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ABSTRACT

The world is currently undergoing large scale development. In the technological field, smart phones have become a commonality even among children, whereas in the past they were regarded as luxury devices. Writers describe this age as the smart phone and tablet era, and many large companies such as Google, Honda, CAT, Sony and Microsoft are currently investing in the robotics as they predict that the upcoming revolution will cue the robotic era, where robots will be as affordable and widespread as personal computers are today.

In view of these developments, our team has designed and developed a cost efficient hand gesture controlled military robot capable of mimicking the hand gesture of a military personal and translate them onto a mobile robot controlled remotely. This report will describe in detail how the robot operates, and how we were able to overcome the challenges encountered during the management of the work, development and building of the prototype robot and the coding procedure.

I. Introduction

The use of robotics technology in military led to a new field called Military Robotics. Military robots need not necessarily be humanoid nor do they necessarily carry weapons; they simply are robots that assist and support the armed forces. Military robots come in different shapes and sizes as per the task they are created for. In our research, we will be working with a gesture controlled unmanned ground vehicle.

II. Problem Statement

Figure 1: War on Terror

US and many other countries are losing many military personnel during war on terror. Casualties of soldiers and war supporters are costly both strategically for the war effort, and emotionally for the friends and family of those lost. Thus, a way of fighting a war, while preserving the lives of as many armed forces members is paramount and is the problem we are looking to solve. The answer that we will propose is that the armed forces use robotic technology for a larger portion of their missions.

III. Solution Proposed

Our idea is to develop a fast response hand gesture military robot that will ensure the safety of the field officers. The robot will be capable of fast deploying in a war battle, overcome harsh terrain, provide feedback, aim at a target, and fire a projectile at it.

A control station will be built and linked to a visual system in order to control a mobile robot wirelessly. Also, a projectile firing mechanism will be build in order to target enemies and fire in the most efficient manner. Hand gestures of a military personal will be mimicked and used to control the arm on board.

The robot will operate as follows: military personal will guide the robot to its target at a desired speed. Then we use his hand to target at the enemy, followed by triggering the weapon on board.

Finally, we will study the sustainability of the project based on the price of different electric and mechanical parts.

IV. Management of Work

The first step was researching; the main focus was to learn from the experience of others. We researched existing solutions that tackled our problem and known difficulties and troubles we might face and many theoretical findings. Since our project is about robotics, many resources are available, whether it was through books, videos or internet sources. For example, to answer one of our questions of which microcontroller/programming language we must use we researched about each type of microcontroller and determined which will be the most suitable. One of the references in our research was a book called “Exploring Arduino by Jeremy Blum,” we focused on the Arduino microcontroller. The main finding in this book was the coding language, the user interface and the board identification. After, completing our research we found out that this microcontroller will be used in our robot because it is user friendly and easy to code.

1. Mind Mapping

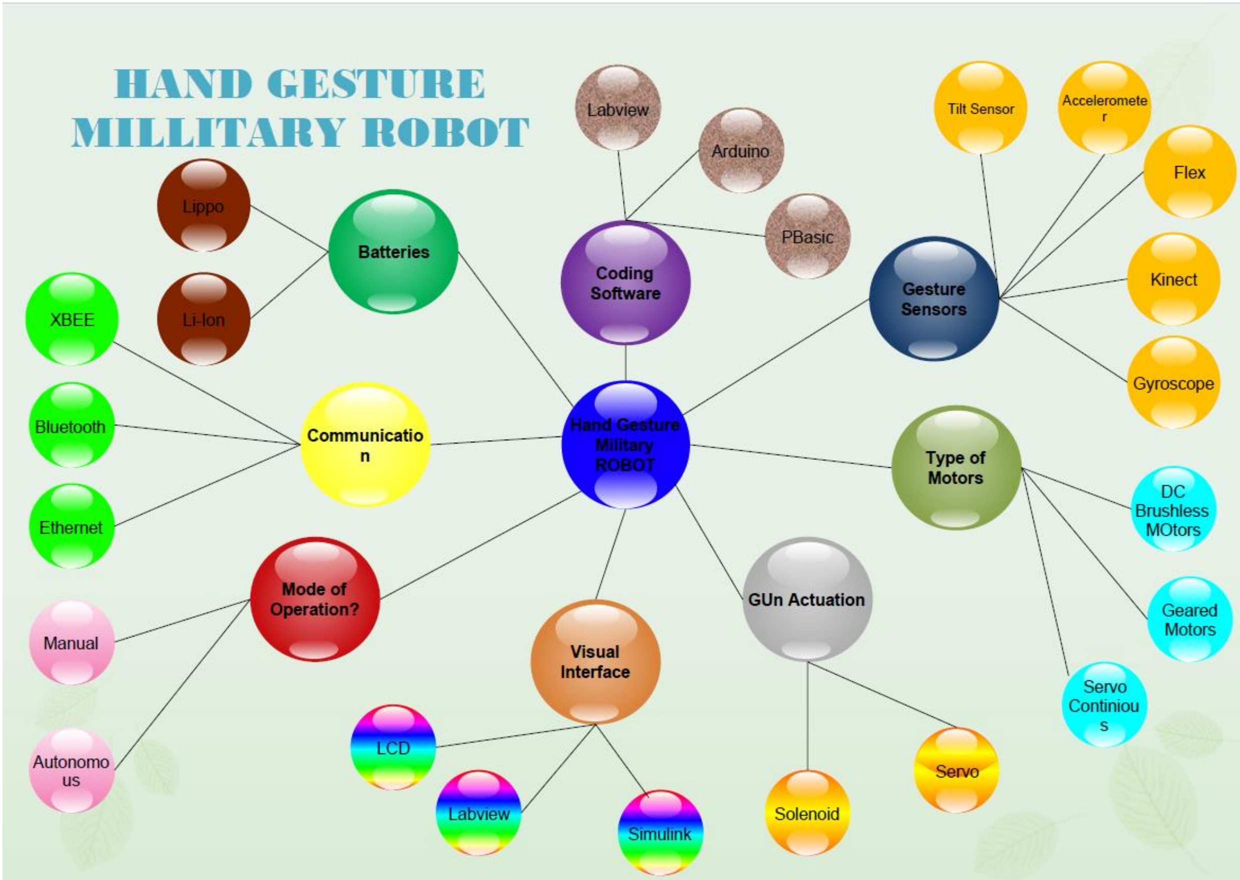

Figure 2: Mind Mapping

The second step was mind mapping. As seen in the Figure 2, we brainstormed and came up with all the possible ideas and questions and used the software Edraw Mind Map to organize them. The idea is to release all of the ideas in our heads and to generate new ones onto paper for better visualization and creativity releasing. First of all, we started by our one point of interest and central idea in the middle which is the robot by placing it in the middle. Then, we branched out of the central idea by writing down anything that comes to mind such as several questions which will help us in building our robot. For example, one of the questions was: What type of sensor should be use for gesture control? The answer to this question was to use one or more sensor combined together. Such sensor include: an accelerometer, gyroscope, tilt sensor, flex sensor or Kinect. To discover the answer to this and other questions we had to start with research.

2. Program Evaluation and Review Technique (PERT)

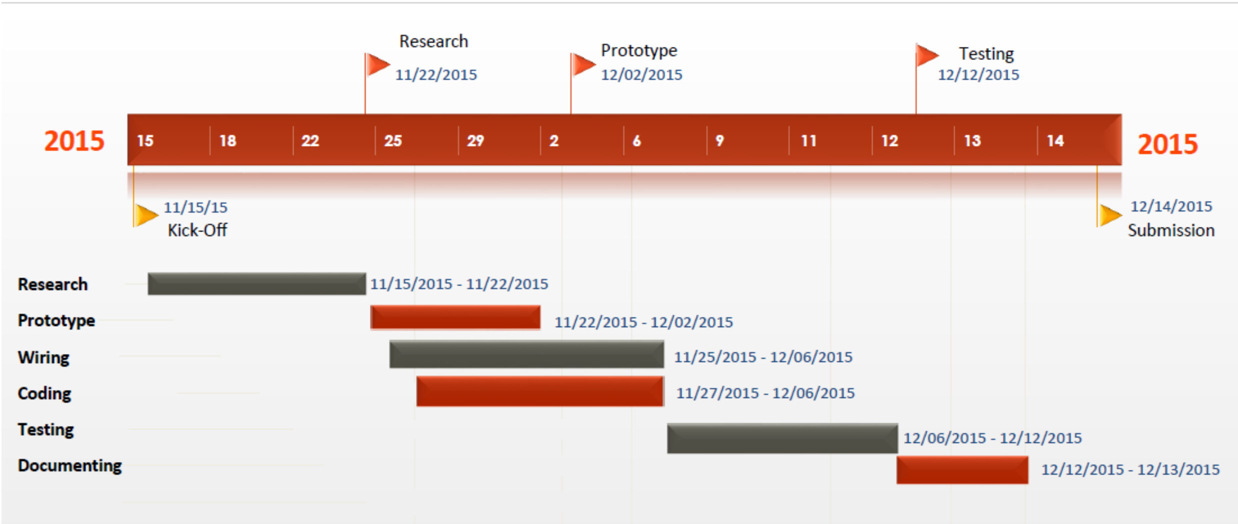

Figure 3: Pert

To ensure that the sum of all task times is within project deadline, the team broke down the design into individual tasks as shown in the figure above, identified each activity and assigned estimated completion time in a logical manner. The PERT diagram generated using Microsoft office shows related project activities in sequential order along the different paths connecting them. There were a total of 6 activities.

We noticed that our project has an estimated duration of 5 weeks. Moreover, the red bars represent the critical path which contains the activities whose dates are if disturbed, will affect the end date of the total project; the critical path is where we need to orient our focus on.

V. Building the Prototype

1. Assembling Robot Chassis and Wiring motors

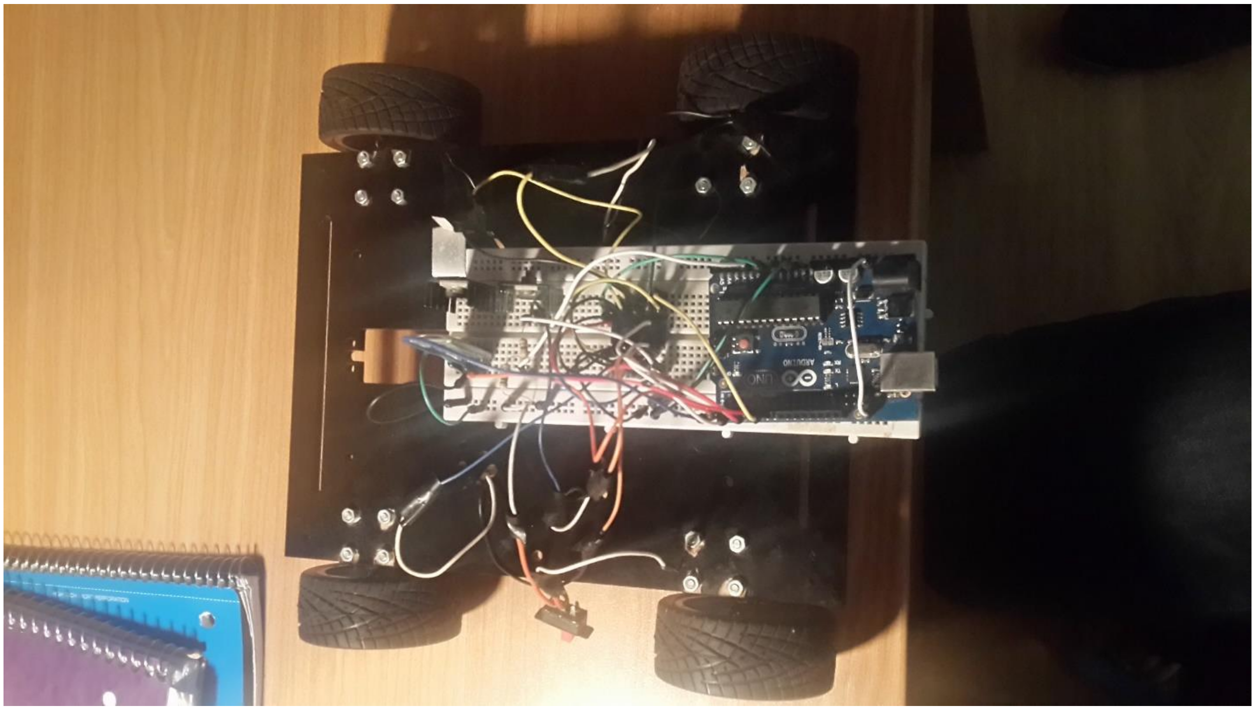

Figure 4: Robot Chassis

The choice of the chassis was not easy. The robot is intended to overcome harsh terrain, have good maneuverability as well as a good structure in order to tolerate the weight of the components that will be installed on it, most notably the batteries, servo motors and arm. At the beginning of the project, a chassis was found at a store in the US to meet the desired requirement, while having an attractive cost which would help our project to have an overall competitive market price. Hence our opted robot with 4 wheels, each wheel driven by a geared motor was adopted.

The motors are controlled by an L293D H-bridge and powered by 7.2V DC Lippo batteries in series. The H-brige was used to control the direction and the speed of the motors. A switch was included in order to power the robot on and off. A circuit was designed to continuously monitor the temperature and the voltage of the batteries. Bluetooth Communication was used to communicate between base and the robot.

2. Aiming at the Target

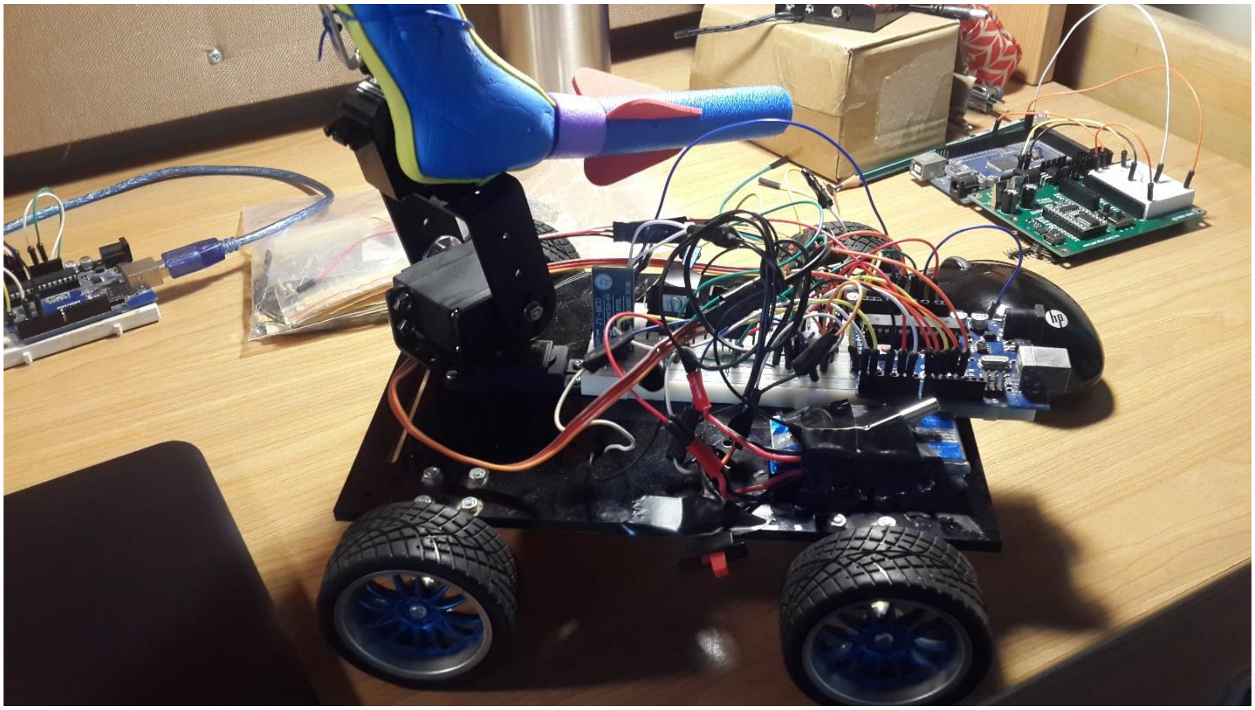

Figure 5: Target Aiming

Aiming at the target is the most important feature of the robot. The two DOF Servo system as seen in the figure above is used to aim at the target. This system is composed of 2 servos: one for the horizontal direction and one for the vertical direction. The hand gesture of a military personal is mimicked using a tilt sensor and translated to the control servo platform.

3. Shooting

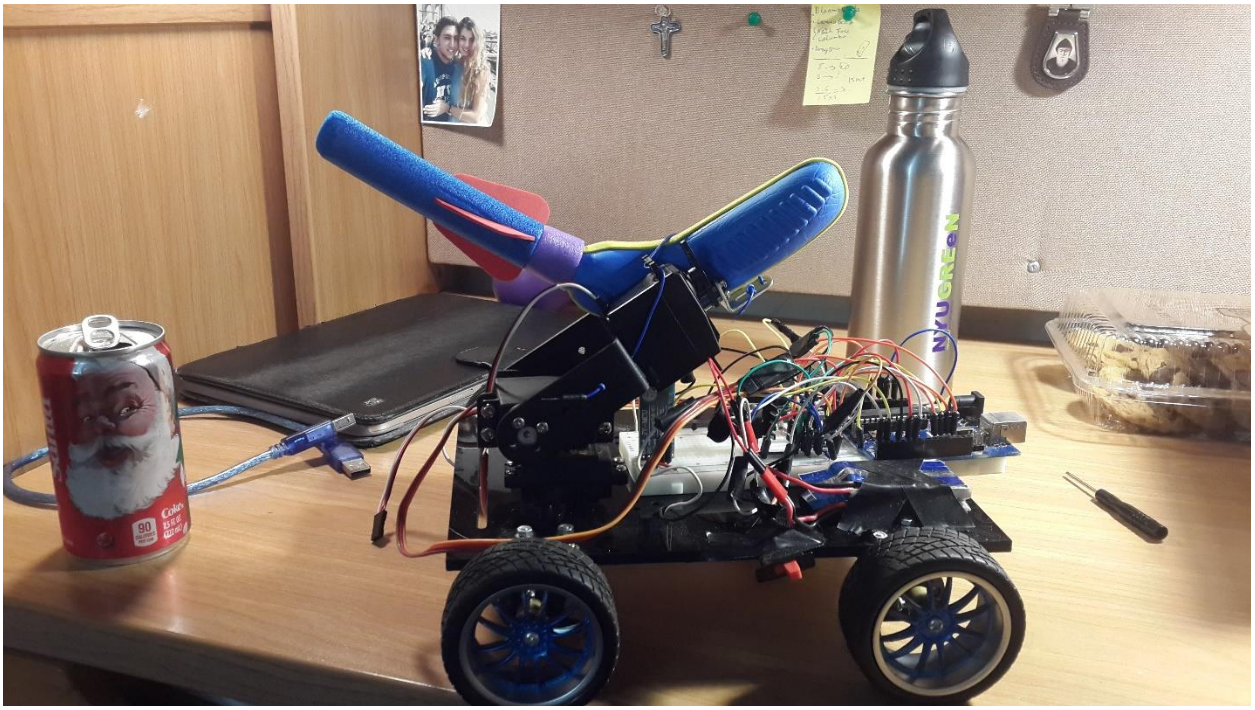

Figure 6: Shooting

In order to shoot, a mechanism was constructed using a servo motor and a wire. The wire is set up so that when the servo begins to turn, the wire constricts the pressured power weapon, which calls it to fire. Whenever the military personal trigger triggers a flex sensor, the servo will turn from 0 to 180 degree and stretch the gun.

4. Control Base Platform

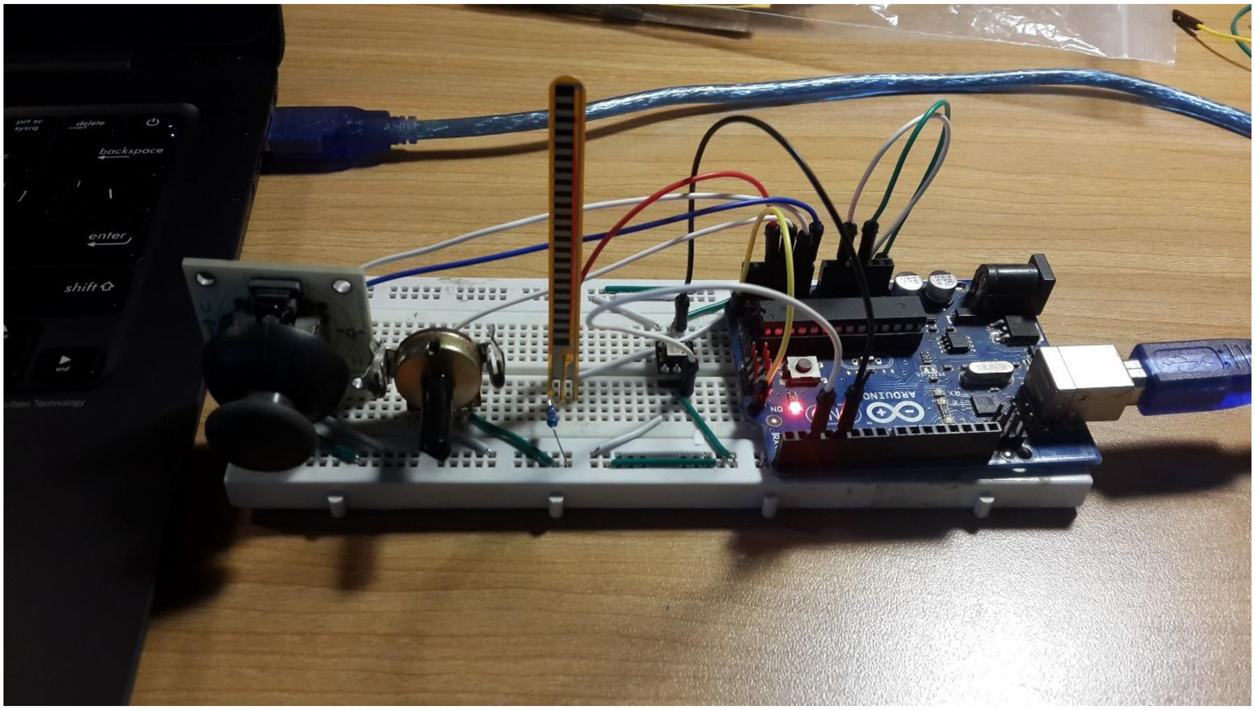

Figure 7: Control Base

A remote control panel was built in order to control the robot manually. Control will be through the remote control platform that can be seen in Figure 7. This control platform will communicate with the PC using serial USB connection. The mode of connection can be replaced by a wireless one. This panel contains: The microcontroller (Arduino), a tilt sensor for controlling the x and y joysticks, a flex sensor in order to shoot, a potentiometer to control the speed of the motor and a joystick to control its direction.

VI. Circuit Design

The circuit of both the robot and the control base were designed on Eagle software as shown in the image below:

1. Control Base

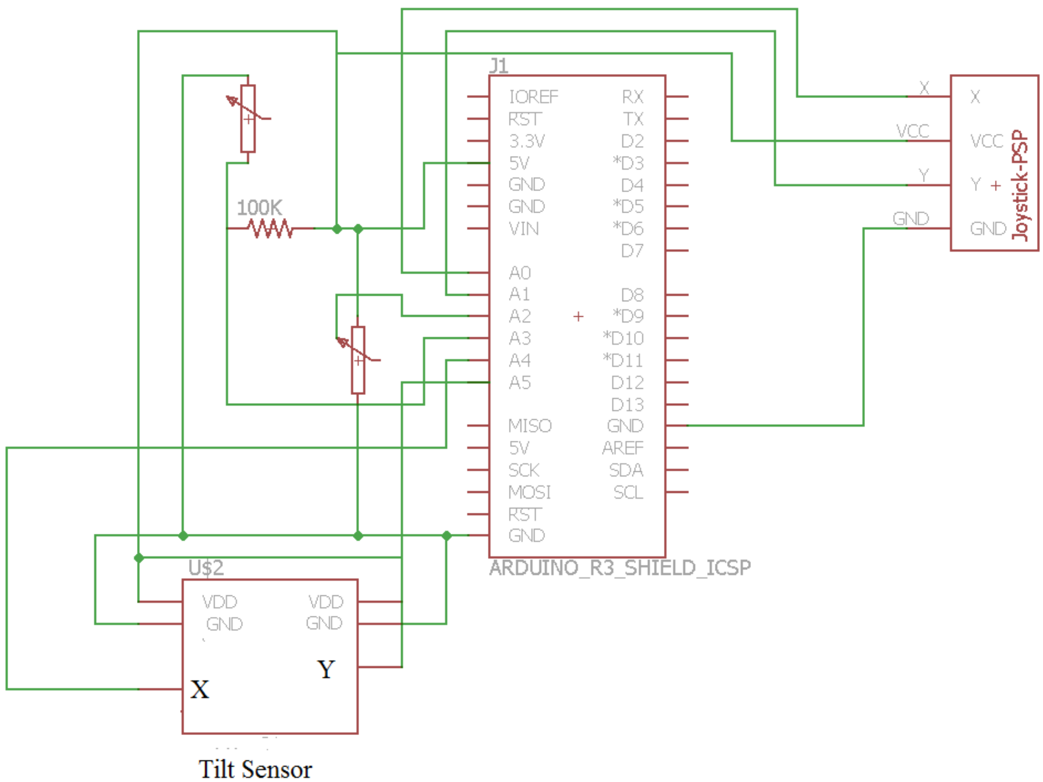

Figure 8: Control Base Circuit

For the control circuit, the flex sensor was paired with 100K resistance and the value was later scaled. The tilt sensor is a digital device that has 2 outputs. Moreover, the potentiometer was branched and the voltage across it was later scaled. The joystick gives two different reading for each direction. And those reading are analog.

2. Robot

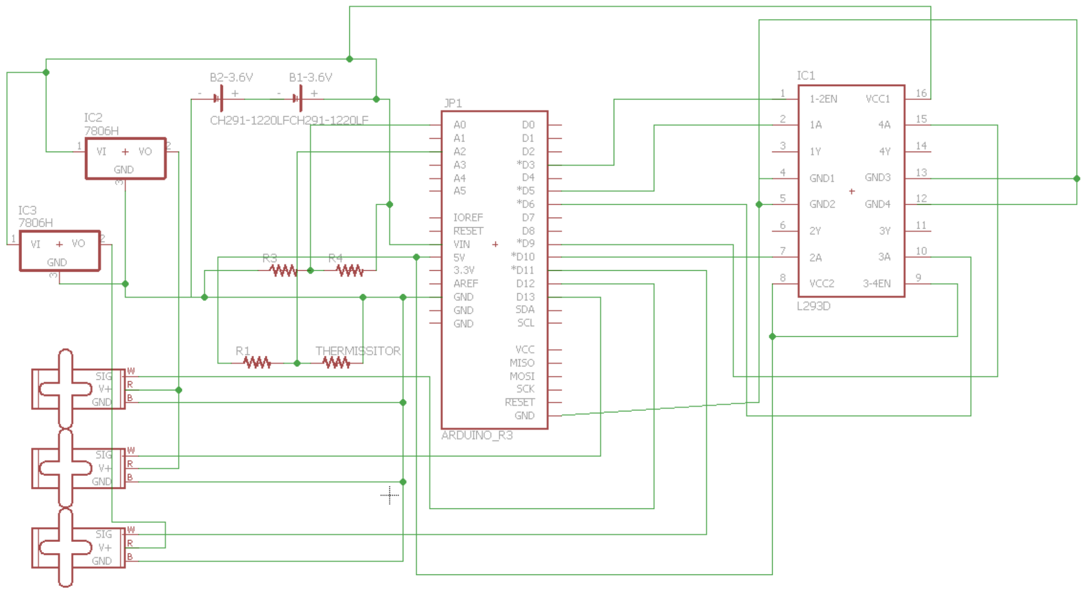

Figure 9: Robot Circuit

The motors are powered by 7.2V but the Arduino board, sensors, servos, Bluetooth and LEDs are in need of 5V. Consequently, two voltage regulators are used to burn 2.2V. One of them provide 5V for the two DOF servo system and the other one provide 5V for the trigger servo. Arduino board is powered directly by 7.2V since it contains an on-board voltage regulator. Since, the amount of voltage burned is large, the voltage regulator will dissipate a large amount of heat to the surrounding air. Fins were used in order to make sure to keep the voltage regulator at low temperature. Fins will increase the surface area of the voltage regulator which will lead to a large heat transfer to the surroundings ($Q=h*A*\Delta T$).

We later designed a circuit in order to check the summing voltages of the two batteries without the need of a voltmeter. The Arduino board is designed in order to read voltages that are below or equal to 5V. Any voltage that exceed this number will damage the board. Thus, the summing voltages are reduced to a number smaller than 5V in order to be read and interpreted. Designing this circuit consists of two identical resistances. The resistances are chosen to be equal to 10Kohm, a large number in order to reduce the consumption of this circuit. Since V=RI, the voltage is constant equal to 7.2V and choosing a large resistance will decrease the current. And, Since P=VI, the power consumed will decrease because power and current are directly proportional.

VII. Coding

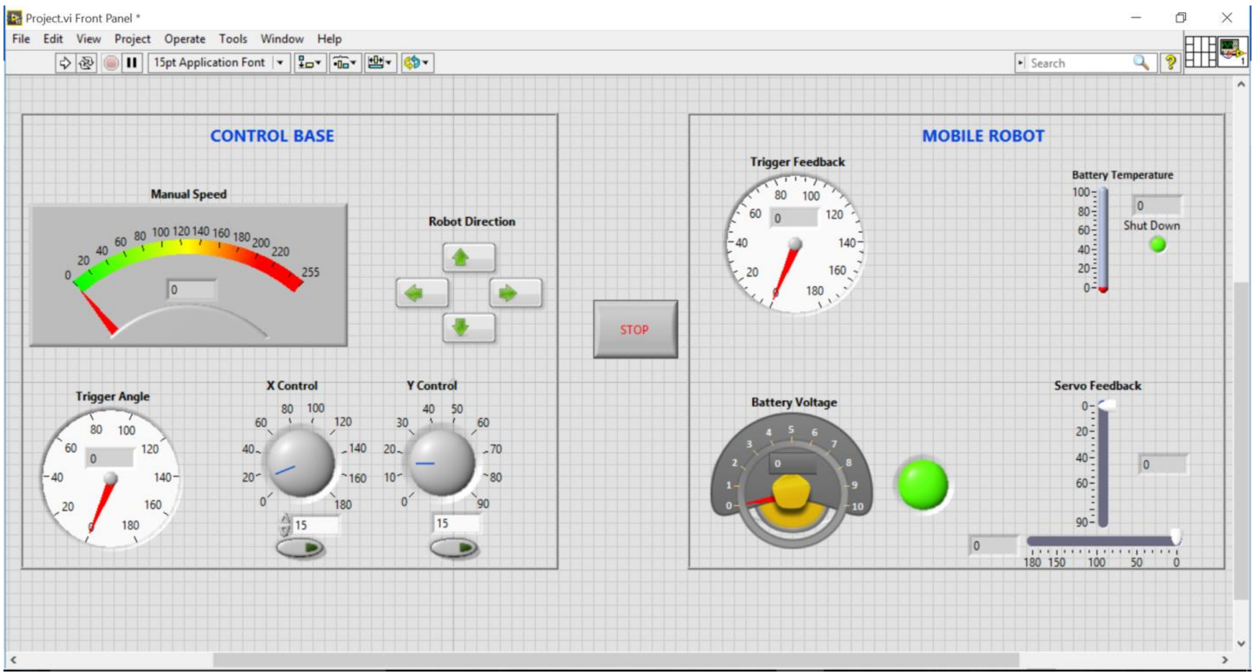

Figure 10: Labview Main Panel

After wiring the chassis and the control base, the next step is coding. LabVIEW is a system-design platform development environment developed by National Instruments that uses visual programming. Throughout our academic curriculum, we have made ourselves familiar with the software where we were required to develop coding programs for applications in the Control System, Instrumentation, Hydraulic and even Pneumatic fields. As a consequent to our acquaintance with the interface, we decided to tackle our robot coding challenge using this software. The challenge consisted in developing a program that controls the movement of the driving motors and the servo motors according to the different readings from different. In addition, the program should provide feedback information for all readings in order to smooth the progress of troubleshooting and system monitoring.

1. Control Base Code

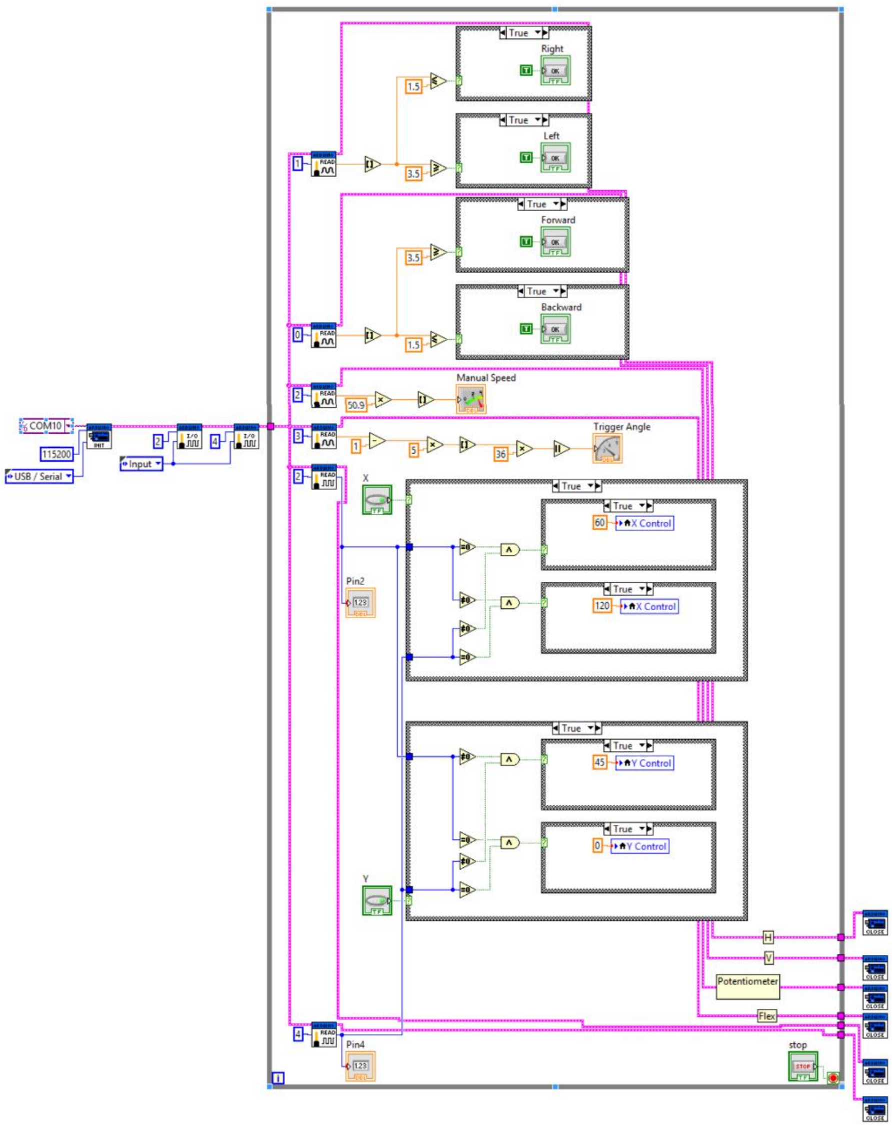

Figure 11: Control Base Code

A serial USB connection is established with an Arduino board connected to the control base. Then pin 2 and 4 are defined as inputs. Those two pins are connected to the digital tilt sensor. Subsequent, a while loop will make sure that the code will keep on running until stopped by the user. The joystick is an analog sensor and the reading are giving by 2 different pin, each one of them representing a direction. Threshold where found and compared in order to know the direction selected. The potentiometer which is also an analog voltage was scaled between 0 and 255 which will be used to send PWM for the h-bridge. The flex sensor analog voltage was read and scaled to an angle between 0 and 180degree which will be used to turn the servo and shoot. For the tilt sensor, each combination of numbers gives a certain direction and angle.

2. Robot Coding

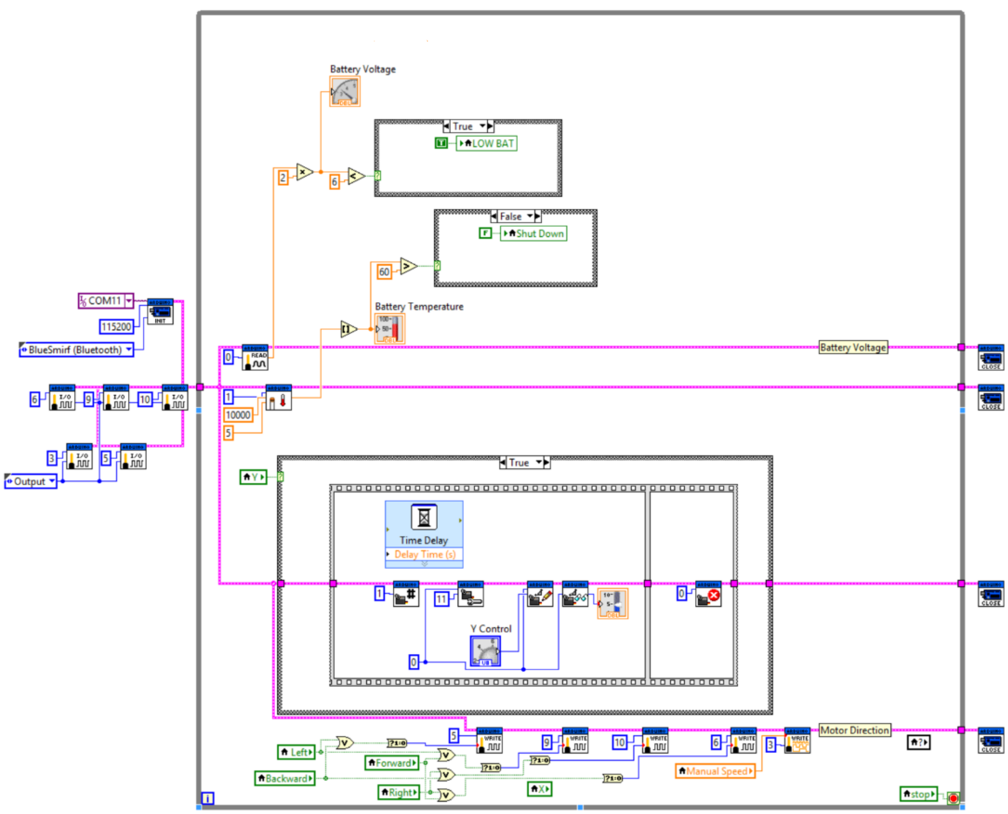

Figure 12: Robot Coding

In order to communicate between Labview and the robot, a Bluetooth connection was established and pin 3,5,6,9,10 are defined as outputs. Those pins will be used to control the speed and direction of the motor. Subsequent, a while loop will make sure that the code will keep on running until stopped by the user. In order to read the battery voltage correctly, the voltage across the resistors was multiplied by 2. Labview provide a function that can calculate the room temperature based on the resistance placed in series with the thermistor, this temperature was scaled to the nearest point. Next, in order to control the three different servos on board, a communication is open to them only when needed in order to reduce the number of byte send and received. Finally, the speed of the motor is controlled using the local variable Manual speed which is the position of the potentiometer scaled between 0 and 255. And different combination of on-off on the H-bridge will define the direction of the robot.

VIII. Guidelines for Safe Operation

Two main features were added to the robot in order to ensure a safety operation. The first one is to always monitor the battery voltage. In case the battery voltage drops down below 6V which is less than the power needed for the Arduino to function correctly than a red light will blink. The user must shutdown immediately the device because the Arduino will start malfunctioning and not follow the code algorithm.

The second feature is to always monitor the temperature of the battery. In case the temperature exceeds a certain threshold, a short circuit is detected. An instantaneous shutdown will happen and the code will stop communicating with the robot. At the same time, the robot will stop sending information to base.

IX. Cost Analysis

Materials	Quantity Usage	Unit of Measure	Unit Cost	Usage Cost
Robot Chassis	1	Each	50$	50$
Flex Sensor	1	Each	10$	10$
Parallax Tilt	1	Each	10$	10$
Arduino R3	2	Each	5$	10$
Joystick	1	Each	2$	2$
10K Pot	1	Each	1$	1$
Resistor Package	6/600	Each	2.5$	0.025$
Breadboards	2	Each	5$	10$
Jumper Wires	2	Each	7$	14$
2DOF Servo	1	Each	30$	30$
Lippo Batteries	2	Each	10$	20$
HC_05 Bluetooth	1	Each	15$	15$
Voltage Regulator	2	Each	1$	2$
L293D H-Bridge	1	Each	0.5$	0.5$
Thermistor	1	Each	3$	3$
Parallax Servo	1	Each	25$	25$
			Prototype Total Cost=	**202.525$**

An important aspect of our project is the financial aspect as the robot is required to be cost efficient. Our valuation of the cost was based on the cost analysis of the prototype we built. Building our prototype robot has cost us about USD 200. The robot should cost no more than USD 900 in real world application depending on the sensor and mode of communication used. However, experts have predicted that the robotics market is expected to exceed 55 billion Euros by 2025. Many believe that the upcoming area is the robotic area, where electronic boards would be printed with costs of production extremely reduced because of competition and economies of scales. This would reduce tremendously the costs of the robot and make it even more appealing from an economical point of view.

X. Advantages vs Drawbacks

Advantages: The main advantage and the reason this study was conducted is that it can produce military work without risking human lives. This then allows the military to preserve infantry for more delicate missions. Another benefit is that it is relatively inexpensive, since recruiting and training human units uses a lot of time and money. Depending on the quality of the robot, it can be more mobile than human units, which is paramount in certain missions

Disadvantages: The drawbacks however were that the LabVIEW program should always remain running on a computer, transmitting information to the robot through cable, Bluetooth or radio-communication, which limited the use of the robot to the range of the latter and depended on the real-time processing speed of the pc, slow response due to number of data sent and received. Moreover, robotic systems tend to make a lot of noise, which can reveal their position to enemies. Flexibility is also an issue, since a robot may not necessarily be as prepared for unpredictable situations as a human would.

XI. Future Improvements

In order to overcome the drawbacks, future improvements are needed. First of all, the robot should communicate with base using a satellite connection which will increase its range of control. The hand gestures should be mimicked using a combination of gyroscopes and accelerometer. The later sensors should be cleaned from any noisy data. Finally, the microcontroller should be replaced by a real time one.

Since this system has proved that a hand gesture can be mimicked and a mobile robot is capable of replacing a soldiers in a war battle. Going even further than the military field, similar robotic systems can be used in many different facets of life. For example, robots such as the one we built can be deployed to fulfill jobs such as delivering mail, picking up garbage and cleaning streets.

XII. Conclusions

The system we built sought to reduce the casualties of war. We did this by proposing a robotic system be sent on dangerous missions so that the risk of casualties in the armed forces is drastically reduced. The system consisted of a remote controlled four wheeled robot that utilizes hand gestured to be controlled. Its capabilities are to move, aim, and fire a projectile. We selected the Arduino microcontroller and created the appropriate circuitry and code to make the robot functional.

There are a few drawbacks to this robot, but the main issue is the need for cable or bluetooth connection, which limits range. However, this is simply a prototype and can be improved in a number of ways. For the issue recently proposed, satellite connection would be necessary for increase its range of control.

The prototype we proposed does not necessarily have to be in the military field. Robots are, by definition, reprogrammable to do many different tasks. Such a system can be used to do a variety of unwanted jobs in everyday life.

REFERENCES

[1] Banzi, M. (2010). In “Getting Started with Arduino”. Published by Make: Books and imprint of Maker Media, Inc.”

[2] Blum, J. (2013). In Exploring Arduino: Tools and Techniques for Engineering Wizardry”. John Wiley and Sons, Inc. (Wiley, 978-1-118-54946-0).

[3] Warren. J. & Adams, J. & Molle, H. (n.d.). In “Arduino Robotics”.