AUTONOMUS SELF DRIVEN VEHICLE

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering.

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DHAKA, BANGLADESH

Date 09.12.2018

APPROVAL

This Project titled **"Self Driven Vehicle"** submitted by Soikat Hasan Ahmed and Mohammad Mehedi Hasan to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering (BSc) and approved as to its style and contents. The presentation has been held on 09.12.2018.

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Fahad Faisal, Senior Lecturer, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ACKNOWLEDGEMENT

First, we express our heartiest thanks and gratefulness to almighty Allah for His divine blessing makes us possible to complete the final year project/internship successfully.

We really grateful and wish our profound our indebtedness to **Fahad Faisal**, **Senior Lecturer**, Department of CSE Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of Embedded System to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stage have made it possible to complete this project.

We would like to express our heartiest gratitude to Fahad Faisal Supervisor, Ahmed Al Maruf CO-Supervisor and Pof. Dr. Sayed Akhter Hossin Head **,** Department of CSE, for his kind help to finish our project and also to other faculty member and the staff of CSE department of Daffodil International University.

We would like to thank our entire course mate in Daffodil International University, who took part in this discuss while completing the course work.

Finally, we must acknowledge with due respect the constant support and patients of our parents.

ABSTRACT

In this research we have tried to demonstrate the implementation of a vision based autonomous vehicle to collect real road data and test different types of vision based autonomous robot algorithms. It started with the hardware implementation followed by different test case scenarios. The main goal of this work is to collect real world visual data and train an Artificial Intelligence based vehicle control model which can be used in full size vehicle for autonomous driving and different types of driver assistance . In this stage of the research, we made a rickshaw as our prototype model in purpose of data collection.

Index Terms - Autonomous vehicle, Vision Based.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Now, in the early decades of the 21st century, the pace of innovation is increasing and the industry is a new technological revolution: “self-driving” vehicles. A self-driven vehicle also known as an autonomous car or driverless car or robotic car. It is a vehicle that can drive one place to another without any assistance of driver. This car is increasing day by day with technology. Now people cannot want to drive themselves and well experience driver cannot be found. So, people are depending on driverless car for their benefit. This cutting age technology could give us solutions to some of our most intractable social problems. Some researchers and company working on developing autonomous vehicles by using expensive LIDER sensor. This solution are not industrial friendly and the production cost of this kind vehicles is not sustainable. The Reacher’s community are now focusing on vision-based solutions. The vision-based solutions not only cost effective but also give more information about the environment.

1.2 Motivation

As we are human being, we have to travel a lot. Most of the case we are depended on road transports. We can see that most of the vehicle are driven by human. So that there is a major problem of road accident. Like autopilot in Airplane but for on road transports there are no established autonomous system which can drive itself or help the driver to drive. After that people start research on autonomous driving system for on road transport.

We have already heard, some country like USA, Dubai etc already start using semi- autonomous car in their country. Some company like Tesla motor and Uber start producing semi-autonomous car and Google, Nissan, BMW are starting R&D to make full autonomous car within 2022. But in our subcontinent country like Bangladesh, we cannot use the technology benefit for the high range of cost also the traffic and road environment are not supported by that autonomous car. We are trying to make a self-driven vehicle using local technologies with low cost and collect local training data for a self-driving vehicle in our country. Our country is developing day by day in

R&D. Government also encourage to do R&D types of project and self-driving project is R&D type project. So, we try to work on it.

1.3 Rationale for The Study

From the statistics data from the Federal Reserve Bank of St. Louis, United State of America drove more than 3 trillion miles last year. People spend around 23,000 years of human life each day doing little more than sitting and focusing on pavement. Car accidents also kill more than 30,000 people in the United States every year that is very worst for a country. On the other hand, according to The Daily Star, July 02, 2018, “Over 2,400 deaths on roads this year and accidents took place due to carelessness and whimsical attitude of the drivers of heavy vehicles including buses and trucks in Bangladesh.

How can we help people rectify their time and stay safer on the road? Replace them with better drivers, of course.

If we can produce self-driving car industrially, the first major change would be to ride shearing services. it will give the opportunity to the taxi companies would rush to replace their drivers with autonomous cars. The disappearance of drivers would cut costs of taxi operations and drastically reduce fares. If riding services become cheap and affordable enough, general people could even reduce or eliminate car ownership. If many Americans gave up car takeover, several changes would quickly follow. Large parking lots, for instance, would be rendered pointless since driverless cars would drop off passengers and have no need to idle. Though this may seem insignificant, reclaiming parking space would fundamentally change how we design our cities, houses and businesses.

A road full of autonomous cars would also change the quality of driving. Computerized vehicles could coordinate their movements with each other, drastically improving their efficiency. The result would be a faster commute that allows people to simultaneously socialize, read or work while on the road. Besides computers cannot become drowsy, distracted, intoxicated or physically impaired; they always obey rules and drive safely. Our goal is to make the road safe by developing low cost and reliable self-driven vehicle by using local technologies.

1.4 Research Question

Followings are the list of things we tried to accomplish in his project.

❖ Can the vehicle detect lane only using camera sensor?

❖ Is it possible drive the custom vehicle using digital control signal from the control computer?

❖ Predicting steering angle to avoid obstacle.

❖ Can the vehicle collect good quality data which are useful to train a good accuracy ML model?

1.5 Expected Outcome

This vehicle is expected to run in real environment and with help of human driver by using gamepad controlling when we collect driver behavior data as well as it can localize itself in the world by using GPS and gyro accelerometer. We hope it also can calculate shortest path and way points in the path by using A star pathfinding algorithm. When it follows the way points it can steer its wheel to avoid obstacles by using the model we train for the vehicle. it also can detect lane by using camera feed of the visual sensor. After the completing this project, we will able to gather real time data about our roads, traffics, environment etc which will help us to make a decision that our local technologies and current self-driven cars are suitable for our country there the road situation is too much uncertain. Safety is an overarching concern. Many thousands of people die in motor vehicle crashes every year in Bangladesh. Self-driving vehicles could reduce that number because software could prove to be less error than humans.

1.6 Report Layout

In Chapter 2, all details about the background of this project. I discussed about the body background and the content background. There is some other application nearly like this project. Then I compare with those applications in this chapter. During this project I faced some problem and it has step by step solved. I take some challenge to complete my project. I also discussed about in this chapter.

In chapter 3, I discussed about requirement analysis of this project. And proposed a Use Case Model with description.

In chapter 4, I discuss about front-end design and back-end design. An interaction design detail is here with some figure.

Chapter 5, there are discussion about the implementation

In chapter 6, summary of this self-driven vehicle and I discussed about think I can develop in future project.

CHAPTER 2
BACKGROUND

2.1 Introduction

In the journey to full autonomous vehicle, there are many intermediate levels that are involving such as:

Level 0-No autonomous: The full-time performance by the human driver of all aspects of the dynamic driving task.

Level 1-Driver assistance: The driving mode specific execution by a driver assistance system of either sleeping or acceleration/deceleration using information about driver conditions.

Level 2-Partial autonomous: The driving mode specific execution by one or more driver assistance system of both steering and acceleration/deceleration using information about driving conditions with the exception that the human driver performs all remaining dynamic sight of the driving task.

Level 3-Conditional autonomous: The driving mode specific performance by an automated driving system of all dynamic look of the driving task with the expectation that the human driver will respond appropriately to a request to intervene.

Level 4-High autonomous: The driving mode specific performance by an automated driving system of all dynamic aspects of the driving task even if a human driver does not respond appropriately to a request to intervene.

Level 5-Full autonomous: The full-time performance by an automated driving system of all dynamic aspects of the driving task under all roadway and environmental conditions that can be managed by a human driver.

2.2 Related Work

The work done by Chun-Che Wang, Shih-Shinh Huang, Li-Chen Fu and Pei-Yung Hsiao [1] aims to improve driving, by creating an assistance system. To enhance driver's safety at nighttime the algorithm includes lane detection along with vehicle recognition system. Lane detection helps to localize the markers so that the lane can be detected while vehicle recognition involves taillight extraction along with tail light pairing algorithm. Another research work [2] done by Xiaodong Miao, Shunming Li and Huan Shen models to locate the positions of road lane in real-time. Operation like canny edge extraction is done to extract edge map to which matching technique is applied followed by the selection of potentials edge points. Finally linking is done to localize the lane lines. In [5] Anik Saha, Dipanjan Das Roy, Tauhidul Alam and Kaushik Deb aims to convert the image from RGB format to grayscale format. Then flood-filling algorithm was applied to label the connected components. Then the largest connected component is extracted which is nothing but the lane. The model proposed by Gurjashan Singh Panna, Mohammad Dawud Ansari and Pritha Gupta [4] in developing a prototype of autonomous car involves implementation of lane detection algorithm along with obstacle detection. Their project aims to build a monocular vision autonomous car prototype which is capable of reaching at a particular destination safely. Another work model proposed by R.Mohanapriya, L.K.Hema, Dipeshwarkumar Yadav, and Vivek Kumar Verma [5] and Ms. D.D Jadhav, Komal Jadhav ,Kajal Shinde , Anjali Sonawane [6] are similar which involves equipping GPS and GSM system on a 4 wheeled robot. The GPS system steers the robot and is capable of reaching from one point to another without any human intervention. While in the former one with the help of GSM system they promise to report theft in case is there is any. An SMS alert is sent to the vehicle owner reporting about the issue and as a result of it,the owner of the car can switch the ignition off and in the latter one the project states that vehicle can only be turned on if the authorized person sends a predefined location to the car. In [7] Dhanasingaraja R, Kalaimagal S, Muralidharan G developed a system that takes the current position and gets the user destination. Then the system finds the shortest path to the destination and also extracts features like latitude, longitude from the graph. So in a nutshell it helps in navigation as well as monitoring the car.

2.3 Research Summary

So as the previous literature survey and study demonstrates there has been decent number of studies in this field to make this types of system more robust. The studies has been fairly successful in their own way. This type of research is done by many researcher in small scale like RC car and in a simulated environment. From studying different algorithm to making re-optimization to the existing algorithm to find better results, researchers has gone through many different ways. The noticeable factor is that although the accuracy has been quite good, yet we have not seen any real implementation of this processes. But from this research we are implementing a full size vehicle in the real environment this give us a real output.

Now-a-days, self-driven car is one of the hot topic for the researcher. Many researchers and company are investing in this field as this is one of the unexplored field. Although few companies are already working on it but the feedback from this field is very little due to it's high expenditure to carry out the research. As a result, some of the researchers are using small size vehicle (RC car) for the research purpose. But RC Car is not good enough to work in real time environment. To use a RC car- we have to make a small version of track which can simulate the environment. As a result if we can make a full size low cost vehicle, it will be helping us to drive the vehicle in the real time environment and collect the data accordingly. The developed model will be able to demonstrate the performance as real life.

2.4 The Scope of This Problem

The scope of this problem is to classify our dataset using different machine learning algorithms which includes training and testing the model.

In Bangladesh an automated driving system would reduce the risk of accident. This research will help new researcher to work in this field by analyzing the output model of the vehicle.

2.6 Challenges

The primary challenge for this thesis is to making the vehicle. We just use a manual rickshaw for the project. We have to make some custom components and electrical circuit to drive the vehicle by the control computer. The other change was stabilize the control commands. As though we use Feedback control system to drive the vehicle the sensor values were too much noisy. which create a jerky control. The other challenge is the dataset. We get good and detailed visual data from the HD webcam but we have to pre-processed them so that anyone can use the dataset. In contrast, finding this type of dataset is quite difficult in Bangladesh.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

When we drive any vehicle, our eye helps us to give visual information about the environment. Our brain can use this visual data into information. By using information, we can take decision what should we do against this situation. Same as human driver we are trying to develop a brain by observing human behavior in a particular situation. so our main focus is at first we collect visual information from the camera and also the driving commands against the image, This data help us to find out the actions that should take a human driver base on the visual information.

3.2 Research Subject and Instrumentation

This research topic is “SELF DRIVEN VEHICLE”. This is the field of image processing system and robotics.

Now we will talk about the Instrumentation for the project.

3.2.1 Hardware Instrumentation

The list of devices which we used to develop our vehicle are given below.

We chose a manual wheeler rickshaw chassis as our base module (for our low cost) with following inexpensive components

- Arduino UNO v2
- Electric tricycle Rear Axle Differential Gear BLDC (brushless DC motor) 48V motor
- 48v brushless DC motor controller
- Four 12v UPS batteries to provide power of 48v
- Logitech c922 USB camera
- HP g240 Laptop
- Gyro sensor model MPU 6050
- Rotational encoder (10 turn 10kΩ precision potentiometer)
- S49E hall sensor module
- Logitech L9228 wireless gamepad

- GPS Module high precision U-blox NEO-3m with compass.
- Sonar Sensor (HC-SR04)
- CP2102 USB to TTL UART serial converter

Almost this type of hardware is needed to implement our project.

Arduino UNO

Arduino Uno is a microcontroller board based on AT-mega328P chipset. It is an open-source electronics platform. We have used Arduino Programming Language with IDE to program our on-board micro-controller of the vehicle.

Figure 3.2.1.1: Arduino UNO

Arduino Uno is a microcontroller board based on AT-mega328P chipset. It is an open-source electronics platform.

We have used Arduino Programming Language with IDE to program our on-board micro-controller of the vehicle. Arduino has some I/O pin which can perform different type of input output operations.

BLDC Motor Controller

Figure 3.2.1.2: BLDC motor controller

To drive the motors an E-Bike BLDC motor controller is used. It will be driving our Electric tricycle Rear Axle Differential Gear BLDC 48v motor. The motor controller specification is as follows:

Rated Voltage: 48 Volts

Rated Power: 1500 Watts

Phase Angle: self-study

Throttle Voltage:1.1-4.2V

Brake level: High/Low

Under Voltage Protection: 42 Volts ±0.5v

3 phase 60° or 120° brushless motor.

Operating Conditions: -40~80 C

Brake: E-ABS

Size: 24.5x8.7x4.3cm

GPS Module (U-blox NEO-3m with compass)

Figure 3.2.1.3: GPS module

We also used a GPS module Ublox NEO – 3M with a compass. This module has on-board GPS antenna with compass. The GPS module has ceramic passive antenna, you can search the satellite in an open area, do not need the external antenna for this. It can communicate with any hardware with UART serial communication. So that this device can be connected with Arduino with UART by using a tinygps library. But we use a CP2102 USB to TTL UART serial converter to use this module directly with a computer via USB port. So that it produces and sends both GPS and compass data to locate the vehicle at a particular time.

Electric Tricycle Rear Axle Differential Gear BLDC (brushless DC motor) 48V motor

Figure 3.2.1.4: Brushless DC motor

We use to two powerful brushless Dc motor to drive our Vehicle. The operating voltage of the motor is 48V and has three phase 120° angle.

12v UPS Batteries

To power the whole system, we use four **12V** ups batteries. In total the four batteries produce

Figure 3.2.1.5: 12v UPS batteries

48V voltage difference and also give 30 amp of current which give backup the whole system around 6 hours in single charge.

On-Board Processing Unit

For processing and controlling the vehicle we chose a middle range HP g240 laptop. It controls all the logic units of the vehicle as well as it is capable to run any pre-trained vision based end-to-end control system. It will also store the collected data from the vehicle on its 1TB HDD. In the training stage a human driver will be running the vehicle with a gamepad. The gamepad is connected with the laptop and the laptop collect different types of command from the gamepad and send them to the microcontroller of the vehicle.

Gyro Sensor Model MPU 6050

The InvenSense MPU-6050 sensor contains a MEMS accelerometer and a MEMS gyro in a single chip. Its accuracy is good, as it contains 16-bits analog to digital conversion hardware for each channel.

Figure 3.2.1.6: Gyro sensor model MPU 6050

Therefor it captures the x, y, and z axis at the same time. The sensor uses the I2C-bus to interface with the Arduino.

10 Turn 10kΩ Precision Potentiometer

A rotary encoder is a type of position sensor which is used for determining the angular position of a rotating shaft. It generates an electrical signal, either analog or digital, according to the rotational movement.

Logitech L9228 Wireless Gamepad

Figure 3.2.1.7: Logitech L9228 wireless gamepad

A middle range wireless gamepad was connected with the whole central processing unit the vehicle so that we can drive the vehicle when the human driver driven the vehicle manually and Logitech L9228 wireless gamepad works fine with the system and it has work within 500m around the vehicle.

CP2102 USB to TTL UART Serial Converter

CP2102 USB to TTL UART serial converter used to connect sensors which communicate by using RX TX modules directly with a computer via USB port.

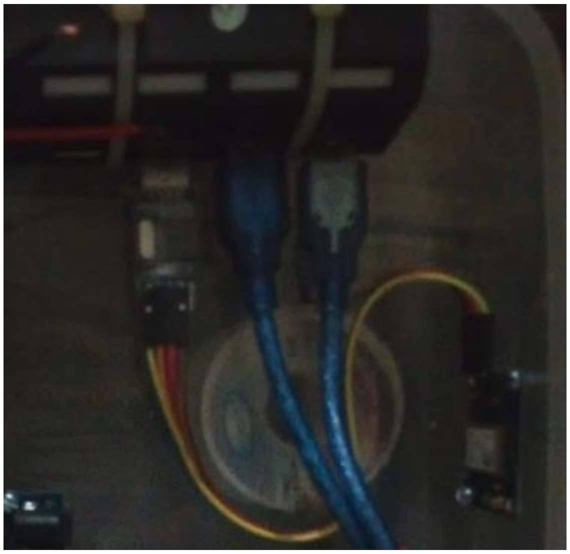

Figure 3.2.1.8: CP2102 USB to TTL UART serial converter.

So that it produces and send both GPS and compass data to locate the vehicle at a particular time.

Camera sensor

Figure 3.2.1.9: Logitech C922 HD webcam

Logitech C922 is a 15megapixel High Definition (HD) camera with resolution of 1920x1080. The camera has auto focus feature that help us to capture stable pictures. In 1080p we got around 30fps and in 720p we got around 60 fps frame rate from the camera.

3.2.2 Software

In this section we discuss about the software and library dependencies of the project.

Ubuntu 16.04 OS

Our operating system is completely based on Linux. This is an open-source OS. In our case 16.04 version has been used.

Python

Python is high level programming language. It is mainly a scripting language. It is very easy to understand. This language is reach with good number of useful library like numpy[8] for numerical calculation, pandas[9] for data manage, scikit learn[10] for different type of science function Tensorflow [11] for machine learning etc. In the background python use C and C++ as its base language.

OpenCV

OpenCV [12]is a library for computer vision. It can manage real time vision data. It have around 2500 algorithms and those algorithms are well organized. We can use this library for object detection, face detection, object classification. Mainly this library is written in C++.

ORB SLAM2

ORB-SLAM[13] is a versatile and accurate SLAM solution for Monocular, Stereo and RGB-D cameras. It is able to compute in real-time the camera trajectory and a sparse 3D reconstruction of the scene in a wide variety of environments, ranging from small hand-held sequences of a desk to a car driven around several city blocks. It is able to close large loops and perform global re-localization in real-time and from wide baselines. It includes an automatic and robust initialization from planar and non-planar scenes.

3.3 Data Collection Procedure

In our system we mainly focused on collecting training data to collect the training data, a human driver drives the vehicle manually on the read to record time stamped videos and other control and sensor data. Then after collecting we copied them to a desktop computer. So that we can processes them with a NVDIA 1060 GPU. After processing them the trained model can run in the on-board computer and will produce the steering angle and speed depends on real time camera feed and different sensor values.

In data collection section we first get the image digital values in to a Numpy array with extension ".npy". In the same array we encoded all the sensor values so that we can load the data set any time we want. We also can load the dataset by the help of Numpy library in a array from. We also store the jpg files so that other researcher can use this data.

Figure 3.3.1: Example of some stored dataset

3.4 Implementation Requirements

There are three categories in implementation requirement. All are described following:

3.4.1 Hardware Design and Connections

To keep the control system simple, we divided the control hardware in two parts. Insist of using one Arduino we take two of them. One Arduino connected with the sensor part of the vehicle and another is connected with the front and rear motors. The main on-board computer collects the driving commands from the wireless gamepad by the help of Pygame library. The analog two axis of the gamepad is perfect to generate commands which drive the vehicle forward, backward, right and left in different speed. As the control microcontrollers are connected by serial USB port, python offer us a library called pyserial for sending the data throw the USB port.

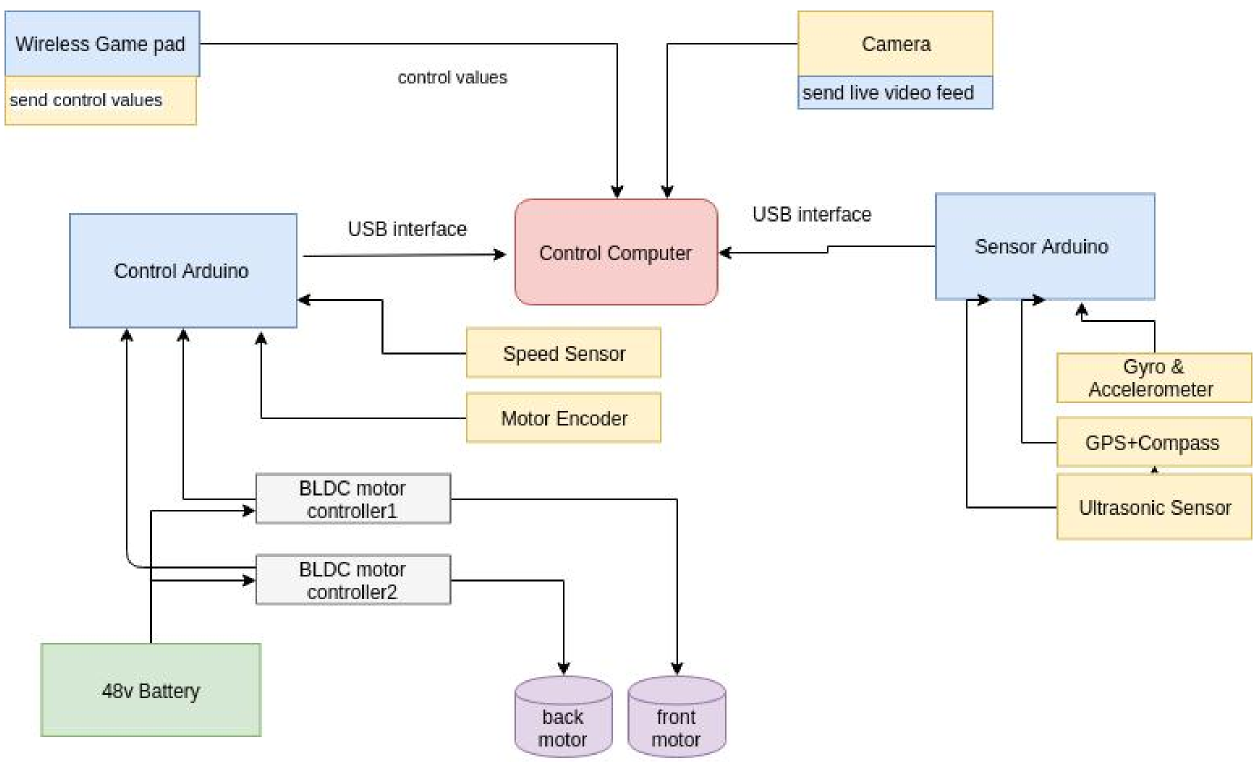

Figure 3.4.1.1: Give us an idea about the whole system.

From the sensor Arduino connect the GPS and compass and the ultrasonic sensor analog values and compute them to useful information. When the on-board computer starts collecting data, the

Arduino start receiving the sensor values from the sensors and send them to the on-board computer by another USB serial port. Now we talk about the motor's connection and its properties.

Rear motor

The tricycle Rear Axle Differential Gear BLDC motor creates the forward and backward movement of the vehicle.

A S49E hall sensor module sensor is used to create a speed meter. We attach a magnet with the wheel. When the wheel make a full turn ,the magnet in front of the sensor and the sensor get a signal and by calculating the wheel diameter we can find the RPM of the wheel . By using RPM we can calculate the speed with the following equation

Mph (miles per hour) = diameter x Pi x RPM/ 1056

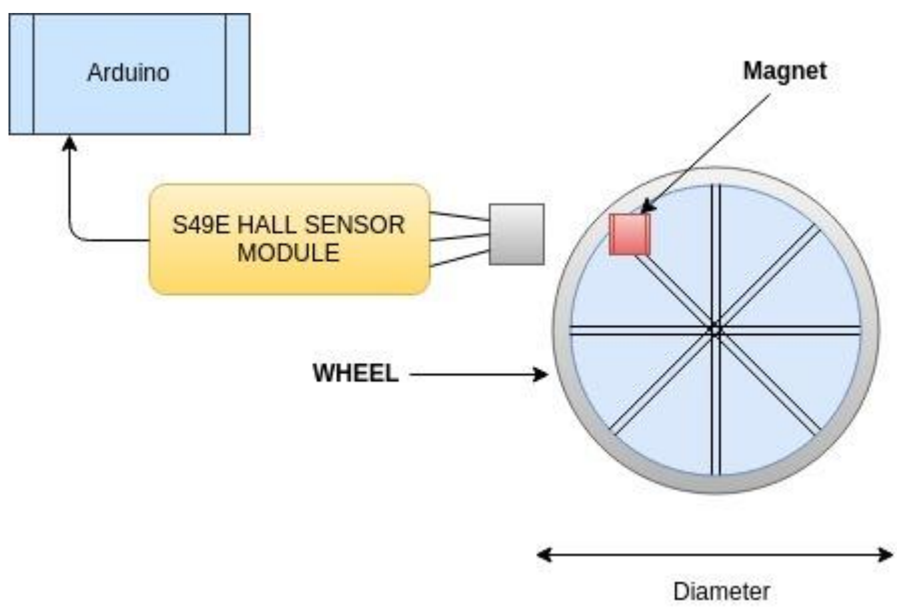

Figure 3.4.1.2: Speed meter using S49E hall sensor module.

To produce different speed with the BLDC motor the BLDC motor controller uses a throttle wire. The throttle receives 1.1-4.2V input voltage to drive the motor different speed.

We simulate the throttle alalog input voltage by an Arduino digital PWM pin. We don't connect the throttle wire and the Arduino PWM pin directly because the digital PWM pin doesn't produce actual analog voltage. So, we make a filter circuit with a capacitor and a resistor to make the DC output voltage smooth which is shown in Fig. 4.3:

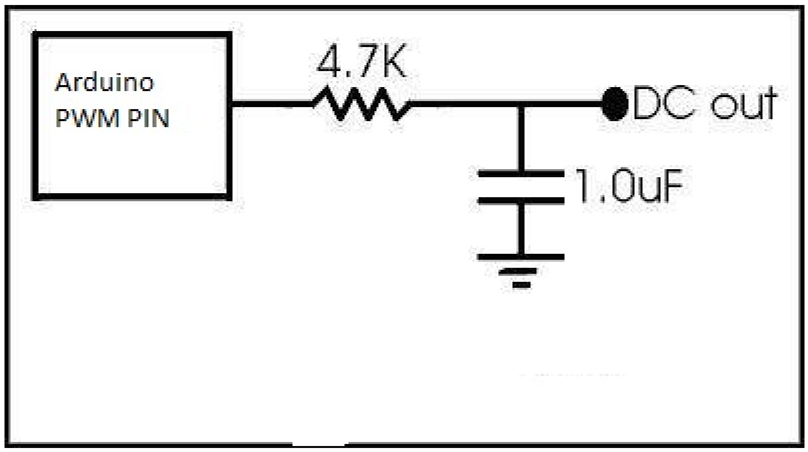

Figure 3.4.1.3: PWM Filter

In the motor controller there is a signal wire to turn the motor into reverse direction. When we connect the signal wire with ground, the motor will turn in reverse direction. So in this stage we used a relay switch to control the forward and backward direction change. We connect pin 5 for PWM and pin 7 for direction change relay switch activator. When we turn on the pin 7, the relay switch will turn on and short the two wire of the motor controller.

The E-ABS brake in the motor controller works fine to stop or slow down the vehicle. Same as Direction change there is a signal wire to send brake command to the motor. When we short the signal wire with the ground, the controller creates an electronic brake inside the motor. We use pin 3 for the braking when we high the pin, it turns on the relay and it starts braking. The detailed configuration of the pin is given below in (Table I):

Table 1: Arduino control flow table

Pin	Values	Functions
5	0 to 255	Speed control
7	Low	Clockwise
7	High	Anti-clockwise
3	High	E-ABS brake
3	Low	Brake release

Front motor:

As this is the three-wheeler vehicle, the front wheel controls the right and left turns. To connect the motor with the front wheel we build a chain drive mechanism shown in Fig 4.3.

Figure 3.4.1.4: Front wheel drive mechanism

For the front motor control, same types of motor and BLDC motor controllers are used. To know the wheel current position, we attach a precision potentiometer (10 turn 10kΩ) with the motor shaft which work like a rotational encoder.

Like the rear motor two digital Arduino pin connected with the BLDC motor controller to send PWM analog voltage with the PWM filter (Fig 4) and to change rotation direction change of the motor. But this time the PWM and the direction change signal pin changes its state depending on the current position of the front wheel. An analog input pin gives us the current wheel position within 0-1023 values when the motor turns. When the value is 512, wheel is centred. But when we turn left, the value will be less than 512 and it will decrease. On the other-hand, when we turn the wheel right, the value will increase up to 1023.

So that we can find out in which direction the front wheel now. Like the back wheel we also use a PWM pin to control the speed and a relay switch to change the rotation direction. To make turn we just give value within 0 to 1023 from the control laptop which calculate the current position of the wheel and give PWM voltage to turn. If the value is less than 512, then the motor goes anti-clockwise by turn on the relay switch otherwise it turns clockwise.

Distance Sensor

To drive the vehicle to the road we have to know about obstacles around the vehicle. The HC-SR04 ultrasonic sensor can give us obstacle data around 2m. We use two of them to know the distance of the obstacle front of the vehicle.

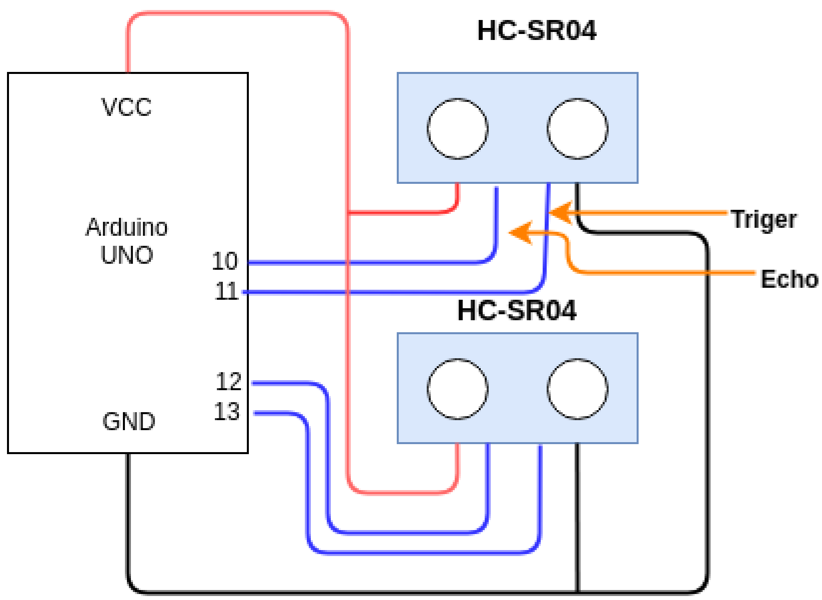

Figure 3.4.1.5: Ultrasonic distance sensor pin diagram.

Four Arduino digital pin operate the two sensor and collect values from them. The pin diagram shown in figure 4.3.

Gyro Accelerometer Sensor

Here MPU6050 sense orientation of the vehicle. It MEMS accelerometer and a gyro in a single chip. It is very accurate, as it contains 16-bits analog to digital conversion hardware for each channel. Therefor it captures the x, y, and z channel at the same time. The sensor uses the I2C-bus to interface with the Arduino. Fig 7 shows the pin diagram.

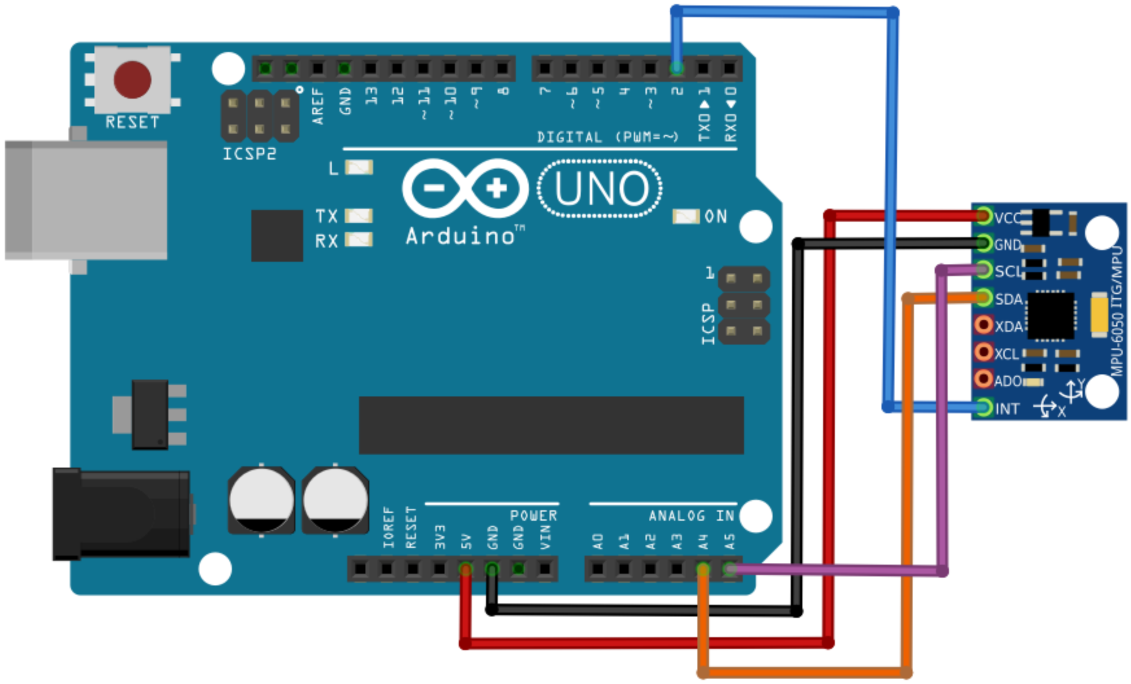

Figure 3.4.1.6: Connection of mpu6050.

3.4.2 Software Design

Figure 3.4.2.1: Nvdia's The trained network is used to generate steering commands from a single front-facing canter camera

In our system we mainly focused on collecting training data.to collect the training data, a human driver drives the vehicle manually on the read road to record time stamped videos and other control and sensor data. Then after collecting we copied them to a desktop computer. So that we can processes them with a NVDIA 1060 TiGPU. After processing them the trained model can run in the on-board computer and will produce the steering angle and speed depends on real time camera feed and different sensor values.

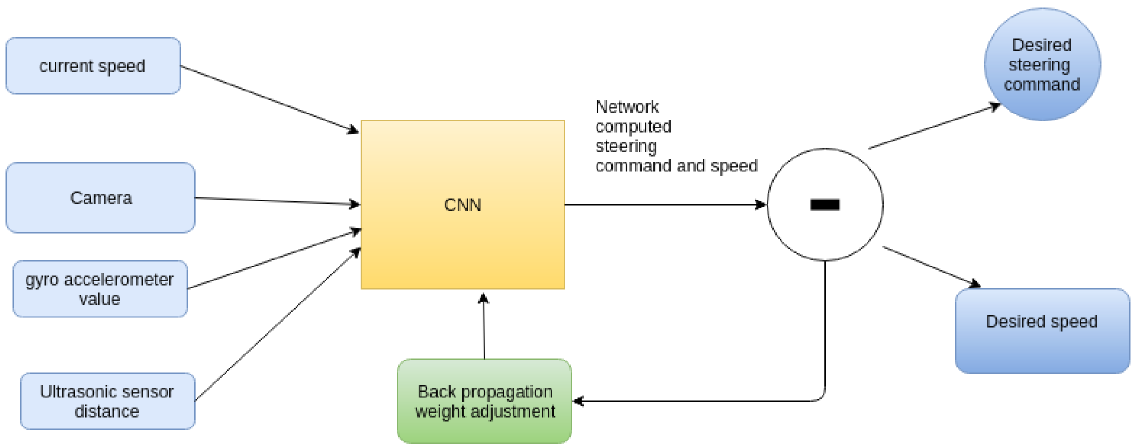

Figure 3.4.2.2: Our Vehicle model

CHAPTER 4
EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction

The first step to training a neural network the vehicle we made is selecting the frames to use. Our collected data is labeled with different road type, weather conditions, and the driver's driving activity. To train a Convolutional neural network to do lane following the vehicle only collect data where the driver was staying in a lane. We then sample that video at 15 FPS. A higher number of sampling rate would result in images that are highly similar and this type of data don't give good information of data.

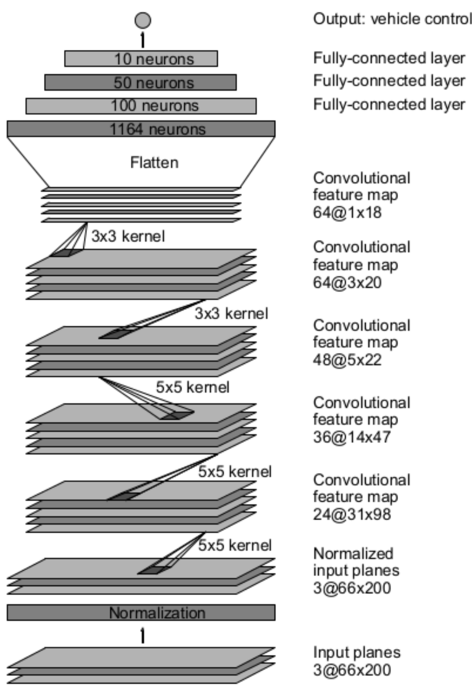

Figure 4.1.1: CNN architecture for the vehicle

Before testing the vehicle in road a trained CNN, we are testing the model and the networks performance in simulation. The simulator takes the collected data from the vehicle in a video from a forward-facing on-board camera on a human-driven data-collection vehicle and generates images that approximate what would appear if the CNN were, instead, steering the vehicle. This test videos are time-synchronized with recorded steering commands generated by the human driver

.

4.2 Simulation test

We are calculating what percentage of the time the trained model could drive the car without any human help. We assume that in real time system of life an actual intervention would require a total of six seconds: it means we assume if there is any error in the system a if any human driver notice if he need six second to take control of the vehicle and he can reset the autonomous steering system. We can find the percentage autonomy by keep tracking the numbers of interventions, then multiplying by 6 seconds and dividing it by the elapsed time of the simulated test, and then subtracting the result from 1:

Figure 4.2.1: The simulation interface

4.3 Visualization of Internal CNN State

In fig 4.3 we can show the visual activity of the first two feature map layers for a example inputs, an unpaved road and an obstacle. In case of the read is not paved, the feature map activations easily show the outline of the road .This demonstrates that the trained CNN model learned to detect useful road features on its own, i. e., with only giving the human steering angle as training commands. We never explicitly trained it to detect the outlines of the road.

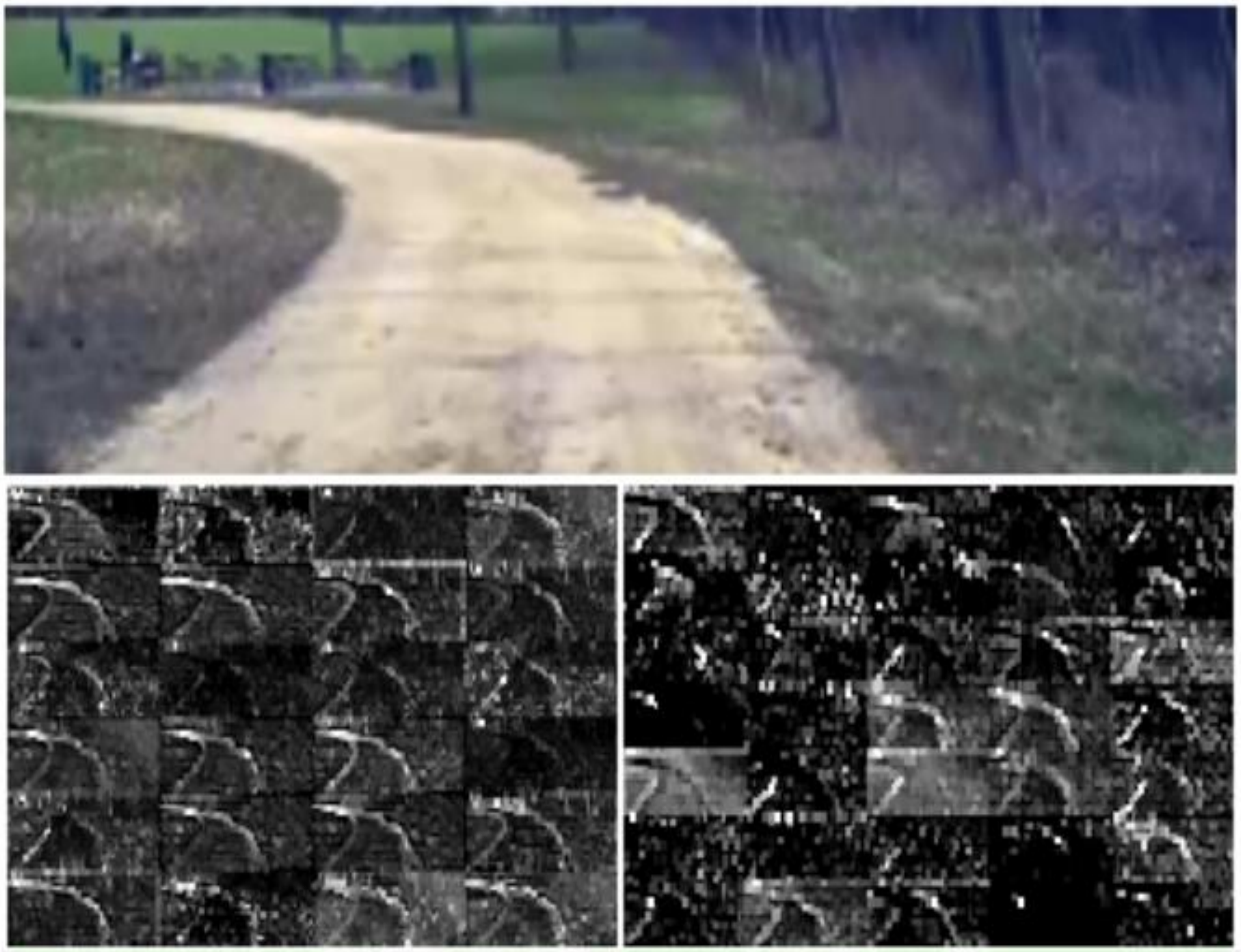

Figure 4.3.1: This how the CNN model see the road and extract feature from it

Chapter 5

SUMMARY AND CCONCLUSION

5.1 Summary of Study

In this research we clearly our custom-made vehicle is able to collect training data from the real world demonstrated that CNNs are able to learn the entire task of lane and road following

Figure 5.1.1: The working prototype model of the vehicle

without manual decomposition into road or lane marking detection, semantic abstraction, path planning, and control. A small amount of training data from less than a hundred hours of driving was sufficient to train the car to operate in diverse conditions,

The full vehicle is given in fig 5.1

5.2 Conclusion

Our expected outcome was that vehicle would collect data and help us to make a dataset as well as the testing different test cases. The vehicle performs as expected. We think the tests we did went smoothly and we had no problems, except for the fact that some hardware gives noisy data. An interesting future study might involve testing the model at different varieties of vehicle to make them Autonomous or semi-autonomous.

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