Pilot Study with a Gyroscopic Hand Rehabilitation Device

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Summary

A portable and compact gyroscopic device was developed for hand rehabilitation. This pilot study validated the device's design and assessed the prospect of using it for therapy. Specifically, the study focused on whether: (i) the gyroscopic torque, generated by the device, can passively move the user's hand and (ii) the produced hand motion can be controlled.

Introduction

Around 795,000 people in USA experience strokes annually [1] and many consequently suffer from hand disabilities such as spasticity, weakened strength, and co-ordination [2]. Gymball – a portable gyroscopic device, was developed for hand rehabilitation. It consists of a fully actuated rotor and gimbal, the details of which can be found in [3]. On controlling the motion of the rotor and gimbal, the generated gyroscopic torque can be changed. The user may choose to either (i) relax the hand and comply with the motion imposed by the gyroscopic torque or (ii) resist the imposed motion. While the former, the focus of this study, aids in relaxing the hand muscles, the latter helps in strengthening of the same.

Methods

A healthy 25-year-old male was recruited for this study. The subject was asked to relax the hand while exerting minimal effort to hold the Gymball. The experiment involved six different sets of operating conditions which have been tabulated in Table 1. Two trials were conducted for each set.

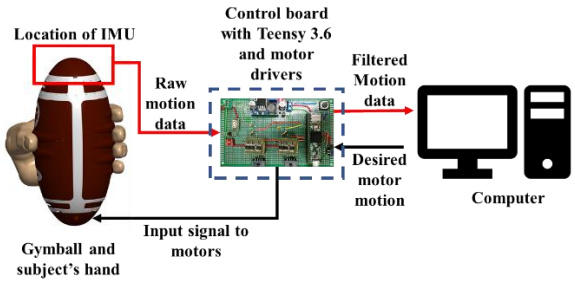

Figure 1: Experimental Setup

Table 1: Sets of operating conditions: the velocity of rotor (R) and gimbal (G) in rad/s

#	1	2	3	4	5	6
R	150	150	−150	−150	150	−150
G	37	−37	37	−37	$37\sin(0.63t)$	$37\sin(0.63t)$

An IMU (MPU 9250), installed within the Gymball, was used to collect pitch and roll motion of the hand. The pitch axis aligned with the wrist's radial and ulnar deviations, while the roll axis aligned with the supination and pronation of the arm.

Results and Discussion

The observed hand motion imposed by the Gymball was considerably higher about the roll axis than the pitch. The positive angular displacements about the roll axis (supination) were greater in magnitude than the negative ones. Future testing will investigate if these are a result of the wrist stiffness varying with the direction of motion. Finally, the direction of the hand's circumduction is dictated by the direction of the gimbal's motion. This dominant character of the gimbal's motion direction was evident while testing Set 5 and Set 6, which involved directional switching.

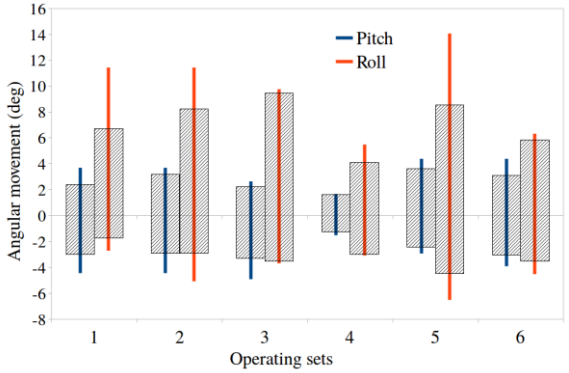

Figure 2: Range of hand motion about the pitch and roll axis. The hatched section represents the average range of motion while the vertical line signifies the maximum angular displacements across the two trials.

Conclusions

The Gymball can be currently used for generating motions about the wrist up to 10°. Future work will involve: (i) developing a controller to generate several hand motion patterns, (ii) conducting studies with human subjects (where tools such as Fugl Meyer and Modified Ashworth Scale will be used to judge the efficacy of the device), (iii) measuring the contact forces between the hand and the device, and (iv) increasing torque generated by adding more inertia to the rotor.

Acknowledgments

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References

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