Live Demonstration: A Wearable Eight-Channel A-Mode Ultrasound System for Hand Gesture Recognition and Interactive Gaming

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***Abstract*—This work presents a wearable, eight-channel A-mode ultrasound system for hand gesture recognition and interactive gaming. The wearable system consists of a custom-built forearm bracelet with eight piezoelectric transducers (1 MHz) evenly distributed, an electronic hub housed on a bicep strap, a laptop with a bespoke machine learning algorithm and a robotic hand for actuation. The electronic hub drives the transducers to produce ultrasound pulses that will travel into the forearm muscles. The reflected ultrasound signals will vary based on the forearm muscular morphology (movement-dependent). By decoding the reflected ultrasound signals using machine learning techniques, a robotic hand can be controlled based on the user's hand motions. In contrast to the conventional surface electromyography methods, the visitor can experience seamless control of a robotic hand and a maze navigation game via ultrasound as a novel sensing modality.**

I. Introduction

Hand gesture recognition (HGR) is a major research area in human-machine interfaces (HMI) with applications ranging from prosthesis control, robotic limb manipulation, to augmented/virtual reality. Presently, surface electromyography (sEMG) is the most popular approach for HGR. Nevertheless, a crucial limitation of sEMG is its shallow depth of recording that is due to the inherent nature of sEMG signals. As a result, it is not feasible to use sEMG to detect deep muscular signals and decode minute motions generated by deep muscles. On the other hand, ultrasound is capable of deeper penetration providing information not accessible to sEMG [1], [2].

As the user performs different hand movements, the forearm muscular morphology will also change. For example, by clenching the fist tightly, the shortening and lengthening of muscles will cause a unique morphological change whereas by relaxing the hand the morphology will return to its initial form. This means that by transmitting ultrasound pulses into the forearm, the reflected ultrasound signals will vary based on the muscular morphology (movement-dependent). The received ultrasound signals can then be analysed using machine learning techniques to decode hand movements. Currently, large, cumbersome instruments are typically used for ultrasound HGR. However, these bulky instruments severely degrade the HMI experience. In this work, we present a wearable, eight-channel, A-mode ultrasound system based on a front-end ASIC (designed in 0.18 μm HV BCD process) and custom-designed 1 MHz piezoelectric transducers for HGR [3].

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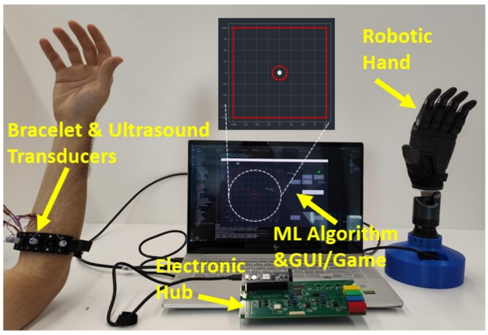

Fig. 1. Overview of the ultrasound hand gesture recognition system.

II. Demonstration Setup

The proposed ultrasound system (Fig. 1) consists of the following components:

- A flexible forearm bracelet with 8 transducers.
- Laptop with ML and maze navigation game.
- Custom-designed electronic hub that fits on a four-layer PCB the size of a typical smartphone.
- A robotic hand to display hand gestures.

III. Visitor Experience

This live demonstration would allow visitors to try out the proposed system by wearing the bracelet around the forearm and strapping the electronic hub onto the biceps using a bicep mobile phone holder. Next, the visitor would be asked to perform several gestures to collect training data. After training, the visitor can perform any of the trained hand gesture and the robotic hand would carry out the same gesture. In addition to controlling the robotic hand, whose range of motions is limited by its motors, the visitor is encouraged to control a maze navigation game shown via a graphical user interface (GUI). This game can show that the proposed system is capable of decoding continuous hand movements, in addition to discrete hand gestures.

References

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