Live Demonstration: A Bioimpedance-Based Robotic Hand Control Platform Using a Customised Neural Network

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***Abstract*—This work presents a high-accuracy hand gesture recognition platform for robotic hand control. The platform consists of a flexible 8-electrode band, a high-performance electrical impedance tomography (EIT) system, a compact customised neural network deployed on a laptop and a robotic hand. The EIT system captures the bioimpedance features from muscle contraction and bone movement in the upper arm. After training, the customised neural network can predict hand gestures using bioimpedance features. The visitor will experience smooth control of a robotic hand by performing desired gestures using this demo platform.**

I. Introduction

Electrical impedance tomography (EIT) detects the inner bioimpedance distribution of an object by injecting an AC current and measuring the induced voltage potentials on the boundary. This non-invasive approach of revealing muscle and bone movement based on changes in impedance has been widely studied and applied to hand gesture recognition for human-machine interaction (HMI). Its application includes virtual reality interaction, sign language recognition and intelligent robot control. Many machine learning algorithms, such as support vector machine (SVM), k-nearest neighbours (KNN) and artificial neural network (ANN), have been introduced to establish the relationship between bioimpedance features and hand gestures [1] [2]. These algorithms often require high computing power because of the large data size collected; for example, the system in [2] uses 32 electrodes to improve spatial resolution at the expense of high computing power and power consumption. This live demonstration presents a compact neural network optimised for high-accuracy bioimpedance-based hand gesture recognition using an 8-electrode band and requiring low computational resources [3].

II. Demonstration Setup

Fig. 1 shows the proposed HMI platform [3], which comprises the following components:

- **Flexible Band:** The eight electrodes are evenly assembled on the inner side of the band.
- **EIT System:** The high-performance EIT system is adopted to acquire 49 impedance features per frame from 8 electrodes [4].
- **Neural Network:** The customised neural network with 33 weights and 11 biases runs on a laptop. A decay filter provides a higher weight to the impedance calculated from the higher signal-to-noise ratio of the recorded voltage. Moreover, the non-fully connected layer is applied to reduce the redundancy of features.
- **Robotic Hand:** The robotic hand mimics gestures that directly demonstrate the predictions of the neural network.

This work was supported by EPSRC under grants EP/R513143/1, EP/T001259/1 and EP/T001240/1.

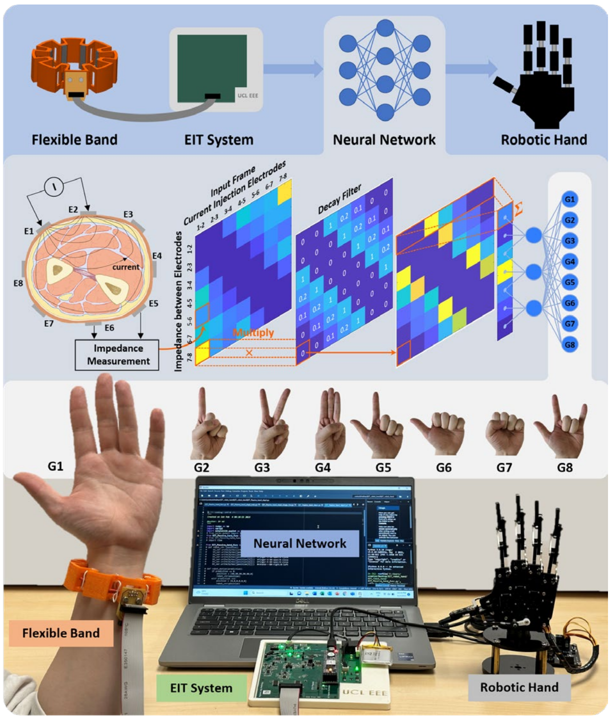

Fig. 1. Overview of the proposed HMI platform [3].

III. Visitor Experience

This demonstration would allow visitors to control the robotic hand by wearing a flexible band around the forearm. First, the visitor would be instructed to perform several gestures to collect EIT data and train the neural network. After training, the visitor could repeat the gestures recorded earlier, and the robotic hand would immediately respond with the same motion. The visitor would also visualise the real-time EIT image revealing muscle and bone movement and monitor the neural network operation.

References

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