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Wearable Haptics for Proprioceptive Feedback of Shoulder Movement

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Introduction

Proprioception is the body's ability to passively sense location and movement without conscious effort. Stroke victims are likely to experience varying degrees of impaired proprioception along one half of the body after a stroke. For the patient, loss of proprioception can mean a loss in posture awareness, weight, movement, and limb position in relation to their environment and other body parts. Our project focuses on creating a wearable haptic device to assist in remedying these losses - essentially 'retraining' the brain by providing the missing proprioceptive feedback.

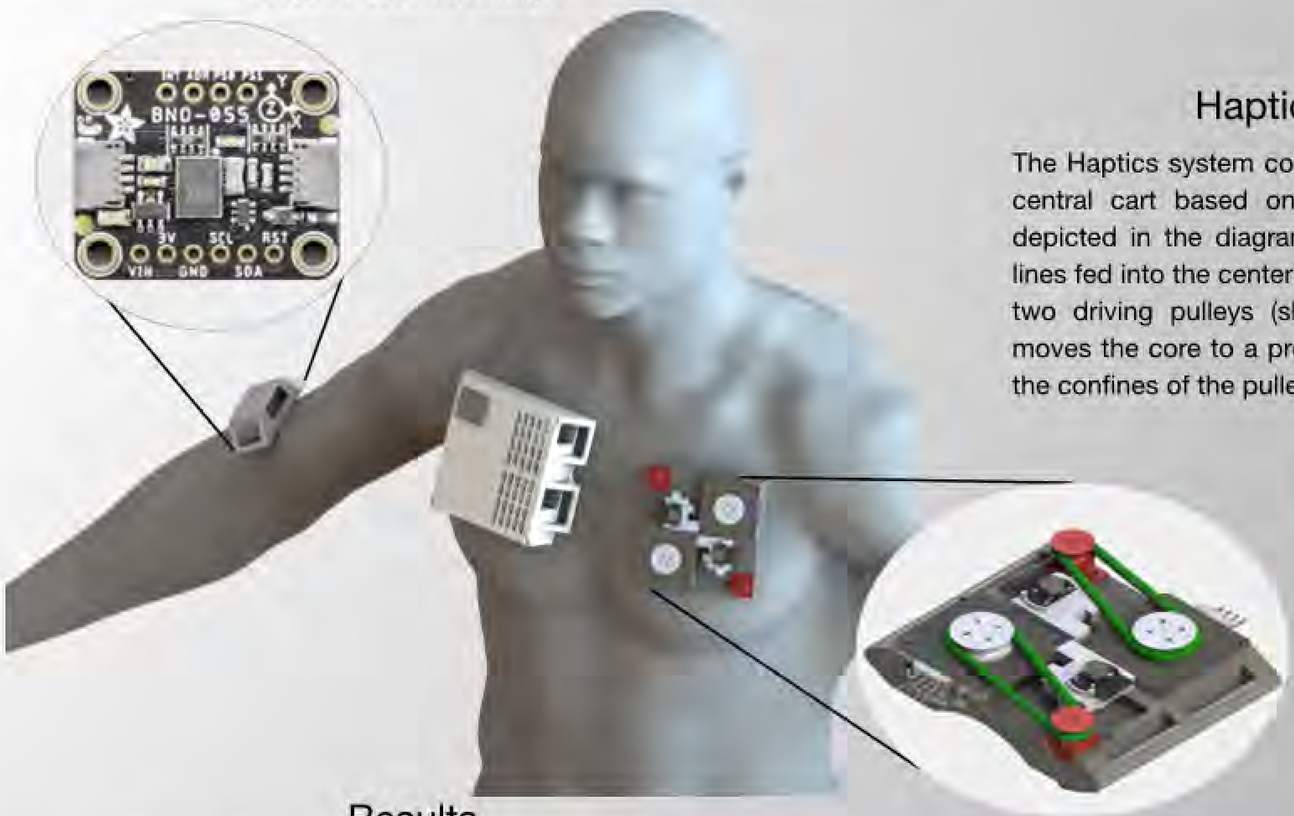
Problem

Our design problem comprises creating two wearable systems – one for sensing shoulder motion through inertial measurement units, the other for conveying this shoulder movement to the user through haptic feedback.

The user experiences a ball caster gliding across their skin on the unaffected half of their upper-chest. The motion of the ball corresponds to certain motions of the affected shoulder, but the data controlling this motion must be interpreted appropriately.

Shoulder Sensing - Method

We use two Inertial Measurement Units (IMU's) on the shoulder and chest. With these, we can compare the differences between the headings and get the rotation from one IMU to the other. When we affix one IMU to the chest and one to the arm, this rotation is the angle at which the user has moved their shoulder.



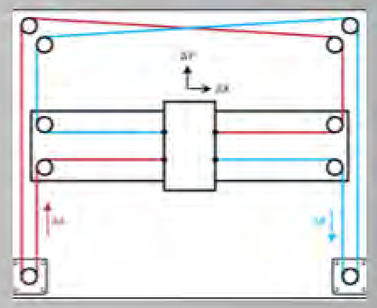
Results

Through testing, we were able to determine the speed and accuracy of the sensing and haptics systems. Our final build satisfies the intended design specifications

Key Metrics	Goal	Pass/Fail
Haptic Dimensions	< 38x100x100 mm	Pass
Feedback speed of system (Delay between motion and feedback)	< 1 s	Pass
Accuracy of angle measurement	±10 °	Pass
Weight	< 1000 g	Pass
Accuracy of feedback system	± 5 mm	Pass
Operable on battery power	True	Pass
Speed of Haptics System (Minimum time to cross the full range of motion)	<= 1 s	Pass

Haptic - Method

The Haptics system consists of several pulleys and a central cart based on the CoreXY theory. This is depicted in the diagram below as the blue and red lines fed into the center rectangle. The manipulation of two driving pulleys (shown in the bottom corners) moves the core to a precise location anywhere within the confines of the pulleys.



Haptics Specifications	
Size	100 x 100 mm
Height	27 mm
Weight	350 g
Speed	132 mm/s
Accuracy	± 2.5 mm

Conclusion

We have successfully created a system that is capable of sensing the user's shoulder movement and translating that information into haptic feedback in the form a moving contact on the users chest. The product meets all of our key design metrics. Moving forward, there is room for improvement - particularly in areas of size, fluidity of motion, user studies, and aesthetic.