MECHANICAL ENGINEERING
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HUR (HUman Rehabilitation) Group
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DESIGN OF A COMPACT AND PORTABLE HAND REHABILITATION DEVICE FOR STROKE-SURVIVORS

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INTRODUCTION

- About 795,000 people experience strokes in the US, annually [1].
- Many stroke victims suffer from hand disabilities such as weakened grip strength, lack of muscle coordination, and hand spasticity [2, 3].
- The state of the art hand rehabilitation devices:
  - focus on specific hand functions.
  - require a considerable active range of motion to operate.
  - are inapt for patients with hand spasticity [2].
- A new compact and portable Hand Rehabilitation Device (HRD) is proposed that would:
  - not demand user's input.
  - rehabilitate the hand in a holistic manner.
  - US Patent Application: 62/413,130.

CONCEPT

Principle

- The HRD is a fully actuated rotor-gimbal assembly, which when actuated imposes a gyroscopic torque on the user's hand. (See Fig. 1)

Functionality

- There are two kinds of therapies that can be implemented with such a device:
  - One involving synchronization of the hand movement with the generated torque – leading to hand muscle relaxation.
  - Another requiring the user to resist the torque – potentially increasing hand muscle strength and coordination [4].

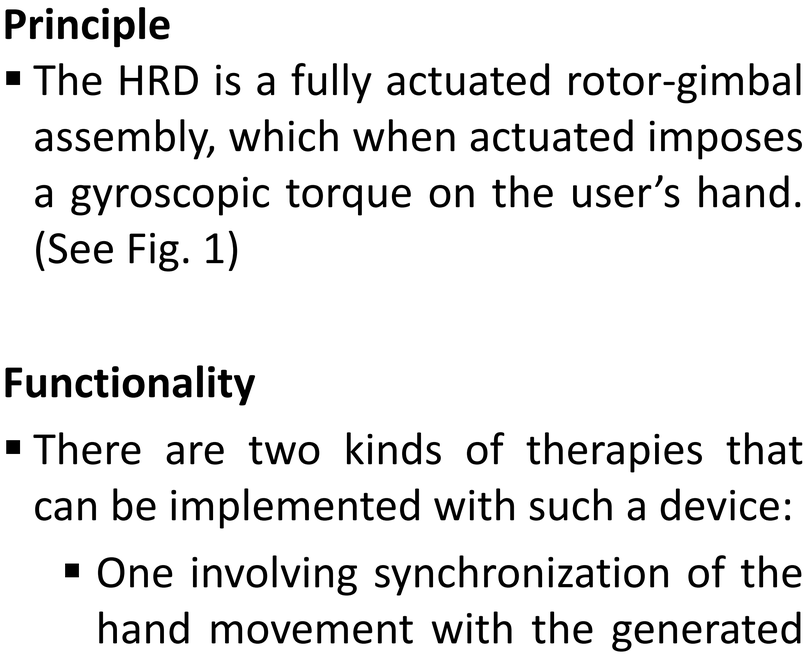

Fig. 1 Device schematic: the red, blue and green components represent the user's hand, gimbal and the rotor, respectively.

Proof-of-concept

- The proof-of-concept model consisted of a fully actuated rotor-gimbal assembly.
- It was observed that the hand holding the device was forced to move about the wrist in a circular and periodic manner.
- It was verified that the imposed hand motion could be manipulated by varying the motion of the rotor-gimbal assembly.

Target specifications

- The HRD should produce a minimum desired gyroscopic torque of 0.7Nm (the amount required to open a jar's lid – an activity of daily living) [5].
- The mass of the device was limited to approximately 550g (mass of a commonly carried half-liter water bottle – another activity of daily living).
- Portability was another desired feature.
- The device should compact – ideally smaller than sphere of 90mm diameter.

FINAL DESIGN

- Mathematical simulations revealed that for the final design can produce a peak to peak torque of magnitude 0.6Nm was attainable.
- This torque can be increased by using high density alloys for the rotor housing.

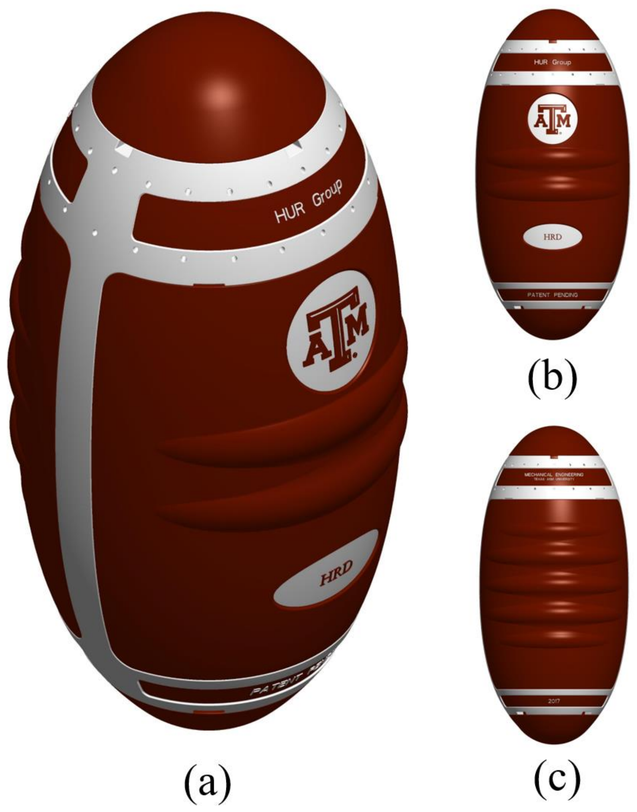

Fig. 2 Multiple views of the device: (a) Isometric view, (b) Front view, and (c) Back view

- The final product was designed to resemble an American football, so that it would appeal to the user. (See Fig. 2)
- Finger holds provided on the front and back of the device facilitate a cylindrical hold.
- The electrical systems are placed external to the device in a satchel that the users can wear.
- Wires for the rotor assembly are mechanically coupled to the motor's leads via a slip ring assembly.
- To ensure symmetry in the design and to avoid rotary imbalances, the rotor and the gimbal housings were directly integrated with the permanent magnet rotor of the chosen brushless DC motors.

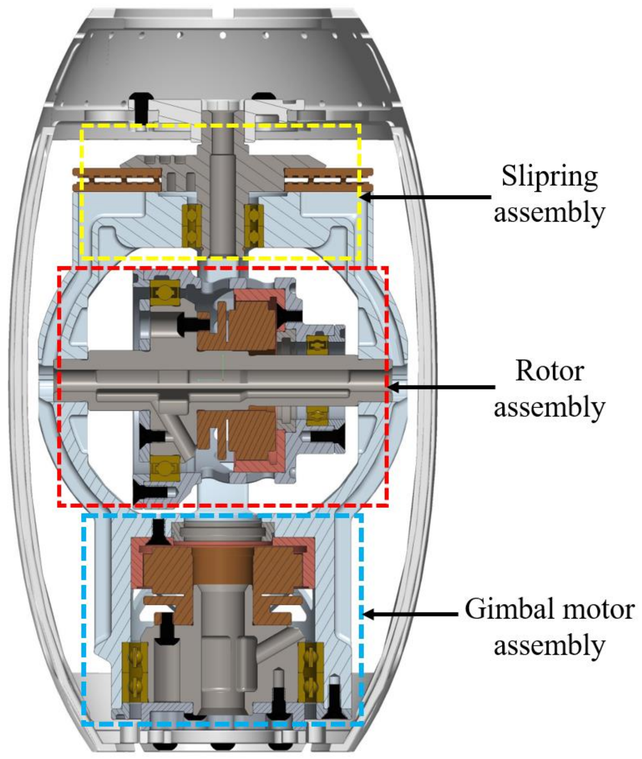

Fig. 3 Main components of HRD

- The structural integrity of the device was assessed through dynamic analysis of the device using Solidworks Motion.
- The forces imposed by the device on the hand were estimated through a simulation. It was found that the imposed forces are within tolerable limits for stroke patients.

CONCLUSION

- Upon fabrication, the device's performance will be evaluated by investigating the motor outcome of the hand and the upper limb post stroke. Fugl-Meyer hand function and Modified Ashworth Scale (MAS) will be evaluated.

Future direction

- The application of the device can be extended to other patients with hand function problems: patients with arthritis, Carpal Tunnel Syndrome, and those recovering from hand injuries/surgeries.

Acknowledgements
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