Tactile Communicator for Use by The Deafblind

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***Abstract*— When people are deaf and blind, daily life is made difficult owing to the lack of linguistic communication that is normally mediated by sight and hearing. The project described herein aims at helping deafblind individual overcome this communication barrier. We describe a tactile communication apparatus that is capable of rich and efficient reproduction of the tactile signs employed by several tactile deafblind languages.**

I. INTRODUCTION

With a view to facilitate communication with the Deafblind, a most urgent need is to make linguistic interaction possible without the help of others. Here, we describe the prototype of a tactile communication device for the Deafblind that is motivated by the latest discoveries regarding "early touch" on [1], [2]; while following a minimalist design approach for robustness, ease of replication, and low cost.

II. DEAFBLINDNESS

Human linguistic communication depends on the availability of vision and audition. This is why deafness-plus-blindness inflicts an enormous handicap when it comes to communicate. A deaf person can compensate for the loss of hearing using sight (and touch) and a blind person can compensate for the loss of vision using audition (and touch). But if a person has the two handicaps, there is no other option than using touch, which is why deafblindness must be recognized as a separate condition.

A. Some numbers

More than three hundred thousand people are identified as deafblind in Europe (about 132,000 in the UK) [3]. Clearly, it would be a great burden for any country to provide a sufficient number of professional tactile signers so that deafblind citizens could communicate at any moment of the day. They are technological aids, such as braille tablets, that can translate text to tactile information, but such media are inconvenient for most deafblind individuals. Moreover, tactile signers cannot interpret speech to more than one deafblind individual at a time and for sessions that can last no longer than 45 minutes. Additional difficulties are due to the different tactile languages used worldwide.

B. Languages

Tactile languages have developed differently in different countries. Most, as is the case of *finger-spelling* languages used in the British Commonwealth, in Italy, and in Germany, are signed by touching the sensitive inside region of the hand at the cost of great discomfort for the tactile signer. Others, such as those used in France or in the US, or *hands-on signing* are signed by touching the outside of the hand, which is more comfortable for the signer. The device that we have developed is intended to stimulate the inside of the hand and thus addresses specifically finger spelling.

Finger spelling is based on brief finger tapping and swiping to sign letters and numbers as shown in Fig. 1.

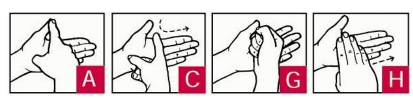

Fig. 1. Four letters of the British Sign Language.

It would be wrong, however, to assume that finger spelling can only express letters and numbers. In reality, its expressiveness is like that of speech. There is prosody, emphasis, and other forms of modulation similar to speech that operate at the lexical, grammatical and semantic levels, in addition to non-lexical shorthand symbols, smileys, geometric figures, directional cues and so-on. The technology that we develop can address these forms of modulation.

III. HAPTIC DISPLAY

Devices for use by the Deafblind already exist [4] but they generally lack expressiveness, being typically based on ordinary buzzers.

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The apparatus, designed to produce finger spelling symbols, accounts for the properties of touch [5] and the ergonomy of the hand [6]. It allows for prolonged hand contact, allowing for the evaporation of the sweat trapped by the contact with surfaces and the evacuation of the heat produced by the hand.

The actuators are very simple, yet efficiently cater to the two required modes of mechanical interaction, namely, tapping and swiping on the skin, and have large dynamic and frequency ranges. The apparatus was designed to be easily built, user-friendly, maintainable, and affordable. Most importantly, its mechanical properties afford a high contrast ratio between the stimulated regions and the rest of the hand.

The hardware using off-the-shelf and 3D printed components, and software will be open-source. The device overview is shown in Fig. 2.

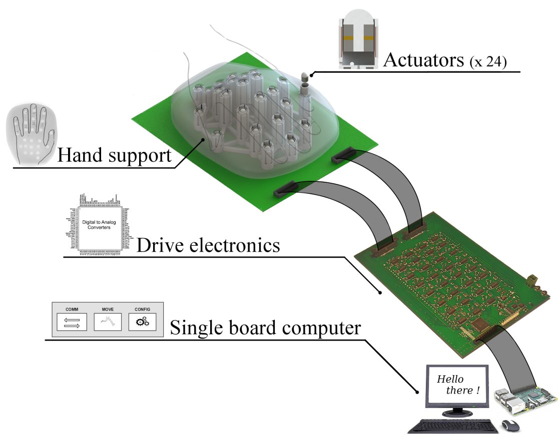

Fig. 2. Overview of the Tactile Communicator

A. Mechanical design

The interface has an outer shell that fits the shape of the palm of the hand at rest. This shell has holes for the evacuation of the sweat and heat. To avoid interference between actuators, the structure holding the actuators is mechanically decoupled from the shell.

B. Electromechanical design

Each one of the twenty four actuators comprise a permanent magnet plunger that drops inside a vertical bore under the action of gravity at are surrounded by a external coil. In a first mode of operation, the actuator is pulsed upward to briefly impact the skin. In a second mode, the plunger is levitated by a biasing current to press gently on the skin. It then can be activated in the manner of a broadband electrodynamic transducer. Circuitry was created to drive up to 32 independent actuators, affording redundancy.

C. Software

Basic software extract sentences from text and translate them into tactile symbols. Creating the sensation of a human hand tapping and swiping is important for the intelligibility of the spelling. The 24 actuators are strategically placed so that the stimulation regions optimally approximate with the hand regions used during spelling. Swiping sensations are created by producing apparent movement from a carrier signal [7]–[9]. Proper modulation of amplitude and timing provides the sensation of continuous sliding movements.

IV. Summary and Future Work

We created a device of minimal complexity that is easily replicated and improved, and which has cost for parts of a few hundreds of euros. Yet it is capable of a great range of expressiveness because of the care that was put in its mechanical organization, the distribution of actuators to take advantage of the non-local property of early haptic processing, and the design of actuators that have time constants that are compatible with the basic physics of tactile interaction with the hand.

Future work is concerned with more design iterations, the optimization of its ergonomy to accommodate the greatest number of hands with a minimum number of designs, and the elaboration of software to address the linguistic aspects of tactile communication.

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