Dissecting the End-to-end Latency of Interactive Mobile Video Applications

Teemu Kämäräinen, Matti Siekkinen, Antti Ylä-Jääski
Department of Computer Science
Aalto University, Finland
firstname.lastname@aalto.fi

Wenxiao Zhang, Pan Hui
Systems and Media Lab
The Hong Kong University of Science and Technology, Hong Kong
wzhangal@stu.ust.hk, panhui@cse.ust.hk

ABSTRACT
In this paper we measure the step-wise latency in the pipeline of three kinds of interactive mobile video applications that are rapidly gaining popularity, namely Remote Graphics Rendering (RGR), Mobile Augmented Reality (MAR), and Mobile Virtual Reality (MVR). We show through extensive measurements that control input and display buffering have a substantial effect on the overall delay. Our results shed light on the latency bottlenecks and the maturity of technology for seamless user experience with these applications.

1. MEASUREMENT SETUP
The measurement setup uses an Arduino compatible board (Teensy LC) connected to the phone through a USB connection. The board is configured to act as a joystick in addition to a serial connection through the USB. This enables us to enter key presses to the mobile device. To simulate touch presses, we use a coin attached to a relay which closes a connection loop to the human tester when activated. This in turn enables us to precisely measure the time when a touch is initiated on the display as the coin conveys the touch input when the relay is activated without user interaction. In addition two photodiodes catch the time when a frame has been updated on the display of the mobile device. The measurement board has also an Ethernet shield attached for Internet connectivity. For the virtual reality application experiments a reference gyro value is attached to compare the responsiveness of the gyro sensor inside the mobile phone.

2. RESULTS
The measurements show that the two major components affecting the overall delay in latency-critical mobile video applications are control delay and frame display. This can be observed in the summary presented in Figure 1. The magnitude of the control delay is highly dependent on the type of input used by the application. A modern mobile device can send gamepad commands to a remote server in a matter of milliseconds while an AR application can wait up to 90 ms to even get a frame from the camera for processing. Top-of-the-line mobile phone (Samsung S7) can process touch and Bluetooth events in roughly 20 to 30 ms while the gyro sensor events arrive faster with an average of 12 ms of delay. Touch screen delays seem to get lower with each mobile phone generation. The gyro sensor delay is also very small with recent mobile phones. The camera feed to the application would however benefit from further optimizations.

3. REFERENCES
[1] J. Deber, R. Jota, C. Forlines, and D. Wigdor. How much faster is fast enough?: User perception of latency & latency improvements in direct and indirect touch. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, pages 1827–1836. ACM, 2015.