Flying Squirrel

NAU NORTHERN ARIZONA UNIVERSITY
Mechanical Engineering

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Abstract

Most stroke rehabilitation devices accessible to people recovering from strokes are large, expensive, cumbersome, and only available for use at hospitals/physiotherapy clinics, so most people can only use them for a few hours per week. The problem we are trying to solve is to create an affordable yet effective at-home physical therapy for stroke rehabilitation that is simple to set up and use. This included learning from problems that emerged during the making of the previous iteration which included a lack of traction due to the propulsion system and a tendency for tipping. These issues influenced the design of the flying squirrel to be cable driven with anchors at the top and bottom to restrict the tendency for tipping and lack of traction. An additional component that was required for this project was motion in the vertical direction in conjunction with horizontal movement to provide exercises with movement that better mimics the motion of the arm, instead of constraining it to the table's surface. The use of lead screws as a lifting mechanism allows for a 1-foot vertical range of motion, and when combined with the cable system enables speeds of 1m/s and forces up to 10N in any direction. In addition, the use of a load cell also allows for variable force output to provide a constant force against the user for muscle redevelopment as well as motor control improvement.

Customer/Engineering Requirements

Table 1: Customer Requirements

Customer Requirements	Importance to Customer (5 highest – 1 lowest)
Precision and Accuracy	5
Cosmetics	1
Affordability	1
Portability	2
3rd Dimensional Movement	5
Life Span	3
User Friendliness	2

Table 2: Engineering Requirements

Engineering Requirements	Technical Importance (7 highest – 1 lowest)	Technical Requirements
Speed	4	1 m/s
Force	5	10 N
Production Cost	1	$ 1000
Size	2	8"x8"x19"
Control and Detection	7	±0.1 mm
Run Time	3	30 minutes
Backlash	6	±0.1 mm
Aesthetics	1	Client Approval

Methods

- Structural components 3D printed out of PLA:
  - Base
  - Top Structure
  - Handle and mount
  - Pulleys
- Motor force output measured using luggage scale
- Battery life tested with human resistance and timer
- Force sensor verified with known weights

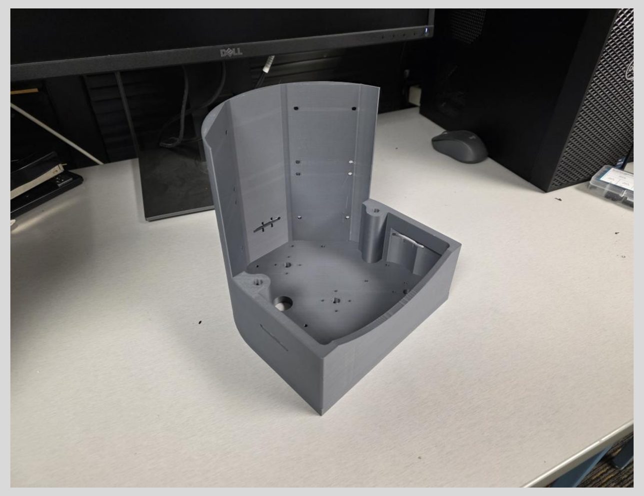

Figure 2: 3D Printed Base

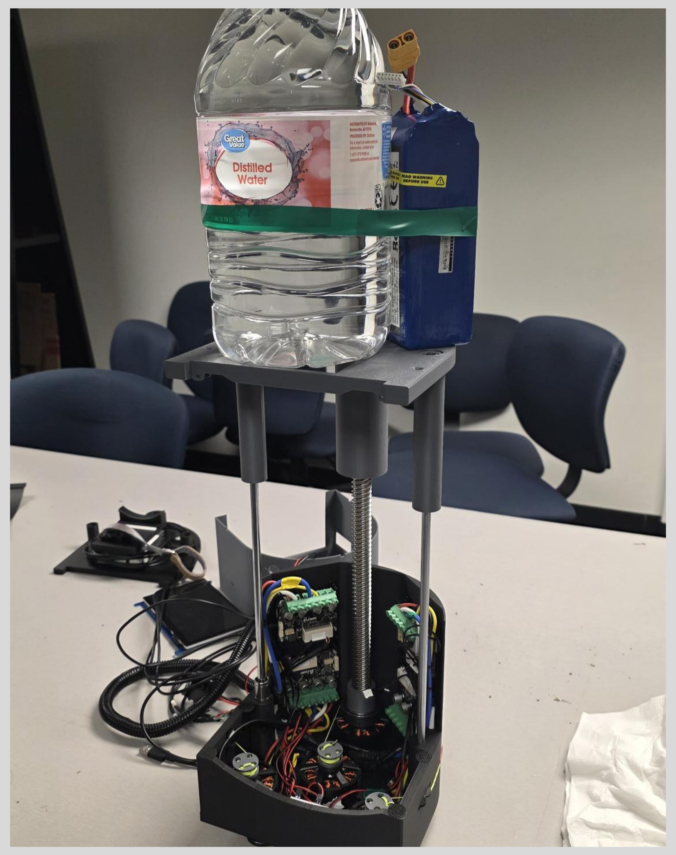

Figure 1: Z Motor Force Output

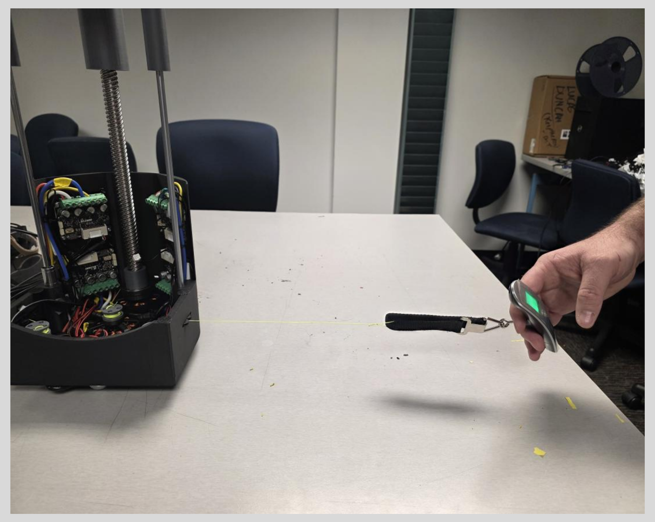

Figure 3: XY Motor Force Output

Figure 4: Battery Life Testing

Figure 5: Cable Anchor

Results

- XY motors were able to output a minimum of 29 Newtons of pulling force
- Z motor was able to move top assembly with hand
- Robot was able to move 1 meter per second
- Battery was able to keep robot moving for 30 minutes
- Final dimensions of robot ended up being 8" by 8" by 19" when top is fully down
- Final construction price of robot was approximately $2800

Figure 9: Physical Model

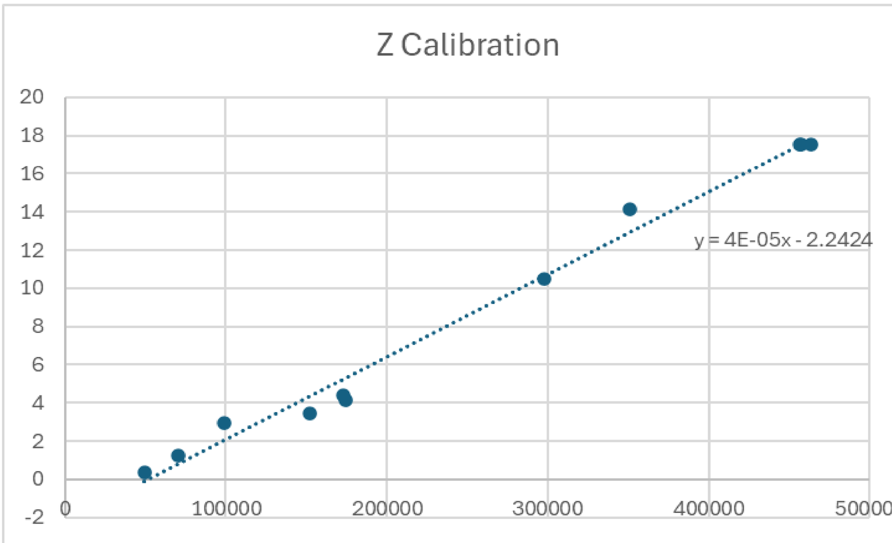

Figure 10: Z –Axis Force Sensor Calibration Data Points and Best Fit Line

Conclusion

- This device will make at-home therapy available to more patients
- The sponsor/client applied his expertise in robotics and control systems to guide the project
- In the future, this design will see actual use by patients in their homes, and be tuned for greater efficiency and ease of use
- Originally production cost was $1000 but after selection of motors and force sensor this cost was considered unobtainable
- XY movement motors were able to far exceed the force requirements
- Z movement motor was able to meet the force requirement
- The battery can supply the robot with power for longer than the required time

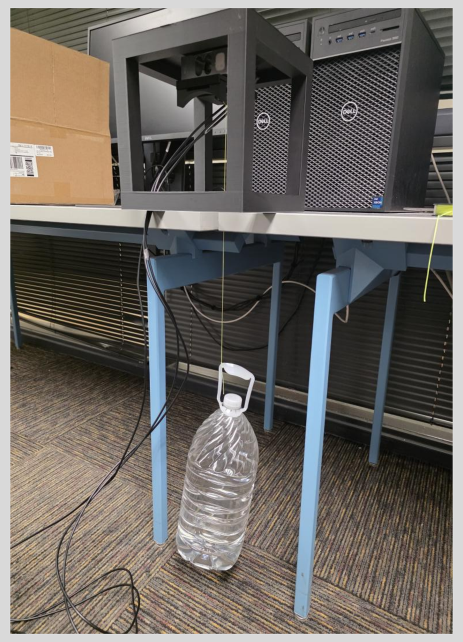

Figure 6: Force Sensor Testing

Figure 7: Creality K2 Plus

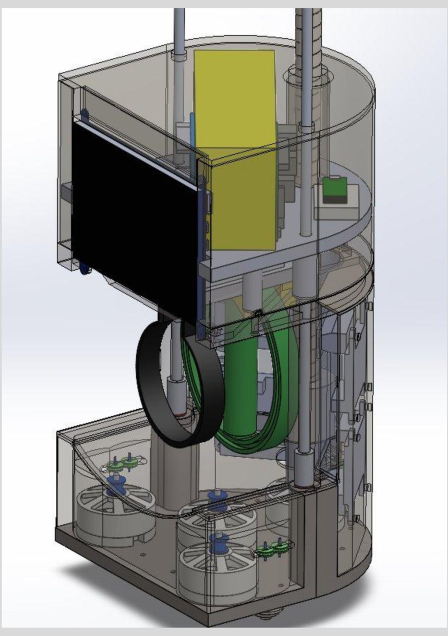

Figure 8: CAD Model with Internals

References

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