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EECE 401 & 402 Senior Design



Final Report

By

Team AutoMoe

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Summary

Team AutoMoe's goal is to develop an autonomous car. We shall achieve this goal by combining the functions of different sensors and modules to emulate high levels of autonomy. Our goal for the 2017-2018 academic school year was to deliver an autonomous RC car that shall perform the following basic functions without human influence: (a) moving from a starting location to a desired destination and (b) avoiding other obstacles (other vehicles, humans, road structures) along the path the desired destination.

Problem Statement

If driving has numerous hazards and obstructions that can damage a vehicle and its passengers then awareness of your immediate surroundings to avoid collisions is the ideal way to increase roadway safety.

Design Requirement

The design requirements that would meet the needs addressed in the problem statement were addressed as an autonomous vehicle; that requires spatial awareness in real time as well as an efficient enough response to avoid obstacles. The *AutoMoe* vehicle must have the following capabilities in order to have a design that is a solution to the problem, a 15cm field of vision ahead of itself, a 8 cm field of vision on both the left and right side , Acceleration control , Motor/Direction control , self sustaining power system. The design requirements is based on our desire for the autonomous vehicle to require no external support, and function without human intervention while also being a cost efficient implementation compared to other systems. A self powering system ensures that a decrease in voltage over time will not have an impact on the

system functionality.

As part of our design requirements, we ensured that our design aligned with the regulations and standard that have been set for electronic devices and the vehicle industry. The Autonomous Car vehicle must adhere to IEEE standard 1582 in regards to non hazardous electronic systems and the stability of the device. Similarly The IEEE standard 11-2000 standard which applies to rotating electric machinery which forms part of the propulsion and major auxiliary equipment on internally and externally powered electrically propelled rail and road vehicles and similar large transport and haulage vehicles and their trailers where specified in the contract.

Current State of Art

The Society of Automotive Engineers released a range of levels to describe automated driving systems which is now adopted by the National Highway Traffic Safety Administration . To start, Level 0 is defined as vehicle functionality is completely controlled by the human driver. Level 1 is assigned to define a vehicle with automation of only 1 function such as cruise control. Level 2 is to define a vehicle with simultaneous automation of more than 1 function such navigation and deceleration, working together in an integrated vehicle system; however, the human driver must remain engaged. Level 3 is defined as functionality of the vehicle is satisfactorily automated to afford engagement of other activities by the driver but human fail-safe feature is available. Lastly is Level 4 which is complete automation. There is no need for a human driver.

Currently, there are many new vehicles equipped with level 1 and level 2 automation features. Mercedes offers an active brake assistance and night vision cameras with automated

danger warnings. On the other hand, there are no current car models with level 3 and level 4 automation features. Self driving cars are still in a research state however we are already in the stage of field tests with a few projected releases for the upcoming years. BMW 7 series enters and exits a garage without driver. Google tested a self driving experimental car that logged over 400,000 miles in a 15 month span where an average of 22.7 times a month a human driver had to take over as the robot car couldn't handle adjusting to various obstacles such bikes, branches, and other cars.

Solution Design

Using the design requirements as guidelines for our solution, our considered two solutions. Design 1, dubbed "Android Car", is a design solution centered around using an Android smartphone to have a waypoint system for the RC car. Android Car is designed to be a level 4 autonomous system. From the Android smartphone, an application will determine your current location using a Google Maps API, ask for a destination and shall show you the path to your desired destination. Using a bluetooth module and Arduino microcontroller, the location information will be sent to the microcontroller (which will also have the motors of the RC connected to it as well) via bluetooth and the RC car shall follow the same path determined by the Android application. The solution will also incorporate the use of an ultrasonic distance sensor for collision prevention.

Our 2nd Design, dubbed "Car-On-Rails", is a design solution based on the idea of "staying in your lane". Similarly to "Android Car" design, Car-On-Rails is another level 4 autonomous design. The car shall recognize on-street lane dividers on the left and right side of the vehicle and perfectly align the vehicle within the lane. The design will use multiple ultrasonic

distance sensors for collision prevention, a photoelectric sensor to determine the reflective lane dividers (median strips, reflective strips on traffic cones), as well as an Arduino microcontroller to take control of the motors of the vehicle.

Below is our solution design matrix, in which our team puts both design in a head-to-head comparison regarding the monetary cost of the design, how much connectivity is required for the design to function, the user friendliness of the design, and the overall convenience of the design.

View the solution design matrix below:

Table 1: Solution Design Matrix

		Android Car (Design 1)	Car-On-Rails (Design 2)

	Weight (1-5)	Score (1-5)	Agg. Score	Score (1-5)	Agg Score.
Cost	4	5	20	2	8
Connectivity	5	3	15	5	25
User Friendly	2	4	8	5	10
Convenience	3	3	9	2	6
Total			52		49

Based on our solution design matrix, the Android Car design is the best solution to our problem. Our design includes:

- (1) Arduino microcontroller - embedded system; operates at 3.3V or 5V
- (2) bluetooth LE module - enables wireless data transmission and receiving for connected devices; operates at 3.3V
- (3) 2 DC motors - enables wheels to move in a rotating motion; operates at 5V
- (4) ultrasonic distance sensor - enables object detection from a range of 2cm to 4m; operates at 5V
- (5) 2 2N7000 MOSFET devices - enables microcontroller to control DC motors

(6) 12kW/hr battery - DC output of 5V via USB

Omitted from the schematic is the Android smartphone with the custom Android application. Below is an overview of our design solution:

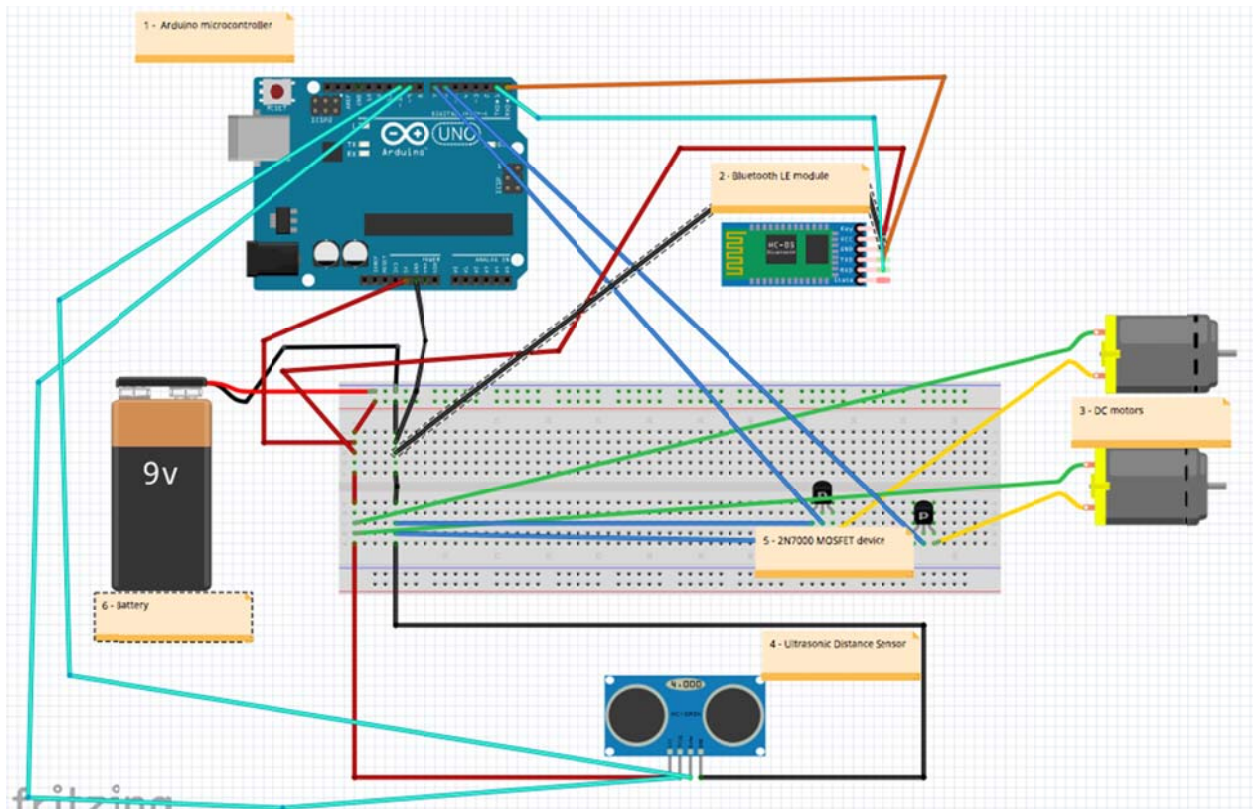


Figure 1: Schematic Design

Project Implementation Plan

Month	Week No	Tasks	Member in Charge	Monthly Deliverables
Jan	1	Winter Break		Blueprint of car and psudeocode
	2	Draft designs for car	Lateef/Tavares	
	3	Start psuedocode for all components of car	Collin/Jordan	
	4	Learn how to use MIT app inventor	Jordan/Collin	
Feb	1	Begin setting up phone UI for GPS	jordan/Collin	Car built
	2	Solder components to breadboards	Lateef/Tavares	
	3	Organize components on RC car	Lateef/Tavares	
	4	Finish assembling car	Lateef/Tavares	
Mar	1	Write code for LCD display and compass	jordan/Collin	Code Finished
	2	Write code for GPS and navigation	jordan/Collin	
	3	Write code for sensors and remaining functions	jordan/Collin	
	4	Test code and make adjustments	jordan/Collin	
Apr	1	Final Testing	Lateef	Autonomous toy car
	2	Project Demo + Presentation Event		
	3			
	4			

Project Implementation Process

Over the course of the semester we were able to follow our project implementation plan fairly well. The first two months of our work focused heavily on hardware components and assembling the car. We were able to successfully test all the hardware components and sensors individually. Once we confirmed there weren't any issues with the individual performances of the components, the schematic was drawn up and soldering of the components began. While the majority of the work was hardware based, the software was still being developed. Using MIT App Inventor, we were able to design the layout of our app. Additionally, we began to research different methods and implementations of transmitting data via bluetooth from phone to arduino.

During March, we saw the formation of several problems on both the hardware and software side. For hardware, we found that the motors may not have been receiving enough power to make the car move. Additionally, the app wasn't connecting with the bluetooth module to transfer data; nor was the full arduino program ready to receive said data and store it correctly. Due to these unforeseen issues, our development took a significant delay. We decided to focus on developing necessary components and leave the LCD display to be integrated at a later date. The motors and bluetooth connectivity had to be finished before the project could move on to any other steps.

The next two weeks of April were witness to different designs, trial and error, development of code and many small successes. We finally were able to provide enough power to the motors to get them to turn when the ultrasonic sensor detected an object in its path. Our

application could successfully connect with the bluetooth module after modifying the code to work with our specific module, which is low energy. Although it connected, data still wasn't being properly transmitted and development continued. The final application we presented could transmit the GPS coordinates to the BLE module; however, the data would be converted to IEEE 754 floating point numbers which wouldn't be converted back to the correct decimal when received by the arduino. For future development of this project, the arduino code needs to be modified to convert the data from IEEE 754 to decimal and correctly use that in our navigation algorithm. On the hardware side, the motor still needs additional power to fully rotate the tires and the LCD display has to be integrated.

Conclusion

Team AutoMoe's goal of developing an autonomous car with an embedded system and additional peripherals was achieved however without restrictions. By implementing an arduino logical program designed to read peripheral(i.e sensor) data to avoid obstacles in conjunction with hard wired as well as software connections to the motor we created our implementation of an autonomous vehicle. Our vehicle was aware of its surroundings as its sensors indicate solid objects in addition to having connectivity with the app in regards to current gps location. Our goal for the 2017-2018 academic school year was to deliver an autonomous RC car with level 4 autonomy that can reach a waypoint while also detecting and avoid objects.: We observed that a substantial amount of power is required to power our vehicle compared to our initial total voltage of 5V. A greater power supply will allow the drive motor to get enough voltage while the sensors are powered as well. The full scope of the project would be to find a large enough power supply to and the next phase would be to add additional sensors such as heat and kill switch

features to ensure a safer product. The final stage of Team AutoMoe's vehicle would be to integrate the toy car system into a fully sized vehicle and scale up the implementation respectively.

References

<http://www.iihs.org/iihs/topics/t/general-statistics/fatalityfacts/state-by-state-overview>

<http://www.ipwatchdog.com/2016/04/07/autonomous-cars-patents-perspectives/id=68045/>