Affordable System for Measuring Motion-to-Photon Latency of Virtual Reality in Mobile Devices

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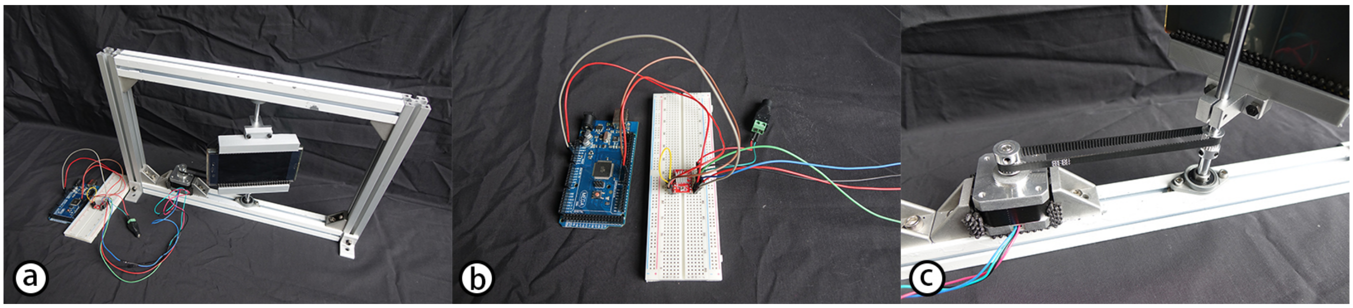

Figure 1: (a) System overview (b) Driver board and stepper motor driver carrier (c) Transmission system with stepper motor

ABSTRACT

Recently, virtual reality on the mobile phone is getting more and more popular. In virtual reality, motion-to-photon latency is a very important element which causes simulator sickness. In this paper, we construct a low-cost system with high accuracy which can precisely measure the latency of virtual reality (VR) in the mobile device. There is no convenient way to measure the latency on mobile devices these years. So we provide a simple method to calculate the latency.

CCS CONCEPTS

• **Hardware** → **Emerging tools and methodologies**; • **Computing methodologies** → *Virtual reality*;

KEYWORDS

Virtual Reality, Latency, Mobile Device, Dizziness

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INTRODUCTION

These years, due to the fast improvement in mobile devices, and new techniques are developed for accelerating the process of computation in virtual reality. There are more and more virtual reality applications which can be run on mobile devices, and the introduction of Google Cardboard in 2014 makes virtual reality for mobile devices suddenly well known to the world.

However, the performance of mobile devices still falls behind the high-level devices which can connect to desktop computers as servers, such as in HTC Vive or Oculus Rift2. When using the VR application in mobile devices, we will observe the apparent motion-to-photon latency during the motions of objects on the screen. And having apparent latency while using the VR application with mobile devices for a long time will sometimes make users feel dizzy and uncomfortable or even disgusting.

Because of this human physiological limitation, researches on latency and dizziness is an important topic for virtual reality[Buker et al. 2012]. But we do not find a state-of-the-art method or system for measuring latency in the mobile devices with a convenient and simple way. We, therefore, propose our low-cost and easy to operate the system with high accuracy in measuring motion-to-photon latency.

EXPERIMENT AND RESULT

Table 1: Mobile device latency.

Device	Application	
	PsViewer	GoogleStreetView
Google Pixel	60.4	50
iPhone 6s	58.3	58.3
Redmi Pro	58.3	58.3
Sony XZ	100	97.9
Huawei Mate 8	83.33	68.75 (ms)

To simulate head movement, we decide to use an electric motor to control our system. There are many kinds of motor, and we select stepper motor for our best choice. The main advantages of the stepper motor are that it can be controlled easily by using driver

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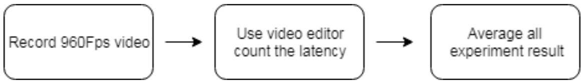

Figure 2: System Experiment Flow

board and stepper motor driver carrier, and we can simply set the rotation angle and speed for simulating the rotation of human head movement when using the VR application with mobile devices.

In our experiment, two mobile applications, PsViewer and Google Street View, are used on the test smartphones. Then put the test phone in our system as Figure 1(a). We use the high-speed camera (Sony RX10 II) to record (with 960 fps) the process of rotation controlled by our structure.

After recording for 2 seconds with 960 fps, we output a 32-second video with 60 fps to video editor (Adobe Premiere). Because the minimum unit of the video is a frame, we manually check the different position of mobile device frame by frame. The motion-to-photon latency time starts at the frame which mobile device begins to rotate from one side to the other side and end at the frame which the scene on the mobile device also begin to move onto the opposite side. Due to the apparent difference between each two frames, we can figure out which frame we want. Also, the error of the latency could be minimized to $1 \sim 2$ frames that equal to $1 \sim 2$ ms (1/960 second per frame), which is an acceptable error for mobile devices.

We count the motion-to-photon latency manually. In order to reduce the human disturbance, we use the following method. There are 4 cycles of rotation in the video, we can get the average latency from counting each cycle. Then we ask 5 people to do the method above. Our final latency value is the average result of these people.

As the data are shown in table 1, those are the latency performance on each application. The worst one has about 100 ms delay. It is not enough for VR application because people feel much dizzier than a normal application. So there is still a long way to go. We would like to measure the Google Day Dream Project certified phones and try to calculate the motion-to-photon latency automatically in the near future.

CONCLUSION

The main contribution of this paper is that we provide a low-cost (about 100 US dollar) and convenient system that can be easily implemented, as compared to the use of robotic arms or the method in this paper[Lincoln et al. 2016]. Although their accuracy can reach to microsecond level, their measuring system is a very special institutional design. Since VR for the mobile device is not able to reach such low latency, so our measuring accuracy is acceptable for now. Our advantage lies in the simple and easy implementation of the system so that people who want to do the relevant research is easy to calculate the latency.

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