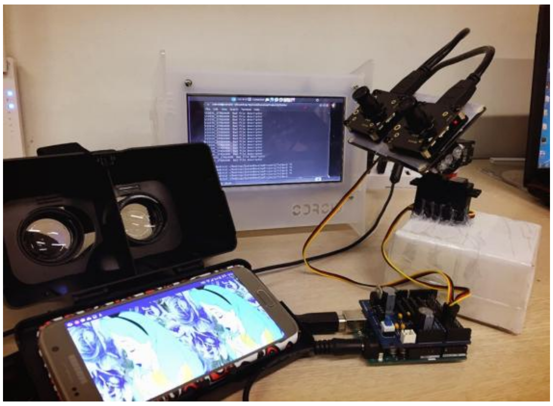

Figure7. Overview of Our System

IV. EXPERIMENT AND PERFORMANCE

We designed and tested the prototype of our system. As users wearing HMD move around, pan and tilt mechanism respond within 0.5 second in average. And after a series of images capture from remote field, it took about 1 second for the JPEG compression, fish-eye rendering for the stereoscopic images, and image merge, then these results are delivered to the user's HMD in 0.5 sec. In addition these images provide spectacular 3D stereoscopic effect with 6.5mm gap capturing module, fish-eye rendering and shading compensation processing. These techniques can be applied to the real-time landscape capture in the various areas.

Usually, the contents offered by HMD service provider may be pre-processed 3D stereoscopic images, which is not real-time or not so realistic. With our proposed system, service provider can produce any number of real-time 3D stereoscopic images as needed. For example, landmark travel or undersea experiences can be provided at a low cost. And there will also be applications that can be combined with the environment that is difficult to approach such as war fields, radioactive areas, undersea exploration drones, remote robotics, and unmanned submersibles, where the user can freely control the viewing area.

Compared with current commercial products manufactured by LG and Samsung which use fish-eye camera, our proposed system does not use fish-eye lenses, thus our system is low in distortion, and can be manufactured at low cost and provide realistic viewing through the stereo camera by the three-dimensional processing. In addition, compared with the conventional 360 ° picture contents using more than 16 cameras, our scheme uses only two cameras, thus it is very excellent in terms of cost.

V. CONCLUSIONS

We designed and implemented real-time 3D stereoscopic video system that can be applied to sightseeing and surveillances purposes. Our system is composed of viewing part, pan & tilt part and processing part. We measure the acceleration sensor and a geomagnetic sensor value to adjust the movement of the pan-tilt camera in real time. Then we capture the phenomenal scene, process the images using two cameras. These images are rendered in 3D stereoscopic format, which is displayed in user's HMD. Response time of our system is less than one sec in average, which is desirable for the commercial applications.

First of all, our future plan is to reduce the response time for more realistic environment. We want to design the system without small computer (ODROID) for more low-cost system. In this case, image processing can be done in the smart phone.

ACKNOWLEDGEMENTS

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