Live Demonstration: Augmented Reality Prosthesis Training with Real-Time Hand Trajectory Prediction and Neuromorphic Tactile Encoding

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I. Description

This demonstration is a combination of the work described in [1], [2], and [3]. The goal of this work is to improve the efficacy of upper-limb prosthesis training protocols using visual feedback based on tactile and proprioceptive sensorization in an augmented reality environment.

II. Demonstration Setup

A Microsoft HoloLens™ headset (Microsoft Corporation, Redmond, WA) is used to give visual cues for object manipulation tasks using a virtual prosthetic arm in an augmented reality environment. The virtual prosthetic arm (vMPL from the Johns Hopkins Applied Physics Lab) will be controlled with the user's surface electromyograph (EMG) signals. Task kinematics are captured using the inertia-based kinematic framework described in [1] and are used to compute hand trajectory estimates. These trajectories are compared against a predefined reference and this comparison is used to give visual feedback to the operator. When the virtual object is being manipulated, tactile forces are visualized using data from tactile sensors embedded in the virtual hand. These forces are translated into biologically-inspired neuromorphic spiking behavior as in [3] for use in closed-loop sensory feedback.

A system overview of the demonstration components can be found in Fig. 1. The user will be wearing a Microsoft HoloLens™, a Myo surface EMG electrode armband (Thalmic Labs, Ontario, Canada) and custom inertial measurements units (IMUs). A laptop is used for data streaming and computation. Two external monitors are used to display the augmented reality environment for a broader audience and to display the hand trajectory and tactile neuromorphic spiking data. Sensor interfaces are written with a combination of custom MATLAB, Python, and Unity code. The setup requires three power outlets, one for the laptop and each monitor.

III. Visitor Experience

At the demonstration, visitors will be able to perform object relocation tasks guided by visual cues in augmented reality. A visitor will use their forearm EMG signals to operate the virtual prosthesis and manipulate a variety of objects using a set of preset grips. On one monitor, individuals will be able to see real-time streams of the raw EMG data, the tactile sensors neuromorphic output, and the estimated hand trajectory computed from the inertial sensors. On the other monitor, the view from the Microsoft HoloLens™ will be mirrored so that individuals not currently operating the headset will be able to see the visual feedback shown directly to the operator. The visualization of these different sensor outputs is meant to highlight the interplay of these different modalities in natural object manipulation and how biologically-inspired processing can enhance user experience during rehabilitation. This demonstration will give visitors a greater sense of the challenges of functionally operating an upper-limb prosthesis as well as give them a greater appreciation of how different forms of sensorization can alleviate some of these challenges.

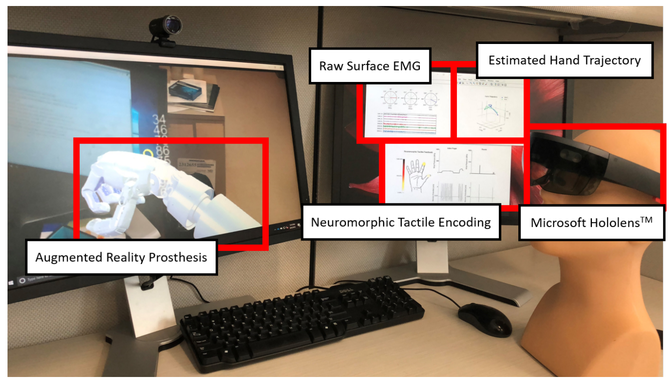

Figure 1. Demonstration setup. The user dons a Microsoft HoloLens augmented reality headset to operate a virtual prosthesis to manipulate objects in their environment. The first monitor mirrors this view for bystanders while the second monitor displays raw surface EMG, estimated hand trajectories, and neuromorphic tactile encoding in real-time.

References

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[2] A. Sharma, C. L. Hunt, J. Betthauser, A. Maheshwari, L. Osborn, G. Lévay, R. R. Kaliki, A. B. Soares, and N. Thakor, "A mixed-reality training environment for upper limb prosthesis control," *Conf. IEEE Biomed. Circuits Syst. (BioCAS)*, pp. 1–4, 2018, paper ID: 6164, Submitted.

[3] M. M. Iskarous, H. Nguyen, L. Osborn, J. Betthauser, and N. Thakor, "Unsupervised learning and adaptive classification of neuromorphic tactile encoding of textures," *Conf. IEEE Biomed. Circuits Syst. (BioCAS)*, pp. 1–4, 2018, paper ID: 6162, Submitted.