

Concept Generation and Eval

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Project Description

Description: Active Prosthetic

This project will provide an affordable prosthetic for below-elbow amputees.

It will be able to:

- Be easily replicable by others
- Be sizeable
- Have sense of touch



Figure 1: Low-cost 3D-printed prosthetic hand

Description: Active Prosthetic

Sponsor: Dr Kyle Winfree

Director of the Wearable Informatics Lab (WIL) and heads the Go Baby Go project at Northern Arizona University (NAU).

Black Box Model

The basic customer need is to close the hand to grip item.

This requires materials, Energy, and Signals to perform the action.

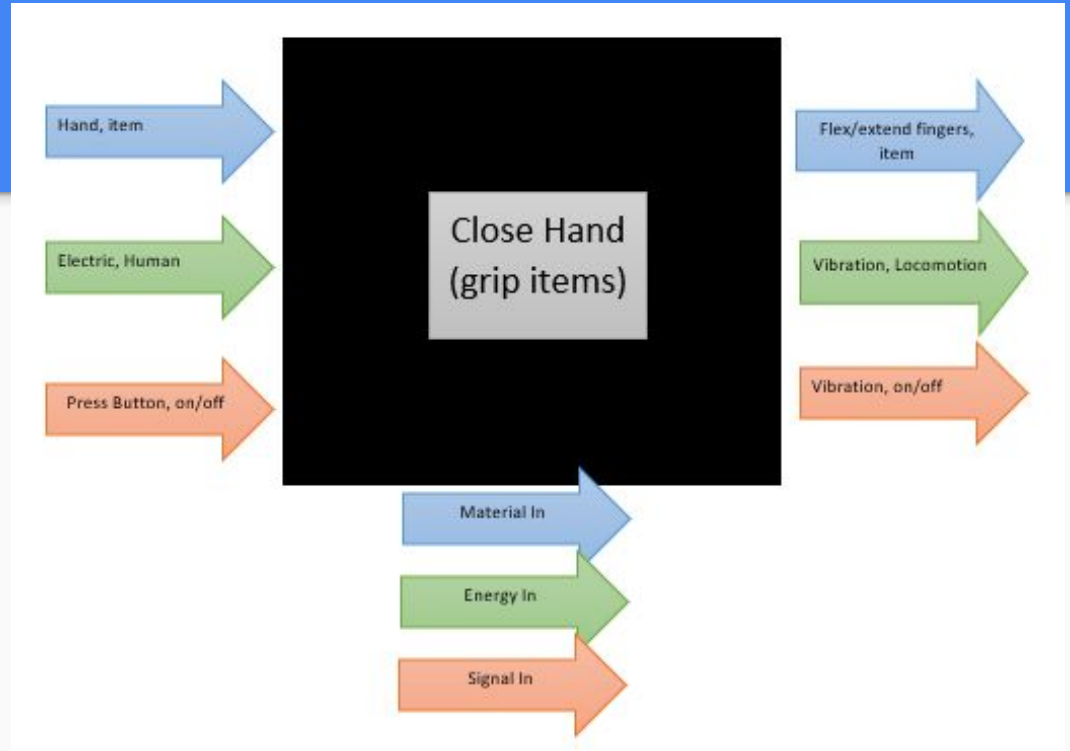


Figure 2: Black Box Model

Functional Model

Decomposition: Follows the flows of Materials, Energy, and signals to fulfill the customer needs.

Concept Generation: the functional models determine components required to complete the customer need. Ex. Batteries, Codes, signal emitters/receivers.

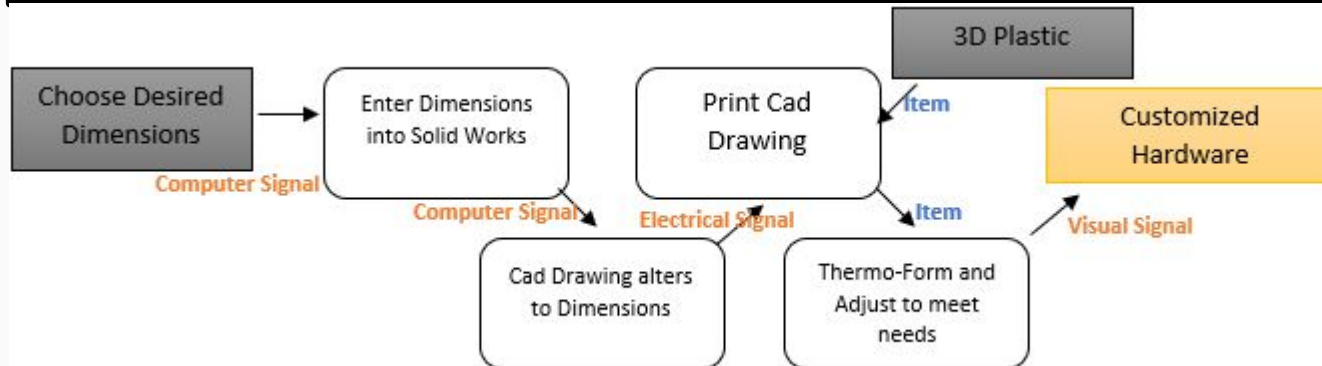


Figure 3: Functional Model Customized Hardware

Functional Model

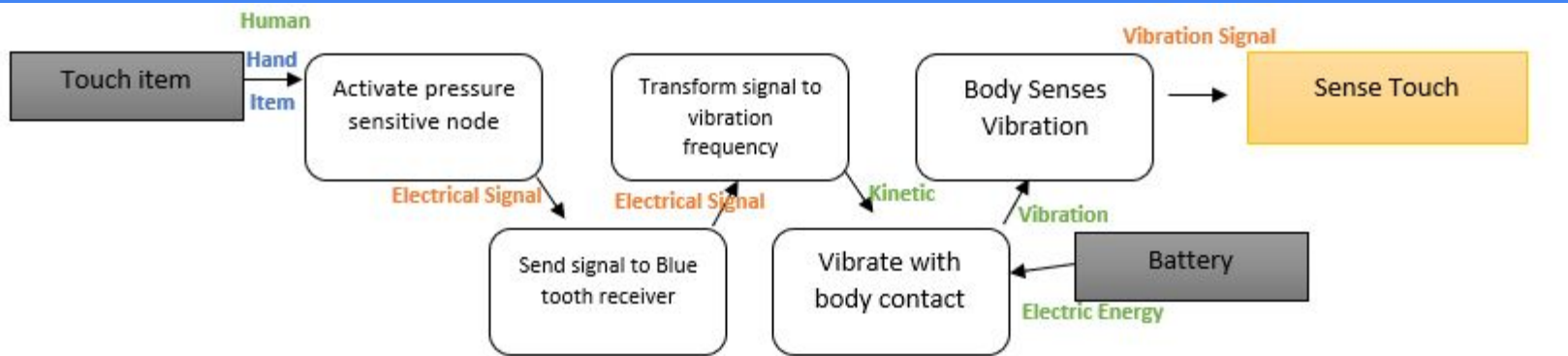


Figure 4: Functional Model Sense Touch

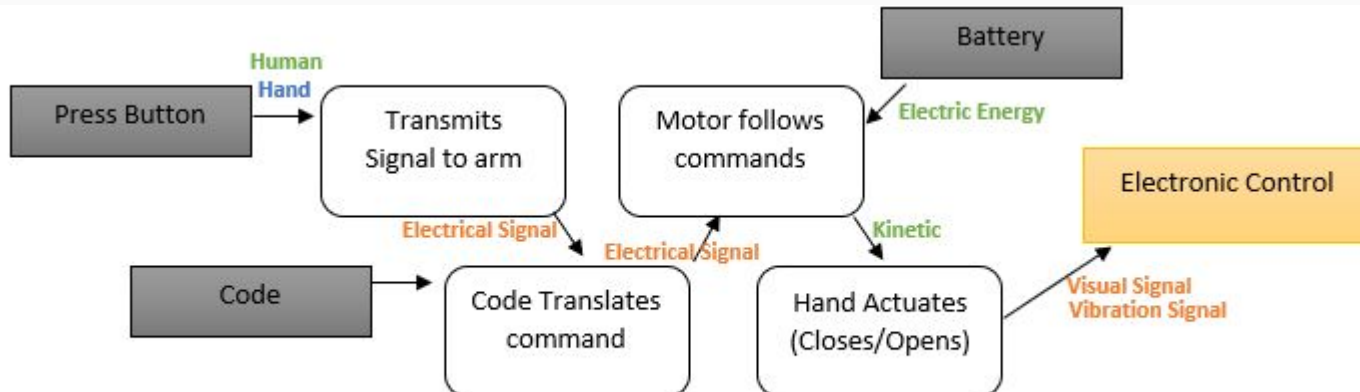


Figure 5: Functional Model Electronic Control

Functional Model

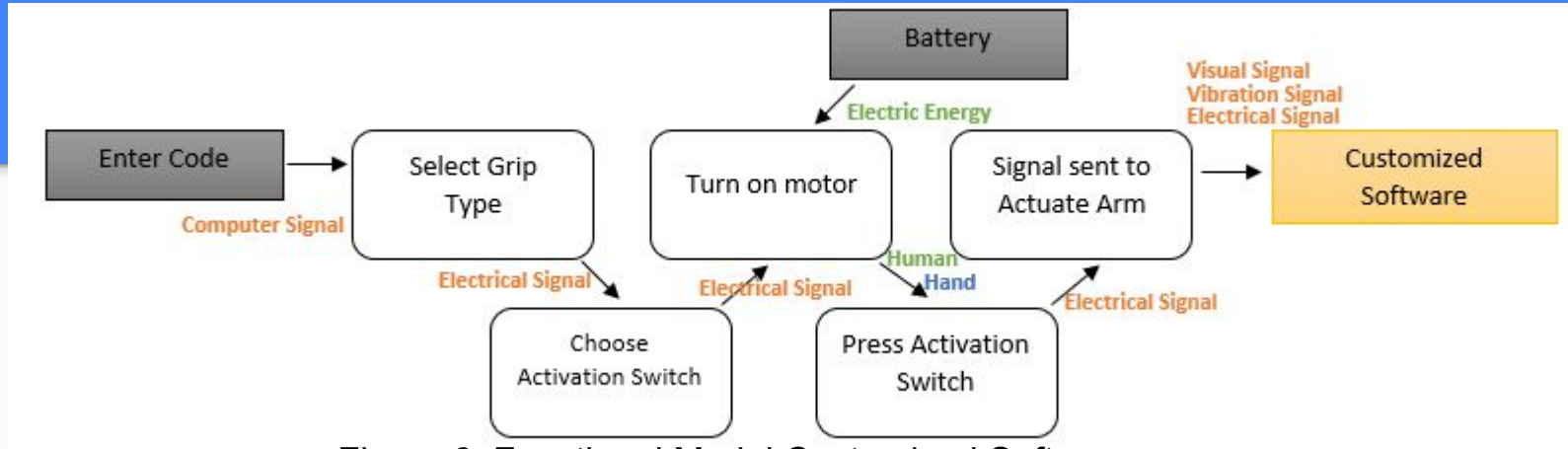


Figure 6: Functional Model Customized Software

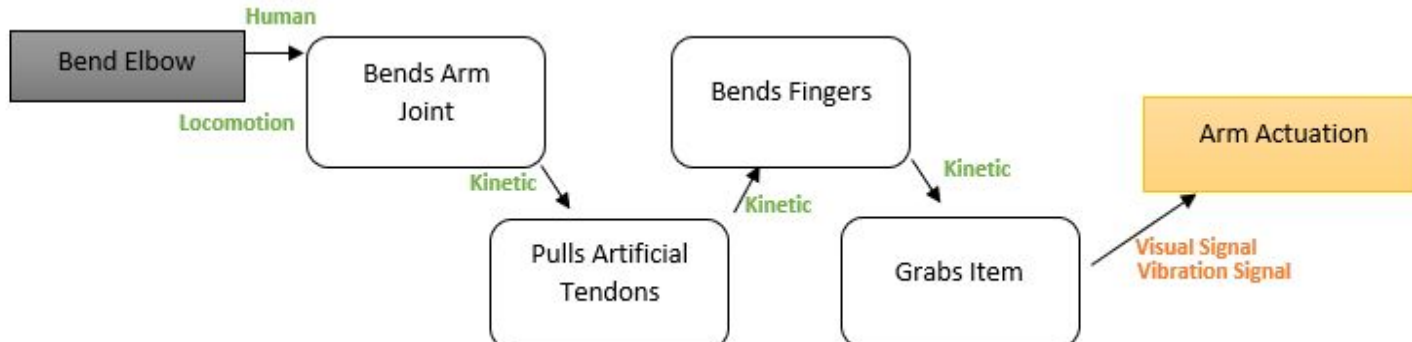


Figure 7: Functional Model Arm Actuation

Designs Considered

Considerations

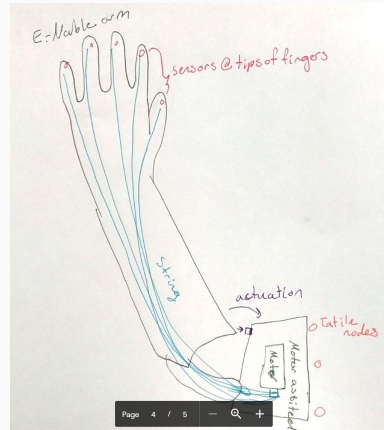
- Because the design had to be an active prosthetic device, most designs incorporated this aspect as well as the ability to provide haptic feedback and comfort to the user.
- Some concepts stood out as key designs to consider
- These key designs were the adaption, foot controlled arm, and the Capt'n Crabby

Adaption Design

This sketch was an adaption of a working model already created however it would have added gear and sensing components. It would be used as the datum for our Pugh chart for comparison.

Advantages:

- Provide excellent Haptic feedback
- Able to be customised



Disadvantages:

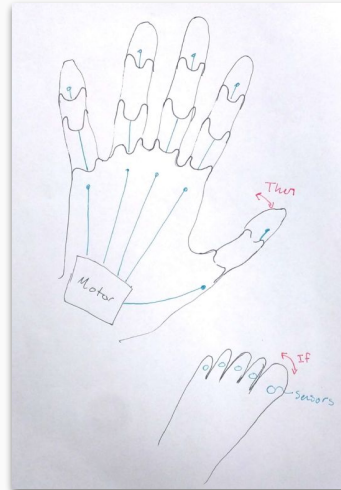
- More difficult to build than other models
- Grip is weaker than other designs

Foot Control

This design would be similar to the adaptation model, however, the controls and sensors would be connected to the foot instead.

Advantages:

- More control
- More comfort than other designs
- Easy to clean



Disadvantages:

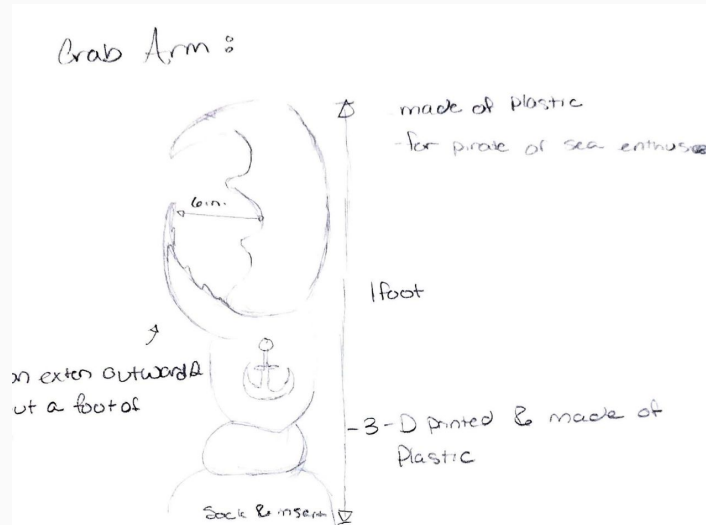
- Not easy to build
- Not the best ability to grip objects

Capt'n crabby

This is our bio-inspired design that is based off a crab claw

Advantages:

- Easy to clean
- Durable
- Aesthetically pleasing(fun theme)



Disadvantages:

- Does not provide successful haptic feedback
- Very heavy
- Not customizable

Other mentions

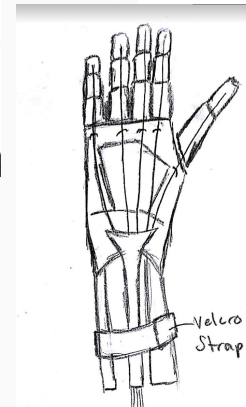
- (1) Customizable skeleton- Had a smaller frame but is able to send haptic feedback as well as be customised
- (2) We got you covered- Similar to the skeleton design but with a glove to provide better grip and more aesthetically pleasing design
- (3) Drawing Tendons- this hand has wires through the fingers to provide better control for the user, but not as durable as other designs.



1



2



3

Antoinette Goss

Designs Selected

Pugh Chart

CRITERIA	Clip-o-Grip	Need-Forearm-Muscles	Customizable Skeleton	Faux Flesh	Visible Nerves	Foot Control	Vine Grab	Pincer	Adaptation (DATUM)	The Blob
Aesthetically Pleasing	S	-	+	+	+	S	+	-	D	+
No Pain/Discomfort/Strain		+	S	S	S	S	-	-		S
Scalable	S	-	-	-	-	S	S	-	A	-
Customizable	S	S	+	+	-	S	-	-		-
Easy to Clean		+	S	S	-	S	+	-	T	-
Light Weight	S	+	+	+	S	S	-	+		-
Durable	S	-	-	-	-	S	S	-	U	+
Haptic Sensing System	S	-	-	-	S	S	-	-		-
Total +		0	3	3	3	1	0	2	1 M	2
Total -		2	4	3	3	4	0	4	7	5
Total S		6	1	2	2	3	8	2	0	1
Total		-2	-1	0	0	-3	0	-2	-6 DATUM	-3

CRITERIA	The Claw	We Got You Covered	Cap'n Crabby	You Can Toucan	Cool Hand Squid Man	Vacuum Hands	Drawstring Tendons	Shape Memory	Magnetic Fingertips	Bendy Fingers and Lace Up
Aesthetically Pleasing	-	+	+	+	S	+	S	+	+	+
No Pain/Discomfort/Strain	S	S	S	S	-	-	S	-	-	+
Scalable	-	-	S	S	+	S	S	-	-	S
Customizable	-	+	-	-	+	-	S	-	-	-
Easy to Clean	-	S	+	+	-	+	S	S	S	-
Light Weight	-	+	-	-	S	-	S	-	-	-
Durable	+	-	+	+	-	+	-	+	+	S
Haptic Sensing System	-	-	-	-	S	-	S	-	-	-
Total +		1	3	3	3	2	3	0	2	2
Total -		6	3	3	3	3	4	1	5	4
Total S		1	2	2	2	3	1	7	1	2
Total		-5	0	0	0	-1	-1	-1	-3	-2

Pugh Chart

CRITERIA	Clip-o-Grip	Need-Forearm-Muscles	Customizable Skeleton	Faux Flesh	Visible Nerves	Foot Control	Vine Grab	Pincer	Adaptation (DATUM)	The Blob
Aesthetically Pleasing	S	-	+	+	+	S	+	-	D	+
No Pain/Discomfort/Strain	-	+	S	S	S	S	-	-	-	S
Scalable	S	-	-	-	-	S	S	-	A	-
Customizable	S	S	+	+	-	S	-	-	-	-
Easy to Clean	-	+	S	S	-	S	+	-	T	-
Light Weight	S	+	+	+	S	S	-	+	-	-
Durable	S	-	-	-	-	S	S	-	U	+
Haptic Sensing System	S	-	-	-	S	S	-	-	-	-
Total +	0	3	3	3	1	0	2	1	M	2
Total -	2	4	3	3	4	0	4	7	-	5
Total S	6	1	2	2	3	8	2	0	-	1
Total	-2	-1	0	0	-3	0	-2	-6	DATUM	-3

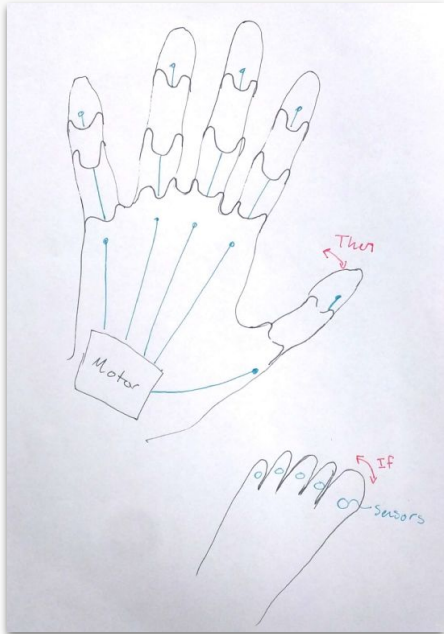
CRITERIA	The Claw	We Got You Covered	Cap'n Crabby	You Can Toucan	Cool Hand Squid Man	Vacuum Hands	Drawstring Tendons	Shape Memory	Magnetic Fingertips	Bendy Fingers and Lace Up
Aesthetically Pleasing	-	+	+	+	S	+	S	+	+	+
No Pain/Discomfort/Strain	S	S	S	S	-	-	S	-	-	+
Scalable	-	-	S	S	+	S	S	-	-	S
Customizable	-	+	-	-	-	-	S	-	-	-
Easy to Clean	-	S	+	+	-	+	S	S	S	-
Light Weight	-	+	-	-	S	-	S	-	-	-
Durable	+	-	+	+	-	+	-	+	+	S
Haptic Sensing System	-	-	-	-	S	-	S	-	-	-
Total +	1	3	3	3	2	3	0	2	2	2
Total -	6	3	3	3	3	4	1	5	5	4
Total S	1	2	2	2	3	1	7	1	1	2
Total	-5	0	0	0	-1	-1	-1	-3	-3	-2

- Adaptation was used as the datum
- All designs ranked equal (total = 0) or lower than the Datum.
- Designs selected for Decision Matrix:
 - Customizable Skeleton
 - Foot Control
 - Adaptation
 - We Got You Covered
 - Drawing Tendons
- Other designs with a score of zero were discarded either because they were similar to designs accepted or determined to be impractical such as Cap'n Crabby and You Can Toucan.

Decision Matrix

Criteria	Weight	Adaptation		We Got You Covered		Foot Control		Customizable Skeleton		Drawstring Tendons	
		Raw Score	Weight	Raw Score	Weight	Raw Score	Weight	Raw Score	Weight	Raw Score	Weight
Secure Attachment	0.1639344262	3	0.4918032787	3	0.4918032787	3	0.4918032787	3	0.4918032787	1	0.1639344262
Durability	0.131147541	3	0.393442623	3	0.393442623	3	0.393442623	1	0.131147541	1	0.131147541
Haptic Sensing	0.1475409836	5	0.737704918	3	0.4426229508	5	0.737704918	1	0.1475409836	3	0.4426229508
Active Control	0.131147541	3	0.393442623	3	0.393442623	5	0.6557377049	1	0.131147541	1	0.131147541
Comfortable	0.1147540984	3	0.3442622951	5	0.5737704918	3	0.3442622951	3	0.3442622951	1	0.1147540984
Easy to Build	0.08196721311	1	0.08196721311	1	0.08196721311	1	0.08196721311	3	0.2459016393	1	0.08196721311
Scalable	0.09836065574	3	0.2950819672	1	0.09836065574	3	0.2950819672	1	0.09836065574	3	0.2950819672
Ability to Grip	0.06557377049	1	0.06557377049	3	0.1967213115	1	0.06557377049	1	0.06557377049	3	0.1967213115
Customization	0.01639344262	5	0.08196721311	1	0.01639344262	5	0.08196721311	3	0.04918032787	1	0.01639344262
Light Weight	0.04918032787	3	0.1475409836	3	0.1475409836	3	0.1475409836	5	0.2459016393	5	0.2459016393
Total	1		3.032786885		2.836065574		3.295081967		1.950819672		1.819672131

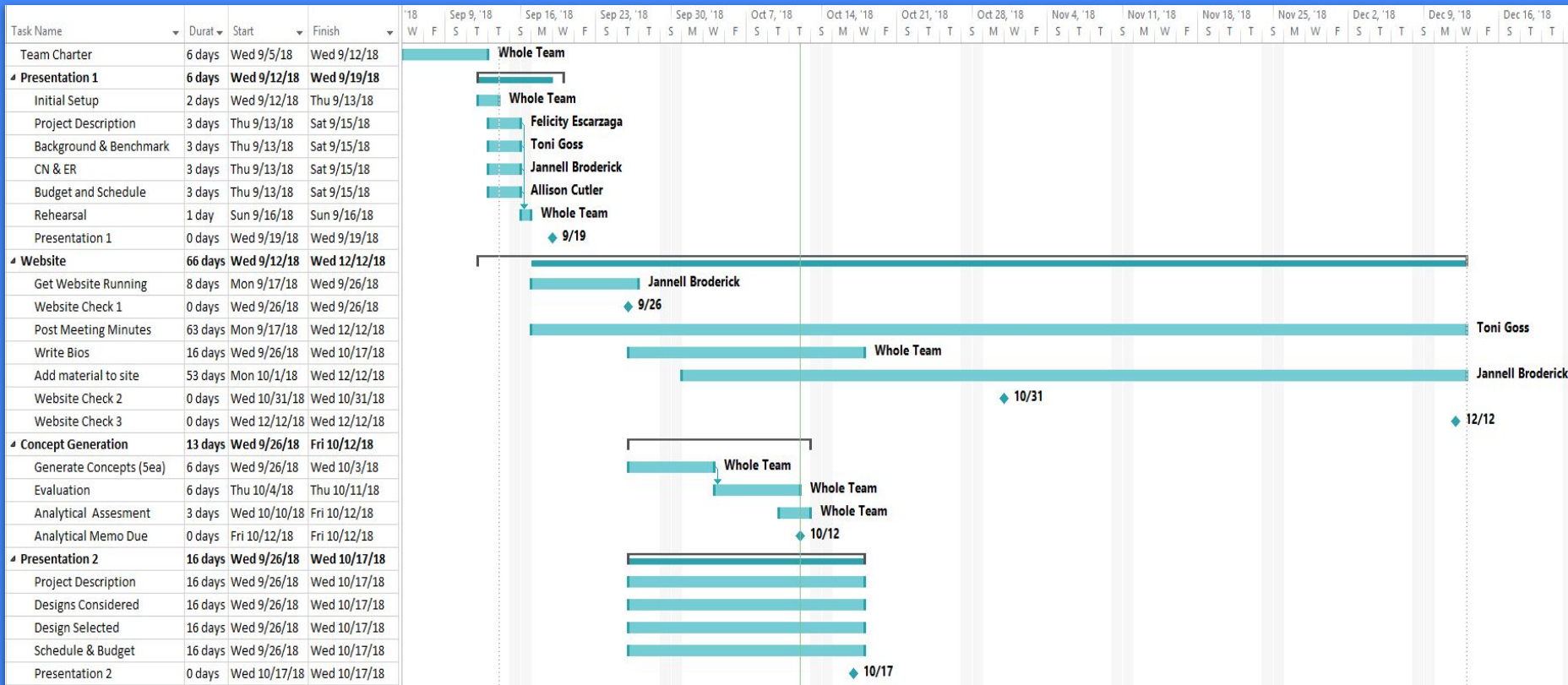
Final Design



- Final design selected was foot control.
 - Includes sensors, which is one of the main requirements of the project.
 - Sensors may be wireless from the foot to the hand to increase comfort.
 - This design requires little effort from the user to open and close fingers.
 - Will be scalable and customizable like current competing designs but will give the user more control.

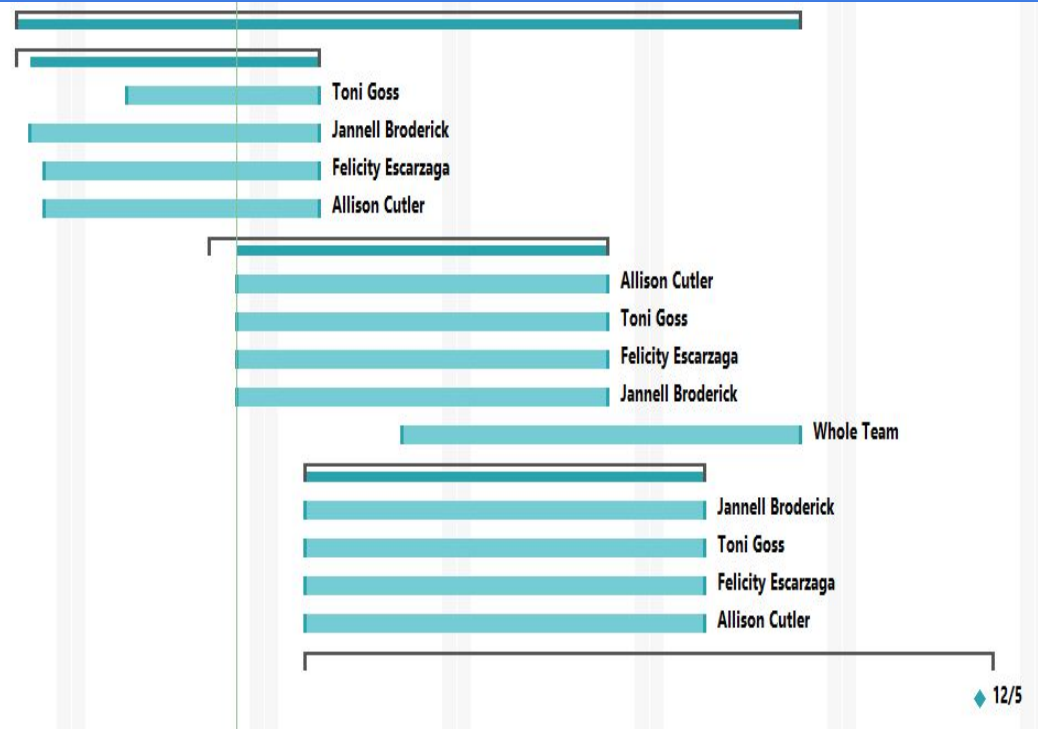
Schedule and Budget

Past-Present



Present-Future

4 Reports	41 days	Wed 9/26/18	Wed 11/21/18
4 Preliminary Report	16 days	Wed 9/26/18	Wed 10/17/18
Section 1 & 5	10 days	Thu 10/4/18	Wed 10/17/18
Sections 2 & 3.3	15 days	Thu 9/27/18	Wed 10/17/18
Sections 3.2 & 3.4	14 days	Fri 9/28/18	Wed 10/17/18
Sections 3.1 & 4	14 days	Fri 9/28/18	Wed 10/17/18
4 Analytical Report	21 days	Wed 10/10/18	Wed 11/7/18
% Infill	19 days	Fri 10/12/18	Wed 11/7/18
Thermo and Strength	19 days	Fri 10/12/18	Wed 11/7/18
Arduino Code	19 days	Fri 10/12/18	Wed 11/7/18
Mechanical Forces	19 days	Fri 10/12/18	Wed 11/7/18
Final Report	21 days	Wed 10/24/18	Wed 11/21/18
4 Presentation 3	21 days	Wed 10/17/18	Wed 11/14/18
Project Description	21 days	Wed 10/17/18	Wed 11/14/18
Design Description	21 days	Wed 10/17/18	Wed 11/14/18
Design Requirements	21 days	Wed 10/17/18	Wed 11/14/18
Schedule & Budget	21 days	Wed 10/17/18	Wed 11/14/18
4 Prototype	36 days	Wed 10/17/18	Wed 12/5/18
Prototype Demo	0 days	Wed 12/5/18	Wed 12/5/18



Budget

Part	Qty	Cost (\$)	
Printing material (kg)	1 per arm	\$15	
	x 5 full arms	\$75	
Motor (arduino-uno, arduino-zero)	1 to 6		
	min	\$30-60	
	max	\$180-360	
Haptic Sensors	4	\$28	only one option
Pressure Sensors	4	\$28	
feedback sensor thing	4	\$28	
Shipping		TBD	
Batteries	TBD	TBD	
	TOTAL	\$283-\$463	

- 4 sensors per Final Design
- Price of Batteries TBD once Motos/Sensors finalized
- EE Team assigned, should know more soon