GANWP 242
Robot Car
Executive Summary

Team GANWP

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EXECUTIVE SUMMARY

The project is designed to inspire K-12 students about the world of STEM. The group is working on providing a robot to K-12 students in order to give them an understanding of the various engineering disciplines. The design the group has chosen was the one made by Brian Ndhlovu. It was chosen after evaluation from the group that it has all the engineering expectations and needs the customer might have regarding the project.

The software design of the project consisted of testing individual components of the car, first the motors, then the sensors along with their integration with the sensors, and finally the live environment testing of the software on a completed chassis with the correctly placed motors and sensors. No issues arose during the software design of the project car and the coding logic performed flawlessly.

The performance of the prototype is nominal. Each of the individual's part is working the way it should. However, the team has a few things to add for the final iteration of the car including: a better battery, speed modulation, increased durability, and wire management to prevent tangling.

I. INTRODUCTION

Our project is primarily designed to enhance the learning experience of the various engineering disciplines to students in K-12 education. With STEM becoming one of the biggest industries in the world, there is more demand for qualified people to improve technologies and improve the quality of life of Earth's inhabitants. Our project was designed to get students interested and curious about STEM in order to pursue STEM learning in the future. The hope is that this project can get younger students passionate and interested about technology so they can grow up to improve the world for everyone and leave an impact for generations to come.

Project based learning provides a context to the learning experience, it extends beyond the theory of the topic at hand by also influencing knowledge, skills, attitudes, and identity of students. [1] It additionally prepares students for the real world, as in reality engineering professionals constantly deal with uncertainties, incomplete data, and often conflicting or competing demands from various clients and the consensus of the general public [2]. For students the future continued exposure to problem-based learning will give them the opportunity to use their creativity to good use. The aspect of memorization of "core content" in learning will become obsolete, instead the various skill sets used throughout project-based learning will prove to be more valuable with the onset of more Artificial Intelligence within the workplace [3]. Overall, the workplace has been changing and the need to adopt new learning methods is becoming beneficial in preparing students for higher demands expected of them.

The core technology used within the project was the Arduino board, supplemented by brushed motors and an ultrasonic sound wave emitter/sensor. As the proverbial brain of the project the Arduino is the device from which all aspects of the car are controlled; its movement, ability to turn, and the spatial awareness the robot car is capable of. This core technology consists of two components, the hardware used for bridging the sending and receiving signals of which the software instructs and sends outs or receives.

II. PROJECT PLAN

The project plans were in late September. It started with obtaining an initial design for our project robot. We started with creating CAD designs through Tinkercad. After sorting through various designs and improving on them through the Heuristic cards, we came up with 3 prototype designs. By late October, we created a survey and had many respondents choose which one of the prototype designs was best based on our project requirements. Through this survey, our respondents chose Brian Ndhlovu's design as the best. After declaring our final design, we obtained our Acrylic sheets which allowed us to begin construction of our robots. The building and testing for functionality started early November. During this time, an advertisement was created in order to inform consumers about our product and persuade our consumers to buy our product. By 11/23, we plan to have our final product available to our customers.

The expected cost of the prototype is approximately $27. This is below our given budget of $30. The Acrylic sheet cost $10.45 but it was a 12” x 12” sheet. We only needed to use about a fourth of it. This brings the cost down to $2.62. In order to save costs, we went without a breadboard. For our design, we chose to maximize the simplicity of the robot in order to keep costs down and allow our robot to be affordable for our main demographic, K-12 students.

Part	Cost
Arduino	$4.27
4 Wheels	$6.64
Ultrasonic Sensor	$3.40
9V Battery	$2.00
Multimeter	$3.25
4 DC Motors	$3.60
Jumper Wire Kit	$1.00
Acrylic Sheet*	$10.45 total, used only $2.62

*Total cost of acrylic sheet, however, we only used ¼ of the area of the acrylic sheet.

Our biggest strength as a group would be how well we work together in order to progress through the stages of the engineering process. Every group member has contributed to the process of creating the final product. Everyone is supportive of each other rather than criticizing others designs or work. Everyone contributed through the various parts of the project such as our initial designs, the survey, the entrepreneurial ad, and the testing and construction of our final product. This contributes immensely to the completion of the project. We can navigate through obstacles and phases of the engineering process with easy and without any major obstacles in our way. The biggest weakness of the team would-be meeting attendance. Throughout our various group meetings throughout the semester, it has been quite rare for all 5 members to attend. As project leader, I am willing to admit I have missed some critical group meetings that likely have set us back in some way. However, our strengths far outweigh our weakness, and we can get back on track quickly.

III. PROTOTYPE DESIGN

The engineering specifications were as follows:

1) The length of the chassis was taken as 6 inches.

2) The chassis width was taken as 4 inches.

3) Weight of the robotic car is 16.4 oz.

4) The maximum speed of the car is 4 mph.

5) The expected battery life is 30 hours.

6) Acrylic sheets were used as the chassis material.

7) The maximum number of components used was 14.

8) The preparation time after car “power-on” is 5 seconds.

9) Maximum manufacturing cost is $34.86

10) The project development time is 3 months.

11) Wheel diameter is 1.4 inches minimum.

12) The wheel width is 0.78 inches minimum.

13) The car ground clearance is 1.5 inches.

14) The maximum 360 degrees turn time is 2 sec.

All the measurements that the group had taken was based on the dimensions of making a 6”x6”x6” robotic car. The chassis material was taken as acrylic sheets to improve stability for the car. The maximum number of components used was 14 as the group wanted to keep the weight of the car to a value which a middle-schooler would appreciate. The project development time was chosen as 3 months because there had been a lot the group had to know about. Due to this, it felt sufficient to take 3 months for development. The cost was set at $34.86 because the group had exceeded the budget of $30 for reasons unknown. Due to this, it was considered that the current price would be accepted. It is also estimated to decrease when it is ordered in a bulk amount.

The final candidate design was done by Brian Ndhlovu, our group’s hardware lead. It was chosen as the best design idea according to a survey conducted by the group. The group also had expressed to adopt it as the final design. The reason was that the design exceeded all the expectations the customer would have regarding their needs and engineering specifications. The design helped pave the way for the usage of acrylic sheets as the group’s base material.

The final design challenge we encountered was that the group switched from cardboard to acrylic sheets as the material as the group felt that cardboard had stability issues.

IV. PRODUCT DEVELOPMENT

Parts Used

The robotic kit came with pretty much all components and parts that were used on the robotic car. Parts used to assembly the current prototype are as follows:

- Arduino Uno
- L298N Motor Drive Controller (H-bridge)
- Wheels (x4)
- TT Gear Motor (x4)
- Servo Motor
- Ultrasonic Sensor
- 23A Battery Holder
- 12V A23 Battery
- Male to Male Jumper Wires (x7) ** 4 wires extend the wiring running from the ultra-sensor to the Arduino * 3 wires extend the wiring running from the Servo to the Arduino and H-bridge*
- Male to Female Jumper Wires (x4) ** Connects the Arduino to the H Bridge*
- Female to Female Jumper Wires(x4) **Runs from the Ultrasonic sensor and gets extended to the Arduino Uno.*
- Modified Blue and White Jumper wires **Blue wire is a 5V wire that powers the Arduino Uno, and the white wire is ground.*

- Black and Red Wires (x4) **They provide power to the TT Gear Motors.*
- Acrylic Chassis (6x4 inches)
- M2.5 x 8 mm Bolts and nuts **To secure the Arduino Uno and the H-bridge.*

Assembly steps

A power saw was utilized to cut the acrylic board used as the car's chassis into a 6x4 inch rectangle. Using the Arduino Uno and H-bridge, holes were carefully marked on the chassis and then a power drill was then used to perforate the board.

I. Glue was applied on each corner of the chassis and then the TT gear motors were quickly placed ensuring that the drive shafts were facing each other.
II. Secured the Arduino Uno and the H-bridge onto the chassis using M2.5 x 8mm bolts and nuts.
III. Carefully installed the wheels on all the 4 TT gear motors.
IV. Applied glue on the front edge of the chassis and then quickly placed the servo making sure that it was centrally positioned.
V. Applied glue on the far-left corner of the chassis and carefully placed the A23 battery holder.
VI. Used an L-shaped plastic material and then secured it to the servo to serve as an ultrasonic sensor holder. The ultrasonic sensor was then glued to the L-shaped plastic raising it about an inch above the chassis.
VII. Four female-to-female jumper wires were connected to the ultra-sonic sensor and then extended below the chassis using male-to-male jumper wires which then connected to the Arduino Uno. Four male-to-female jumper wires were used to connect the H-bridge to the Arduino Uno. Three male-to-male jumper wires were used to extend the wiring from the servo and then connected to both the Arduino Uno and the H-bridge. Two red and two black wires were used to serve as the source of power for all the 4 TT gear motors. A blue and white wire was used as the source of power for the Arduino Uno where the blue wire is the 5-volt power wire, and the white wire is ground.
VIII. A red and black wire from the battery holder is connected to the H-bridge 12-volts and ground slots respectively.

Challenges Encountered

The number one challenge faced by team GANWAP was the inability to meet in person to work on the completion of the prototype. The solution to this problem was the use of video calls through Microsoft Teams however allowing the team members get over some technical issues which would have required both hands on and face to face interactions. None of the team members had access to 3D printing and initially the team had agreed to use cardboard material for the robotic car chassis and finally after design review, acrylic material was suggested as the strongest and durable material for the chassis. After the fabrication and wiring had been completed the team was faced with a new challenge. The available 9 volts batteries were unable to power all the components of the car. Five 12 volts batteries were purchased and connected in parallel with the hope of increasing the current, unfortunately this solution only worked for less than a minute and no video was recorded for the showcase.The temporary solution to this problem was the use of a 12 volts 2A power adaptor which allowed the car to drive around obstacles. Unfortunately, the desired 12 volts 3.0A battery was then delivered a few hours after the presentation. The battery was tested, and it worked perfectly fine on the robotic car.

V. SOFTWARE DEVELOPMENT

Programming Design

Provided code for the car design firmware:

https://github.com/GANWP/Project-Car-Firmware/blob/main/Car-Firmware-0.8.0.ino

README.txt for setup and configuration of firmware:

https://drive.google.com/file/d/1Fm1LqZVLCy1IQk4exaPETFdbLIBRx_Xw/view?usp=sharing

The code itself consists of three major components, assigning the input/output pins with the appropriate variables, creating the logic sequence used to control the entirety of the car, and confining the settings of performance parameters of the car. All of the pins utilized on the Arduino are of course assigned their respective pins in the first few lines of code located at the top of the program. The debugging ultrasonic sensor logic then takes precedence with a slew of actual sensor logic afterwards. The logic itself works in the following fashion: The ping sensor is activated in a LOW state for 2 microseconds to activate it, this helps get a proficient reading because the sensor will normalize the current within it to send a full complete wave when set to HIGH. After this the sensor is set to HIGH to for 10 microseconds to send an 8 cycle burst of sound waves, and when these bounce off a surface area the echoPin is then waiting to receive them and soon after two functions translate the time the wave traveled into distance of either centimeters or inches. A 100-microsecond delay is then used between each cycle to allow dissipation of sound waves to prevent inaccurate readings. The wheels then turn in the respective direction depending on the distance of the sensor to the proximity of the nearest surface area (ex. Less than 20 centimeters actuates turning of the car to the right, away from the wall, and more than 20 centimeters powers both motors in the same direction to provide forward linear movement).

Testing & Fabrication

The programming aspect of the car design fabrication consisted of three phases during the testing: (1 Actuation of forward and reverse operations of the motors, (2 obtaining distance from the duration of wave pulses in the Ultrasonic sensor and then integrating this with motor operations, (3 Performing live tests of the sensor and motors on a chassis in a realistic environment to prove reliability and functionality of the entire design.

Fabrication video of motor test, displaying the operation of the motors in both forward and reverse operation which proves the wheels can turn the car at a moments notice:

https://drive.google.com/file/d/1cAdtlcMNscqLLNiDB65_3_jL8mnm_XBu/view?usp=sharing

Fabrication video of sensor and motor integration test, showing the sensor working in tandem with the motor in allowing the motor to reverse its direction in the case the sensor detects a surface area within 20cm of the proximity of the sensor echo module:

https://drive.google.com/file/d/1tzEWkwQYOafGxWjm5Y4AdM4JL2K9Rcdb/view?usp=sharing

Software Challenges

No software challenges were encountered, the Arduino IDE (Integrated Development Environment) and the C/C++ language proved more than enough meet the requirements and capabilities of the robot car design. It was easy to translate the pseudocode into actual code and understand how to order the programming logic. The hardware side of the development is where all the struggles manifested themselves.

VI. PROTOTYPE TESTING

The prototype's performance is adequate for a first iteration. The prototype's individual parts are functional, meaning that each motor works on its own and the sensors work. However, the group may need to use an additional power source to improve functionality of the final car. As far as safety is concerned, the prototype can withstand minor bumps without compromising the functionality, but the group should try to steer clear from any significant drops or hits for now. The durability of my prototype is satisfactory as a first iteration. However, I believe that the group can increase the durability for the final car.

The prototype's weight is approximately 16.4oz. The power requirement for the prototype seems to require a battery beyond the 9v battery that came along with the kit. The speed is nominal, but the team wants more fine-tune control for the final iteration of the vehicle. The sensors seem to be functioning, but the power needs to be increased so that everything can work in tandem. The only engineering specification that the group altered was the dimensions. It was decided that 6 x 4 looks better than 6 x 6. Other than those minor changes, the team stuck to the initial engineering specifications.

The group did have a few performance issues, mostly relating to the battery. Multiple people in our group were unable to keep the car running for long unless the car had a large power source. Therefore, the team has opted to buy a larger battery. Other performance issues to tackle include wire management to prevent tangling, more fine-tune control of the speed, better adhesive, and some minor durability issues that can be mitigated by some software tweaks. The team is off to a good start.

VII. RECOMMENDATIONS

Given more time to work on the robotic car the team did consider looking into a method of incorporating an LCD that is programmed to display the name of the robotic car as well as a welcome message. With less than a week before presentation the team will work tirelessly to ensure that the car is ready for showcase as final product tests and conclusions are done.

VIII. CONCLUSIONS

The main objective of the group is to create an Arduino robotic car for middle-school students. The base material used was acrylic sheets as there was not many resources present due to the COVID-9 pandemic. The group strongly agrees that this project has helped in many ways. It has helped in teamwork, create items with less cost, learning new things in an exciting manner but the most important thing it has done was create new friendships. The group believes that this venture will impact many people in a positive manner.

REFERENCES

LIST ALL SOURCES CITED USING IEEE CITATION FORMAT:

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