CODEBOTS EXECUTIVE SUMMARY

CodeBots

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Robotic Car Prototype Summary

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EXECUTIVE SUMMARY

The project's final product is oriented to K-12 STEM students to allow them to understand the practical appliance of STEM concepts in life. The method used in work through this project is the Project-based learning approach, which has plenty of benefits on students as projects are closer to reality and impact each student's performance from low-performing to high-performing. The primary technology that allowed the final product to possess functionality is the Arduino Uno R3 board.

The course of the project was split into 7 subsections that contributed to the design and functionality of the robotic car as it progressed from a cosmetic design through to a fully coded and operational robotic car over the course of group led team's meetings. After each section was completed the overall cost for materials was $46.90 and the cost for a working prototype was roughly $28.97 based on parts used in the design.

The prototype design is a 3-D printed chassis of the team's second candidate design that was made based on the engineering specifications that the group gathered over the course of the project. The design suits many of the requirements for the project as well as the addition of several features that add to the appeal of the design. The design was too big for the size requirements so it was split into two pieces that are fitted together by connecting bars for stability.

Two types of components were used in the project – pre-required, such as Arduino, DC motors, and H-bridge controller. and 3-d printed, making 3-D printing a fabrication method that had a place in this project. The assembling process goes in 6 steps, as several components had to be connected to be further utilized. Because of this project's specifications, challenges were faced in the fabrication process, as a new system of connecting elements of the body had to be developed to be 3-D printed and assembled afterward.

Software is an integral part of our robotic car's operations. For the robotic car, the code was written to control the motor based on the data from the sensor. More so, the LEDs were configured to blink during operation. Two videos of the fabrication process are provided to illustrate the workings of the hardware components. Although challenges were present, the end code is easy for users to both understand and use.

The robotic car is capable of driving forward and stopping when getting too close to a wall. The constructed robotic car weighs about 3 pounds and can travel at speeds of about 1 foot per second. The robotic car is powered by a 9 volt battery that is included in the package and will be attached to the car. Improvements were made to the coding and the general design of the car to allow for better performance.

I. INTRODUCTION

Through designing, assembling, and testing, the project had specific goals – allow K-12 students to make their first STEM project and provide an understanding of how to apply STEM concepts to practice in life. The motivation that follows the primary goal was to give students a simple opportunity to step into the STEM world with the minimum required knowledge. This project will impact how K-12 students think of STEM and understand how certain concepts can be applied in real life. K-12 STEM students will choose what they will do in the next few years or whole life, so it is beneficial to allow students to understand what STEM looks like and try this field with lower requirements, further helping students make a better choice.

Project-based learning is a learning method within universities and high schools, where students are focused on doing a project. It is an engaging instructional method to make learners active constructors of knowledge [3]. Engineering specialties This educational approach has similarities and differences with the problem-based approach, as both ways are based on self-direction and collaboration, and that they both have a multidisciplinary orientation[1]. It differs from problem-based learning, as in project-based learning, project tasks are closer to professional reality, project work is more directed to the application of knowledge, and self-direction is stronger in project work since the learning process is less directed by the problem[1]. Successful completion of projects required the integration of all areas of engineering's undergraduate training[1]. This educational approach is influential as it impacts students' performance on STEM subjects. Low performing students showed statistically significantly higher growth rates on mathematics scores than high and middle performing students over the 3 years[2].

Completing the project, the main core technology that gave the final product's main functionality was the Arduino board. Arduino board is a programmable board for making automatization systems and robots. This technology provided the opportunity to program the product providing its ability to follow objects, which is the main practical application besides the project's education appliance. The simplicity of utilizing this technology will allow the final product to reach the purpose of this project – provide an understanding of how to apply STEM concepts in practice in life – which is achievable with the least possible initial knowledge of STEM concepts. Finally, as the Arduino board makes product function], this technology is the core technology used in this project.

II. PROJECT PLAN

Project Plans & Schedule

During the course of the semester the group met after each lecture on Mondays and Wednesdays to go over any project details and assignments that had been covered in class. In each meeting the group would strategize on how to complete each assignment as well as planning other teams meetings for later that day or on days when there was not class. As the project progressed the group would separate each aspect of the assignment to the member who's role best suited the work portion. The group completed the project in a series of 7 stages that built upon the work done in the previous section to complete the project. The stages were completed as follows: Weighted Benefit Analysis, Candidate Designs, Motor Programming, Circuit Testing, Sensor Coding, 3-D Printing, and Final Assemble for testing.

Table 1: Cost of Materials Used

Materials	Amount	Cost
Arduino	1	$4.27
Breadboard	1	$1.43
Motor Controller	2	$3.00
2/pack of Wheels	2	$6.64
Sensor	1	$3.40
Battery	1	$2.00
Multimeter	1	$3.50
Remote Control	1	$2.09
2/pack DC Motors	2	$3.60
LEDs	2	$0.20
Joystick	1	$1.12
Female-to-male Wire	12	$3.00
Soldering Iron	1	$6.29
Soldering Wire Pack	1	$0.50
Extra Soldering Tips	1	$1.50
PLA Filament	218.2 grams	$4.36
Total Cost		**$46.90**

Cost of Materials & Manufacturing

The total bill of materials for the team's project is $46.90 for all materials and objects used for the completion of the project. The overall cost of the prototype is roughly $28.97 for all materials that are needed to make the car function properly. The total cost for the prototype is close to the suggested $30 cost for the project due to a large quantity of 3-D printed plastic being used in the chassis of the car.

Team Strengths & Weaknesses

Through the course of the project the team showed competence in the leniency of the members and their flexibility when finding ample time to work on different project aspects. The team also displayed strength in areas of discipline and teamwork as each member would check the work of other members and brainstorm different options that better suit the project's needs. Although the team did work well there were some struggles in time management as often the team worked on assignments close to the due date instead of leaving time to work on it over multiple days.

III. PROTOTYPE DESIGN

Table 2: Engineering Specifications

ENGINEERING SPECS		
	Metric	Target Value
1	Size	<6x6x6in
2	Price minimum	<= $30.00
3	Assembly time(beginner/expert)	7 min / 4 min
4	Speed	3 feet/minute
5	Weight	5 pounds maximum
6	Can turn at an angle of at least 30 degrees	30 to 60 degree turn radius

Engineering Specifications

Through the course of the project the team used a table of engineering specifications to influence the design and build of the car. The team found that the car should fit into a small space, weigh less than 5 pounds, have a fast assembly time, drive approximately 3 ft/sec, as well as having a small price point. The specifications are the 5 most important aspects of the car that are necessary in order to complete the project effectively. The team implemented each specification into the car's design to satisfy project requirements and work around project limitations.

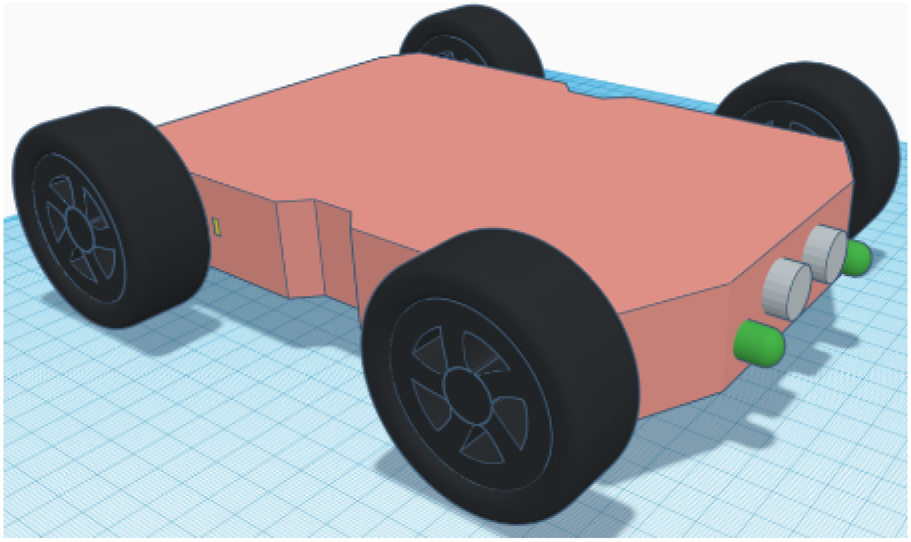

Figure 1: Second Candidate Design

Final Candidate Design

The group chose the second candidate design to be manufactured and printed as the chassis of our car. The team chose this design based on the simple characteristics as well as additional features that add to the cars functionality and appeal. The chassis design was too long to fit into a 6 inch square container so the design was split into 2 parts that would be assembled using 8 3-D printed poles. The dimensions of the team's chassis is 12.5x21x3.05 cm based off of the printed model of the car.

Technology Challenges

After printing the design for the team's second candidate design there were many areas that needed to be fixed before it was ready for use. First, the parts for the chassis came with extra-unnecessary plastic that needed to be shaved off before they could fit properly. Secondly, the connecting bars meant to fit the pieces together were too big to fit into their holes so the holes were widened to allow them to fit properly. Finally, the colors of the chassis did not match and needed to be fixed to help with the design appear.

IV. PRODUCT DEVELOPMENT

Materials and Elements Used

Through the project, two sorts of elements were utilized - one was required by the professor and the second sort of detail was designed and printed on a 3-d printer. Required components, such as DC motors, H-bridge controller, Arduino Board, and ultrasonic sensor, were the active part of this project, which provided the product's main functionality, while 3-d printed elements construct the body of the product.

Table 3: Elements of The Product

Element	Quantity
Arduino Uno R3	1
L298N Motor Drive Controller Board Stepper Motor Control Module Dual H-Bridge	1
DC Motor	4
Smart Car Wheel	4
Ultrasonic Sensor	1
3-D Printed Chassis	1
Connecting bars	8
Plastic Covering for The Top of The Car	1
I-Type 9V Battery Connector	1
9v Battery	1
Male to Female Jumper Wires	10
Male to Male Jumper Wires	10

Fabrication Process and Assembly Plan

The fabrication method in this project was 3-D printing, as elements of the chassis and connecting bars were 3-D printed. The product assembly process takes place in 6 steps. The first step of assembly is to connect two sides of the chassis with kernels. Further, in step number 2, DC motors are placed, and on each side of the car, motors are connected. In step 3, motors are wired to each other. One of the motors on each side is wired to OUT1, 2, 3, and 4 on the H-bridge controller. Further, the process of assembly goes to step 4, where 5v and ground outputs are connected to Arduino board's pins Vin and GND, EN1 and 2 inputs are connected to pins 5 and 6, and IN1, 2, 3, and 4 are connected to pins 7, 8, 9, and 10. As the controller is connected to the Arduino board, the step 5 sensor has to be connected to specific pins – Vcc is connected to 5v, GND to GND, Trig to 12, and Echo to 11. Finally, in step 6, a 9v battery is connected to the motor controller, as "+" wires to 9V input on the H-bridge, and "-" to GND.

Fabrication Challenges

Through the work on the product, several problems were faced. The most significant challenges in the project were preparing the design to be 3-d printed, as a new system of connection had to be developed. Also, through the project, another challenge faced – as to correctly function, the wiring had to be correctly placed so that multiple elements could be provided with enough power and function properly

V. SOFTWARE DEVELOPMENT

Software Overview

The main goal of the below code is to control the 4 DC motors according to the data collected from the ultrasonic sensor. If the sensor detects an object which is less than or equal to 10 inches away, the robotic car will turn 90 degrees to the left. This action is made possible by adjusting the direction and speed of the 4 DC motors, allowing the robotic car to continue following a wall.

Fabrication Process & Software

Throughout the fabrication process, the team has created 2 videos detailing the motor actuating process and the sensor integration process. The motor actuation process's video (Group13_Intro_Motor_Video.mp4) shows 2 of the members displaying the spinning wheel. In the second video (Group13_Sensor_Integration_Video), a member in the team has shown the sensor to cause the motors to spin/not spin backed on if the sensor has detected motion in its path. The final video (Group13_FinalPrototypeVideo) shows the group's fully functioning prototype. The README text with code explanations are presented in the following document: READMEText_&_CodeExplanations

Software Challenges

There were a few challenges during the software development. For instance, It was a challenge understanding how to make the wheels turn 90 degrees to the left especially without the use of additional sensors; however, with the abundance of resources online and trial and error, we were successfully able to implement this action. There was also a difficulty of having the sensor detect changes, but the Serial monitor was a great asset for testing.

VI. PROTOTYPE TESTING

Prototype Performance

The robotic car is capable of driving forward and stopping when getting too close to a wall. All of the parts are safe to use and won't cause any harm to anybody. All of the parts of the robotic car are high quality and come brand new with purchase. The robotic car and parts are built to last at least 3 years with sufficient care.
Test Report

Test Report

The constructed robotic car weighs about 3 pounds and can travel at speeds of about 1 foot per second. When the robotic car detects a wall that is within 10 inches the wheels on the car stop spinning. The robotic car is powered by a 9 volt battery that is included in the package and will be attached to the car. The prototype does meet all of the course engineering specifications because it is currently capable of turning left and right.

Performance Issues

Some performance issues that were encountered early on was that some members were having trouble getting their wheel spinning and not getting the LED to blink. Other issues that were found later on was adding the ability for the robotic car to turn on its own. Improvements that were made to the coding and the general design of the car to allow for better performance. Improvements were also made to allow the robotic car to fit in a 6x6x6 box by splitting the chassis of the car into two pieces. Other minor improvements were made to make assembling the car easier.

VII. RECOMMENDATIONS

The robotic car offers control of the motors and other components via the code only. In the near future, a remote control feature would be offered that would allow the user to control the speed and direction of the car. This added functionality was highly recommended during the Design Review Survey. More so, a new add-on functionality will allow the car to have a digital screen for fun applications. Overall, our current prototype covers a lot of the features sought for by the customers and the product will soon launch to the markets.

VIII. CONCLUSIONS

The goal for this product was to design and build a robotic car using an Arduino Uno R3. This robotic car can stop when it gets too close to a wall and it spins clockwise until it finds an open path. Then it moves in that direction until it detects another wall and repeats the process. All parts necessary to build the robotic car are included and you can choose from multiple designs that best fit your taste. Instructions and multiple sticker packs are also included when you buy this product. The total cost of the robotic car is about $30 due to a large amount of 3-D printed plastic. The dimensions of the team's chassis are 12.5x21x3.05cm based on the 3-D printed model. The instructions that are included with the product are very easy to understand and it requires very basic knowledge to follow along. With the code provided the robotic car is capable of moving in a straight line and when it detects a wall in front of it it turns to find a more open path. The weight of the robotic car is about 3 pounds and can move at a maximum speed of roughly 1 foot per second. In the future, more features and updated designs will be released.

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