Wearable Haptics for Proprioception of Shoulder Movement in Stroke

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***Abstract*— Severe impairment of proprioception with prevalence on one side is common in people with stroke, and is a predictor of poor functional outcomes. In this work in progress paper we present preliminary work on the design of a system that can convey proprioceptive information through haptic feedback, by measuring shoulder position with an IMU and mapping the readings to a two degrees of freedom actuation haptic interface worn on the chest. We describe a first complete prototype which can be worn in such a manner, and highlight limitations and future steps.**

I. Introduction

Proprioception impairment is a severely debilitating condition, where the person affected is unable to sense the position of their own limbs in space. This can happen as a consequence of many illnesses, but a common example is people with stroke, where approximately a third of people examined show impairment of proprioception [1]. Previous work has shown that haptic feedback can be helpful in conveying proprioceptive information from a prosthetic hand [2]. In this paper we try to extend this approach to deliver a similar approach to people with stroke.

II. Work To Date

The top half of Figure 1 shows a concept for the proposed system. The idea is to have a sensing system on the shoulder to track kinematics in real time, and then feed this information as input to a haptic interface that will interact with the user's chest to convey information on the movement. The long term goal is to build an assistive system that can provide information on upper limb movement to users with proprioceptive impairment, for continuous use in daily life.

The lower half of Figure 1 shows the finished prototype, which was built using an Inertial Measurement Unit to track shoulder angles, and two-degrees of actuation system on the chest that is commanded by two stepper motors (Bipolar Sanyo Pancake Stepper, 200 Steps/Rev, 50×11mm, 4.5V, 1 A/Phase.), which were chosen because of their flat shape that makes it easier to build a system that can be hidden under the clothes. The stepper motors command two pulleys, that are attached through cabling to a cart with a rolling contact providing the haptic feedback. The shoulder ad/adduction and flexion/extension degrees of freedom are mapped linearly to the two degrees of actuation of the haptic device, so that the maximum and minimum value of the two considered shoulder angles are mapped to minimum and maximum cartesian coordinates of the rolling contact.

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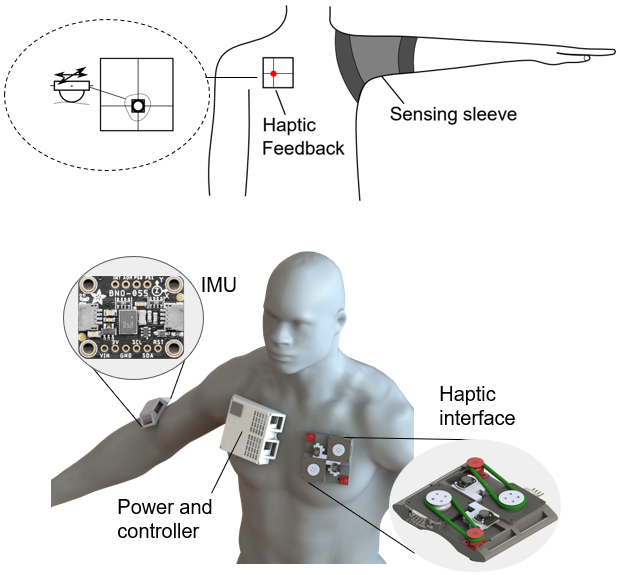

Fig. 1. Concept and system prototype.

III. Ongoing work

We are currently in the evaluation stage for our prototype. In particular, we plan to do user studies where able bodied participants are asked to identify target posture on a virtual avatar based on the feedback from the haptic interface. We will consider different mappings from the measured shoulder angles to the device, including linear and loragithmic mappings as well as which cartesian coordinate to map each of the two considered shoulder angles to. We will consider the possibility of adding pressure as a third cue, although we anticipate that mapping more than two shoulder angles to the device will be difficult, owing to the challenges associated with trying to convey multiple cues with a single haptic device. Finally, since our long-term vision for this device is to be low profile and hidden under the user's clothes, we are currently evaluating alternative designs that would enable a more compact and wearable setup.

References

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