Deliverable H: Prototype III and Customer Feedback

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Abstract

The Department of National Defense requires an automated, user-friendly and cost-efficient robotic arm that can provide the potential to assist crew members on ships to complete certain tasks with minimal supervision. The design criteria were taken into account when we calculated budget and timeline restrictions.

Table of Contents

1. Introduction

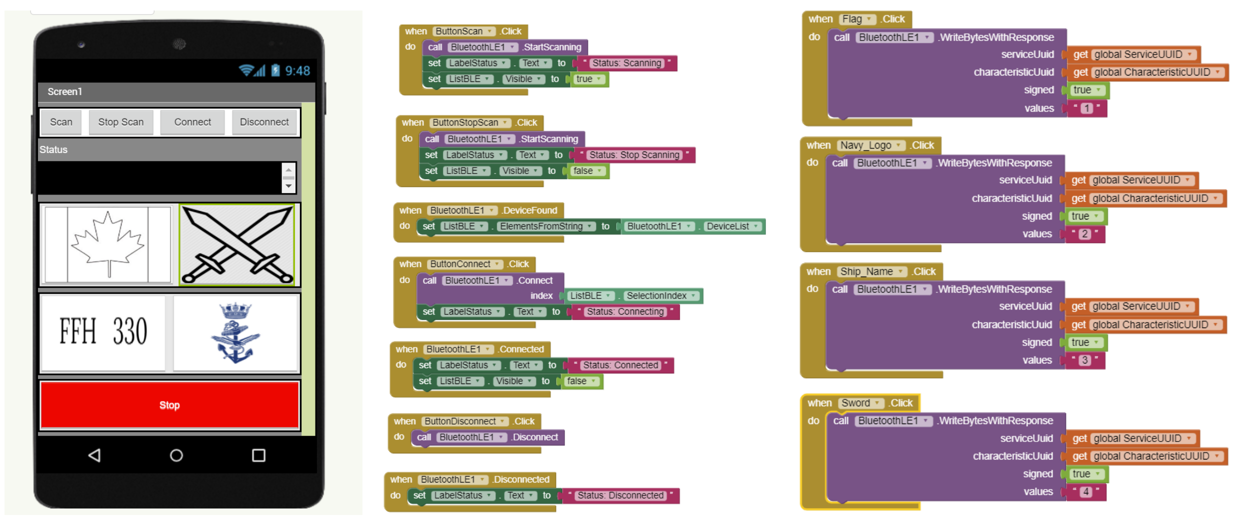
In this deliverable, the team developed, manufactured, and tested the final prototype. Advancements were made for the inverse kinematics, app development, and logo specifications. The team is now in the final stage for testing the software subsystem in order to deliver the minimum viable product.

2. Customer Feedback

- V.B.: Rather than user uploading an image, produce preset images that will send a character to arduino and initiate drawing when clicked on.
- V.B: Keep focus on design day presentation if prototype isn't up to expectation
- D.K.: Focus on the minimum viable product for design day

3. Results

3.1. User Interface



The purpose of the user-interface is to provide a simple yet efficient method of operating the robotic arm. In this prototype, priority was made towards the bluetooth connectivity, as we'd like to demonstrate how easy it would be for the device to scan nearby devices (assuming multiple robotic arms are on site) and connect to a specific one to operate. After the connection is made, multiple preset images will be displayed and the one that is chosen will prompt the robot to proceed with drawing it.
This is different from the original idea of uploading your own image and sending the image path to the arduino, as the feedback received had stated the arduino isn't powerful enough to store such data. Additionally, assumptions have been made where preset drawings would be the best

process as there will be increased accuracy and the client isn't in need of all the possibilities, but rather limited to the royal canadian navy logos and such. A display and block code of the user interface has been provided above.

3.2. Code

```
# Length of links in cm
a1= 5.2
a2 = 6.9
a3 = 6.8

# Desired Position of End effector
px = -14
py = 3

phi = 90
phi = deg2rad(phi)

# Equations for Inverse kinematics
wx = px - a3*cos(phi)
wy = py - a3*sin(phi)

delta = wx**2 + wy**2
c2 = ( delta -a1**2 -a2**2)/(2*a1*a2)
s2 = sqrt(1-c2**2)  # elbow down
theta_2 = arctan2(s2, c2)

s1 = ((a1+a2*c2)*wy - a2*s2*wx)/delta
c1 = ((a1+a2*c2)*wx + a2*s2*wy)/delta
theta_1 = arctan2(s1,c1)
theta_3 = phi-theta_1-theta_2

print('theta_1: ', rad2deg(theta_1))
print('theta_2: ', rad2deg(theta_2))
print('theta_3: ', rad2deg(theta_3))
```

Figure One: Code for Inverse Kinematics

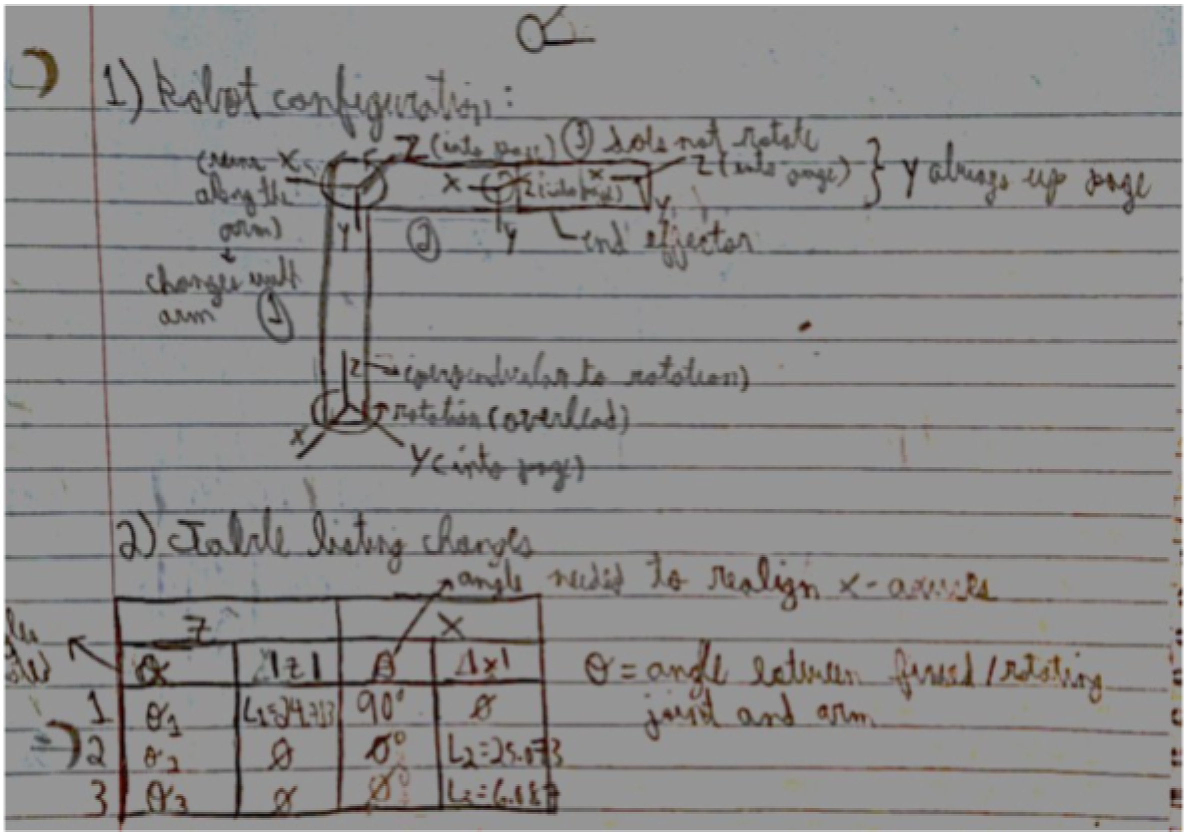


Figure 2: The Mathematical to Inverse Kinematics (Part a)

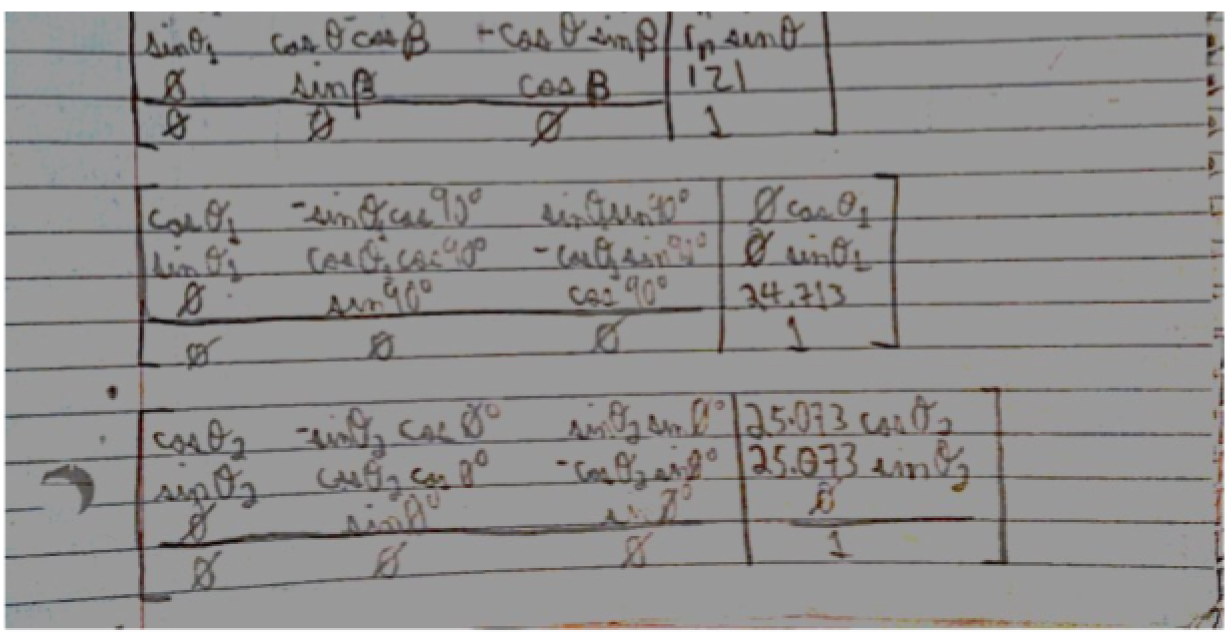


Figure 3: The Mathematical Approach to Inverse Kinematics (Part b)

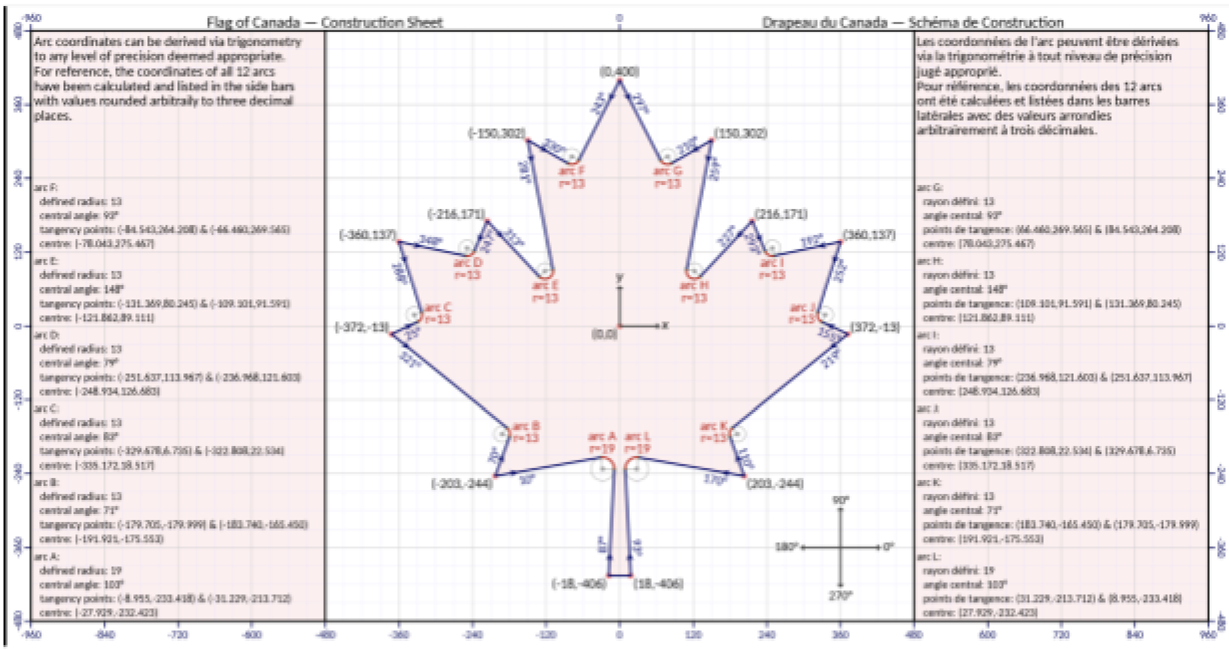


Figure 4: The coordinates of the Canadian Flag

The coordinates of the Canadian flag will be scaled down to the range of motion of the arm. As seen in Figures 1, 2, and 3, Inverse kinematics will be used: working backwards from the coordinates of each vertice on the Canadian flag, the servo motors will be moved ‘x’ degrees to go from vertex to vertex on the map. The marker attached to the end effector will then draw from point-to-point on the Canadian flag (x and y directions), and the marker will lift off the page (z direction) in order to create gaps in the drawing. The code we made was based on an open-source Github repository with expressed permission from the owner.

3.3. Objective Fulfillment

Objective	Status	Details
Acquire Further Feedback	Complete	Reached out to TA, class members and client with prototype 2. Feedback has been incorporated into the third prototype.
End Effector Mounting System	Complete	Modifications have been made based on the second prototype, waiting for test fit. Mounting holes and pen-holder have been modified for best fitment.
Ensuring the arm and GUI work together	In progress	The mobile app has been tested for bluetooth discoverability, arduino connection pending.
GUI prototype	In progress	Mockup created, contains main elements of the user interface, including code.
Image uploading	Canceled	Process discovered to be inefficient as arduino has limited capabilities.
Image library	In progress	One image is set to be included in the library thus far; the Canadian flag.
Design day pitch preparation	In progress	Material needs to be practiced for design day (e.g. a short demonstration video prepared, talking points, etc.)

4. Model

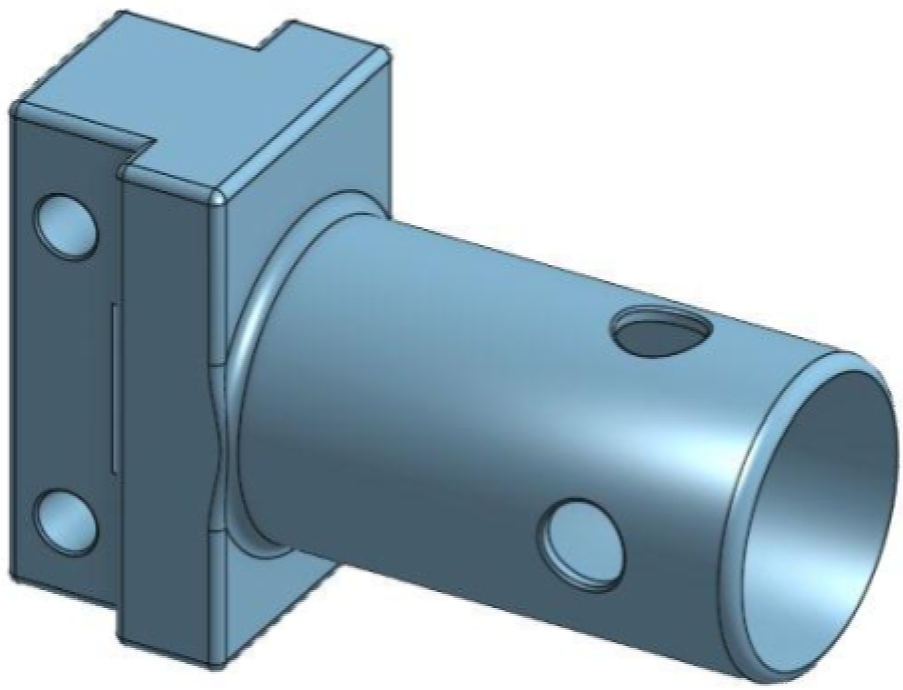


Figure 5: Onshape Model of Final Prototype

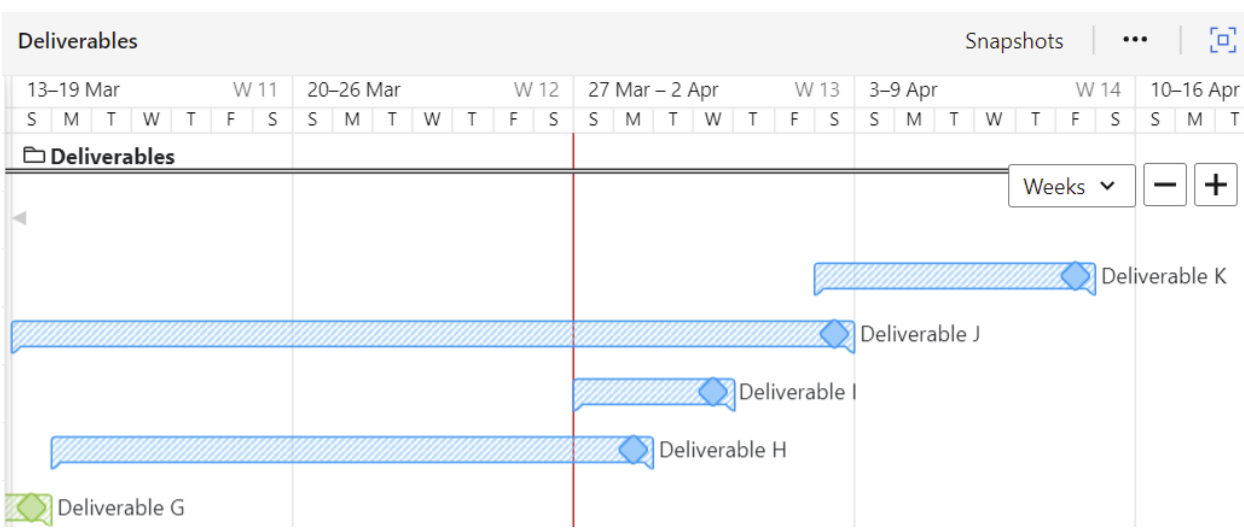
The design is intended to be mounted with screws onto the robotic arm and the marker is supposed to be held with a screw mechanism similar to a pencil compass found in geometry sets.
Modifications were made to prototype two based on the results from testing the prototype and the robotic arm. The measurements for the mounting holes and the pen holder were changed for better fit. The onshape design is shown above in figure 2 and is slated to be printed on Monday 27 March 2022.

5. Updated Bill of Materials

Item Name	Description	Units of Measure	Quantity	Unit Cost (CAD)	Extended Cost (CAD)	Link
HM-10	Ability to connect Arduino to Smartphone via bluetooth	26.9mm x 13mm x 2.2 mm	1x	$14.39	$14.39	Bluetooth Module
Marker	Used for drawing tests		1x	Free	Free	Provided
Whiteboard	To document the drawings		1x	Free	Free	Provided
MIT App Inventor	A program to develop the user interface	N/A	1x	Free	Free	App inventor
Arduino Uno	An Arduino Uno will be used to control the robotic arm.	2.7” x 2.1”	1x	Free	Free	Arduino Uno
Screws	Screws to hold the end effector	M3	1x	Free	Free	Provided
Jumper Cables	To make connections	4.72in	30x	Free	Free	Jumper Cables
Power Supply	To provide power to the Arduino	9v	1x	Free	Free	Power Supply
Laptop	To dump the code into Arduino	N/A	1x	Free	Free	N/A
Total product cost (without taxes or shipping)					$14.39	
Total product cost (including taxes and shipping)					$16.47	

6. Prototyping Test Plan

Test ID	Test Objective(*why)*	Description of Prototype used and of Basic Test Method*(what)*	Description of Results to be Recorded and how these results will be used (*How)*	Estimated Test duration and planned start date (*when)*
1	Ensuring the minimum viable product is met	Full test runs from start to end as intended before design day	Document each image drawn, regardless of whether or not it worked, and modify the code so the image output is clear	~3 days
2	Produce a video of the arm drawing the image	From the previous test ID, show proof of minimum viable product	Multi-angle recording of the arm performing the desired task	~1 day



***********Please refer to wrike for project schedule/task plan***********