Final Report

OMNI VACUUM JUKEBOX

GNG 1103 C

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Abstract

From the moment the course starts, the class was divided into groups in order to build something great that will attract and interact with people. Considering the fact that the event will be having a steampunk theme, the project must also have the same output as the theme. Also what the groups learned during the laboratory like programming arduino, etc must apply on the project.

After a brief brainstorming with the group, finally had an idea of combining different ideas such as a robot that is programmable to move like a remote control (RC), a DIY vacuum, a speaker and the steampunk-designed theme. Then after the brainstorming part, we go and proceed and build our first prototype, encountered problems but also found some solutions and an improved ways to make our prototype workable. Second is the same concept of the idea of what it was brainstormed and with first prototype, however we ask some customer's feedback to give the team a constructive criticism. In the end the third prototype is like a second prototype but an enhanced one and now with a touch of the steampunk theme.

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I. Introduction

On May the 17th 2017, a national science and innovation gala will be hosted by the ***Canada Aviation and Space Museum***, our potential clients. They were expecting innovative technological ideas to be established to attract guests from all classes; secondary and post-secondary students, teachers, leaders (business, industry, politics etc.) and innovators. They will promote the demanding role of young future-makers in the field of steampunks.
The primary theme to attract customers on the event is steampunk, our robot should be able to entertain visitors through interaction.

Then the customer also stated their worries toward potential damage that designs could cause on other exhibitions such as priceless aircraft. Therefore it is essentially needed that for the design to move in a relatively small radius, and also to be non-aerial to prevent any potential accidents from the very beginning. Other than the safety required, the customers also desire a design piece that is particularly safe for the visitors and staff. Safety should always be prioritized in order to create a safe and stressless environment for both working staff and visitors
Beside prioritizing safety aspects of the robotic piece, the customers also want to have a engaging design that is interesting and engaging to visitors, so the robotic piece needs to be dynamic in order to better entertain visitors of all ages. Dynamic exhibitions are capable of attracting visitors' attention for a long period of time and appeal to be more engaging.For a while, we want to let them feel that they're in the city of the future.

However for this project, there are two potential customers other than the Canadian aviation and space museum. Which are high school teachers and entrepreneurs. Even though entertaining the users is important, the steampunk robot should also be a motivating teaching platform for all ages. It should promote learning experience to students in order to have a better knowledge of their environment and build interest towards robotics.

The other potential customers who are entrepreneurs, share the similar needs with the Canadian aerial and space museum. The entrepreneurs want a eye-catching and attractive design piece that is able to appeal the general public.

II. Problem Definition

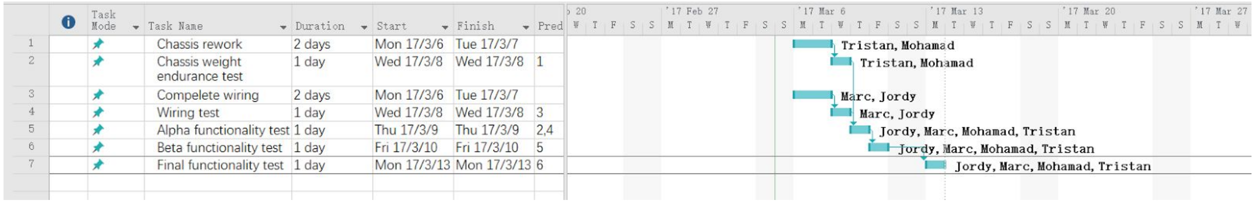
"To provide entertainment, to show innovation, interaction, dynamic, upgraded and STEAMPUNK related design"

Ill. Related Work, Research and Benchmarking

According to our robot’s function and desired needs obtained from the meeting, a list of prioritized design criteria were outlined. However, not only the requirements were revealed but also the constraints which needed further attention in the designing process. First of all, the client expected the design to be highly related to steampunk theme. Such a non-functional requirement suggested to the design to be cosmetically steampunk. Steampunk elements such as rusty steel pipes, exposed gear rings and metal patches are essential in order to create the steampunk atmosphere and better integrate our design into the museum. After that, the client also specified their expectation regarding the interactive and entertaining aspects of the design.

In order to truly prevent any potential damage that the design may deal to the exhibition, the design is non-aerial to ensure the controllability of the design piece. However, not only the safety of exhibitions, the safety of visitors and working staffs is also required by the clients. Consequently, the design needs to be reliable and has round and smooth surface. Also the travel radius of the design is limited to 5 meters. the client mention their desire of engaging and dynamic design. That is a function requirement and the design criteria needed is sensor-directed motion but we could not implement due to the complexity of their incorporation to the system and we decided to use a ps3 controller instead. High school teachers expect an educational design. Basically, in order to meet this, the design is straight-forward and intuitive . In fact, the structure are also thoughtfully integrated using joints and wires instead of something irreversible such as glue.

Other than functional and nonfunctional requirements, there are some numerical constraints needed to be taken in consideration. To ensure safety and the mobility radius is no more than 5 meters. The weight of the robot is less than 15kg to maximize the controllability of the design. Moreover, since the showroom area is limited, the length and height of our design need to be less than 1.5 meters.



	Task Mode	Task Name	Duration	Start	Finish	Pred
1	✓	Chassis rework	2 days	Mon 17/3/6	Tue 17/3/7	
2	✓	Chassis weight endurance test	1 day	Wed 17/3/8	Wed 17/3/8	1
3	✓	Compelete wiring	2 days	Mon 17/3/6	Tue 17/3/7	
4	✓	Wiring test	1 day	Wed 17/3/8	Wed 17/3/8	3
5	✓	Alpha functionality test	1 day	Thu 17/3/9	Thu 17/3/9	2,4
6	✓	Beta functionality test	1 day	Fri 17/3/10	Fri 17/3/10	5
7	✓	Final functionality test	1 day	Mon 17/3/13	Mon 17/3/13	6

Figure 1.1: Test plan grantt chart

IV. Design Criteria

The project will focus on getting the attention of the audience; using interactions and dynamic capabilities of our end product, it will also provide safety counter-measures to make it user friendly and safe for both museum staffs and audiences. However the theme “Steampunk” constrains our project, we’ll need some add-on designs to give awe to those who are watching; such as LED lights, programmed sensor controlled omni-motion and smooth mechanisms. We are also looking forward to engage young ones, specifically students to engage more in science specially in the field of physics. With that awesome learning experience we would inspire students to become future engineers.

Rank	Needs	Design Criteria
1	● Steampunk related	● cosmetically steampunk
2	● Interactive and entertaining	● LED Lighting and few functions such as tracking people
3	● Safe for other exhibitions	● Hover & Simple mechanic
4	● Safe for visitors and working staffs	● Safety measures and will be moving on small radius
5	● Engaging and dynamic design	● Sensor-directed motion
6	● Educational（for potential customers）	● Collapsible and portable; inspiring design

Table 1: Needs and Design Criteria

According to our robot’s function and desired needs obtained from the meeting, a list of prioritized design criteria were outlined. However, not only the requirements were revealed but also the constraints which needed further attention in the designing process. First of all, the client expects the design to be highly related to steampunk theme. Such a non-functional requirement suggests the design is cosmetically steampunk. Steampunk elements such as rusty steel pipes, exposed gear rings and metal patches are essential in order to create the steampunk atmosphere and better integrate our design into the museum. After that, the client also specified their expectation regarding the interactive and entertaining aspects of the design. To meet that functional requirements, the design has unique characteristics that attract visitors’ attention and also capable of display-worthy function such as tracking visitors’ movement and following them automatically. With a function like tracking movement, visitors can be involved and also be entertained at the same time. Furthermore, the client also mention their such as aircrafts. With that said, the design's mobility is relied on simple mechanics to minimize the possible damag In order to truly prevent any potential damage that the design may deal to the exhibition, the design is non-aerial to ensure the controllability of the design piece.e. However, not only the safety of exhibitions, the safety of visitors and working staffs is also required by the clients. Consequently, the design needs to be reliable and has round and smooth surface. Also the travel radius of the design is limited to 5 meters. Safety precaution equipment such as fire-extinguisher and first-aid kit are also essential in order to create a stress free and cheerful atmosphere for everybody to enjoy. Finally the client mention their desire of engaging and dynamic design. That is a function requirement and the design criteria needed is sensor-directed motion but we could not implement due to the complexity of their incorporation to the system and we decided to use a ps3 controller instead. Sensor-directed motion can be achieved by applying Arduino board with self-designed syntax. The motion can help the experience become more engaging and also make the design appeal to be more dynamic.

Beside our main client which is the Canada aerial and space museum, potential client such as high school teachers are also have their distinct needs. High school teachers expect an educational design. Basically, in order to meet this, the design is straight-forward and intuitive . In fact, the structure are also thoughtfully integrated using joints and wires instead of something irreversible such as glue.

Other than functional and nonfunctional requirements, there are some numerical constraints needed to be taken in consideration. To ensure safety and the mobility radius is no more than 5 meters. The weight of the robot is less than 15kg to maximize the controllability of the design. Moreover, since the showroom area is limited, the length and height of our design need to be less than 1.5 meters. Funding wise, the cost of the entire project is limited to 400 dollars since we have a set budget. After the stated requirements and constraints, benchmarking is highly significant to outlining the specific design ability by comparing potential competitors' products.

Functional Requirements	**Non-functional requirements**	**Constraints**
Dynamic (mobile) by itself	Serving a unique task for the event[1]	Small operational area
Robotic based/ not only a machine	Safe	Non-repetitive/ unique
Controllable	Steampunk-looking/engaging design	Functions on land(not aerial)

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[1] For example, we cannot create a robot that serves food while there already exist one that serves food.

	Educational to the target audience/ guests; students	

Table 2: Design Requirements and constraints

NOTE:

In the benchmarking section, we are going to use the color methodology to mark importance of the specifications.

Numerical Legend: Green +3
Blue +2
Orange +1
Black : Neutral: 0

Benchmarking

Specifications	**Option 1**	**Option 2**
Software part	**Uno Arduino**	**Mega Arduino**
Approximate board price	40$	45$
Board Pros	Small	54 available input/output pins
Maximum operational area[2]	20 meter cubed	
Company	Interaction Design Institute Ivrea (IDII)	
Control method	No sensors	Ultrasonic sensors
Dynamic tool	Omni wheels	
Wheels	IG32	IG42
Single wheel bearing	75 lbs.	100 lbs
Price per wheels package(4 wheels)	150 $	200 $

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[2] This piece of information was stated by our guest after we asked her about the area availability.

Compatible Gear Motor[3]	24VDC IG32 195 RPM	24VDC IG32P 190 RPM
Motor approximate torque	7.5 kg-cm	35 kg-cm
Motor price[4]	20$	26$
Cleaning tool	Circular mop	Vaccum
Cleaning tool price	10 $	40$
Energy source	Batteries	Sustainable solar boards
Energy source cost	40 $	40 $
TOTAL	**15**	**12**

Table 3: Benchmarking designing products

Equipment and prices:

Equipment	**Quantity**	**Price per 1 quantity (without tax)**	**Comments**	**URL**

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[3] http://www.superdroidrobots.com/shop/custom.aspx/atr-mechanical-overview/51/

[4] http://www.superdroidrobots.com/shop/item.aspx?itemid=374

PS3 orginal sony wireless controller that supports bluetooth	1	78.99	fake option works	https://www.amazon.ca/Dualshock-Wireless-Controller-Black-PlayStation/dp/B0015AARJI/ref=sr_1_6?rps=1&ie=UTF8&qid=1489040612&sr=8-6&keywords=ps3%2Bwireless%2Bsony%2Bcontroller&th=1
DC geared 12v motor	4	29.27	• The gear motor is not intended for instant reverse • 200 rpm • shaft diameter: 6 mm	http://www.robotshop.com/ca/en/ghm-16-gear-motor-rear-shaft.html
		29.27	• #12VDC 120RPM 15oz-in GHM-02 Spur Gear Head Motor • #100 rpm • #6 mm • #Specially designed to operate at low speed	http://www.robotshop.com/ca/en/ghm-02-spur-gear-motor.html
		17.32	• 12V 100RPM 583 oz-in Brushed DC Motor • 100 rpm • 6 mm	http://www.robotshop.com/ca/en/12v-100rpm-583-oz-in-brushed-dc-motor.html

Mecanum wheels	1 package of 4 wheels	109.87	• Aluminium • 2x left and 2x right • diameter: 100 mm • Compatible Hubs: 6mm hub 8mm hub 10mm hub 12mm hub 16mm hub 12mm key	http://www.robotshop.com/ca/en/100mm-aluminum-mecanum-wheel-set.html
Simple Z axis Couplers	4	0 $ (3d printer)	Don't work	http://www.thingiverse.com/thing:533928
				http://www.thingiverse.com/thing:1192614
				http://www.thingiverse.com/thing:1849281
				http://www.thingiverse.com/thing:964671
				http://www.thingiverse.com/thing:1192614
Battery 12 V 1.3 A	2	approximately 8	NO ones found online (must be purchased in any electric shop)	
Original arduino motor drive shield	2	28.99	version 3	http://www.robotshop.com/ca/en/arduino-motor-shield-rev3.html
Original Arduino UNO V3	1 with USB (master) 2 slaves	26	robot shop	http://www.robotshop.com/ca/en/arduino-uno-r3-usb-microcontroller.html
		22.19	arduino.cc	https://store.arduino.cc/product/A000066
Approximate TOTAL WITH TAX	**475.5 CAD**			

Table 4: Equipment and prices

VI. Prototypes: Solutions

Prototype l:

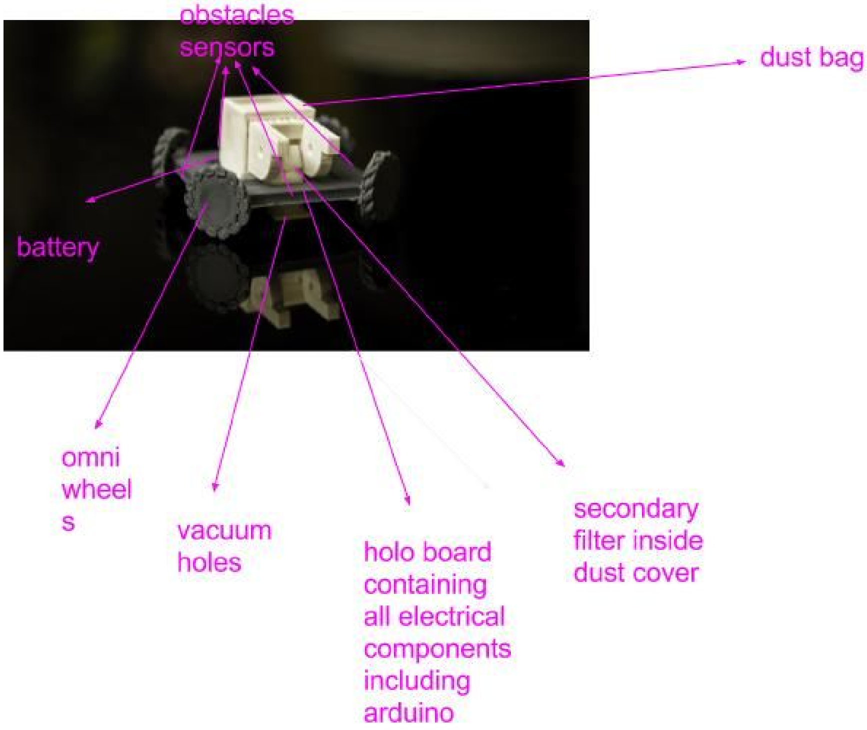
obstacles sensors
dust bag
battery
omni wheels
vacuum holes
holo board containing all electrical components including arduino
secondary filter inside dust cover

Figure 1.3:

Physical prototype 1 of the robot

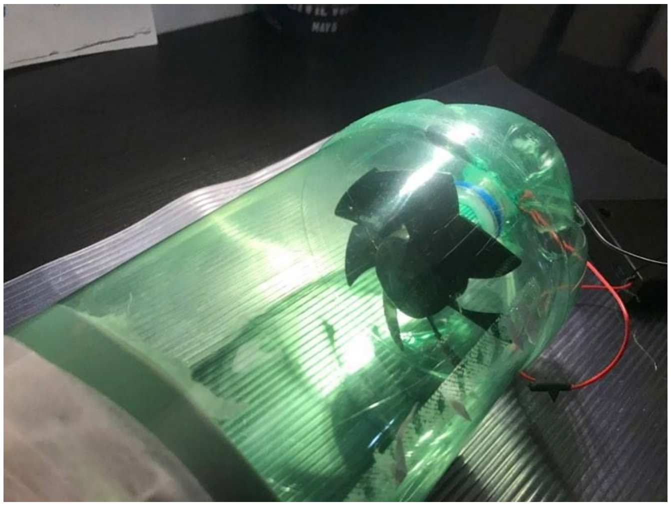

Figure 1.4: Vacuum physical prototype

Prototype II:

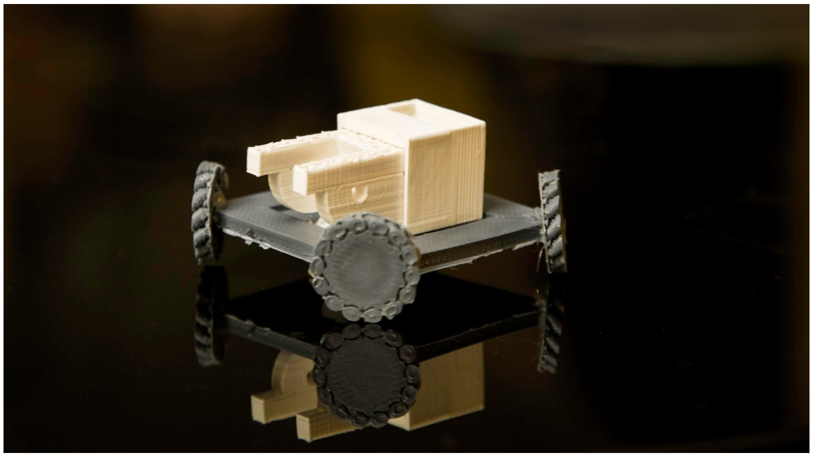

Figure 2.1: Robot physical prototype II annotated

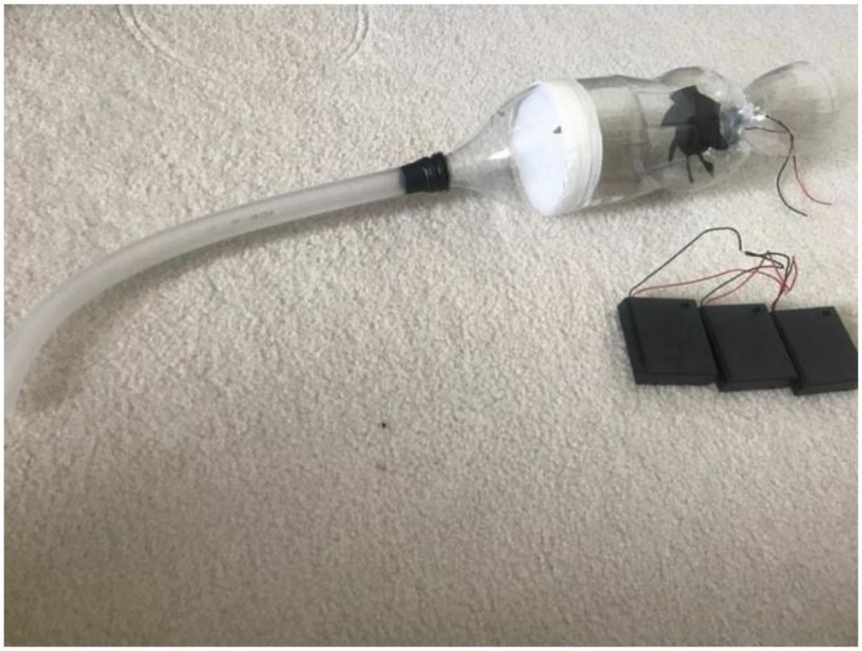

Figure 2.2: Vacuum physical-comprehensive prototype II annotated

Prototype III:

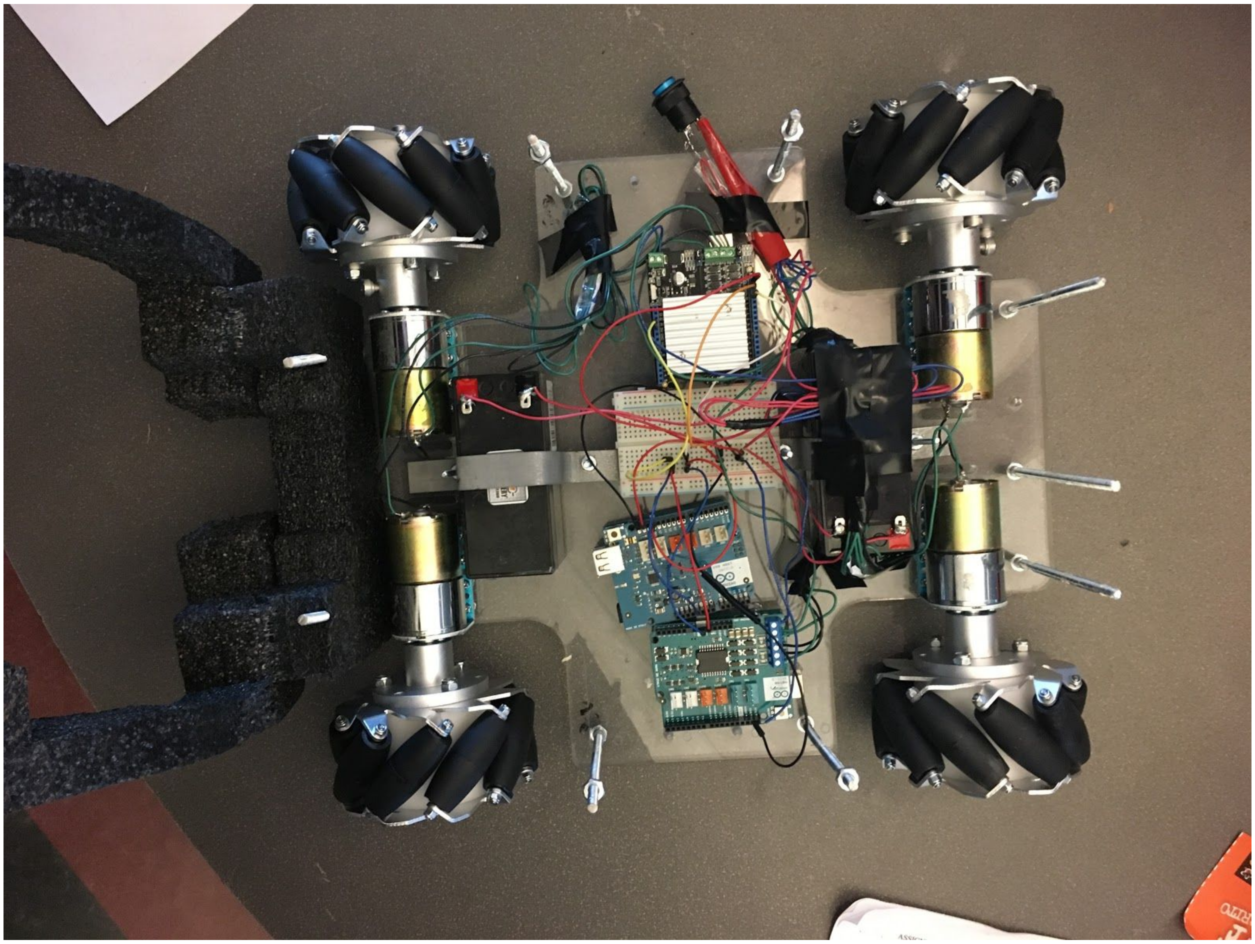

Figure 3.1: Final comprehensive-physical robot prototype

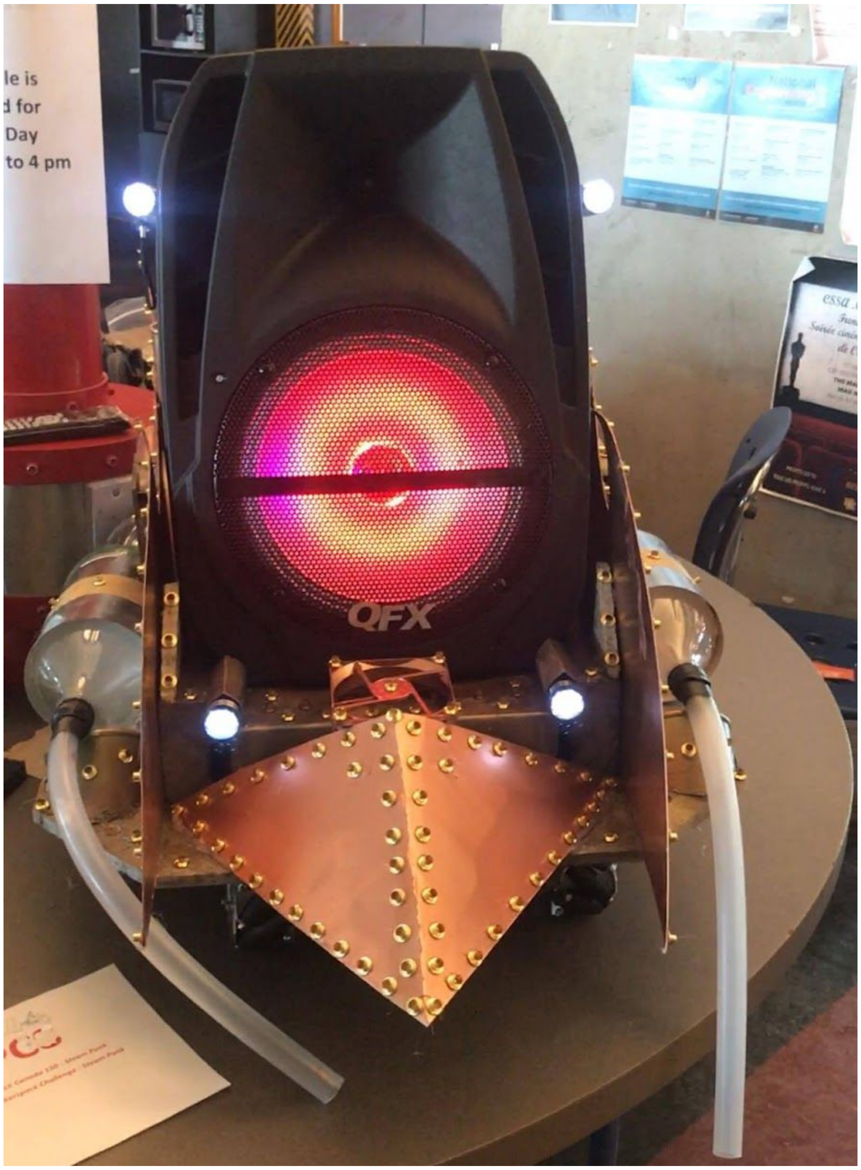

Figure 3.2: Final full comprehensive prototype.

VII. Customer Feedbacks

Why are we doing this test?

This is an introduction. Capture the reasons for the test, giving enough background information to justify doing ***any*** *prototyping at all. Is the* ***general*** *objective one of: learning, communication, de-risking, etc.*

This test is a actual performance test for the sake of a professional future prototype. We make it to show what we have improved on the second prototype and to catch also feedbacks from the customers on the parts that needs improvement. It also enlightens the prototype's deficiencies which we have need to work on through criticism of the customer.

Test Objectives Description

What are the ***specific*** *test objectives?*

-*To show an well improved sample for the customers rather than describing the prototype to them which is boring inefficient and unattractive.*

-*To figure out and correct all the failures/errors of calculations we made in the first prototype and*

-*try to attract funders interested in our future project*

To develop a more reliable circuit design which can be more consistent in various conditions.

What ***exactly*** *is being learned or communicated with the prototype?*

From this prototype, we learned:

"The arduino boards need to be well arranged and the wires burnt when touching each other"

"The sucking of the vacuum is better using a thin wire gauze for the filter and put more big holes

due to the insufficiency in sucking "

What are the possible types of result?

The possible results can be a well improved robot that meets customer standards and ready to entertain the users by its speaker which play pleasing musics

The possible results can also be a robot that can not roll at all because of a problem in the circuit connection.

The speaker can also makes too much noise which will no longer make it entertainable for the users

How will these results be used to make decisions or select concepts?

This results will force us to work on the failures of the prototype to make a better next prototype regarding the customer's feedbacks

What are the criteria for test success or failure?

The criteria of the test success are to check whether the whole features of the prototype allows it to sucks the dusts which is the main function of a regular vacuum and if it can change the directions using serial monitor . The prototype should also entertain the users by the songs from his speaker

***What** is going on and **how** is it being done*

*Describe the prototype **type** (e.g. focused or comprehensive) and the reason for the selection of this type of prototype.*

It is a PS3 stick wireless-controlled omni robot vacuum that is programmed using 3 arduino boards. It can clean dust while avoiding all obstacles in all ways . It has a hose inserted inside a hole in its base which carries a box that acts as a dust bag.

We've chosen this kind of prototype for two main reasons: testing vacuum and

Describe the testing process in enough detail to allow someone else to build and test the prototype instead of you.

- *buy mecanum wheels, 3 arduino boards: 1 arduino uno and 2 slaves*
- *Add the motors to the wheels and fix them*
- *Watch a youtube video on how to do a vacuum using a bottle*
- *add the vacuum over the base*

*What information is being **measured**?*

-vacuum sucking ability

-the weight of the board

-size of robot relative to homes and shops

-sizes of the robot's parts ' relative to each others

-The battery life

-The Arduino code

-the ability of the board with the 4 mecanum wheels to support the load of the whole system

-the board aquar&ly

*What is being observed and how is it being **recorded**?*

The vacuum and the speaker were working perfectly but we got an issue with the circuit where one wheels could roll not the other ones due to

What materials are required and what is the approximate estimated cost?

The materials and the estimated cost will be attached to pdf document

What work (e.g. test software or construction or modeling work or research) needs to be done?

the test software needs to be done is a code which make the vacuum rolling and sucking any kind of dust which it sees.

The constructions which need to be done is the assembly of the 4 mecanum wheels and the setup of the circuit which will enable the vacuum to turn back if encountered any kind of obstacles

When is it happening?

How long will the test take and what are the ***dependencies*** *(i.e. what needs to happen before the testing can occur)?*

The test will have a duration of 5 days. Of course the dependencies are something we must consider in order to proceed the planned testing smoothly and effectively. First of all the circuit should be refined and sorted before everything else can start. After the wiring is done, the more rigid connection between the omic board and the cosmetic design. Once a more rigid connection is developed more chassis testing can be conducted to insure the entire design work as a whole. First the fully assembled chassis with all the possible load would be use to test its stability around a straight line and also cornering with speed. Then a beta testing would examine how well the entire design can resist external forces such as wind and unexpected collision with crowd.

When are the results required (i.e. what depends on the results of this test in the project plan)?

The results are required before the final presentation since we would like to present the most refined and completed version to showcase our design to our peers.

VIII- Testing

Components	**Verification Method**
Gear motors / Vacuum motors	Battery to motor through direct simple circuit to verify functionality
Wheels	Battery to wheel direct circuit testing
Arduinos	General testing method: -Checking LEDs all working when connected to usb port -using the multimeter
Circuit	Multimeter
Robot	Arduino Serial pointer analytical simulation
Vacuum/ Robot batteries	Voltmeter
Code	Serial pointer/ Arduino compiler
Vacuum absorption	Using light particle of paper

Table 5:Testing required

IX. Conclusions and Recommendations

In the end the conceptual design that we have sketched and brainstormed has turned into reality, meeting the customer's expectations as well in the end. It is a combined ideas of the team by putting 4 ideas together which is the mechanuum robot, DIY low-cost vacuum, an extra feature which is the integrated multi-functional speaker and lastly a touch of steampunk theme since the engineering event and the team for which our team is invited was a steampunk event.

The team, although faced a lot of difficulties, even tensions between team members, conflict with ideas has somehow managed to use that as a source of strength to build this beautiful project that most of the people during the event get awe with not only the appearance but also the functionality of it.

Improving the prototype, enhancing its functionality is the main key towards the success of the project, of course it won't be possible without the help of some customer feedbacks to its functionality. Lastly testing multiple times is also a must to know whether it will perform what it was programmed or created for.

X. Bibliography/References

** Mentioned on going basis in the report*