Passive RFID-based Intelligent Gloves for Alternative and Assistive Communication – A Preliminary Study

Adnan Mehmood[1], Zahangir Khan[1], Aleksi Vianto[1], Tiina Ihalainen[2], Johanna Virkki[1]
[1]Faculty of Medicine and Health Technology, [2]Faculty of Social Sciences, Tampere University, Tampere, Finland
{adnan.mehmood, zahangir.khan, aleksi.vianto, tiina.ihalainen, johanna.virkki}@tuni.fi

***Abstract*—We introduce intelligent gloves based on passive ultrahigh frequency (UHF) radio frequency identification (RFID) technology, which comprises of four antenna parts and three RFID integrated circuits (ICs). Each of the ICs (in middle finger, ring finger and small finger) have their unique IDs, which can be activated by gentle touch of thumb, and used to send a specific message, which is displayed on a computer screen. Two users tested the gloves in an office environment with M6 mercury RFID reader and a specially developed software. The achieved success rate in these preliminary tests was 100 %. We consider these results promising first steps for future wearable passive RFID-based augmentative and alternative communication (AAC) solutions.**

Keywords— Alternative and assistive communication (AAC), passive radio frequency identification (RFID), special needs, wearable electronics.

I. INTRODUCTION

Recently, versatile body-centric intelligent devices have shown to provide human-computer interaction inputs based on body movements, gestures, and/or touch [1]-[6]. Especially passive ultrahigh frequency (UHF) radio frequency identification (RFID)-based wearable human-computer interaction has gained a lot of research interest lately [4]-[6].

When integrated into basic gloves, passive RFID technology enables tailored augmentative and alternative communication (AAC) solutions, which can solve the challenges related to currently available high-tech AAC solutions, such as touch-enabled systems or separate AAC devices, which are often restrictive for users who are physically or cognitively impaired [7].

In this study, we are presenting intelligent passive RFID-based gloves, where the IC activation works on the principle of on/off, and which comprises of four copper tape antenna parts and three RFID integrated circuits (ICs). Each of the ICs (in middle finger, ring finger and small finger) have their unique IDs, which can be activated by gentle touch of thumb, and used to send a specific message, which is displayed on a computer screen.

II. INTELLIGENT GLOVES

The first prototypes of these cotton-based intelligent gloves were presented in [8], where the detailed manufacturing process of the glove antennas from copper tape was presented. The findings were encouraging, as the gloves showed reliable on/off functions by finger movements in an office environment. This motivated us to present a real-life application, which is a simple wearable AAC solution.

The fabricated intelligent gloves are shown in Fig. 1. When the copper tape antenna on the thumb touches the IC pad on the finger antenna (also fabricated from copper tape), the specific IC on the finger is "turned on", which means it becomes readable for the RFID reader. Thus, only the touched IC is readable, while other ICs are "turned off".

Fig. 1. Integrated copper tape antennas on the palm side of an intelligent glove (left) and on the backside of an intelligent glove (right).

In our system, each finger corresponds to a special message, which appears in an image format on a computer screen. The fingers 1) middle finger, 2) ring finger and 3) small finger correspond to 1) "I have something to say", 2) "I need assistance" and 3) "I need urgent assistance" messages, respectively. These messages (shown in Fig. 2) are important alert messages for people who are unable to speak and need assistance in communication and activities of daily living.

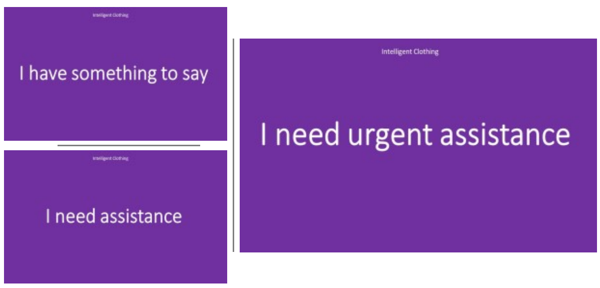

Fig. 2. Messages corresponding to respective ICs in middle finger (top left), ring finger (bottom left), and small finger (right).

III. Testing and Measurements

The intelligent gloves are tested in an office environment (see Fig. 3) with people, computers and cell phones around, making it an ideal environment for practical testing. The testing setup includes a M6 RFID reader, which operates at the European UHF range (865.6-867.6 MHz) and with a power of 27 dBm. The M6 reader is connected to a circularly polarized RFID reader antenna through a connecting cable.

The testing setup includes a specially developed software, a WinForms desktop application, which uses ThingMagic library to connect and communicate with the M6 reader. The reader detects the IC and triggers an input with the specific ID of the IC through the "TagRead" function. In this preliminary test, the detected input of a specific ID returns output in a picture format on the computer screen.

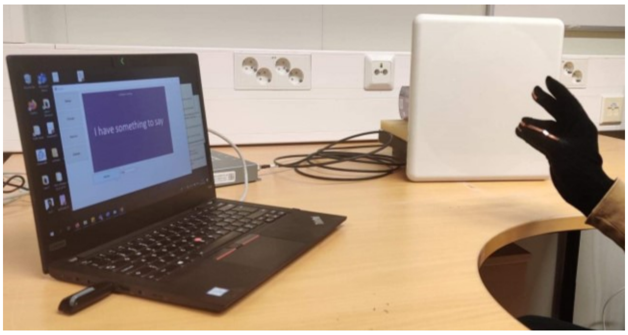

Fig. 3. Testing setup of AAC gloves in an office enviroment.

In the test, two users, both familiar with the used passive UHF RFID technology, are given 200 random orders, the user acts correspondingly, and the output is shown on the computer screen as a picture with a specific message. A wrong picture or no picture is considered a failure. As shown in Table 1, both users achieve a 100 % success rate in this preliminary test. Thus, we can consider these prototype gloves as promising first steps for future wearable passive RFID-based AAC solutions.

TABLE I. SUCCESS RATE OF MEASUREMENTS TAKEN IN AN OFFICE ENVIRONMENT

User	**Success rate**
User 1	100 %
User 2	100 %

IV. Discussion

The main advantage of the "AAC glove" presented in this study, is its passive nature: There is no need for a battery in the glove. Further, it is possible to tailor the amount of RFID ICs in the glove, which means we can use different types of hand gestures as inputs to the world around us. We will further explore the possibilities of these gloves by bringing new outputs in the forms of pictures, texts, and sounds. As the output can be tailored for each individual user and use environment, the developed system provides great flexibility for practical use. In addition, it's essential that AAC solutions are easily available and fast to use in everyday life.

V. Conclusion

A basic cotton-based glove with integrated passive UHF RFID technology provides the possibility of giving inputs to the surrounding world through a specially developed software and a basic M6 RFID reader. The developed intelligent glove has three input points in fingers (in middle finger, ring ringer and small finger) and each corresponds to a message ("I have something to say", "I need assistance" and "I need urgent assistance", respectively), which is shown on a computer screen.

In this preliminary study, the developed glove was tested by two users with a 100 % success rate. Based on the achieved results, these intelligent gloves provide new possibilities for easily available and individually tailored AAC solutions. The possibilities of the gloves in teaching and learning, as well as in the entertainment sector, for example as game controllers, are interesting future aspects to study as well.

Acknowledgment

This work was financially supported by the Finnish Cultural Foundation, the Academy of Finland (decision numbers 294534 and 332168), and Jane and Aatos Erkko Foundation.

References

[1] H. Zhou, Y. Gao, X. Song, W. Liu, W. Dong, and Y. Jiang, "Wearable-based human-computer interaction with limbmotion," Proceedings of the 16th ACM Conference on Embedded Networked Sensor Systems (SenSys '18), Shenzhen, China, 2018.

[2] K. J. Raiha, A. Hyrskykari, and P. Majaranta, "Gaze-based human-computer interaction," Proceedings of the 10th international conference on Intelligent user interfaces (IUI '05), San Diego, California, USA, 2005.

[3] J. Burstyn, P. Strohmeier, and R. Vertegaal, "DisplaySkin: Exploring pose-aware displays on a flexible electrophoretic wristband," Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '15), Stanford, California, USA, 2015.

[4] H. He, X. Chen, L. Ukkonen, and J. Virkki, "Clothing-Integrated passive RFID strain sensor platform for body movement-based controlling," IEEE International Conference on RFID Technology and Applications (RFID-TA), Pisa, Italy, 2019.

[5] S. Amendola, L. Bianchi, and G. Marrocco, "Movement detection of human body segments: passive radio-frequency identification and machine-learning technologies," IEEE Antennas and Propagation Magazine, vol. 57, no. 3, pp. 23-37, 2015.

[6] H. Ding et al., "A platform for free-weight exercise monitoring with passive tags," IEEE Transactions on Mobile Computing, vol. 16, no. 12, pp. 3279-3293, 2017.

[7] Y. Elsahar, S. Hu, KB. Marouf, D. Kerr, and A. Mansor, "Augmentative and Alternative Communication (AAC) advances: A review of configurations for individuals with a speech disability," Sensors Journal, vol. 19, no. 8, pp. 1911, 2019.

[8] A. Mehmood, H. He, X. Chen, A. Vianto, V. Vianto, and J. Virkki, "ClothFace: A batteryless glove-integrated user interface solution based on passive UHF RFID technology," IEEE 8th International Conference on Serious Games and Applications for Health (SeGAH), Vancouver, BC, Canada, 2020.