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CDC Computerized Cognitive Testing Platform Design Team

Exploring Human Interface Devices

In our project, we will create a system using a power efficient embedded device such as a Raspberry Pi to test the cognitive abilities of non-human primates. These primates will respond to questions presented on a screen and select an answer using a joystick and button, receiving food from a dispenser if they select the right answer. While there are still many things which are not yet determined about our design, I can assume with some certainty that the device the primates will interact with will be some form of Human Interface Device. This ubiquitous standard is used for a variety of devices, from mice and keyboards to barcode scanners and MRIs [1]. This paper will explore how we could create a HID that fits the requirements of our design problem, the decisions that will have to be made regarding the parts used in the device, and the potential of integrating more complex APIs such as XInput into the project. Obviously, the suggestions outlined in this paper are not set in stone, as we need more details from Dr. James Weed, our project advisor at the CDC, before decisions can be finalized; however, exploring these topics will give us a technical background that will aid us immensely when we are making critical design decisions.

Choosing a Board

At the bare minimum, the device the primates will interact with must have three parts: a joystick to select the answer, a pushbutton to confirm the selection, and a controller board to interpret the inputs and send them to our embedded computer. A board such as the U-HID would be well suited for our needs in this situation [2]. This device has either eight or fifty (depending on the model) configurable inputs that can be used for buttons, keys, mice, and a variety of other digital and analog inputs, with on-board flash memory retaining the configuration settings following initial setup. Additionally, the device receives all the power it needs from its USB connection with our embedded system, not requiring its own internal power supply. For our needs, the \$39 Nano board with eight configurable inputs would most likely be sufficient. The company also offers the BlueHID, which is the same product but with Bluetooth connectivity instead of USB. Although the HID profile began as an offshoot of USB, it has been fully implemented into Bluetooth, creating a unified standard across wired and wireless devices [3]. While wireless connectivity could offer some

interesting possibilities, I ultimately believe that a USB connection is more practical for this project. A wireless connection is inherently less stable than a wired one, potentially becoming a source of great frustration to the end user. Also, the BlueHID relies on battery power for operation, unnecessarily complicating the device. The end user shouldn't have to worry about powering the Raspberry Pi and keeping the BlueHID charged. For these reasons, I believe that the U-HID Nano would be a good potential HID board for our device.

Joysticks: Analog vs Digital

We also must decide whether the joystick we use is analog or digital. A digital joystick is simply four switches arranged in the shape of a plus sign: two switches for the vertical, and two for the horizontal. Including diagonal where both a horizontal and vertical switch are closed at the same time, the digital joystick offers eight possible inputs. If fewer inputs are desired (e.g. removing the diagonals), a restrictor plate can be added to limit the motion of the stick. By contrast, an analog joystick uses two potentiometers to measure the stick's movement in both the X and Y directions, allowing for much greater control [4]. At this time, I believe that a digital joystick would be best suited for our design. Analog joysticks are vulnerable to calibration issues where the stick comes to rest off-center or the internal spring becomes loose and loses tension. Digital joysticks, by comparison, are much more equipped to survive the abuse of a primate. Right now, I believe that 8 directional inputs will be adequate for cognitive testing; however, we need to have additional conversations with Dr. Weed about what exactly those tests are before we can make a final decision. Either way, HID classes already exist for both analog and digital joysticks, so implementing either will not be an issue [5].

The Potential of Xinput

Xinput is an API splintered off from HID created by Microsoft for video game controllers [6]. It was specifically designed to easily integrate the Xbox 360 controller into Windows, but it can be adapted for a variety of devices. It supports both analog and digital joysticks, as well as digital pushbuttons and analog triggers. While all those features could be implemented in our own HID class, it offers three unique features that could have interesting applications in the cognitive tests: audio input, audio output, and haptic feedback. We could integrate vibration motors or a built-in speaker to provide feedback when a primate makes a choice, and their verbal response to stimuli could be recorded with an integrated microphone and included with the normal test results.

Obviously, this decision is ultimately up to Dr. Weed, but these are interesting possibilities that could make Xinput a viable option for the device.

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