Initial Project Proposal

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1.0 Description of Problem:

For individuals with severe hearing loss or deafness, communication in the form of a gesture-based sign language is often required. There are a wide variety of signed languages, and specific knowledge about a signed language and its (possible) oral equivalent are required to effectively communicate with the hearing impaired or deaf person. Signed languages carry a substantial learning curve, and the learning effort must be taken on by every individual who wishes to communicate with the deaf community. A simpler, more effective method is desired.

2.0 Proposed Solution:

The team proposes a system for converting written or spoken language to a signed language. The system would consist of an interface which would collect written or spoken input. This input would then be processed by an embedded microcontroller and converted to a series of movement commands. These movement commands would then be relayed to a robotic hand, which would perform the mechanical signing to communicate with the deaf person. In this way, communication from spoken individuals to signed individuals would be possible (the reverse process, interpreting signs and converting to spoken/typed language, is a difficult signal processing task and is not considered here).

The hand would feature basic functionality, being able to understand hand-based signed gestures, including most basic sign-language alphabets. Hand for the Deaf would initially provide support for the basic American Sign Language alphabet, but software libraries could be developed for other international sign languages (such as Spanish, French, German, Chinese, and others), and support for these languages could easily be added in software. The hand would initially support typed or file-based input, but a voice recognition interface could be added to further expand the capabilities of the hand. A concept sketch of Hand for the Deaf is included in appendix 1.

3.0 ECE477 Course Requirements Satisfaction

3.1 Expected Microcontroller Responsibilities

ECE477 is an embedded systems course which requires the use of a student-programmed microcontroller. For the project proposed, a microcontroller will be used for the purposes of interfacing to various inputs, device priority, text input processing, motor command lookup, and

motor control. Future functionality may be included in the area of voice recognition and speech processing.

3.2 Expected Printed Circuit Board Responsibilities

ECE477 is an embedded systems course which requires the use of a student-designed and built printed circuit board (PCB). For the proposed project, the PCB is expected to incorporate a microcontroller, external memory, power supply and regulation circuitry, and motor control circuitry. Other functionality may be included as the ECE477 design semester progresses.

4.0 Market Analysis:

According to research from the Gallaudet Research Institute, an estimated 9 to 22 out of every 1000 people in the United States have a severe hearing impairment or are deaf [1]. Worldwide, an estimated 360 million people have disabling hearing loss according to the WHO [2]. A potential usage case for the device would be for a school for the deaf to have a few of these devices on hand for use; a brief internet search of deaf schools revealed 215 unique institutions with contact information [3], although many more are thought to exist.

5.0 Competitive Analysis:

5.1 Preliminary Patent Analysis:

Advantageous to the project proposed, there appears to be some existing prior art in the field to help protect the project against patent infringement claims. This prior art is described in further detail in sections 5.2 and 5.3. There is, however, some relevant intellectual property in the field, and this is described in the subsections below.

5.1.1 US Patent Application US20130204435 A1:

Patent Title: "Wearable robot and teaching method of motion using the same"
Patent Holder: Samsung Electronics Co., Ltd.
Patent Filing Date: February 4th, 2013

This patent [4], assigned to Samsung, pertains to a pair of wearable gloves with haptic or electromechanical feedback to the user. In this way, the user is able to more effectively learn sign language to then communicate with individuals experiencing hearing impairments. The advantages to this approach are that users can learn sign languages and once learned, communicate naturally with hearing impaired individuals. The disadvantages to this approach (relative to the proposed project) are that the sign language education still takes place one user at a time and the user must still devote time to the sign language learning curve to communicate with individuals with severe hearing disabilities.

5.1.2 US Patent Application US20130115578 A1

Patent Title: "Sign language action generating device and communication robot"
Patent Holder: Honda Motor Co., Ltd.
Patent Filing Date: November 5th, 2012

This patent [5], assigned to Honda, involves the use of a humanoid robot, such as Honda's Asimo robot system, to communicate full-body sign language gestures in much the manner desired by the ECE477 project proposed. The patent claim requires a complete robot, though, and as such the use of a robotic hand does not infringe upon the patent claims. The advantages to this method of sign language communication are the ability to convey complete sign language gestures beyond simple alphabets. The primary disadvantage of this solution to the problem is that it is highly cost prohibitive; a small mechanical hand will always have a significant cost advantage over a full-sized android robot. The leasing costs for Honda's current generation of Asimo robots are estimated to be approximately $150,000/month [6].

5.1.3 US Patent Application US8411824 B2:
Patent Title: "Methods and systems for a sign language graphical interpreter"
Patent Holder: Verizon Data Services LLC
Patent Filing Date: May 14th, 2010

This patent [7], assigned to Verizon, describes a virtual sign language communication system in which spoken languages are input in the form of text or speech. The system then queries a database, seeking animation information for the equivalent phrases in a sign language. In this way, communication is achieved between speakers of spoken languages and signed ones. Based on the claim language, there may be some potential for patent infringement here; a patent lawyer should be consulted for further legal analysis.

5.2 Commercial Product Analysis:

Thorough targeted web searches were conducted on Google as well as major online commercial marketplaces (Amazon, eBay, Google Shopping). Although search efforts revealed research and academic projects (to be discussed in 5.3), no commercial products similar to the described project available for sale could be found. Other commercially available solutions to sign language communication involved the use of video animations. The advantage of these systems is that they're software based and don't require any moving parts. The disadvantage of these systems is that they seemingly lack the depth and realism that a robotic hand is able to provide.

5.3 Open Source Project Analysis:

A number of research, academic, and hobbyist projects exist that are highly similar to the desired project. Three such projects are described below.

5.3.1 Using Robotics to Teach Irish Sign Language

A pair of high school students submitted a robotic sign language hand to the 2011 Google Science Fair [7]. The project utilized Lego Mindstorms and underwent field trials at a school for the hearing impaired, where it received positive responses from participants, as well as providing the creators a spot on national television. The functionality initially demonstrated in this project could be further developed. Particularly, creating a professional version of the project which does not use lego blocks would help improve the realism and motor control of the finished

project/product. The design could be further expanded upon to support voice recognition and a variety of different types of sign languages.

5.3.2 Sign Language; Hand Spelling Robot:

A simple sign language robotic hand project was submitted to the 2003 California State Fair, where it won first prize [8]. The hand featured the use of servo motors and text was entered in the form of an alphanumeric keypad; control was handled through the use of a BASIC Stamp microcontroller. The project was excellent and the earliest known prior art on the subject at the time of this writing. The project was somewhat large and bulky, and a contemporary refresh of the design could provide significant performance improvements. Further refinements could be made by accepting keyboard input over a standardized interface, such as USB or Bluetooth, accepting file input, and other innovations.

5.3.3 Sign Language Ring

Days after the Hand for the Deaf project was proposed, a Sign Language Ring project was publicized and described in the 2014 Red Dot Design Contest [9]. The ring is an extremely clever design which utilizes accelerometer data from a series of rings to communicate with a bracelet, as well as voice recognition and a speaker to allow two-way communication between signed and verbal speakers. Unfortunately, the project could only be found as a rendered design, and no technical details are provided. It is highly unclear when, or if, the design challenges related to the system can be practically overcome and a commercial product produced.

6.0 Sources Cited:

[1] Mitchell, Ross E. Gallaudet Research Institute (2005). *How many deaf people are there in the United States?* Available: http://research.gallaudet.edu/Demographics/deaf-US.php

[2] World Health Organization (2013). *Fact Sheet N300: Deafness and Hearing Loss.* Available: http://www.who.int/mediacentre/factsheets/fs300/en/

[3] DeafConnect (2011). *World Deaf Directory – Deaf Schools.* Available: http://www.deafconnect.com/deaf/school.html

[4] Moon, Kyung Won et. Al (2012). *Wearable robot and teaching method of motion using the same.* Available: https://www.google.com/patents/US20130204435

[5] A. Shiina, Y. Nagashima (2012). *Sign language action generating device and communication robot.* Available: https://www.google.com/patents/US20130115578

[6] Hesseldahl, Arik. Forbes (2002). *Say Hello to Asimo.* Available: http://www.forbes.com/2002/02/21/0221tentech.html

[7] C. Foy, M. Mulqueen (2011). *Using Robotics to Teach Irish Sign Language.* Available: https://sites.google.com/a/cco.ie/gsf/

[8] Miura, Shingo (2003). *Sign Language Hand Spelling Robot.* Available: http://classic.parallax.com/tabid/549/Default.aspx

[9] Zu-Wei, Cao et. Al (2013). *Sign Language Ring.* Available: http://www.red-dot.sg/en/online-exhibition/concept/?code=1033&y=2013&c=16&a=0

A1. Hand for the Deaf Concept Overview

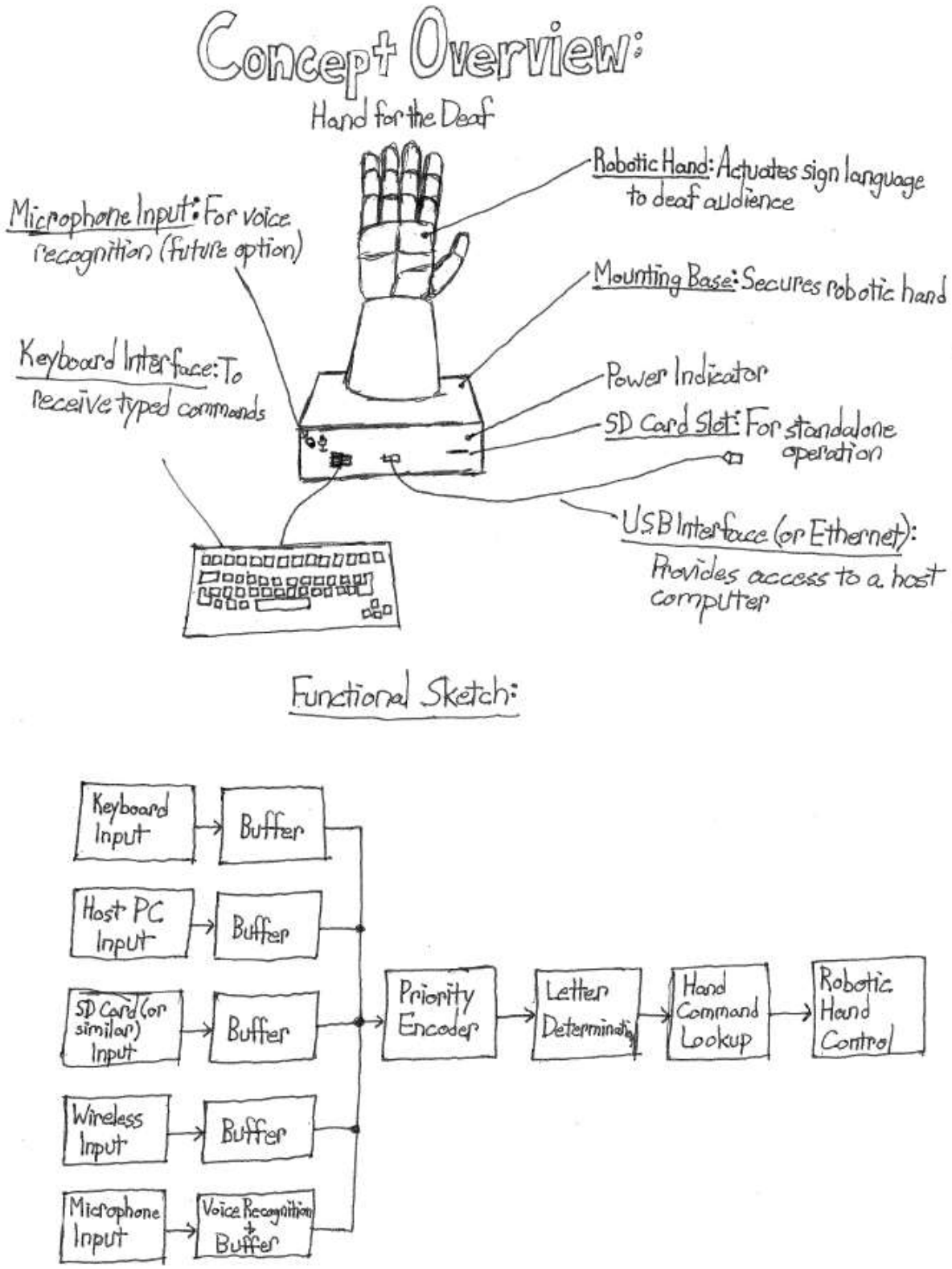

Fig. 1. Hand for the Deaf Concept Overview Sketch