Functional Specification

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Team Members:
Member 1: Angie Near **Email:** angienr872@purdue.edu
Member 2: Sam E. Conductor **Email:** samecond976@purdue.edu
Member 3: Saul Duringiron **Email:** saulder875@purdue.edu
Member 4: Ray D. O'Signal **Email:** raydsig274@purdue.edu

1.0 Functional Description

Hand for the Deaf shall accept input from a USB device or integrated SD card. Hardware or software buffering shall be implemented on the interfaces to ensure that no data is lost over the interfaces, and priority encoding will similarly be used to mitigate communication conflicts. Individual characters will then be determined and these characters will be looked up in a database of letters for the currently selected signed language. The robotic hand control commands and timing for the corresponding character will then be determined and executed in sequence. This will be repeated for all characters in the text sequence. The desired end result is successful one-way communication using signed language. A diagram outlining the functional operation of the Hand for the Deaf is depicted in appendix 1.

2.0 Theory of Operation

For individuals who suffer from severely damaged or functionally nonexistent hearing, verbal communication is intractable and ineffective. For these individuals, communication is facilitated through the use of a gestured-based signed language. One of the most widely known and popular signed languages is the American Sign Language (ASL), but hundreds of different signed languages exist across the world. In general, signed language is a mechanically and computationally difficult process, often utilizing full body gestures, facial expressions and emotions, nuanced contexts, and other variables. However, American sign language, as well as some of the other signed languages of the world, incorporate sign-language alphabets [1] which rely largely on gestures of the hand and forearm, and are thus a tenable place to begin work on computerized communication between the deaf and hearing impaired. Through computerized replication of these signed language gestures, one-way communication between verbal speakers and signed speakers is believed to be possible.

3.0 Expected Usage Case

Hand for the Deaf is a device that is targeted at being used by educators within schools for the deaf and hearing impaired. A single Hand for the Deaf should be capable of being set up in a classroom of students and used to communicate to them. The classroom setting could be either American or international in nature, and no assumptions should be made about the technical expertise of the operators.

4.0 Design Constraints

4.1 Computational Constraints

The primary computational functions being performed by the Hand for the Deaf are expected to be USB and SD card interfacing, LCD display interfacing, and servomotor control of the robotic hand. The processor should include integrated USB interface hardware as well as a dedicated SPI interface for SPI SD card control. Future iterations of the Hand for the Deaf may potentially include speech recognition; additional computing resources for sampling and the use of an FFT should be considered for this purpose.

From a memory perspective, the primary memory constraints for the Hand for the Deaf are anticipated to be servomotor commands to recreate the letters of the currently selected sign language and sufficiently large memory space to hold several minutes of buffered text input. According to internet research, the average professional typist can type at sustained rates as high as 80 words per minute, or 500 characters per minute [2]. Hand for the Deaf should be capable of holding one minute of typed input on the processor. Motor libraries for additional signed languages as well as additional typed language or files of typed language can be stored on an onboard SD card and loaded into the microcontroller on an as-needed basis.

4.2 Electronics Constraints

The major components anticipated for this project include a USB keyboard, SD card, motor controller hardware, a microcontroller, an LCD display, and a robotic hand. The anticipated interface requirements for the project include a dedicated USB interface for communication with the USB keyboard, a dedicated UART interface for communication with an SD card, a UART or SPI interface for communication with a servomotor controller for the robotic hand, and an interface for an LCD display that is not known at the time of this writing; possible candidates include USB, UART, SPI, or GPIO.

The Hand for the Deaf is expected to be lightweight and portable, but battery operation is not required to effectively satisfy the expected usage case. Power will thus be drawn from a wall outlet. Since the device is anticipated to be used in an international setting the device must be capable of conforming to the power grid standards of various international countries. For this reason, few assumptions will be made about external power and internal regulation circuitry will be used to protect circuit components and ensure proper operation.

4.3 Thermal/Power Constraints

As it is in a classroom setting the Hand for the Deaf should be designed to avoid excessive heat, with a maximum desired operating temperature of 113° F (45° C). Power is not a major consideration for the Hand for the Deaf, and while it should operate efficiently no special considerations are anticipated to be made for the power dissipation of the device.

4.4 Mechanical Constraints

The Hand for the Deaf is intended to be portable, and as such should be capable of being easily carried and lifted by an end user. A maximum target weight of 10 pounds is therefore desired to ensure ease of transportation; focus group studies could be used to assist in refining this and other portability targets. The base may need to be weighted to ensure operation of the robotic hand without the device falling over. The device should be relatively small and non-awkward to move or carry. For this reason, a maximum target device envelope, excluding the keyboard and possible external LCD display, of 8”x8”x12” is desired. The device should be somewhat durable and resistant to spills, and the device should be able to survive common classroom accidents, such as being knocked over.

4.5 Economic Constraints

Preliminary competitive analysis for the Hand for the Deaf revealed that most direct competitors to the Hand for the Deaf were research projects and not commercial in nature. With this in mind the device enjoys some freedom from immediate economic pressure placed on the device by competitors. With that in mind it is desirable for Schools for the Deaf to buy several Hands for the Deaf, so a certain affordability is desired. An initial cost target of $1000 USD is therefore proposed.

4.6 Other Constraints

The Hand for the Deaf will have to communicate at a realistic speed to achieve successful, practical communication with the deaf and hearing impaired community. As such, a target latency of 1-2 seconds per signed language character is desired.

As the Hand for the Deaf is intended to be used in a classroom setting, some users may be forced to observe it from considerable distances, possibly as much as 30 feet or more. To assist in successful sign language recognition at distances, it is suggested that the various fingers of the Hand for the Deaf be given different colors, to make finger movement and recognition more apparent from a distance.

5.0 Sources Cited:

[1] ASL University. *Fingerspelling & Numbers: Introduction.* Available: http://lifeprint.com/asl101/fingerspelling/fingerspelling.htm

[2] Wikipedia. *Words Per Minute*. Available: http://en.wikipedia.org/wiki/Words_per_minute.

Appendix 1: Functional Block Diagram