U-Cube: Spider Cage for Cerebral Palsy Patient

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Abstract

Cerebral Palsy is an incurable neurological disorder that mostly affects children. There are current therapies available for the treatment of CP, but they are complex, expensive, and not easily accessible. The goal of this project is to develop a spider cage device and full body suit tailored to a specific individual with a design that can be generalized to fit a wider-reaching audience once it is made available on United Cerebral Palsy of Greater Dane County's website. This device will need to be easy to fabricate, safe, and less expensive than previously made designs

Background

- Cerebral Palsy (CP) is a neurological disorder that disrupts an individual's ability to maintain proper motor control[1]
- Results from damage sustained to brain during early neurological development
- Non-degenerative and incurable
- Effects about every 1/323 children in the United States[2]
- Current designs include a fencing unit, a harness similar to a rock climbing harness, and bungee cords connecting the harness to the sides and tops of the surrounding fence.
- Commercially available cages cost between $5500 and $7000
- TheraSuit is the current leading design with respect to CP "suit therapy"[3]
- Suit training costs $1600/week
- Comes in one size fits all for adults

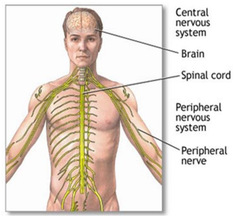

Figure 1: CNS and PNS diagram (1)


Figure 2: TheraSuit (2)


Figure 3: Spider Cage (2)


Figure 4: Spider Cage (2)

Motivation

Problem Statement: Design a device that is cost effective, easily replicated, and can function safely even when used alone so that individuals with CP can continue to improve their overall quality of life.

Design Specifications

- The spider cage design must:
  - Fit into the client's barn
  - Support a 230 lb. man
  - Include a full body suit
  - Cost less than the commercially made devices priced at $7000
  - Be easy to assemble
  - Include safety features to protect client's wellbeing

Final Design

- Structure specifications
  - 8'x8'x8' cube
  - Customizable height
  - Telescoping features
  - Open face for entry
  - Easy to assemble/disassemble
  - Heaviest part is 12.8 lbs
  - Perforations every 1 inch for customizable attachment
- Total cost: $1,196.20

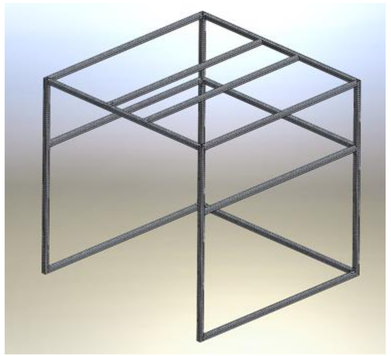
Figure 14: U-Cube SolidWorks design

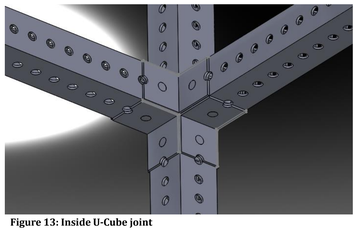
Figure 13: Inside U-Cube joint

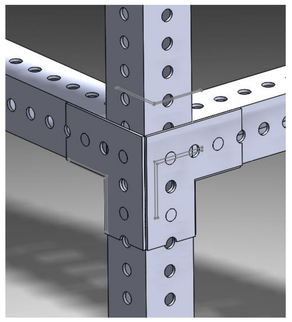
Figure 15: Outside of U-Cube joint

Part	Amount
10' 1-3/4" X 1-3/4" perforated square tubing 14 GA	2
16' 2" X 2" perforated square tubing 12 GA	14
Corner Bolt Small for 2" Anchor	60
5/16" Heavy Hex Jam Nut for Corner Bolt	60
Lock Pin (3/8" Gravity Pint Lock Thru 2-1/2")	16
L-Fitting For Telespar (1-1/2" Fitting)	4
Sign Bracket 90 Degree Fitting (1-1/2" Fitting)	20

Table 1: U-Cube part quantities

Testing Procedure

- Subject wore rock climbing harness and was attached to stand alone pull up bar
- Tests were performed at 100% weight as control, then at various weight suspensions
- Exercises performed with Xbox Kinect:
  - Standing jump both legs (10 times)
  - Standing jump left leg (10 times)
  - Standing jump right leg (10 times)
  - Jog in place (10 seconds)
  - Drop jump from step stool (10 times)
- Exercise performed with Wii Balance Board:
  - Left leg balance with eyes closed (30 seconds)

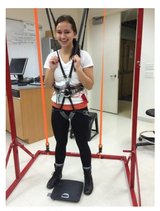
Figure 7: Testing


Figure 8: Testing

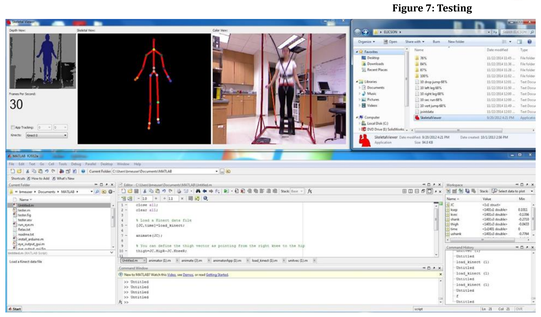

Figure 9: (Top left) Skeletal Viewer program opened using C++ code. (Top right) various .txt files created from Skeletal Viewer program. (Bottom) MatLab code that animates .txt files created by Skeletal Viewer.

Results & Discussion

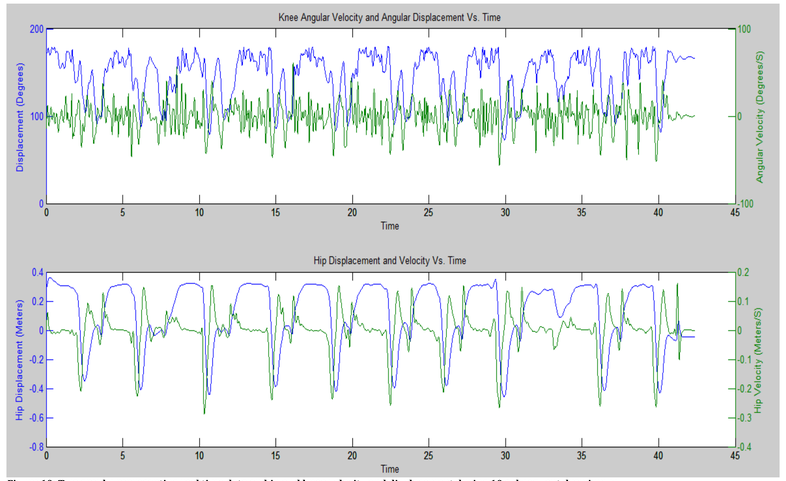

Figure 10: Two graphs representing real time data on hip and knee velocity and displacement during 10 subsequent drop jumps

- Downward velocity (green) peaks before downward displacement (blue).
- Max velocity and displacement taken at 10 most negative peaks and averaged between trials at different suspended weights to provide 6 different means for each variable over a range of 0% to 40% normalized weight suspension.
  - $R^2 = 0.9361$
  - $SS_{resid} = 0.0032$
  - $SS_{total} = 0.0499$
  - $R^2 = 1 - SS_{resid} / SS_{total}$
  - $R^2 = 0.6565$
  - $SS_{resid} = 0.0005$
  - $SS_{total} = 0.0015$

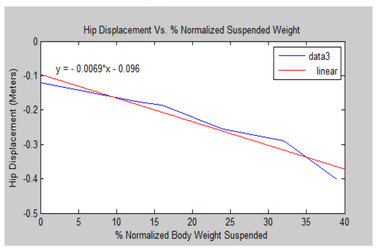

Figure 11: Hip data during drop jump

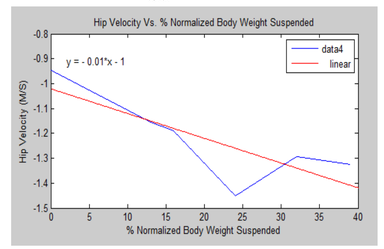

Figure 12: Hip data during running

Future Work

- Continuing project next semester
- Will finalize design of cage, acquire funding, purchase materials, build prototype, and perform further analysis
- Will design suit/harness
- Integrate all data and technology together for final design

Acknowledgements

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References

[1] Alvarez, N. (n.d.). Cerebral Palsy Causes, Symptoms, Treatment - Cerebral Palsy Causes - eMedicineHealth (W. Shiel, Ed.). Retrieved October 6, 2014, from http://www.emedicinehealth.com/cerebral_palsy/page2_em.htm
[2] Data & Statistics for Cerebral Palsy (CDC). (2013, December 27). Retrieved October 6, 2014, from http://www.cdc.gov/ncbddd/cp/data.html
[3] TheraSuit Method. (n.d.). Retrieved October 8, 2014, from http://www.suittherapy.com/