Measurement of Input Latency in the Army's Dismounted Soldier Training System from Inertial Sensor Physical Stimulation to Display Visual Response

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***Abstract*—**

Objective

Development of a method for the effective measurement of total input latency in the Army's Dismounted Soldier Training System. In this context total input latency is defined as the time elapsed between the physical stimulation of an inertial sensor and the display of a corresponding change to the visual environment on the output display device.

Background

The Army's Dismounted Soldier Training System (DSTS) is a wearable simulation system that allows the wearer to become immersed in a virtual environment, and participate in a common training mission with other soldiers wearing the same device. The DSTS hardware consists of four main components: a backpack computer system; a head mounted display (HMD); an instrumented weapon; and an inertial sensor network to register the movements of the wearer in the virtual environment. Multiple studies have shown that a large transport delay or input latency in a simulation system could cause discomfort or motion sickness in the user. Further, characterization or measurement of this parameter is often difficult, technically challenging, and specific techniques are required for each particular system. As part of an investigation of reported sickness associated with the use of the Army's Dismounted Soldier Training System (DSTS), we were tasked with the development of a method for reliable measurement of input latency in the DSTS.

Methods

Our approach was to feed the signals from a) an optical interrupter sensor, that detects the yaw axis movement of the inertial sensor located on the helmet of the wearable system, past a boundary edge; and b) a photo-transistor that detects a corresponding change on the screen, into an oscilloscope that measures the time differential between the two signals. A physical implementation of this concept was designed and build, and after a lot of trial and error, we were able to measure the input latency. In addition, we designed and built another module to stimulate a regular pointer device, or mouse, using the same physical platform as for the inertial sensor. This allowed us to take input latency measurements of just the software part of the simulation system as it responded to regular input. Further this also allowed us to take measurements of other game engines that had not been instrumented to use the inertial sensors for input. These additional measurements, provided us with a baseline for better understanding and context of the ones of interest.

Results

In the end we were able to obtain measurements from various configurations of the DSTS system. The mean input latency for the default DSTS configuration, using VBS2 and the head inertial sensor was $145\,\mathrm{ms}$ with a standard deviation of $17.7\,\mathrm{ms}$ out of a sample of 50 measurements. For the case of VBS2 with mouse input the mean was $123\,\mathrm{ms}$ with a $\sigma = 11.4\,\mathrm{ms}$ out of a sample with 30 measurements. In the case of a different graphics engine, Unity3D, with mouse input, we measured $30\,\mathrm{ms}$, $\sigma = 6.1\,\mathrm{ms}$; $106\,\mathrm{ms}$, $\sigma = 10.0\,\mathrm{ms}$; and $115\,\mathrm{ms}$, $\sigma = 13.0\,\mathrm{ms}$ for the graphics settings of "Fastest", "Good", and "Fantastic", respectively.

Discussion

The goal of our research was to develop a method to obtain an input latency measurement from the DSTS, and to take some sample measurements under typical conditions. It was outside of the scope and funding of this research to a) provide a characterization of the DSTS under all conditions; or b) to provide any interpretation of the results in the context of an explanation or cause for the problem under investigation. We were able to develop and implement our measurement system as a system agnostic external tool that can be replicated for further research, and that is general enough to be used in environments other than DSTS. In addition, we were able to obtain baseline measurements without the use of the inertial sensors, and with a second graphics engine, to provide some context for the DSTS measurements. Even though we can not directly compare measurements produced by the two different graphics engines; we can compare the default case to the case where mouse input was used instead of inertial sensor, and from

the resulting data conclude that most of the latency occurs within the VBS2 engine itself, and not inside the hardware or software components of the sensor data processing.