Preliminary Investigation Report

The purpose of this document is to help you identify specific needs within the broad domain of physical medicine and rehabilitation. (i.e. this is where you do the research! You are identifying your own problem statement to solve for this competition—this gives you more flexibility to pursue your interests). For this report, pick an area of interest like "improve wrist mobility" and deeply research that area. Please conclude with a brief statement on how you would go forward from here.

Here is a quick resource to get you started: (yes, it's chegg. 😊)
http://www.chegg.com/homework-help/describe-six-steps-typical-preliminary-investigation-analyst-chapter-2-problem-5q-solution-9781285633190-exc

DEADLINE TO SUBMIT: MARCH 9th, 2018, Midnight
One doc per team.
SUBMIT IT HERE: https://goo.gl/forms/sAGewglaL1JZ2SP63

After you submit this proposal, your team may be selected to continue in the competition and you will then work to develop a specific need statement, a set of functional requirements, and a prototype.

Problem Domain Area: Prostheses for people with C6/C7 injuries

TEAM MEMBERS	PROFESSIONAL MENTORS	ACADEMIC MENTORS
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Project Start Date	**3/7/18**
Document Updated	(for committee use)
Checked & Approved	(for committee use)

Relevant Definitions:
- Quadriplegia: the term defining paralysis of the upper and lower limbs. Also known as tetraplegia.
- Paraplegia: paralysis of the lower limbs.
- C6 and C7 are the names for the 6th and 7th spinal vertebrae of the neck, in descending order. Injuries in these locations may cause either full or semi-tetraplegia.
- Nonsteroidal Anti-inflammatory Drugs (NSAID) are used to help reduce inflammation in the area of cord damage while helping to aid as much motor and/or sensory function.
- Anterior cervical discectomy and fusion (ADCF) surgery is done to allow entire frontal access to the cervical spine in order to remove the disk between two vertebrae bones and a fusion is done to stabilize the cervical segment by grafting.
- Electromyography (EMG) is a electrodiagnostic technique used to record electrical activity produced by skeletal muscles. Most oftenly these signals can be used to analyze abnormalities and activation level in human movement.

General Background:

Every year about 40 million people are affected from spinal cord injury, most of which are young adults ranging from 20 to 35 years old (Yip, 2012). 1% of those affected are children and primarily occur within the cervical region (Mahan, 2009). One particular spinal cord injury that occurs frequently is the C5, C6 and C7 nerve root, located at the lowest levels of the cervical spine. This vertebrae region affects muscles in the arm and hands and provides support and protect the spinal cord. Most oftenly, symptoms include numbness and paralysis to control motor functions as well as a false cause of carpal tunnel syndrome (Levine, 2016). Treatment concerning this region of spinal cord injury include surgery, medication including NASID, and physical and mental therapy being the most important in recovering lost functions (C6,C7,C8 Spinal Cord Injury, n.d.).

Problem Summary:

Despite having surgeries, such as an ADCF which is commonly used to treat a C6, C7 problem, there is still a need for physical therapy to recover (Levine, 2016). For patients with acute and subacute damage to their spinal cord, their condition is stable enough to try to transition back to their daily activities. However, complications may arise in the long term, so physical therapy is relied upon. One of the most important complication is joint contractures in the extremities. Conditions which impair movement in the hands and finger severely limit a person's ability to live on their own, from not being able to open a door, to not being able to dress oneself. A solution that would allow a person affected by such an injury to open and close their hand, and therefore grab, pick up, open, and possible twist objects and fixtures would greatly enable that person to live more independently.

Existing Solutions:

In order to let those affected by motor impairment in the upper limbs, prosthetic and wearable devices have been developed to restore the ability to use their hand as one normally would; this includes to pick up and manipulate objects, open doors, and to do other things independently. Current prosthetic devices consist of the MyoFacil system from Ottobock. The system consists of a solid basic fitting that covers the hand and opens and closes through muscle signals.

Another existing solution is the prototype bionic glove made by inventor Peter Abolfathi, that won the British Council Eureka Prize for Inspiring Science. This invention is equipped with wires that mimic tendon and ligament movements and with the slightest movement, the cables would move. Another similar invention is the Exo Poly Glove, which like the aforementioned device, allows movement in the hand using cables which contract, being attached to the tips of the fingers, and closes the hands in a natural way so as to let the user grab things. This devices uses an actuator that moves the cables.

Current Limitations of those Solutions:

Limitations to current solutions for a prosthetic device is using surface electrodes to record EMG activity in the muscles. Most oftenly from recording EMG activity there contains motion artifact generated from the stress and strain of the double layer interface. This problems results in a lower accuracy in deciphering and obtaining clear signals. Obtaining these signals from electrical appliances can also have its own limitations including the type of material used. For instance, the Ag/ AgCl is good at recording measurements and helps fix motion artifacts generated from electronics; however, it is fairly toxic as a biomaterial. Often times, there may occur thermal or resistance noise occurring from the interface of the product. Flicker (pink) noise is composed in all electrical devices including the impurities between the fluctuations in the voltages applied.

Another aspect of limitations in these solutions are inefficiencies in letting the user effectively do what they need to do. If a button is needed to be pressed, there is a real-time inefficiency in performing an action. If the electrodes which attempt to read electric activity in the muscles misinterpret some signal, there is decreased practicality in the solution.

Other Solutions currently in Preliminary Stages:

Currently, the bionic glove by Peter Abnolfathi is now trying to improve how it can control its artificial muscles electronically using tiny crystal monitors, an alloy that remembers their shape.

Relevant Patents:

Patent No.	Name	Source
	MyoFacil System	https://www.ottobock.com.au/prosthetics/upper-limb/solution-overview/myofacil-prosthesis-system/
	Bionic Glove	https://www.smh.com.au/articles/2004/08/10/1092102451636.html
Developed in South Korea	Exo Glove Poly	http://biorobotics.snu.ac.kr/rehabilitation-robot/exo-glove-poly/

(Briefly) Where do you see new potential for a device? i.e. how can your team contribute to a solution in this area?

Currently, there doesn't seem to be a cost effective and sufficiently effective solution that can allow a user to perform what they want to do in a way that is most efficient. The level of efficiency is dependent on the user and their level of motor impairment/disability. If a person is able to move their arms, and not their fingers, an efficient solution for them might be to activate movement in one of their arms (through use of a wearable device which mimics hand contraction) by a gesture, or movement. If a person is completely paralyzed from the neck down, an efficient solution might be voice activation of a device (which would allow arm and finger movement) using a keyword or phrase. The goal of a solution we want to create is one which will allow the users the ability to do what they need to do in their daily lives, and to decrease dependency on others.

References/Resources

(n.d.) C6, C7, & C8 Spinal Injuries. Retrieved from https://www.spinalcord.com/c6-c7-c8-vertebrae-spinal-cord-injury

Levine, J. E. (2016). All about the C6-C7 Spinal Segment in the Neck. Retrieved from https://www.spine-health.com/conditions/spine-anatomy/all-about-c6-c7-spinal-segment-neck

Levine, J.E. (2016). C6-C7 Treatment. Retrieved from https://www.spine-health.com/conditions/spine-anatomy/c6-c7-treatment

Mahan, S. T. ,Mooney, D., Karlin, L.I.,& Hresko, M T. (2009). Multiple Level Injuries in Pediatric Spinal Trauma. Journal of Trauma and Acute Care Surgery, 67, 537-542.

Nas, K., Yazmalar, L., Şah, V., Aydın, A., & Öneş, K. (2015). Rehabilitation of spinal cord injuries. World Journal of Orthopedics, 6(1), 8–16. http://doi.org/10.5312/wjo.v6.i1.8

Yip, P. K., & Malaspina, A. (2012). Spinal cord trauma and the molecular point of no return. *Molecular Neurodegeneration*, *7*, 6. http://doi.org/10.1186/1750-1326-7-6

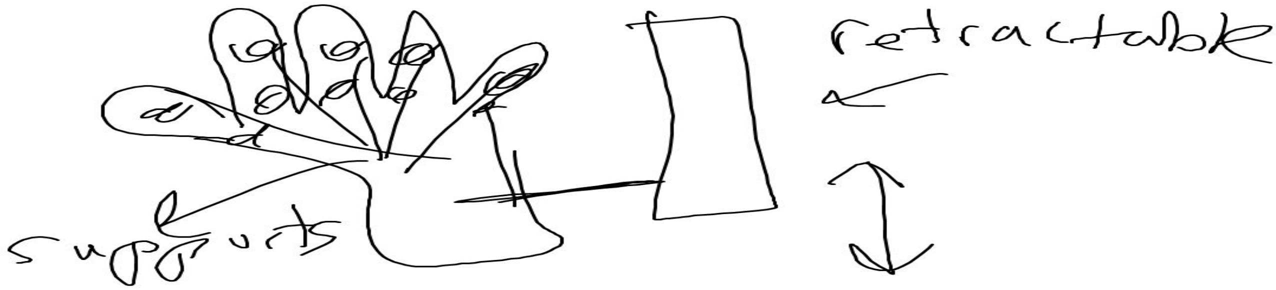
3/21/18
NOTES:

- For people with abnormal resting hand positions, prosthetic can naturally open the hand to make grasping bigger things easier (whether with a firm material or mechanical action)
- Form: tendons that flex from the underside of the hand (like natural tendons)
- Waterproof?
- Rechargeable battery?
- The exo-glove uses button, can we use electrode or voice recognition instead?
- LImitations: how strong to grip, shape of objects, when to stop gripping (pressure sensor - these are normally very expensive)
- Can we use minute electric shocks to pinpoint finger muscles for more accurate movements? How to detect intention (voice recognition?)
- We need to go to maker space to see what materials we can get and what we need to order (buy from outside) (Maker Studios EER schedule Mon-Fri 8-8PM)
    - Material Ideas:
        - Artificial Muscles: https://en.wikipedia.org/wiki/Artificial_muscle
        - Mechanical
        - Flexes to water vapor: https://gizmodo.com/5975218/this-polymer-film-flexes-like-an-artificial-muscle
        - Nylon fiber flexes to heat (relatively cheap): http://news.mit.edu/2016/nylon-muscle-fibers-1123
        - Electroactive polymer (flex with electricity): https://en.wikipedia.org/wiki/Electroactive_polymers
- puya@viso.space the email for the guy who made the bionic glove
- http://www.jhuapl.edu/prosthetics/scientists/neural.asp articles talking about neural framework for controlling a bionic arm.

3/22/18 IDEAS:

Prototype idea-

#1)



Stick is retractable and helps the hand open. Supports are used to help make sure the hand can grab onto whatever we need to grab. Lastly to let go of the object that is desired, the supports has opening mechanism of releasing (button of somesort?)

Electrical impulse that controls hand movement. Designing software to help move hand

3/22/18 Meeting Summary:

- Drew found a UT lab (Reneu Lab) (https://www.youtube.com/watch?v=gZLO2Am0Zk8)
- who works on a glove that does exactly what we're interested in. We emailed them asking for advice and if they could meet with some of us by the end of next week.
- We want to decide the materials and form of our prototype by the end of tomorrow (Friday, 3/23)
- We went to the EER Maker Studios to ask about materials and services:
    - They have wood, 4 types of plastic:(PLA, ABS, Nylon, AMA), and PCB (Printed Circuit Board)
    - They have big mills and the laser cutter in the ETC maker studios (need training). Whoever out of Drew, Laura, and Fawad can get a laser training appointment first on Monday will be in charge of doing that.
- Our budget: $80, divided equally is $16/person

WORKSHOP 1 NOTES (3/23/18):

- Goal- sketch a prototype design outline with all the essential materials/parts we need, inputs/outputs, how we are going to implement it.
    - Design Goal: Independence in exoskeleton and be able to pick/grasp multiple objects. Access in open and closing fingers- bidirectional.
- Mentor Advice:
    - Articles and Ideas:

        - *Vok (publications july 2017)- paper & classification of grasps
        - Aaron? - Arizona) to define pressure sensors
        - maestro? (contains mechanical design)
        - NASA space suit mobile glove with GM (for pressure)fatigue problem with actuation at fingertips
        - **Harvard (lou)- robotic hands and graspers-
            - simple design (moving multiple joints at once with one input sensor)
        - *Maciejasz review paper on limb rehabilitation:
            - https://jneuroengrehab.biomedcentral.com/articles/10.1186/1743-0003-11-3
        - When reading papers, get the most of what we want to do? Check website!
    - Make it simple - 1 month to make prototype.
        - Passive element: assume resting position is open and then have one degree of freedom of closing. Linear #df = 2(actuators)
        - Less actuators and keep motors slow (cheaper alternative to do Impedance or benze control), potentiometer (for feedback)
    - Design Considerations
        - Where is the optimal place to put at pressure sensor?
            - - Dependent ons what you are grasping
                - ex) key grasp:
        - EMG incorporation to classify scope of grasping:
            - Pro: Follow up contribution to what we want to do and what we can do
            - big picture connection
            - Con: expensive
        - Loads on the hand based on the design (safety concern)
        - You can't do perfect torque with a tendon system,
        - actuation - thumb (fine manipulation) or finger,
        - Advice- how many degree of freedoms we need to move/grasp for your system.
            - Cons- less degree = less flexible but it could be simpler.
            - Ratio of degrees of freedom finger to thumb?
        - Issue on independence: How can we make sure the user can put on the device?
            - Putting the glove on: use a ramp, make sure the person can see their hand when putting on *glove,* and the directions they move their hand are different
        - Exoskeleton material (expensive but can make it cheap)
            - Advice: 1 finger/thumb.
            - Finger (more degrees of freedom of motion).
            - Most of material cost is using actuator and motor (major budget monster) to move finger/thumb.
        - Controls - Relatively slow

        - Impedance (~Resistance)- potentiometer
        - 2 broad controls: position and torque
            - Position control/gearbox w/o torque = limit commands or velocities for position based control (safety precaution for joint range)
        - Tendons = more compact but high force involved - damage (not too sure about costs)
            - Alternative- pulley system (possible forces in the palm)
                - helps reorient impact into the tendon which causes injury.
                - Con- loses compact because distributing high forces
        - All motors at axis (angle deflection sensing = potentiometer or encoder or rotational)
            - improves quality and finite range of motion
        - Joint angles
            - Joint angles - sensor at middle joint and palm and mechanical joint to move
            - Coupling(all joints) based on one.
    - Implementation software - need to research tutorial on how to use
        - PID (basic and widely controlled) - commanding motors to actuator in torque (torque sensing), gear boxing (torque awful), positional (caution injury related).

Summary:

- Make the prototype simple (1 month + $80 budget)
- Make a decision on what object or type of action we are grasping.
    - ex) key grasping, opening a door, grabbing a water bottle
    - Depending on what motion we need to design scope of mechanics.
- Recommend working with 1 finger/1 thumb or 2 fingers with an actualizer and motor
    - Consider how many degrees of freedom of movement in the finger.
    - Note Df = 2*actualizer (most of the money).
- Controls: need to implement slowly (safety precaution):
    - Choose between positional or torque control (read above)
- Need to learn how to implement PID (good for commanding motors and actualizer)

3/22/18 Meeting Summary:

- Cater glove size towards the population (i.e. if more women than men, make glove smaller)

- https://www.youtube.com/watch?v=5M_eDLyfzp8
- Pros/Cons to different methods to model the glove
    - Fabric/plastic glove
        - Pros
            - Comfortable
            - Discrete for user
            -
        - Cons
            - More difficult to clean
            - Need to design “waterproof’ or detachable circuit design
        - To-do/figure out before modeling
            -
    - Silicone mold
        - Pros
            - Easy to clean
            - More durable
            - Can design shape to meet electronic needs
        - Cons
            - More effort to fit onto user (new molds)
            - Need to ‘set’ the electronics into silicone
        - To-do/figure out before modeling
            - What material to use and where to get it
            - Build mold for model in solidworks
- General TO DO:
    - To do for actuator:
        - Find and purchase servo
        - Design system to use one servo, possibly with gear mechanism
    - For program/software
        - What board/microcontroller to use
        - What IDE/language to use
        - Interfacing inputs/outputs

    - Hard plastic exoskeleton
        - Last resort
    - Designing commands for
        - Activation
        - Grip strength
        - Release
        - Differentiation between touching and grabbing

PAPERS TO READ:

1. **Reneu Papers: https://reneu.robotics.utexas.edu/publications**
2. **PID Theory (important with designing): http://www.ni.com/white-paper/3782/en/**
3. **Papers about making an exo-glove: https://drive.google.com/open?id=1PSzs1ckGEWVifpMgczV9_fr4SvODNJ9r**

Design Ideas so Far(April 2nd):

@fawad-
https://create.arduino.cc/projecthub/robotgeek-projects-team/control-a-small-linear-actuator-with-arduino-315815

- Using a small actuator with arduino (tutorials)

Breaker cable

- Springs at joints that have knobs to adjust tightness so resting position is open hand. This makes it so we only have to worry about closing the hand.The knob can have a dial system so whatever the knob is tightened to we can adjust the amount of force to overcome the springs+close the fingers
- Use stoppers on the bolts of the joints of finger to stop ROM of particular part of finger at a specified angle, this ensures that the fingers close as expected. Stopper can also be used on opposite side of bolt(opening of hand) to prevent the hand from opening too much and straining the ligaments

Budget: $70 spending max and maybe $100 (if reusable items). Total material cost $120. Must turn in receipts by 4/13 midnight.

(current spending $65.29) - green+yellow (excluding arduino)-73.80

Green- have/approved/ordered

Yellow-confirm with group/ waiting on order

Red- finding materials/need help

- 2 servos - ($18 each) - $36
    - 20kg*cm high torque at 6.6V , control angle 270 degrees (LewanSoul LD-27MG)

Product description

Specifications:
Weight: 65g(2.32OZ)
Dimension: 40*20*40.5mm(1.57*0.78*1.59inch)
Speed: 0.16sec/60°(7.4V)
Torque: 20 kg·cm (277.6 oz·in) @6.6V
Working Voltage: 6-7.4V
Min Working Current: 1A
No-Load Current: 100mA
Spline: 25T(6mm in diameter)
The servo wire: 30cm(11.8inch) in length

Control Specifications:
Control Method: PWM
Pulse Width: 500~2500
Duty Ratio: 0.5ms~2.5ms
Pulse Period: 20ms

Wire Layout:
Red Wire: +
Black Wire: GND
White Wire: PWM/Signal

Please make sure that the duty cycle of the controller you are using conform to our specifications, otherwise the servo can't turn up to claimed degree

Package Contents:
1 x Digital servo
1 x Servo horn kit(as shown in the figure)

If you have any questions, please feel free to contact us, we will help you as soon as possible

Note:
Please be sure to avoid locked-rotor when using servo, locked-rotor means that artificially or machine obstructs the servo to rotate normally, the locked-rotor will lead to internal current increased to more than 7 times and the temperature increases, servo will burn out.

Notice for use:
1. It's recommended that use lithium polymer battery with high rate discharge(min 5C), please don't use dry battery.
2. Please use a short and thick power cord, don't use Dupont cord

- 3D printing - Free
- Arduino uno - $8.51
- 4 wires - wire rope $1.68 + sheath (about to get)**
- Buttons (attached with velco)
- Battery casing - 3D print (Free)**
- Spool - 3D print (Fee)**
- Armpit attachment - 3d print (Free)**
- Spring for starting position ????
- Protoboard - Laura has**
- Belt with velcro- ???
- ~~Relay - $9 for 5 (alternative method: use stepper motor to servo)~~
- Shoehorn cuff - ??- 3d proint
- Force Sensors - adafruit round force sensitive resistor (402) - $13.11

Product description

FSRs are sensors that allow you to detect physical pressure, squeezing and weight. They are simple to use and low cost. This sensor is a Interlink model 402 FSR with 1/2 diameter sensing region.

FSR's are basically a resistor that changes its resistive value (in ohms Ω) depending on how much its pressed. These sensors are fairly low cost, and easy to use but they're rarely accurate. They also vary some from sensor to sensor perhaps 10%. So basically when you use FSR's you should only expect to get ranges of response. While FSRs can detect weight, they're a bad choice for detecting exactly how many pounds of weight are on them.

FSRs are made of plastic and the connection tab is crimped on delicate material. The best way to connect to these is to simply plug them into a breadboard or use a clamp-style connector like alligator clips, female header, or a terminal block. It is possible to solder onto the tabs but you must be very fast because if your iron is not good quality or you dally even a few seconds, you will melt the plastic and ruin the FSR! **Don't attempt to solder directly to your FSR unless you are absolutely sure you have the skills to do so.**

For a full tutorial with wiring diagrams, code examples and project ideas, please read the FSR tutorial page !

Product information

Package Dimensions	2.4 x 1.4 x 0.1 inches
Item Weight	0.32 ounces
Shipping Weight	0.16 ounces (View shipping rates and policies)
Manufacturer	Adafruit
ASIN	B00XW2MIRQ
Customer Reviews	1 customer review 5.0 out of 5 stars
Best Sellers Rank	#5,844 in Computers & Accessories > Computer Components
Date first available at Amazon.com	May 19, 2015

Feedback

If you are a seller for this product, would you like to suggest updates through seller support?
Would you like to tell us about a lower price?

- Power source - 2 batteries ($14.25 for 2) - $14.50
  - 15A (lithium ion battery), 3000mAh, 3.6V (Samsung 30Q INR 18650)

Product description

Specs:

- Style: Flat Top
- Chemistry: INR
- Nominal capacity: 3000 mAh (Max)
- Max Continuous Rated Discharge: 15A (at -20 to 75 degrees Celsius)
- Dimensions: 64.85 ± 0.15 mm (L) x 18.33 ± 0.07 mm (D)
- Weight: 48g (Max)
- Discharge Cut-off Voltage: 2.5V
- Nominal voltage: 3.6~3.7V
- Full Charge Voltage: 4.2V ± 0.05V
- Protected: No, Unprotected
- Cycle info: Capacity drops to 60% after 250 full charge/discharge Cycles
- Standard Charge: Constant Current 1500mA, Constant Voltage 4.2V, & Cut-Off 150mA
- Rapid Charge: Constant Current 4000mA, Constant Voltage 4.2V, & Cut-Off 100mA
- Operational Charging Temperature Range: 0 to 50 degrees Celsius (best below 45 degrees Celsius)
- Operational Discharging Temperature Range: -20 to 75 degrees Celsius (best below 60 degrees Celsius)

What You Will Receive:

- Samsung INR18650 30Q Flat Top Rechargeable Battery x2

4/6/18

Workshop 2:

Rapid Prototyping Presentation:

1. **Enumerate your requirements**
2. **Of all solutions, determine the fastest path to proving or disproving its viability**
3. **Design at a modular "unit" level**

Tools -- Shrink your problem space and test more quickly

A. **Simulate on softwares - can we simulate our exoskeleton in SOLIDWORKS?**
B. **3D Printing**
C. **Proto-board circuit designs**
D. **We can use "stack exchange" to find out what**

Arduino tutorial Packet:
https://playground.arduino.cc/uploads/Main/arduino_notebook_v1-1.pdf

Cable infomation:

http://ariel-square-four.blogspot.com/2014/02/cables-cable-making.html

Meeting <u>4/11/18</u> Minutes:

- **Modelling:**
    - Update by Sunday
    - We need implementation for thumb
    - Openings for upper and lower cables
    - Kinks around twisting portion to stop twisting after some maximum degree (when closing *and* opening)
- **Opening Hand:**
    - In resting position, springs on the upper hand will apply a tension on the cable that pull the fingers open to a certain degree
    - When closing, the servo will pull against the spring.
- **Arduino Coding:**
    - Change angles at certain speed
    - Implementation:
        - Hold down to start grasping
        - Number of clicks for grasp strength
        - Force sensor starts grasping
    - Interfacing with force (analog) sensor
    - Implement a piezo to make a sound to tell when the grasping has started
- **What We Still Need to 3D Print:**
    - 2 spools to wind the cable- Andrew
    - A cylindrical housing for the servo to keep the sheath in place-Laura
    - A battery casing to keep the batteries in place and safety - (65mm Height, 14.5mm D)- Victor
    - Hand scaffolding for spring implementation
- **Items We Need to Buy:**
    - Listed up in the budget listing

Problems:

4/17/2018

Things that we still need to do (electronics)

Determine whether batteries (real 8.1V) is okay to use with 6-7.4V servos.

Get servos to function properly with arduino

Integrate button and piezo with arduino.

Make attachment platform for button (side or arm, band, strap, etc.)

Link to Rubric:
https://docs.google.com/document/d/1EQNfM38iPESophGEAMmKftCOfbmu3Dnq-2Gw49CW8ZA/edit?usp=sharing

LAST MINUTE RESPONSIBILITIES:

Clear objective: (STUFF TO KNOW WHILE PRESENTING)

5 Categories to address:

Research Problem

- *Is there a clear objective?*
    - *Exoskeleton for people with c6/c7 injuries. Help for doing daily simple tasks independently as a support not for therapy.*
- *Is the objective relevant to the needs of the potential user?*
    - Yes, user's independence to do simple daily tasks without a need for help. (see patient feedback - Paul)

Design & Process

- *Does the solution demonstrate improvement on previous alternatives?*
    - Cost effectiveness, *independence? (not there yet)*
- *Understanding of limitations of results and conclusions?*
    - Short lifetime, however can be made of laser-cut metal to improve lifetime vs. cost.
    - LImitations is battery life (set amount of hours before you need to charge)
    - More finger movements need more motors. Tradeoff with cost and mobility

Execution

- *Is the solution workable?*
    - Hell yeah
- *Acceptable to the potential user?*
    - Paul's input
- *Has the solution been tested according to the conditions it will be used under?*

- c

- **Fawad**
  - Compiling videos to display during poster session (Compiled in shared Facebook album)
  - Organizing the budget, making budget sheet
  - Fix that 270 degree bug in code
  - Credit my code
- **Drew**
  - Make springbox bigger
  - Adjust rotation of joints around end
  - Add more support around attachment point
  - Make a socket fix for the servo(s)
- **Someone**
  - Circuit diagram of Servo/Sensor/Button/Arduino circuitry -done
  - Research important key points about the 5 categories and summarize it into the google doc.
  - User-friendliness preparations: hoisting button in convenient location, etc.
  - Connect force sensor to long wires in order to put on fingertip
- **Everyone**
  - Read details on categories.

Important paper to know:

http://journals.sagepub.com/doi/pdf/10.1177/0278364915598388 - Reneu lab jusificatin as to how we design the prototype

Meeting With Paul:

- **Extend the thumb scaffold to allow for contact pressure between fingertip of index finger and scaffold. Paul said this would be huge**
- **Pressure in between index and middle finger that isn't huge deal but could be annoying over time**
- **Shorten arm of thumb scaffold to ensure tips of fingers touch**

Outline For Presentation

- **Define the problem**: People with C6/C7 vertebrae injuries have almost no capability of being self dependent due to inability to use fingers.
    - Explain that c6/c7 injuries lead to paralysis below ribcage but very limited finger movement
    - 12,000 new cases a year with 250,000 total in US (https://www.spinalcord.com/c6-c7-c8-vertebrae-spinal-cord-injury)
    - More common in men and young adults

- **Objective:** Create a device that allows users to perform two most used/important grasps (pinch and power). They make up 60% of grasps (http://grasp.xief.net/documents/THMS_taxonomy.pdf)
    - Surveyed 5 people with c6/c7 injuries and asked what tasks do they wish they could do on their own. Almost all answers related to grabbing items and gripping items
- **Design:** Utilizes a servo and wire to pull individual joints closed. Sheath is used to prevent buckling of wire. Force sensor used to monitor how much force is being applied and stops at desired point(3 different levels). Springs are attached to each finger segment that is utilized to make sure the fingers stay in a open position when no force is being supplied