MyVox—Device for the communication between people: blind, deaf, deaf-blind and unimpaired

Fernando Ramirez-Garibay, Cesar Millan Olivarria, Alejandro Federico Eufracio Aguilera, and Joel C. Huegel
Biomechatronics Laboratory
Tecnologico de Monterrey–Campus Guadalajara
Zapopan, Jalisco, Mexico

***Abstract*—Humans are social creatures. We learn by connecting with those around us, through communication. While people with hearing or visual impairments alone can find a way to share their thoughts with others and understand them, deaf-blind people face a much more difficult communication task. Here, appropriate technology can play a decisive role.**

The small size and low power consumption of ARM-based computers, such as the Raspberry Pi, have opened the door for many embedded applications, including a heart monitoring method and an assistive navigation system for the blind.

Some estimates place the number of deaf-blind people in the U.S. at around 40,000 individuals. While a commercial view considers this a small market, thus making communication devices not commercially viable; from a humanitarian view, this is a significant number of people who would greatly benefit from a technological means of communication.

This paper presents the design, prototype and testing of a portable keyboard and speaker device with a braille refreshable display for the communication between two people (either being deaf-blind) that has both, a comparatively low cost, and many possibilities for further development on the ARM-based computer system.

I. INTRODUCTION

A deaf-blind person is one with impaired senses of hearing and sight. Those who have lost only one of these senses can use the rest to compensate up to a certain point, and can develop techniques to successfully communicate with others. Blind people can hear and speak, deaf people can learn how to write, understand sign language, and read lips. deaf-blind people, however, left mainly with touch and smell to connect with the world around them, do not have direct access to the main communication channels that others use in their every day life.

To live a fulfilling life, a person must be able to connect with others. A conversation can give you an insight into the world around you, whether you can see or not; by speaking with another person, you can learn much from their experiences; and it is only through collaboration with other people that we can achieve our goals. A deaf-blind person can communicate with others with the help of an interpreter, but more often than not, they do not have someone who can be with them all day long; also, according to what a deaf-blind person told us[1], talking with someone else through an interpreter is a very different experience than speaking directly with someone.

Two of the most used methods for deaf-blind communication are tactile sign language and braille. Other methods include touch cues, using known objects to represent ideas, print on palm, tactile finger-spelling, and Tadoma (now rarely used; it is speech recognition by tactile sensing). Most sighted and hearing people do not know sign language nor braille, which raises the need for an interpreter or a technological solution.

With the aid of technology, a person with limited hearing and sight can communicate with others whether or not they speak sign language or read braille. Others have presented solutions both in the academic and commercial fields, but we believe that technology has advanced enough to provide better options than those currently available. By presenting our work we seek to bring attention towards the deaf-blind community so they can find more inclusion into our society.

The National Center on deaf-blindness in the United States places the number of deaf-blind persons younger than 22 years old at 9,525 on 2012 [1]. Along with an estimate made in 1993 of the adult deaf-blind population that places the count at 35,000 (lower estimate) [2], we can consider a number of around **40,000** deaf-blind people *in the United States*. A report from 2004 [3] places places the number of people over the age of 12 with combined hearing and vision loss, *in Canada*, at **69,700**. These numbers are too low for commercial perspectives, thereby resulting in a lack of availability of technological solutions. This is why we intend to raise interest towards deaf-blind people who could greatly benefit by an affordable and complete technological means of communication.

We present the design and development of a communication device prototype that addresses the accessibility of communication between sighted and/or hearing people and deaf-blind people. Each may use different methods of communication, which is why MyVox is a device that includes a textual display for those who can see, a speech output for those who can hear, and a braille display for the main users: those with no hearing or sight.

II. THE USER AND MYVOX

While this prototype was completely designed and developed by students, the idea was proposed after a meeting between a deaf-blind person, his interpreter and a professor. The user has Usher syndrome; because of this, he was born unable to hear, and as he grew older gradually lost his sight. While he could still see, he learned sign language, and after

[1]To be noted, he told us this by using the device presented here.

becoming blind he learned how to *feel* signs, thereby retaining a way to communicate.

Being only able to communicate with people who speak sign language, he approached us looking for a way to communicate with others without always relying on his interpreter. Having accepted, we found that current solutions are not just expensive, they can be vastly improved by using newer technology.

The user was asking for a device that could allow him to communicate with anyone, whether or not they speak sign language. Even at home, he is often unable to speak with his family without his interpreter. Living among siblings with sensory impairments, a device that was able to transmit a message through different channels was necessary. The proposed result was named MyVox, alluding to his being able to speak with anyone.

III. Current Approaches

Over the years, some communication systems for those who are deaf-blind have been proposed. The ones that have found acceptance among the deaf-blind community are mostly those that use braille output.

Some approaches, meant more for research than to have direct impact on the public, have attempted to recreate aspects of non-written communication. In 1987, Dexter was designed to represent finger-spelling with a robotic hand [4]. In 1993 OMAR was developed as a haptic representation of speech to be used alongside something similar to the Tadoma method for tactile lip reading [5].

When computers were text–based or at least did not include complex graphical environments, they were ideal to be used by deaf-blind people with the use of refreshable braille displays. Such approach was taken by Durre [6], as well as Sriskanthan and Subramanian [7] in 1990. Before them, Bazzani and Mumolo presented a system actually meant not to control a computer, but to communicate with others through a telephone line [8].

More recent approaches to communication are the works of Ohtsuka et al. who propose different methods [9], [10] for the remote communication for deaf-blind people. While they present novel approaches, the use of non-standard communication methods means that there is much trial and error to be done before their system becomes widely accepted.

A communication system developed by Su et al. [11] in 2001 appears to be a precursor of currently available products. They built a system that had a simplified keyboard and LCD for the sighted user, as well as a Perkins Brailler type of keyboard and Braille display for the deaf-blind user.

As mentioned, current products exist that resemble the approach by Su et al. These products have costs ranging from approximately $3,000 to $8,200 USD. Some include very convenient features such as wireless connectivity, e-mail, SMS messaging and a TTY mode. Even with these features available, it appears that there are some aspects that they do not consider. Furthermore, with current technology, these aspects can be addressed. For example, several of the systems require a cellphone for the deaf-blind person to communicate with a sighted counterpart or to use some of their more powerful features; moreover, the products that include a QWERTY keyboard, have embedded it: While this can be seen as space reduction, it also reduces the possibilities for the user to adjust the system to their needs, such as using different layouts according to their language.

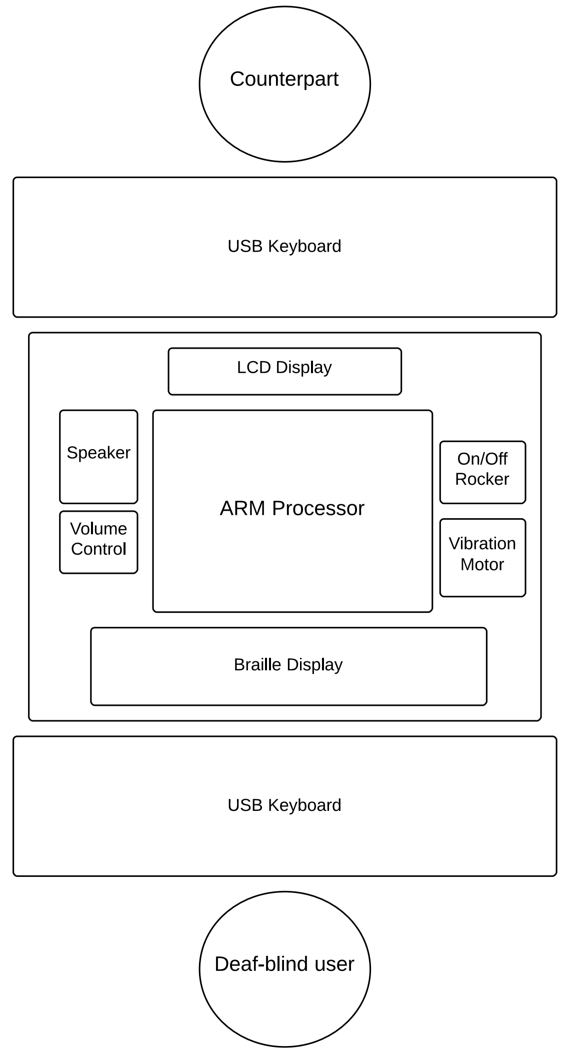

Fig. 1. Diagram that presents the locations for the different components proposed in the MyVox system.

IV. System Architecture

The proposed system (figs. 1 and 2) consists of an ARM-based computer as the main processing unit; the different output channels: an LCD display for the text, a speaker for the speech synthesis output, and a braille refreshable display; a vibration motor to let the deaf-blind user know when a new message has arrived; and a Real-Time Clock to help the user keep track of time.

A. ARM-Based Computer

Current technology allows us to have computers that fit in the palm of a hand, and the most well-known of these

Fig. 2. Picture of the first model of the system. The first deaf-blind person to try it is already actively using it at home. A second model is currently being built.

small-size and low power-consumption computers are those based on the ARM family of microprocessors. One example which has received much publicity over the last few years is the Raspberry Pi. This is the computer that we use in the MyVox system.

By harnessing the processing power of a computer in this system, developers have to worry less about fitting an entire software system into a microcontroller and can focus more on completely addressing the user requirements. This also means that new applications can be made available to the user beyond just communication purposes, and access to them would not require technical knowledge.

B. USB Keyboards

For the input devices we decided best to use USB keyboards. Foremost, they are immediately compatible with the ARM-based computer, so any standard keyboard will work, no matter the manufacturer or its layout. We consider the possibility to use regional layouts a great advantage because a new user, no matter the language they speak, can easily use the same system just by plugging their own keyboard in.

There is a wide range of keyboard options, and the user can benefit from this by choosing the one that best suits the needs. If the user requires maximum portability, flexible keyboards may be used; if the plan is to spend long periods of time talking with others or writing texts, the preference may be for a more ergonomic one. One particular convenience is that one could use a keyboard with embossed braille characters if one is still unfamiliar with the keyboard layout.

Further customization can be done, such as developing a Perkins Brailler type of keyboard. This option is yet to be explored.

C. Speaker

The MyVox system includes a speaker that reproduces the speech synthesized version of the written message. We have found this useful under different circumstances during our tests.

Blind counterpart: When the deaf-blind user is communicating with a blind user, a speech synthesized output is necessary; otherwise they would have to share the braille output, which could lead to confusion.

Fig. 3. Picture of the first time our deaf-blind collaborator was able to express himself to a large number of people without an interpreter.

Distracted or away counterpart: Unaware of whether or not their counterpart is reading the display, the deaf-blind user might send a message that could be missed. To call the attention of the counterpart as well as to allow them to be looking elsewhere while they listen (a parent watching over their other children), the message is conveyed through the speaker.

Public speaking: The deaf-blind person we have been working with was able to tell an auditorium full of people a little bit about himself using the speech output (fig. 3. This was the first time he had been able to speak directly to that many people and is interested in continuing to do so. For example, volunteering at a school for blind.

The system employs an embedded speaker to make the system as portable as possible. While currently it is only possible to use the included speaker, we plan on changing this to allow for headphones or external speakers to be connected.

D. LCD Display

Another output is the LCD display, which allows a sighted person to read the message. We currently use a 16 by 2 character display, as this matches the size of the braille display. We are exploring the option of using a bigger display to be able to present larger fonts that prove helpful for a reduced-sight user.

E. Braille Display

We use a 16 cell refreshable braille display produced by Metec AG. This is by far the most expensive component of the system. We will continue to be looking for state of the art technology that could allow us to reduce the costs of the system further.

It is piezo-acuated, with 8-pin braille characters, and works with a high voltage but very low current. One benefit of these actuators is that they are not too rigid, allowing the reader a similar experience as that of reading on embossed paper.

F. Real-Time Clock

deaf-blind people have difficulty in perceiving the time. At best, a deaf-blind person can only distinguish between night and day, and this is only if they have residual eyesight. We decided to include a real-time clock so that the users may easily tell the time whenever the device is at hand.

G. Vibration Motor

To help the user know when a new message has arrived, and to provide other relevant information, such as a complete boot-up of the system, a vibration motor has been included.

V. Future Work

Our deaf-blind collaborator currently uses the device everyday with his family and friends. During our work on this first prototype and while testing it, we became aware of several features and possible improvements that can be implemented in the next version of the system.

Internet: By harnessing the capability to access Internet through the ARM-based computer, we can provide a wider range of applications and access to information than go beyond the current in-person communication.

Applications: Along with Internet access, the users could install custom applications that can be developed by anyone and made available online. Examples could range from new languages (for speech synthesis, braille contractions, etc.) to SMS messaging, even books or games.

Portability: While the device is currently portable, modifications can be made to reduce the size even more and ensure its portability.

Braille display: By far, the most expensive component of the system is the refreshable braille display. We plan to continue our search for a more accessible technology.

VI. Conclusion

We have presented a device for the communication of deaf-blind people. While their lack of hearing and sight could represent a limitation when communicating with others, technology is presented that can be of use for communicating with others who do not speak sign language. The communication device, named MyVox, has proven to be a useful tool for an Usher syndrome patient who is now able to communicate with others without the need of an interpreter. Based on his feedback, we are developing an upgraded system that will also be tried by a larger population of deaf-blind users.

Acknowledgment

The authors would like to thank our Usher syndrome collaborator that gave us the inspiration to begin this work and who has helped us by testing the device and giving us ideas about how to improve it.

References

[1] NCDB, "The 2012 National Child Count of Children and Youth who are Deaf Blind," Tech. Rep. September, 2013. [Online]. Available: http://documents.nationaldb.org/products/2012-Census-Tables.pdf

[2] D. Watson and M. Taff-Watson, *A model service delivery system for persons who are deaf-blind*. Rehabilitation Research and Training Center for Persons who are Deaf or Hard of Hearing, University of Arkansas, 1993.

[3] C. Watters, M. Owen, and S. Munroe, "A study of deaf-blind demographics and services in Canada," Tech. Rep., 2004. [Online]. Available: http://disabilitystudies.ca/wp-content/uploads/2010/08/deaf-blind-demographics-report-dec-2004.pdf

[4] A. Meade, "Dexter–A finger-spelling hand for the deaf-blind," in *Proceedings. 1987 IEEE International Conference on Robotics and Automation*, vol. 4. Institute of Electrical and Electronics Engineers, 1987, pp. 1192–1195.

[5] S. Eberhardt, L. Bernstein, D. Coulter, and L. Hunckler, "OMAR a haptic display for speech perception by deaf and deaf-blind individuals," in *Proceedings of IEEE Virtual Reality Annual International Symposium*. IEEE, 1993, pp. 195–201.

[6] K. Durre, "BrailleButler: a new approach to non-visual computer applications," in *[1990] Proceedings. Third Annual IEEE Symposium on Computer-Based Medical Systems*. IEEE Comput. Soc. Press, 1990, pp. 97–104.

[7] N. Sriskanthan and K. Subramanian, "Braille display terminal for personal computers," *IEEE Transactions on Consumer Electronics*, vol. 36, no. 2, pp. 121–128, May 1990.

[8] M. Bazzani and E. Mumolo, "PC-based telephone communications system for deaf-blind people," in *IEEE Global Telecommunications Conference and Exhibition. Communications for the Information Age*. IEEE, 1988, pp. 43–47. [Online]. Available: http://medcontent.metapress.com/index/A65RM03P4874243N.pdf http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=25807

[9] S. Ohtsuka, S. Hasegawa, N. Sasaki, and T. Harakawa, "Communication System between Deaf-Blind People and Non-Disabled People Using Body-Braille and Infrared Communication," in *2010 7th IEEE Consumer Communications and Networking Conference*, vol. 1. IEEE, Jan. 2010, pp. 1–2.

[10] S. Ohtsuka, N. Sasaki, S. Hasegawa, and T. Harakawa, "Helen Keller Phonea communication system for deaf-blind people using Body-Braille and Skype," in *2012 IEEE Consumer Communications and Networking Conference (CCNC)*. IEEE, Jan. 2012, pp. 30–31.

[11] M. Su, C. Chen, and S. Su, "Portable communication aid for deaf-blind people," *Computing & Control Engineering Journal*, vol. 12, no. 1, pp. 37–43, Feb. 2001.