Development of Haptic Data Gloves for Bilateral Communication

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Introduction: According to a survey conducted by Japan's Ministry of Labor and Health, over 23,000 individuals in the country are deafblind, with many more experiencing gradual losses of both their sight and hearing due to their disabilities. Deafblindness results from the impairment of the two fundamental human sensory functions, namely vision and hearing, frequently giving rise to communication challenges. An early work of Caporusso [1] described an assistive hardware/software system called DB-HAND, consisting of an input/output glove equipped with sensors and actuators to transmit the traditional Malossi alphabet. Similarly, Gollner et al. [2] presented a Lorm glove as a communication and translation device for the deafblind. In our work, we extend the above methods by introducing a more intuitive input interface supporting single-hand signing for enhanced mobility and employing piezoelectric actuators for the haptic feedback. More specifically, we are developing a haptic data glove that utilizes the mobile Malossi alphabet [3,4] to facilitate two-way communication through tactile and vibratory means. The innovation aims to diminish the reliance of deafblind individuals on caregivers and interpreters, thereby enhancing their independence.

Materials and Methods: The prototype of the message-sending glove is shown in Figure 1(a). The glove is made of synthetic leather, with added buttons and wiring installed through perforations to track the user input. The prototype of the message-receiving glove, as depicted in Figure 1(b), closely resembles the message-sending glove. However, it incorporates a number of piezoelectric actuators for haptic feedback and could be enhanced by adding a screen and speaker on the back for facilitating interactions with helpers. The activation of each sensor in the sending glove and the corresponding piezo in the receiving glove corresponds to a Malossi letter, with pinching substituted by the activation of lateral sensors.

(a) (b)

Fig. 1. The prototypes of the left-hand message-sending glove (a) and the right-hand message-receiving glove (b)

The signal flowchart for the integrated system, illustrated in Figure 2, shows the Arduino Nano microcontroller, with the IO Expanders, interconnecting the message-sending and the message-receiving gloves. Note that the communication with the message-sending glove is driven by interrupts (IRQ-based), while the message-receiving glove is controlled directly through a triac matrix that switches the higher AC voltage needed for the piezoelectric actuators. This construction allows the data from the message-sending glove to be promptly transmitted to the message-receiving glove and used for providing real-time tactile feedback. Two-way communication with two pairs of gloves can be achieved by connecting their Arduino microcontrollers to the USB ports of a Windows PC.

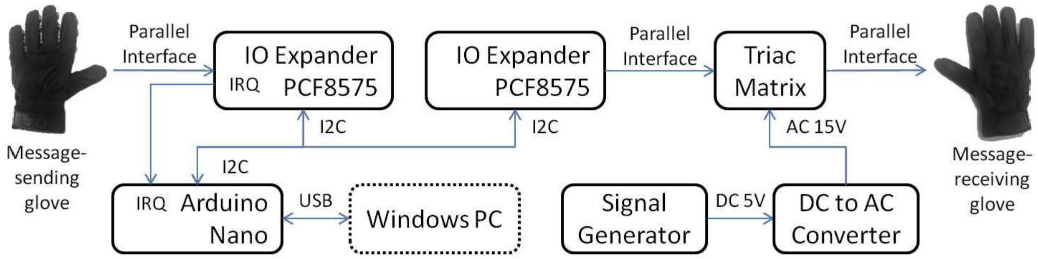

Fig. 2. Signal flow diagram of the integrated system.

Conclusions and Future Works: This work presents the prototype design of tactile input and output data gloves as human-machine interface components, specifically tailored to support two-way communication for individuals who are deafblind, both locally and remotely. The work can be extended to other application domains, such as emergency services, critical operations, and disaster management. In particular, data gloves can play a crucial role in extreme situations like earthquakes, hurricanes, floods, and fires, where hearing and vision can be severely impaired. Therefore, we intend to explore the design and development of specialized waterproof and/or fire-resistant data gloves that utilize reliable communication channels and can operate independently for extended periods in such circumstances.

References

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Biography

Mr. Hao-An Tseng is a master's student in the Department of Computer Science at National Cheng Kung University in Taiwan. His main research topic is federated learning. He has a Bachelor of Computer Science from the National Taipei University of Education in Taiwan. Mr. Jasper Tsai is an undergraduate at the Department of Mechanical Engineering at the National United University in Taiwan. Currently, they are visiting research students for the data glove research project at the Faculty of Business and IT, Ontario Tech University in Canada.