Technical Report for Design Project

GNG1103

Group C1

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ABSTRACT

This paper summarizes the procedure of the final project that was given to us for the course GNG1103 section C. In the first section, it states the problem that we have, the user requirements and why our design is better than other products. We then determined our customers and users, gathered information from them and using the information, we determined their needs and prioritized them, resulting in our problem statement. Next, we researched other products on the market and compared them and established our own design criteria, including functional and nonfunctional requirements and constraints. After pitching many ideas, we chose our top 3 designs, which we further analyzed, making sure that it met our requirements, which in turn helped make our final decision. We talked about how our proposed solution, and why it was the best choice for our problem and constraints. We use different types of testing and modeling strategies to build and improve our prototypes, and explained our steps. In the end we looked back at what we did and what we ended up with, and considered how things could have been changed to further improve the project and fit the needs of our customers better.

1.0 INTRODUCTION

To develop a successful project idea and implement it, key steps must be followed in order to achieve quality results; these steps, shown in Figure 1, are known as the 5, or 6, steps of the Engineering Design Process.

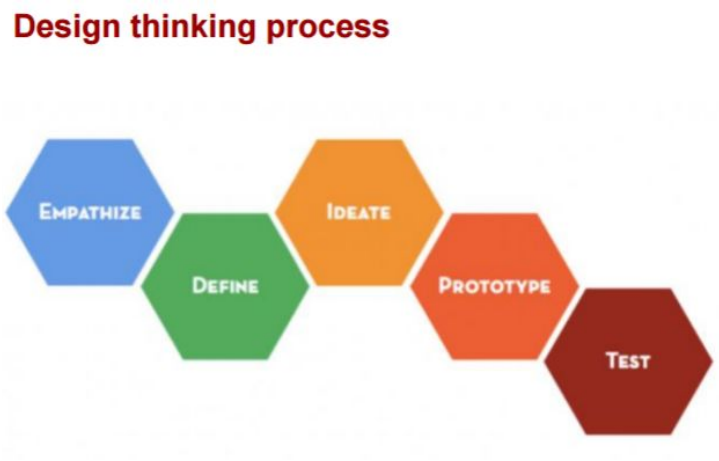

Figure 1: The basis of the Engineering Design Process
*Source***:** https://dschool-old.stanford.edu

According to Figure 1, the steps as listed are: Empathize, Define, Ideate, Prototype, Test. The first step is to empathize with the target customer or user to determine and understand what is the problem that must be solved. In this step, the product developers consult with clients to gather information about the client's perspective on the problem at hand. The next step, define, is a phase where the developer must interpret the client's needs and transform them into critical needs that are expressed as attributes of the product. Define is also where a problem statement must be generated which identifies the problem that will be addressed by the design process based on the needs of the clients. In the next step, ideate, developers brainstorm ideas and choose viable concepts that may solve the problem and meet the needs of the client. The fourth and fifth step involve prototyping the best concept and testing it to analyze whether the solution would work or if it needs to be improved. The last step of the design process is to repeat all the steps until the correct solution is achieved, or time and money runs out.

For our Engineering Design course, we were presented with an opportunity to create a product for display at the Canada Aviation and Space Museum for Canada's 150th Anniversary

Showcase. The requirements for both the Engineering Design course and the showcase outlined the theme and the function of the product. The product must have a steampunk theme as to make it aesthetically pleasing and it must have at least one technological aspect incorporated into it, allowing it to interact with users. Throughout the design process, those two requirements had to be respected, no matter the end product.

After choosing the best concept to be prototyped and tested, we created a unique solution that respects both the steampunk element and the interactive technology while being innovative and new. Our product, called Robo the steampunk dog, is the only robotic product made in our section that is inspired by an animal and is made purely out of recycled or household materials, with the exception of the circuitry used to interact with users. We utilized materials given to us by our client such as fur, galvanized metal wire and materials found at Brunsfield Centre such as sheet metal, and wood to build our robotic dog without having to rely on dissecting a premade stuffed dog. We incorporated a PIR sensor in Robo so when a user or audience member pets the head of the dog, the interaction will trigger the tail of the dog to start wagging and one of the eyes to start glowing. These mobile features form the fun factor that determines how entertaining the overall product will be.

This report will explore the design process that was implemented to create our product and the path we took to achieve our results. This report will clearly outline each step we took as a group and any obstacles we faced through the endeavor.

2.0 GATHERING AND INTERPRETING CUSTOMER DATA

In this section, we will be discussing the users and clients, and their needs and requirements, and how we prioritized them based on our users and clients.Our prioritization will clearly reflect the user, showing that we have empathized with them and that we did lots of relevant research and critically analyzed the situation.

2.1 Clients and Users

For this project, our client was the Canada Aviation and Space Museum, and we were approached by Sharon House, who told us about Canada's 150th anniversary celebration, and the gala that was taking place in mid May. Our second client would be our professor, Umar Iqbal. He wanted us to create a robot, with the requirements of the Canadian Aviation and Space Museum, but with a moving component. Our users would be people that attend the gala, meaning that there will be various types of people attending. People from the Canadian Aviation and Space Museum, such as Sharon and the CEO are users too, since they will also be attending the gala and touring the different projects and displays that people have build and set up.

2.2 Customer Needs

Our first customer, Sharon, would like a project that is interesting, fun, and aesthetically pleasing to people visiting the gala. It needs to be of impressive size, but should be able to fit in the given space. It should be steampunk themed, which corresponds with the rest of the gala. Our second customer, our professor, said that the project needed to have a moving component, and that is should be relatively cheap, as close to the $100 budget as possible. The project should show technical skill, and it would be better to have more than 1 moving component to show as much skill as possible.

2.3 Interpreting the Data

Table 1: Interpreted needs of customer statements

Question	**Customer Statement**	**Interpreted Need**
Typical Uses	I need a product that is interesting, fun, and aesthetically pleasing to people visiting the gala	Product must be interesting and engaging to the customers
	I need a product that has a moving component	Product must have a component that moves by itself
	I need a product that has a steampunk theme	Product must reflect the steampunk theme that is associated with the 150th anniversary celebration
Likes	I like it when it is cheap	Product must be cheap to produce
	I like it when it is small enough for the project space, but big enough to have a wow factor	Product needs to fit within the given space, but be big enough to have an impact on ongoing viewers at the gala
Dislikes	I don’t like it if the product does not reflect the steampunk theme	Product accurately fits with the steampunk theme of the gala

	I don't like it if there is no moving component	Product has a moving component that is able to move by itself
Suggested Improvements	It is good if it has more than 1 moving component	Has more than one moving component so that it is more impressive and shows more technical skill

2.4 Organizing and Prioritizing Needs

Table 2: Importance of needs of the customers

Number	**Need**	**Importance**
1	Product needs to be fun and interesting to interact with	2
2	Product needs to reflect steampunk theme	5
3	Have some sort of technology implemented	1
4	Mobile in some aspect	3
5	Be low cost	4
6	Small but impressive size	6
7	Easy to transport (light)	7

2.5 Problem Statement

A need exists for the Canada Aviation and Space Museum to design a steampunk themed robot that is aesthetically pleasing and is capable of mobile interaction while maintaining cost effectiveness.

3.0 DESIGN SPECIFICATIONS

In this section, we researched robots in order to benchmark and compare their specifications and using the interpreted needs from section 2.4 and 2.5, we were able to deduce the design criteria of our design project and come up with design specifications.

3.1 Benchmarking

To determine design criteria and target specifications as well as metrics, we conducted research to benchmark some robots in today's industry. Table 3 below compares specifications and shows the lowest scoring robot, as having the best attributes.

Table 3: Comparison of several specifications between various robots

Colour	Red	Yellow	Green
	Worst = 3	Moderate = 2	Best = 1

Specifications	Importance	Robot Name		
		Nao V5	CHiP	Zoomer
Cost (USD)	2	~9,500	~200	99
Weight (kg)	1	5.4	1.1	0.36
Dimensions	1	22.6" x 12.2" x 10.8"	8.66" L x 7.5" W x 9" H	8" x 11" x 9"
Power Supply	4	Rechargeable Lithium ion battery	4 AAA Batteries, and has a charging port	rechargeable internal lithium ion battery (via USB)
Life-span on Single Charge	5	90 min	N/A	30 min
Sensors	3	2 Cameras, speakers/microphone, 2 sonars, 2 infrared emitters and receivers, 9 tactile and 8 pressure sensors, multi-language support, and more	Voice, gesture, low battery, beacon, touch sensors. Has infrared vision, and can be controlled using a smartphone application.	Motorized joints and sensors in chest to detect motion, objects and touch. responds to voice commands in three different languages: English, Spanish and French.
Total		23	31	24

From Table 3, we were able to determine that the most important specifications that dictate whether a certain concept is successful as follows:

- Cost
- Size

- Features
- Aesthetics

3.2 Design Criteria

From the interpreted needs, we were able to determine functional and nonfunctional requirements as well as constraints for our design.

Functional Requirements

- Implement use of technology such as Arduino Sensors, programmable motors, etc.
- Mobile aspect (i.e. degrees of freedom, angle of movement (°), length of moving part (cm))
- Uses sensors for interaction (e.g. movement sensor, temperature sensor, light sensor), type of reaction to interaction (e.g. movement, sound, light)

Non-Functional Requirements

- material, colour and pattern, texture, industrial elements
- Reliability in terms of stable structure
- Elegant and simple appearance
- An innovative appearance
- Safety: does not cause injury to user and no sharp edges

Constraints

- Size of robot when deployed (height, width and length)
- Maintain low/reasonable cost
- must not be over the size of 15-20 square feet (i.e. the robot should not require over 20 ft of space to maneuver around)
- Time to build final prototype (Due date Design Day)
- Operation conditions (motor may overheat if temperatures too warm or if running for too long)

3.3 Engineering Design Specifications (EDS)

Table 4: Engineering Design Specifications table

	Design Specifications	**Relation (=, <, >)**	**Value**	**Units**	**Verification Method**
	Functional				

	Requirements				
1	Have a moving component (wagging tail)	=	yes	N/A	Test
	Constraints				
1	Weight	<	30	lbs	Analysis
2	Cost	<	100	$	Estimate, final check
3	Operating situations (lots of movement)	=	yes	N/A	Test
4	Size when deployed	=	5 x 3 x 1	ft	Test
	Non Functional Requirements				
1	Be aesthetically pleasing and interesting for	=	yes	N/A	Test
2	Steampunk themed	=	yes	N/A	Test
3	Reliability	=	yes	N/A	Test

As shown in the table above, those are the target specifications we used to try and achieve or aim for with our design concept. The metrics we used were common units of CDN $ for cost, lbs for weight (mass), and ft for dimensions.

4.0 CONCEPTUAL DESIGNS

We generated many ideas while brainstorming and freehand sketching, but narrowed them down to three conceptual designs.

4.1 Shoe Shiner Crab

A motion sensor detects when a shoe or item is placed underneath the robot, which triggers the robot to lower its arms that are firmly holding a cloth or cleaning apparatus. After lowering to a certain height, the robot will start to move the cloth/etc in a back and forth motion. The shoe can be adjusted in its position after periods of 30s and then the robot will resume cleaning. After 4 periods the robot will end the cleaning process. This design satisfies many of the specifications outlined in the previous deliverable. It is small

in size (about a 1.6ft in all dimensions) so it can easily fit within the allocated space of 15-20 square feet. It is also hollow making it relatively light and therefore easy to transport. The robot will be interesting for judges since it actually performs a task with a clear outcome at the end: a cleaned shoe. The audience's interaction with the Cleaning Robot will be entertaining and will add to the museum's event. It also has steampunk elements such as it's rusty metal material and aviator goggles. Scrap metal and metal sheets will be used to make it.

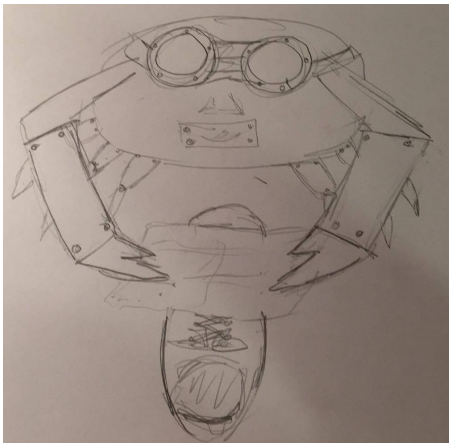

Figure 2: Shoe shiner crab

4.2 Humanoid Dancing Robot

This robot is the size of a child, around 4 ft tall, 1 ft in length, and 0.5 feet in width. The size of the robot is fairly small since it needs to fit in the area that we are given. There will be a motion sensor in this robot, where it is able to detect objects in its way, so that it is able to walk without bumping into anything. There will be also a few buttons on the back/top of the robot's head, and when a certain button is pressed, it will start dancing in a predetermined pattern. The robot will walk to a person, and it will ask if the person would like to see him dance, and if so, to press the buttons on his head. When a button is pressed, there will also be music being played while the robot is dancing. This way, people/spectators are able to enjoy the dancing of the robot, while the fun music being played will interest people nearby. There will be bolts, wires and gears on the robot, which will make it have a steampunk feel, and the body will be a dark brown and old colour, following the theme. To reduce cost, the body will be made with metal sheets, meaning that the robot is hollow in the middle. Many of the gears or bolts will be made with cardboard of plastic, meaning that the cost and the weight is reduced. There will probably be a portable battery, with a long life of at least 4 hrs, so that it is able to move around freely for a long time without being restricted by cords.

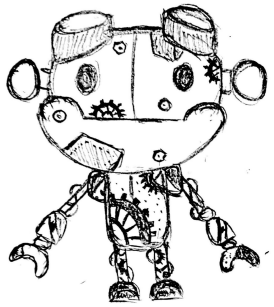

Figure 3: Humanoid dancing robot

4.3 Robo the Dog

The above design concept will satisfy many of design criteria outlined per deliverable C. Since we have limited space allocated to each group, the “canine” robot above will have dimensions of about 5 ft in length, 3 ft in height, and about 1 ft in width. The sensors that will be primarily used will contain a PIR motion sensor, and light sensors. This will dictate whether the robot activates its functions. When a hand is moved above or place about the nose of the robot where the sensors will be placed, LED lights will activate in the eyes of the dog, causing them to glow. In addition, its tail will move in a circular motion via a motor that will generate mechanical movement. When a spectator comes to observe the robot, they may be prompted to “pet” the dog on its nose which will activate the lights and cause the tail to move. This interaction between the user (spectators, judges, etcs) will make the robot truly entertaining. Pleasing the audience satisfies our non-functioning criteria of pleasing the audience. The steampunk elements added to the robot design will enhance the visual appearance and also appeal to the non-functional design criteria that is most essential to the design event. Since one of the essential constraints placed was cost, this robot will use very cheap materials and household items to create that dusty and steampunk themed look. The arduino board and sensor hardware will be relatively cheap as well. In addition, the entire body of the robot will be hollow as to reduce weight and cost. Most of the body will be designed from cardboard material with sheet metal platings to give it a steampunk aesthetics feel. Consequently, the weight of the robot will be relatively light due to the nature of the materials. This robot also satisfies the functional requirements set in place by the museum design committee where technology of any kind has to be implemented into the robot so that it can perform an impressive function that will allow the museum spectators to interact with the robot and thus stimulate an amusing and innovative environment.

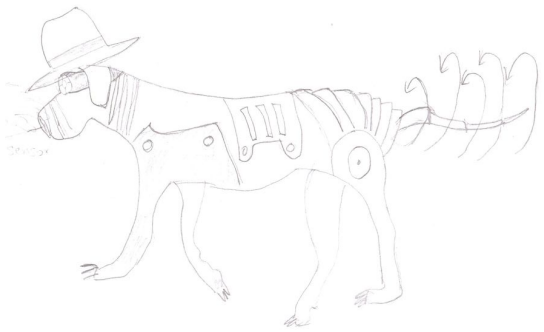

Figure 4: Robo the dog

4.4 Analysis of Chosen Concepts

Table 5: Comparison of several specifications between conceptual designs

Specifications	**Robot Name**			
	Importance (1 - highest importance)	**Robo**	**Shoe Shiner**	**The Dancing Robot**
Designer	N/A	Zarak Ali	Zary/Michal	Zarak Ali/ Ai Qing Li
Body Material	2	Metal sheets, household items, cardboard material, plastics	Scrap metal, cleaning cloth	Scrap Metal and Plastic/ Cardboard
Approximate Cost (CDN)	1	<$200	<$200	<$250
Body Type	4	Canine	Crab	Humanoid
Dimensions (ft)	2	5 x 3 x 1	1.6 x 1.6 x 1.6	4 x 1 x 0.5
Sensors	3	PIR motion sensor, Light sensor	Motion sensor	Motion Sensor
Functional Capabilities	2	Mechanical tail capable of motion via a motor, LED glowing lights	Cleaning items/shoes Motion of arms, use of cleaning	Showcasing great moves to an audience, providing

		installed in the eyes	apparatus	amusement to those interacting.
Production Difficulty (1 - easy, 10 - very difficult)	1	3	6	9
Total		23	31	25

Colour	**Red**	**Yellow**	**Green**
	Worst - 3	Medium - 2	Best - 1

4.5 Choosing Global Concept: Robo

As a team, we chose to move on further with the Zarak's Canine idea named Robo. From the benchmarking design process we determined that Robo was the highest ranked when taking into account all the design criteria. In terms of body material, Robo had the best specifications and because of this, it would most likely hold up better against wear and tear compared to the specs of the other 2 robotic designs. According to our estimated costs, Robo is estimated to have the least cost along with the Shoe Shiner, whereas The Dancing Robot may cost the most. Cost is a very important aspect as we are given an allotted budget and cannot go over that amount of 200$ or we will have to pay out of our own pockets. By the description of body types, Robo has the second best design specification, next to the humanoid robot which is most impressive in modern robots. However, a canine robot might look more aesthetically pleasing than a crab-like robot. For dimensions, the Crab-Like robot had the most efficient specifications but not by a whole lot ahead of the Robotic Canine and The Dancing Robot. The size of the other two can still be accommodated and built relatively well within our parameters and they do not exceed the allotted space given to us by the museum. Bigger size is not always a negative aspect as it may be better for user experience but it is harder to build and may cost more. In terms of sensors used for each robotic design, Robo clearly had the top rated motion and light sensors that would be easily integrated within its function. Implementing the PIR motion sensor and utilizing the light sensor will allow for a greater range of motion and creativity and an overall better user experience. From the robotic functional capabilities specified in the benchmarking process, The Dancing Robot has the highest determined rating according to predicted amusement for those interacting with the robots. Having a robot perform dance moves will give the audience something to laugh at or imitate which will provide a great experience for museum goers. We deemed that Robo

would have the same ranking as the Shoe Shiner in this aspect, because in the end, the amount of amusement is subjective to each person, and the Shoe Shiner performs a useful task, whereas Robo provides amusement via interaction with users with its response to being petted. Production, alongside cost, was also the most important for our team as determined in the benchmarking process. In the end, we are all 1st year students at the university, and as our technical capabilities in producing a robot are limited, it is integral that the steampunk robot should be relatively easy to produce and falls within our estimated production range. If the robot is predictably easier to produce, it means that the estimated end concept idea has a much better chance of being perfectly replicated and we can be more assured that every other aspect listed in the design criteria will match what we think it will represent in the end for the robot's design. (e.g easier to produce -> higher % chance of better functional capability). The crab like structure may be easier to produce because of its relative size, but again, the concept is very unique and it may be hard to replicate if we do not have a similar model to follow from experience. As for the humanoid dancing robot, it is the hardest to produce as outlined in the conceptual design because of the difficulty associated with producing a humanoid that should replicate accurate, aesthetically pleasing, and fluid dance moves. The technical capabilities of our team may not be able to achieve such a range of motion and may fall far from our estimated end product design and may not give anywhere near the user satisfaction that we had initially predicted.

5.0 DESIGN SOLUTION

Our design solution is Robo the canine robot. The idea was that Robo was a reanimated dog, so part of him was still furry and a real dog, while some parts were robotic and made out of metal and leather. The robot has two features: his eye lights up and his tail wags when someone pets him. There is a PIR sensor on the top of his head that detects motion; it is enabled when the user moves his/her hand over Robo's head which in turn activates the LED in his eye and a servo attached to his tail. The servo rotates 180 degrees making it look like Robo's tail is wagging. The use of the motion sensor makes the robot interactive since the user has to pet the dog to activate its features. This interactivity makes our robot unique and entertaining for customers/users.

The body is made almost entirely of scrap materials which makes Robo cost effective. The shape of the body is made of wireframing with fur, leather and sheet metal over it. The fur makes Robo look more like a dog and makes it more appealing to users since it gives it a cute and furry look. We used leather and sheet metal on the body to add steampunk elements and to make Robo look like he was reanimated. The sheet metal was spray painted to look like it was rusty. The legs, which were also made of wireframing, were covered with cloth that was spray painted grey to look like like steel and the claws were made of spray painted aluminum foil. The tail was

covered in fur so that it looked realistic and cute when it wagged. Only one eye was lit up using an LED while the other was replaced with a gear since Robo is a rescued dog. All the arduino circuitry was put inside the head and body of the dog, with wires connected the motion sensor, LED and servo. We also added other steampunk elements such as goggles over his eyes and gears and spray painted straws to imitate pipes all over his body to add more of a steampunk feel.

6.0 MODELING, PROTOTYPING STRATEGY & TESTING OBJECTIVES

Our prototyping strategy was first making prototypes of the two main subsystems: frame and arduino, and then making a prototype of all the subsystems integrated together. All our prototypes were experimental models since we physically built them.

6.1 Prototype I

The first prototype was a physical focused prototype. It was a basic design made out of cardboard and hot glue. The purpose of this prototype was to establish a basic understanding of what the product would eventually look like. It specifically focused on the frame subsystem of the dog so we did not include any technology in this one. The main test objective was to design a miniature version of our robot dog, Robo, using household items with minimal cost. Another objective was to reduce uncertainty about the body shape (i.e. we want it to look like our conceptual design). In addition, we wanted to test whether or not the body shapes (for example head shape, main body and tail) would work when the arduino hardware was installed. In other words, we needed the body to be compatible with the desired hardware to be installed. We presented this to our peers as well as family and friends. Most of the feedback was positive and encouraging. People liked the pleasing look and the general idea or our design. We could not test it as there was no technological aspect to it. However, we did test the dimensions and overall size of the design.

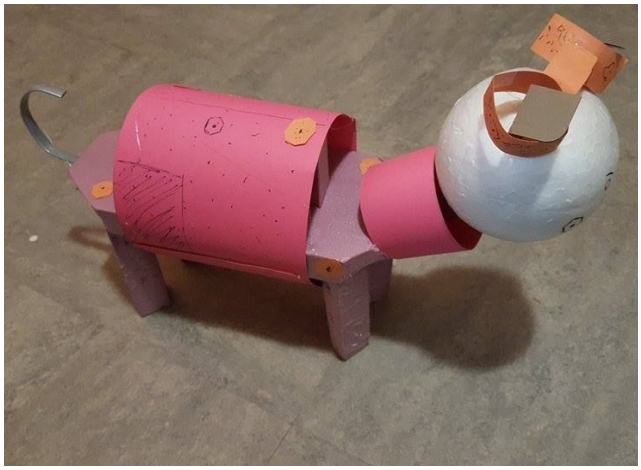

Figure 5: side view of prototype I: frame

6.2 Prototype II

The second prototype was also a physical focused prototype which was of specifically the critical subsystem. It was an arduino board programmed to carry out a function. This prototype of the arduino subsystem was the backbone of the product as it was used to test the functionality and it was the part that interacted with people. One of the test objectives was to make sure that when our robot dog was being pet, that his tail wagged. This meant testing that the motion sensor worked with the servo that will be attached to the tail. Another objective was to reduce risk of the project failing by testing to make sure the critical subsystem worked properly and if not to re-allocate time properly. In addition, we wanted to get user feedback about the functionality of our robot and if it met the criteria expected. Another test we wanted to conduct was whether or not the motion sensor would relay a signal so that the LEDs which will be installed in the eyes of the dog would function. We presented our second prototype to our peers and family members to get feedback. The response was even more positive than for the first prototype. We tested this prototype by waving over the sensor, and having users do the same, which would sense a change in heat and therefore enable the servo and LEDs. We did come across some issues as it did not work everytime or the sensor was sometimes too sensitive. However we were able to program the arduino correctly and make the critical subsystem function correctly.

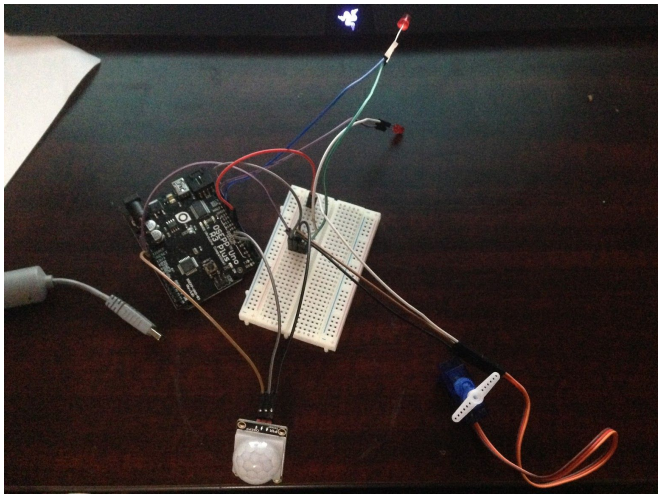

Figure 6: overhead view of prototype II: critical subsystem, arduino

6.3 Prototype III

The third prototype was a physical comprehensive prototype since it integrated both subsystems from the two previous focused prototypes. This prototype was building the final version of our steampunk dog for Design Day, which combined the arduino circuitry and the physical body of the dog. In order to do this, we used metal wire to frame the body while using planks of wood for support. The body, head and butt end of the dog were covered in cloth and then fur and sheet metal to add a steampunk feel. The arduino circuit was placed in the head where wires lead to the eye socket for placement of the LED and other wires lead to butt end to power the servo. Since we wanted to reduce cost as much as possible, we used as much scrap materials as possible, this included duct tape and glue to attach pieces together.

One of the test objectives was to make sure that when our robot dog was being pet, that his tail wagged. This meant testing that the motion sensor worked with the servo that was attached to the tail and making sure the tail's weight and positioning didn't impede the servo's rotation. Another objective was to reduce risk of the project failing by testing to make sure the two subsystems worked together properly and if not to focus on fixing the issue. In addition, we wanted to get user feedback about both the functionality and the aesthetics of our dog, especially about how the two integrate together. We got feedback from peers and friends before design day, and then peers, professors and judges on Design Day. Overall there was both positive and negative feedback. The positive feedback focused on how unique and interesting our robot was. People also said that the interactivity was very entertaining. The negative feedback was focused on how our robot did not resemble a dog much. Because of its head it looked more like a hairy alligator and

some people said they were a little scared of it. Also it was noted that because of the weight of the tail, the servo would sometimes overheat and stop working.

Figure 7: side view of prototype III: integrated subsystems

7.0 CONCLUSIONS & RECOMMENDATIONS FOR FUTURE WORK

Overall, most of the feedback from Design Day was positive. Many people said they liked the idea and that the robot worked well. However some improvements they suggested were to change the head shape to make it more recognizable as a dog and to expand the petting feature to not only work on its head but also its body.

The feedback for the third prototype was rather unanimous amongst all our clients. They liked the functionality of the robot and said it was implemented well, however they all commented that the head made it confusing which animal was supposed to be. The main improvement that we would need to focus on for a next iteration would be changing the head shape to make it look more like a dog.

7.1 Future Goals/ Plans

In the end we completed all the components that we wished to accomplish, which was to build a steampunk themed dog that was aesthetically pleasing and attracted spectators, and had a moving component. Our project definitely caught the attention of ongoing spectators, but many people were confused on what it was and what it was supposed to do. This means that we need to improve the aesthetic component. A few ways to do this would be have a better plan of the frame and how each part would be made and attached

to each other. Something that could be made better would be the legs, since it was very unstable and it was not very visually pleasing.

For the technological components, the tail and LED did glow when motion was sensed, but it did not work 100% percent of the time. This was probably because the motion sensor could not be visible since it affected the visual component, and this probably lowered the reliability of the motion sensor. For our servo, it was too small, meaning that it had some trouble lifting and rotating the tail, and since it was so small and the load (the tail), was too heavy, the servo quickly gets overheated, which makes the servo dysfunctional. This forced us to unplug the servo after every use, which was a hassle and not efficient.

For any further improvements, the most effective avenues for developing future aspects are working on the aesthetic features of Robo as well creating more technically advanced functional capabilities for the dog through the program Arduino.

Through feedback received, one of the greatest concerns was whether Robo was realistic enough and pleasing to the eye for the user interacting with its function. So spending more time on each separate body part and how they will combine together for the overall look of Robo through meticulous planning will definitely be taken into consideration for a distinct and sleek canine design that is easily recognizable with better suited material and model frames. By understanding what is the most efficient way of connecting those parts as well as the functional subsystems together and how they will coincide prior to building, the end product will be much more stable and smoother after functional implementation.

For further functional advancements the greatest improvements were adding a larger servo, another arduino R4 board and motor shield, cleaner implementation of wiring and detachable rear and front ends, and creating more technological parts like an LCD screen, more LEDS, and an increased amount of motion sensors along the whole body of the dog, or sound detection and barking. A larger servo will give less stress to the circuit and a lower chance of overheating by being able to adequately support the weight of the tail and handle the heat generated by the current. Another arduino board will allow us to include more functional aspects and will also generate a better current to all facets of the canine to light LEDS, power the servo, etc. Cleaner implementation of the wiring and arduino parts will benefit the aesthetics and give a sleeker look and also decrease the chance of errors occurring during interaction. Having easily detachable front and rear ends for where the arduino and breadboard and servo are located will give us a chance to easily modify any aspects and fix any errors smoothly so that no major stability of Robo

is altered. Lastly, adding more technological capabilities will better the experience and interaction for the user, and make Robo a truly unique and fun canine robot.

Overall, this was truly a great experience for understanding what it takes to develop a steampunk robot and to satisfy a client's needs through empathizing, defining, ideating, prototyping, and testing until a final product is created that meets all the requirements set beforehand. It will definitely prepare us for future years to come in engineering, whether it be in University, or even afterwards.

8.0 CONCLUSION

Canada's 150th anniversary of its confederation will take place across the country and marks many festivities and challenges to celebrate this occasion. The museum director requires entertainment for a gala being held and has asked the University of Ottawa engineering design students to develop suitable projects to be presented. A strong need exists for the Canada Aviation and Space Museum to design a steampunk themed robot that is aesthetically pleasing and is capable of mobile interaction while maintaining cost effectiveness. The inception of Robo, the canine robot, among other concepts generated, is a viable option because it satisfies the cost and functional/aesthetic requirements. This report discussed the design thinking method utilized and various critical engineering analysis techniques that are previously defined by institutes in order to effectively identify and satisfy the client's needs to develop Robo: Empathize, Define, Ideate, Prototype, and Testing. An overview of the advantages of certain techniques and how they were used was also provided.

This report has presented the major design thinking techniques and their use for developing the steampunk canine robot Robo, and the following conclusions have been drawn:

- Through interviewing Sharon, a list of needs was interpreted from her concerns, and these needs were organized and prioritized for relevant importance
- Design criteria were developed by identifying metrics based on constraints and functional/non-functional needs. We benchmarked similar products (nao v5, zoomer, etc) in the market that satisfy the predetermined requirements to create target specifications that were either ideal or acceptable moving forward.
- Ideas were brainstormed and three effective concepts were generated and sketched that would result in entertainment and functionality while being unique
- Robo, the canine robot was chosen after in-depth analysis of the criterion and 2 physical prototypes were developed for testing and feedback, the first being a comprehensive physical model of the dog, and the second being a focused functional representation of the arduino circuit with specified code to be written and programmed

- A third and final prototype was created which was a combination of the two integrated subsystems that would utilize scrap materials for its design and focus on implementation of the functionality within the body and its aesthetic

To fully implement the technological and functional aspects of Robo and entertain the user, more development and testing is required. For instance, the types of processes that fall within each type of modelling method or selecting the appropriate component based on a specific body part (motion sensing triggering barking in the head) needs to be investigated further.

9.0 APPENDIX

sketch_mar12d | Arduino 1.8.1

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sketch_mar12d §

```
#include <Servo.h>

Servo myservo;  //creates a servo object
                        //a maximum of eight servo objects can be created

int pos = 0;        //variable to store servo position

//amount of time we give the sensor to calibrate(10-60 secs according to the datasheet)

int calibrationTime = 10;

//the time when the sensor outputs a low impulse
long unsigned int lowIn;

//the amount of milliseconds the sensor has to be low
//before we assume all motion has stopped
long unsigned int pause = 5000;

boolean lockLow = true;
boolean takeLowTime;

int pirPin = 12;            //digital pin connected to the PIR's output
int pirPos = 13;           //connects to the PIR's 5V pin
int ledPin = 8;
int ledPin2 = 7;

void setup(){
  myservo.attach(4);    //attaches servo to pin 4
  Serial.begin(9600);    //begins serial communication
  pinMode(pirPin, INPUT);
  pinMode(ledPin, OUTPUT);
  pinMode(pirPos, OUTPUT);
  digitalWrite(pirPos, HIGH);

  //give the sensor time to calibrate
  Serial.println("calibrating sensor ");
  for(int i = 0; i < calibrationTime; i++){
    Serial.print(calibrationTime - i);
    Serial.print("-");
    delay(1000);
  }
  Serial.println();
  Serial.println("done");
```

sketch_mar12d | Arduino 1.8.1

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sketch_mar12d §

```
  //going HIGH immediately after calibrating
  //this waits until the PIR's output is low before ending setup
  while (digitalRead(pirPin) == HIGH) {
    delay(500);
    Serial.print(".");
  }
  Serial.print("SENSOR ACTIVE");
}

void loop(){

  if(digitalRead(pirPin) == HIGH){  //if the PIR output is HIGH, turn servo

    /*turns servo from 0 to 180 degrees and back
    it does this by increasing the variable "pos" by 1 every 5 milliseconds until it hits 180
    and setting the servo's position in degrees to "pos" every 5 milliseconds
    it then does it in reverse to have it go back
    to learn more about this, google "for loops"
    to change the amount of degrees the servo turns, change the number 180 to the number of degrees you want it to turn
    **/
    for(pos = 0; pos < 180; pos += 1)  //goes from 0 to 180 degrees
    {                                  //in steps of one degree
      myservo.write(pos);              //tells servo to go to position in variable "pos"
      delay(5);                        //waits for the servo to reach the position
      digitalWrite(ledPin, HIGH);
      digitalWrite(ledPin2, HIGH);
    }
    for(pos = 180; pos>=1; pos-=1)    //goes from 180 to 0 degrees
    {
      myservo.write(pos);              //to make the servo go faster, decrease the time in delays for
      delay(5);                        //to make it go slower, increase the number.
    }

    if(lockLow){
      //makes sure we wait for a transition to LOW before further output is made
      lockLow = false;
      Serial.println("---");
      Serial.print("motion detected at ");
      Serial.print(millis()/1000);
      Serial.println(" sec");
      delay(50);
    }
    takeLowTime = true;
  }

  if(digitalRead(pirPin) == LOW){
      digitalWrite(ledPin, LOW);
      digitalWrite(ledPin2, LOW);
    if(takeLowTime){
      lowIn = millis();            //save the time of the transition from HIGH to LOW
      takeLowTime = false;    //make sure this is only done at the start of a LOW phase
    }

    //if the sensor is low for more than the given pause,
    //we can assume the motion has stopped
    if(!lockLow && millis() - lowIn > pause){
      //makes sure this block of code is only executed again after
      //a new motion sequence has been detected
      lockLow = true;
      Serial.print("motion ended at "); //output
      Serial.print((millis() - pause)/1000);
      Serial.println(" sec");
      delay(50);
    }
  }
}
```

Figure 8: Pseudo-code for arduino IDE

10.0 BIBLIOGRAPHY

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