Obstacle Avoidance and Object Detection for Semi Autopilot System of an Electric Car

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A thesis submitted to the Department of Electrical & Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science

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BRAC University
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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Ethics Statement

We, hereby, declare that this thesis is based on results we found ourselves. The materials of work conducted by other researchers are mentioned in References. This is to affirm that this thesis report is submitted by the authors listed for the degree of Bachelor of Science in Electrical and Electronic Engineering to the Department of Electrical and Electronic Engineering under the School of Engineering and Computer Science, BRAC University. We, hereby, declare that the research work is based on the results found by us and no other. The materials of work found by other researchers have been properly acknowledged. This thesis, neither in whole nor in part, has been previously submitted elsewhere for assessment.

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Abstract

In this modern era of transportation we are experiencing the best utilization of technology in our daily life though using different types of advance vehicles. If we look at the transportation industry one similar thing we can easily locate among all the giant vehicle manufacturing companies that is autonomy. As applying autonomy in the transportation system is the next revolution in vehicle market so almost every renowned companies from different corner of the world trying to integrate driverless vehicle control operation in their new designs. In this process the control part is the main focused area to achieve maximum percentage of accuracy. In this following research paper we are also focusing on development of control system of a driverless car. Applying CAN Bus networking system ensures a smooth data transfer. Integrating different sensors like Kinect, Camera, high resolution ultrasonic range finder, human movement detection sensor etc. into one single system makes the design unique. Image processing operation helps the system to take correct decision about mobility, obstacle avoidance and lane detection. Critical experimental analysis of the system helps us to measure the parameters of accuracy in real life scenario.

Table of Contents

List of Figure:

Chapter: 1: Introduction

1.1. Introduction:

If we look at the greatest vehicle manufacturer companies of the world now then we can see that almost everyone is making visible movement to integrate autonomy into their drive system. Not only vehicle manufacturing companies but also many tech companies like Google, Uber etc. are also making approach to develop driverless car. As this is will be the revolutionary movement of vehicle industry. So everyone are trying their best to achieve the perfection. This topic is also emerging between modern researches also. Among students it is getting popular as a topic of interest day by day. The main motto of this research is to develop the control system of self-driving car so that it can be integrated into different cars for converting them into autonomous car. As this topic is emerging so in this research paper we have approached a responsive control system for self-driving operation of vehicles. We have built a four wheeler electric vehicle from the scratch to integrate our system. For avoiding obstacles and detecting human movement we have integrate couple of high performance sensor based approach into our system. As we will run the vehicle on a proper road with proper lane system so we have integrate lane detection method using image processing operation into the system. CAN Bus system has been applied into our model for smooth running of data. As the technology is growing so we have applied trial and error base method to achieve desired result.

1.2. Motivation

The world is moving towards autonomy. Every system will taste the flavor of autonomy in near future. In recent years applying autonomy in the vehicle industry has increased in a significant way. So for better research opportunity we get motivated to this topic. Developing control system of driverless car will also help us to achieve expertise in embedded system. We can enrich our professional expertise in different field of automotive industry by this research work. The scope of future development of this topic is also high. So for better research scope and enrich our skills we have selected this topic

Chapter 2: Literature Review

For a successful research the most important part is studying the previous related works. As we are dealing with driverless car operation so we have also studied previous works related to autonomous car and driverless car for making the research successful. For that we have collected related research papers and works. First of all we have started with a paper titled Message authentication in driverless car [1]. In this paper different types of driverless car has been described from different company. This paper also presents a novel message verification plot that ensures cars from false messages and makes VANET strong to Denial-of-Service (DoS) assaults. The work incorporates a reenactment system that coordinating vehicle and information activity models to approve the viability of the proposed message verification plot.

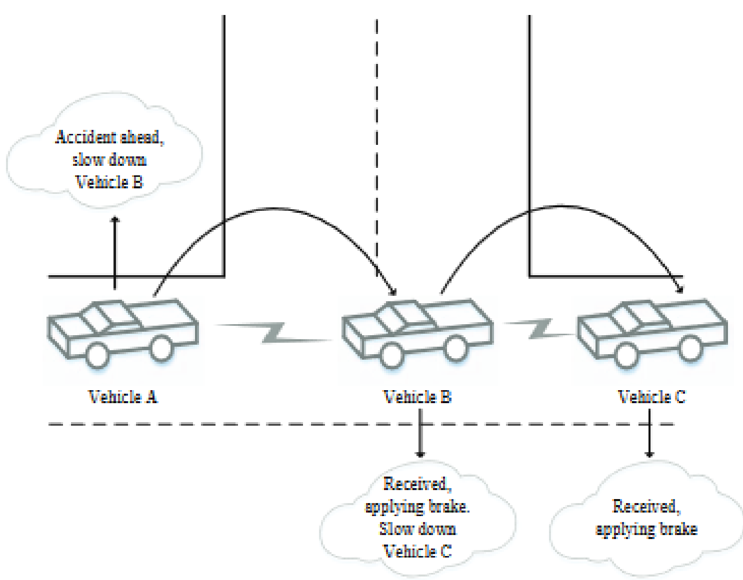

Fig.2.1. Message authentication in driverless car

The next paper we have go through has a title Behavioral cloning for driverless cars using transfer learning [2]. In this paper a machine learning calculation for choice making in driverless route is created. This strategy is executed through adjusting existing demonstrated convolutional neural systems to the current issue. Compared to the conventional strategies bolstered by calculations from computer illustrations, this exchange learning strategy tend to optimize all handling steps at the same time, hence driving to superior execution whereas keeping up a tall performance-to-cost proportion. A new type of mechanism name transfer learning has been implemented through this paper.

Fig.2.2. Transfer learning in different scenario

The next paper we have studied titled Model of motion control system of driverless car [3]. In this paper a motion control system has been proposed for the autonomous car drive system. Their arrangement is conceivable with the assistance of a viable movement control framework. Data processing is realized with the assistance of fake insights, organs of "faculties" and official components. For the usage of this assignment, a critical step is the compilation of a scientific model. With the help of this model the mobility can be set in a structured system.

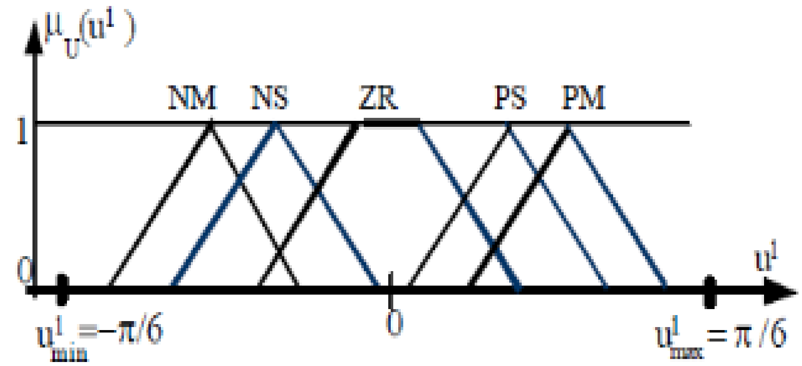

Fig.2.3. Motion control mechanism

Moving on to the next paper named Design and fabrication of robotic systems: Converting a conventional car to a driverless car [4]. In this paper a robotic system has been proposed for converting a regular car to a self-driving car. A pneumatic framework is planned to mechanize the planning stage separated from the engines. The mechanical structure is a fundamental portion of an independent car and is to be modified and planned in such a way that it is powerfully immovable. Advance changes will make the framework competent of being commercially created.

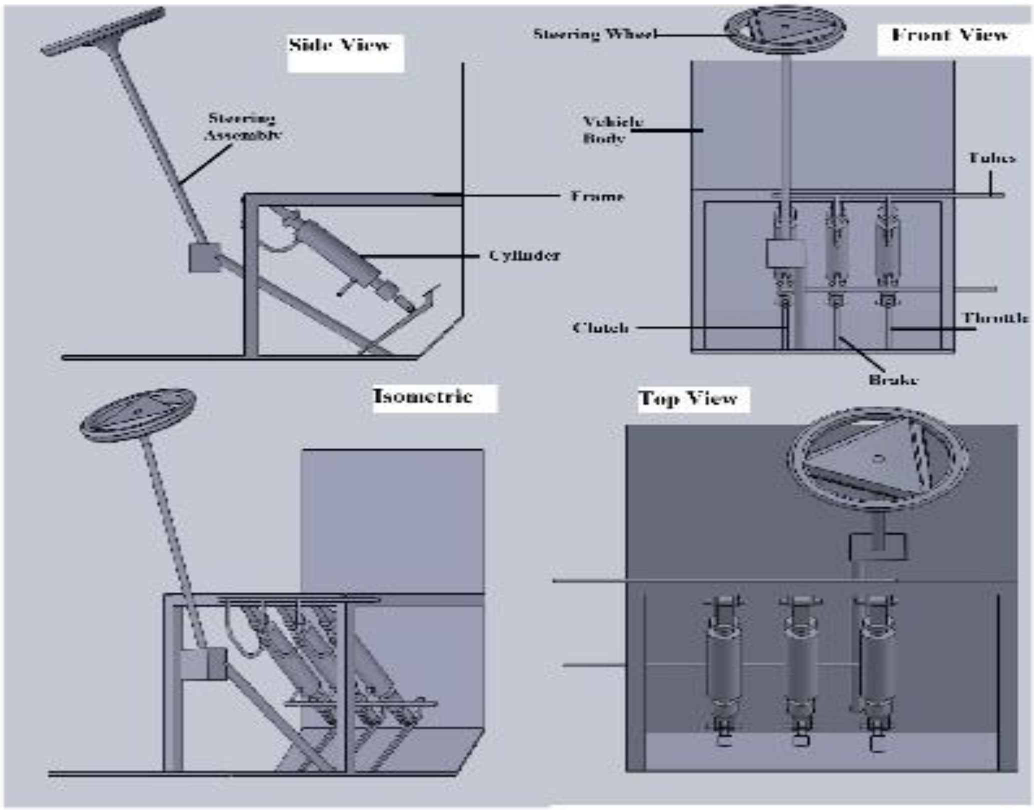

Fig.2.4. Proposed pneumatic design

The next paper we have studied titled The path to driverless cars [CTA Inside] [5]. In this paper the interest of general people towards the driverless car has been shown through a survey. In the paper three misconception point has been found regarding driverless cars. They are 1. Customer of cars do not want autonomous cars, 2. The journey of driver assistance cars to driverless car is a straight line, 3. Fully autonomous cars need to be errorless. From this paper peoples thoughts regarding driverless cars has been introduced.

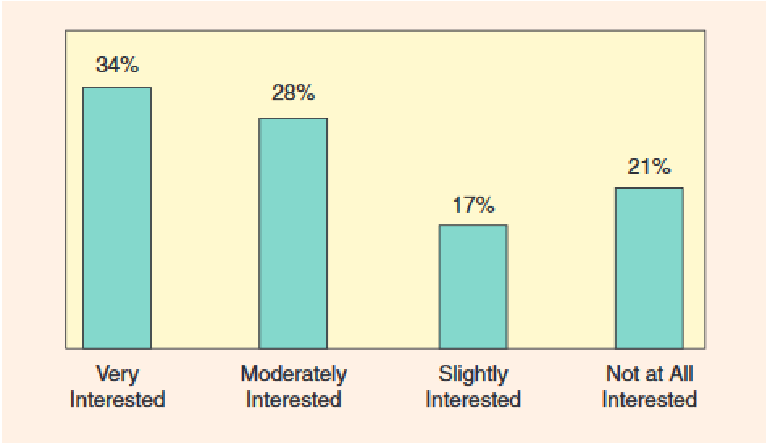

Fig.2.5. Peoples rate of interest for driverless cars

The next paper we have go through is named Human – Man Interface concept for Autonomous car [6]. In this paper the concept of car company Renault about autonomous cars has been discussed. The driverless SYMBIOZ version of car from Renault can apply the new Human – Man interface (HMI) concept.

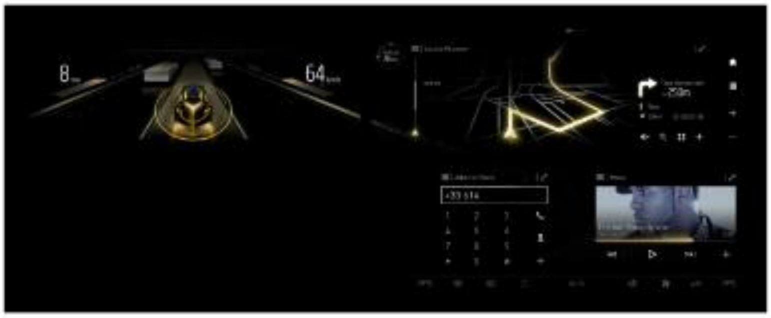

Fig.2.6. Concept of HMI

The next paper titled Autonomous Driving System based on Deep Q Learnig [7] has been studied by us. This paper bargains with the reenactment comes about of an independent car learning to drive in a disentangled environment containing as it were path markings and inactive impediments. Learning is performed utilizing the Profound Q Organize. For a given input picture of the road captured by the car front camera, the Profound Q Organize computes the Q values (rewards) comparing to the activities accessible to the independent driving car. These activities are discrete points through which the car can control for a settled speed. The independent driving framework within the car upholds the activity that has the most noteworthy remunerate. Our recreation comes about appear tall exactness in learning to drive by watching the paths and bypassing impediments.

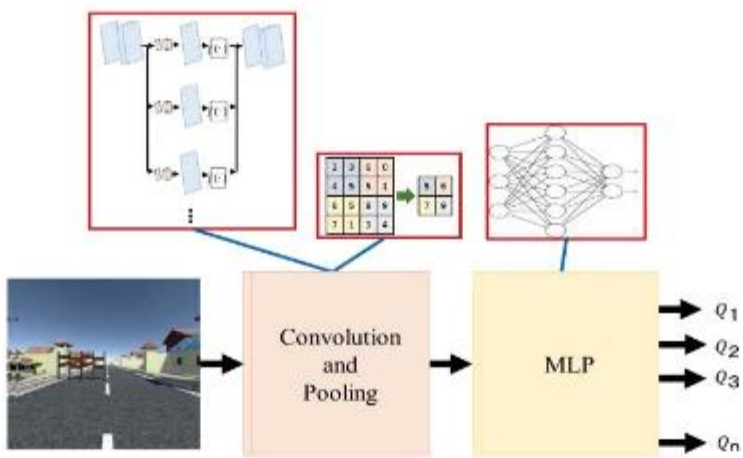

Fig.2.7. Q – Network with deep learning

The next paper we have studied is named Driving Decision-Making Analysis of Car-Following for Autonomous Vehicle under Complex Urban Environment [8]. In this paper a virtual urban situation has been created and using 6-DOF dynamic model vehicle dynamic has been simulated. Rough set theory is also proposed into the system. Using all these the decision making system has been critically analyzed for autonomous cars in tough urban environment.

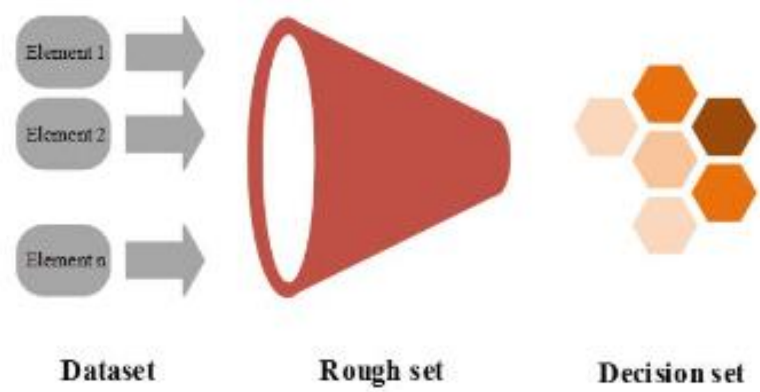

Fig.2.8. Rough set application

After critically analyzes all the system we have gathered so much knowledge about driverless car operation. We have also found comparison of our system with other system. Most of the system are installed in conventional cars, but in our case we have built custom car that's why we can teach the system autonomous drive using trial and error base mechanism which is an advantage. Also we can easily modify our system. As we are using couple of sensors so the protection level is in standard level for our system by using that we can avoid unwanted accidents. If we can continue the research then we can surely achieve 100% autonomy on the road in near future.

Chapter 3: System Overview

As our system is consist of multiple sections, so for better outcome we have divided the total system into four major sub system. The sub systems are as follows

Hardware

In this sub system we have developed a four wheeler vehicle according to our requirement. We can buy any vehicle from the market and modify that for autonomous run, but as contribution to the research and for our compatibility we have built the vehicle from scratch. So we have divided the total hardware system into four sub sections. The sub sections are as follows

Chassis

Chassis is the most important skeleton of a vehicle. It contains all the other components on its body. In the event that we go through a definition at that point it states that a car chassis is the Central establishment which clasp all the parts like wheel, Drive Motor, Body etc. In our case we have go through many designs to achieve the specified plan. After studying couple of designs we have selected space frame design for our system. Within the space frame there's a triangular which clearly has three hub. Presently the concept is in case we apply constrain on the best most hub at that point in case the drive is lesser than the unbending nature of the portion between the other two hubs at that point the push can be similarly conveyed to the other two hub which can diminish shape twisting. We moreover utilize two pipe as our primary structure but we have input triangulation with the two fundamental pipe which truly expanded the unbending nature and effortlessly conveyed the push in each strut. For making the chassis lighter than the ordinary chassis we have utilized 1.5/1.5 inch square box pipe which is solid as well as less in weight. The entire length of the chassis is 96 inch.

Suspension

In this present day time of versatility we are getting a charge out of way better quality of ride than some time recently. One of the foremost critical portion interior a vehicle which offer assistance us to savor on the street is suspension framework. Presently address is what is a suspension framework? From the word itself Suspension ready to get it that it is approximately to promote a portion from the surface to inevitably suspend for reducing the response of the strengths of the surface on that particular portion. After analyzing different suspension system we have selected double wishbone suspension system for our design. In this system high performance has been used between chassis and wheel mount so that when wheel faces any rough terrain then the shock absorber can absorb that shock due to uneven terrain.

Wheel

To realize the mobility there's no other productive way than wheels. After the innovation of the wheels individuals can cover separate distance at a minimum time. One of the most prominent development within the history is the wheel. Presently we are having the foremost progressed and modified wheels with so numerous highlights. In our car we have also used wheels as the main source of mobility. We have considered distinctive estimate and shape conjointly try on our car for finding the assigned one. After several trial and error basis effort we have selected a wheel with 22 inch diameter.

Fig.3.1. 3D CAD model of designed car

Drive Engine

In this contemporary world the “Green” is getting popular in everywhere. So now question is what is green system? It implies that anything we are doing for our living we got to do it in a way which is environment inviting. For illustration ready to take the transportation framework. On the off chance that we see exterior we are able discover that most extreme number of vehicles are using fuel or gas which hurts the environment. In case we change over the vehicle drive framework in such a way that's not destructive for the nature at that point it'll title as a green transportation framework. That’s why we have selected an electric drive engine for our system. The drive voltage for our electric motor is 48V with a control of 1000W. The revolution per diminutive of the shaft is between 3000 – 3300 with a speed of 25 – 35 km/h. The speed proportion of the electric motor for the traveler is 1:10. The overall proficiency of the motor is 85%.

Fig.3.2. Electric Drive Engine with inbuilt differential

Electronics

As we are making an autonomous drive system so we have to collect data from the road or environment through sensors. Couple of different types of sensors has been used for data set collection. The sensors are as follows

High resolution ultrasonic range finder Sensor

When moving on the roads obstacle avoidance is one of the prime concern for an autonomous drive system. For fulfilling that requirement we have studied couple of sensors to find the best choice. Initially we need to detect obstacle in between 0 – 5 meter of range so we have selected high resolution ultrasonic range finder sensor for that operation. This is a 43 KHz ultrasonic sensor with an operating voltage of 2.5 – 5.5 V. The supply current is low for this sensor which is 2mA. It has also a reading range of 20 Hz. It has couple of output like RS232 serial output, analog output 10mV per inch and PWM output 147uS per inch.

delay.

Fig.3.3. High resolution ultrasonic range finder sensor

Microwave Radar – Human motion sensor

Another important detection for a self-driving car is the human motion detection. As on the road there will be lots of human being roaming around so if the motion cannot be detected carefully then accident might be occur. So for avoiding that issue we have studied about couple of human motion detection sensor. After critical analysis of different sensors have selected microwave radar – human motion sensor for our system. The working voltage of this sensor is between 4 – 28 V and operating current is less than 3 mA. The output voltage for this module is 3.3V and output current is 100mA. It has a detecting range of less than 120 degrees taper angle within 7 meters. It consist of repeat trigger mode with 2 seconds of delay.

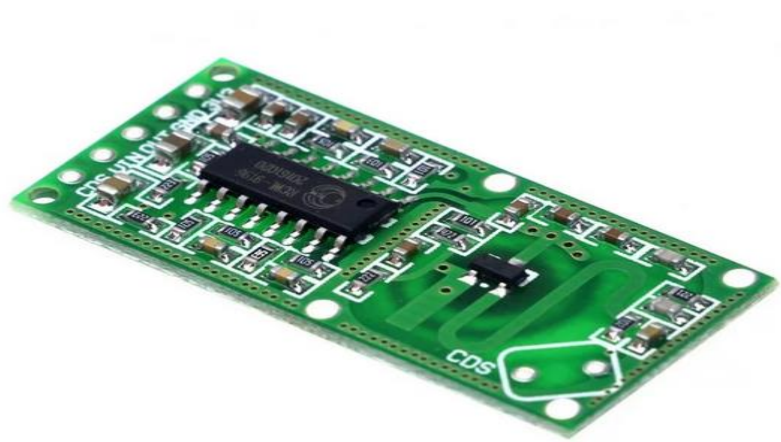

Fig.3.4. Microwave radar – human motion sensor

Voltage Sensor

For continues follow up on the battery unit we need to measure the data of the battery unit after a certain time. So for that reason we need a voltage measurement sensor. As there are couple of voltage measurement sensors are available in the market but we have decided to make it by our self as a contribution to the research. So we have studied and found that using voltage divider rule we can easily measure continues data of voltage.

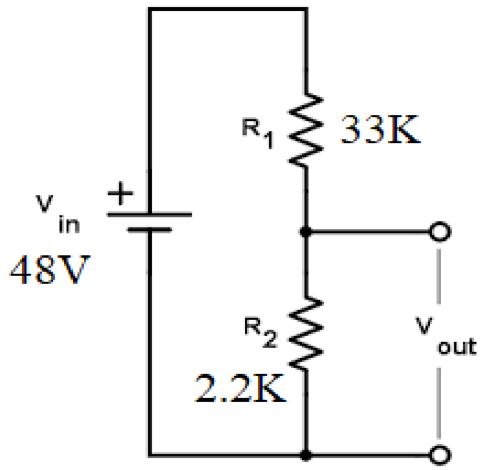

Fig.3.5. Voltage sensor using voltage divider rule

If we look at the diagram then we can see that R1 is 33K and R2 is 2.2K and the Vin means input voltage is 48V as our battery unit consist of four 12V battery's connected in series. So when we measure the Vout using the voltage divider rule equation which is

$V_{out} = V_{in} X R_2 / (R_1 + R_2)$

then we can receive the voltage from the battery units through the value of Vout. The maximum voltage can be measured by this system is 80V. We have measured up to 65V with the help of this sensor.

Current Sensor

For calculating the drain of the battery unit with respect to time we have to measure the current from the battery units. As from current value we can make a graph about the battery efficiency, so we have studied about couple of current sensors. As most of them are low in rating but we need a sensor with higher rating because the current draw of our system is high. After analytical and experimental study of different sensors we have selected ACS – 758B – 100 current sensor for our system. This sensor can work between 3 – 5.5 V with 12 KHz typical bandwidth. It can measure up to 100A of current. We have measured current from 20 – 44 A by this sensor into our system.

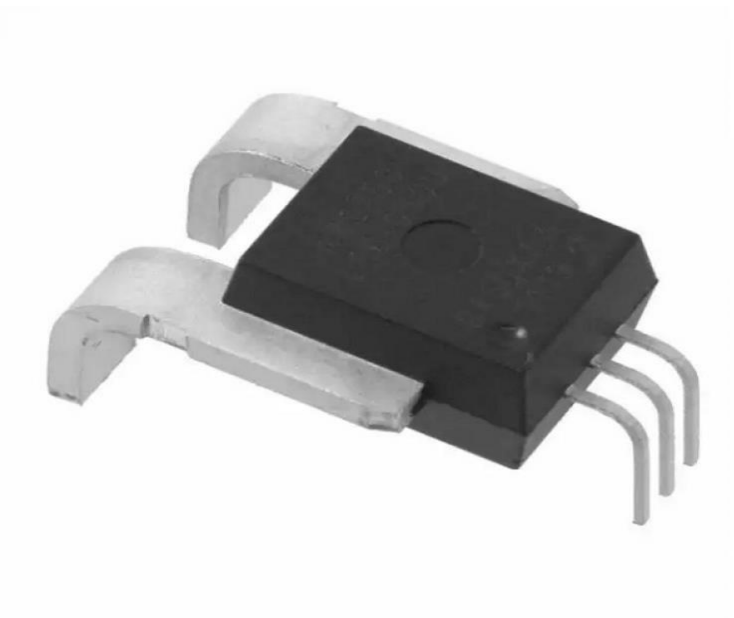

Fig.3.6. Current Sensor

GPS Sensor

One of the prime concern of autonomous car drive is navigation of the vehicle without using internet. Which means we have to locate the car offline and making a map based on that. For fulfilling that requirement we have choose GPS system. The Global Positioning System (GPS), initially Navstar GPS, may be a satellite-based radionavigation framework claimed by the Joined together States government and worked by the United States Discuss Force. It may be a worldwide route fawning framework that gives geolocation and time data to a GPS recipient anyplace on or close the Soil where there's an unhindered line of locate to four or more GPS satellites. Deterrents such as mountains and buildings square the generally powerless GPS signals. After studying about couple of sensors we have selected Ulox – NEO – 6m GPS sensor for our system. The features of that version of the sensor perfectly match with our system. It has cold start time of 38s and hot start time of 1s. Supply voltage of this sensor is 3.3V. It has a configurable baud rate between 4800 – 115200 baud. It has also 5Hz position update rate. Operating temperature of this sensor is -40^{o} C – 85^{o} C.

Fig.3.7. Ulox – NEO – 6m GPS sensor

Camera

Detecting the lane of a road or detecting any material or obstacle on the road image processing through camera module has been a useful system. In our system we have also used camera modules for performing image processing commands. As we have a central processing unit on the car so we have selected USB cameras for this operation. USB Cameras are imaging cameras that utilize USB 2.0 or USB 3.0 innovation to exchange picture information. USB Cameras are outlined to effortlessly interface with devoted computer frameworks by utilizing the same USB innovation that's found on most computers.

Fig.3.8. USB Camera

Kinect

Measuring the depth of the surroundings is one of the main issue n self-driving car. For solving that issue a depth measuring sensor can be used. But the sensor needs to measure the depth in 3D. So the sensor needs to plot a 3D image of the surroundings and define objects inside the image to measuring the depth from those objects. After several study of depth sensing sensor we have come up with Kinect as our depth measurement module. Kinect (codenamed Extend Natal amid advancement) could be a line of movement detecting input gadgets created by Microsoft. At first, the Kinect was created as a gaming embellishment for Xbox 360 and Xbox One video diversion comforts and Microsoft Windows PCs. Based around a webcam-style add-on fringe, it empowered clients to control and associated with their console/computer without the required for a diversion controller, through a characteristic client interface utilizing motions and talked commands. Whereas the gaming line did not pick up much footing and in the long run ceased, third-party designers and investigates found a few after-market employments for Kinect's progressed low-cost sensor highlights, driving Microsoft to drive the item line towards more application-neutral employments, counting joining the gadget with Microsoft's cloud computing stage Sky blue. The version of Kinect that we have integrated into our system has three vital element. They are an RGB color VGA video camera, a depth sensor and a multi array microphone.

Fig.3.9. Kinect Sensor

Accelerator

As we have built the car from scratch so for acceleration we need an accelerator. As our system is fully electric so normal car accelerator will not work in our system. We need to give input value with calculated measures for accelerate the car. So based on our requirement we have selected electric pedal accelerator which can take values using feedback mechanism to send command in a calculative manner. The accelerator works in 5V input voltage and it has a potentiometer based inbuilt feedback mechanism in it.

Fig.3.10. Electric Accelerator pedal

Other than sensors there are some more electronics component has been used for the driver less vehicle for giving signals to other cars or pedestrian. The components are indicator light, headlight, back light and horn. These systems are complex to control as there are too many wires out from these modules. For reducing the complexity from the system we have developed a separate control system to control these modules. The control system is consist of microcontroller, relay modules and voltage regulator. We can easily manipulate the microcontroller program for our desired result.

Fig.3.11. Control Circuit for lights & horn

Communication

In the communication system for reducing complexity we have implemented controller area network or CAN Bus system. In this system there will be only two wire which will carry all the data from each sub section and send it to the ECU.

CAN Bus

As automobiles and other vehicles have gotten to be more ecologically inviting and more mechanically progressed, it has gotten to be progressively imperative to have a central organizing framework. This framework interfaces all the modules working all through the vehicle so that they can work together to run viably and effectively; for illustration, the motor reports the vehicle's speed to the transmission, which in turn must tell other modules when to move gears. Interfacing all these person modules to each other got to be as well complex, so a central organizing framework got to be essential to proficiently run the vehicle. The Controller Region Arrange, or CAN transport, is one of these central organizing conventions utilized in vehicles without a have computer.

In expansion to making lighter vehicles, the CAN transport convention has numerous other noteworthy benefits. By interfacing all the modules in a vehicle to one central line, the control framework is rearranged and more effortlessly controlled. This plan permits any associated module to alarm the most controller to an occasion that because it happens which is able cause the rest of the framework to reply appropriately. The shared information line permits different modules to be connected with less obtrusive endeavors, making the potential for blunder much lower.

In case one module on the CAN transport comes up short, it does not essentially cause the disappointment of other modules. Unless the two frameworks are straightforwardly related and one cannot run without the other, the solid modules will proceed to operate superbly in spite of the misfortune of one bad module. This makes the complete framework more secure.

Moreover, diagnostics of the vehicle are easier and more particular due to the specialized and self-contained nature of the modules. Diagnostics can presently pinpoint the precise cause of the module disappointment with precision and speed. When one module needs upkeep, that module can basically be targeted and supplanted instead of tearing separated the complete vehicle.

One of the foremost critical benefits of CAN transport innovation is the proportion it offers of cost to execution. As of now CAN bus is one of the foremost reasonable network systems in expansion to being one of the foremost dependable, making it the most cost-effective choice of vehicle producers around the world. CAN transport offers a basic interface for connecting an extra hub. The hub can be utilized for diagnostics, reconstructing, checking, and more. Numerous instruments have been made to tie into the CAN transport. Right now, there are arrangements to do USB to CAN, remote to CAN, PCIx to CAN, and indeed a CAN transport lumberjack.

Independent mechanical apparatus, as well as portable machines, have been progressively joining CAN transport convention since of the implanted control within the framework. Based on the unwavering quality and proficiency of the convention, therapeutic and military gear have also seen a rise within the application of CAN transport. As apparatus gets to be progressively complex, the application of the CAN transport framework is likely to rise with the innovation.

Can Bus Sensor Network

As we are using can bus network for data trafficking so for that we need can bus module to collect data from each part of the vehicle. We have designed low cost custom Can Bus module as a contribution to the thesis. The design consist of MCP2551 module, Atmega328p microcontroller chip and LM7805 voltage regulator. The module MCP2551 is a high speed can transceiver. It has 1 Mb per second data transfer rate with operating voltage of 12v and 24v. This module has couple of protection system like low current standby operation and automatic thermal shutdown protection. Up to 112 nodes can be connected with one single module. The module is connected with a microcontroller chip and it gives all the data to the chip to transfer it to the CPU. A voltage regulator IC LM7805 has been used for power up the module.

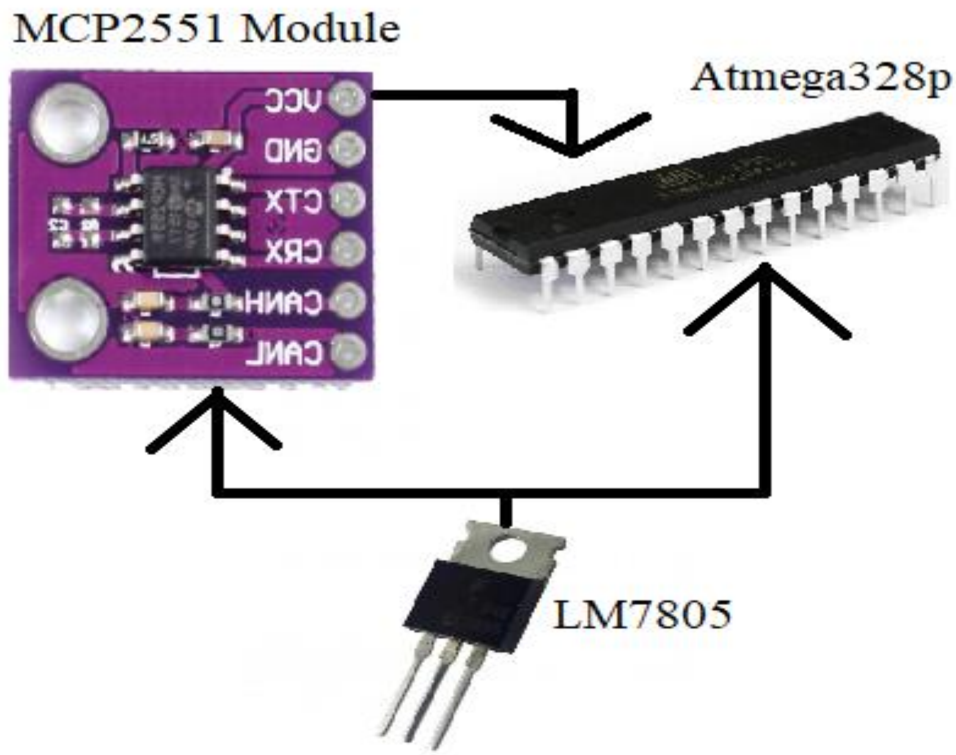

Fig.3.12. CAN Bus module diagram

We have divided the total data collection system into five different nodes. As we are implementing an errorless smart data acquisition system for the driverless car so we have decided to make small node for separate data collection zone. In this way we can ensure the error free data transfer unit with plug & play facility so that we can change the damaged modules within no time. The five nodes are as follows

Node – 1

Node – 1 consist of four different modules. The modules are high resolution ultrasonic range finder sensor, microwave radar human motion sensor, Atmega328p microcontroller chip and a custom made CAN Bus module developed by us. All these elements are organized inside a box and placed on the rear side of the looking glass of our vehicle. This particular node will work on the left side of the vehicle while moving. It will collect different data related to obstacle avoidance, human motion detection and send it to the CPU through CAN Bus network.

Fig.3.13. Developed Node – 1 module for CAN Bus network

Node – 2

Node – 2 consist of four different modules. The modules are high resolution ultrasonic range finder sensor, microwave radar human motion sensor, Atmega328p microcontroller chip and a custom made CAN Bus module developed by us. All these elements are organized inside a box and placed on the rear side of the looking glass of our vehicle. This particular node will work on the right side of the vehicle while moving. It will collect different data related to obstacle avoidance, human motion detection and send it to the CPU through CAN Bus network.

Fig.3.14. Developed Node – 2 module for CAN Bus network

Node – 3

Node – 3 consist of three different modules. The modules are Ublox NEO – 6m GPS module, Atmega328p microcontroller chip and a custom made CAN Bus module developed by us. All these elements are organized inside a separate PCB and placed on the dashboard of our vehicle. This particular node will work on the navigation system of the vehicle while moving. It will collect different data related to mapping, path planning and navigation without internet connection and send it to the CPU through CAN Bus network. Using this GPS system we can easily locate the desired path through our custom offline mapping system. We can also locate the current position of the vehicle into our mapping system through this particular node.

Fig.3.15. Developed Node – 3 module for CAN Bus network

Node – 4

Node – 4 consist of four different modules. The modules are custom built voltage sensor, LCD module, Atmega328p microcontroller chip and a custom made CAN Bus module developed by us. All these elements are organized inside a box and placed on the dashboard of our vehicle. This particular node will work on the battery unit of the vehicle while moving. It will collect different data related to battery voltage drops, initial voltage, starting voltage and send it to the CPU through CAN Bus network. It will also show the voltage rating in the LCD module situated on the dashboard of the vehicle. As we need to inspect voltage rating continually so this particular module will help us to achieve this milestone.

Node – 5

Node – 5 consist of four different modules. The modules are custom built current sensor, LCD module, Atmega328p microcontroller chip and a custom made CAN Bus module developed by us. All these elements are organized inside a box and placed on the dashboard of our vehicle. This particular node will work on the battery unit and power drainage ratings of the vehicle while moving. It will collect different data related to battery voltage drain rate, initial current, starting current, pick current rating and send it to the CPU through CAN Bus network. It will also show the current rating in the LCD module situated on the dashboard of the vehicle. As we need to inspect current rating continually so this particular module will help us to achieve this milestone.

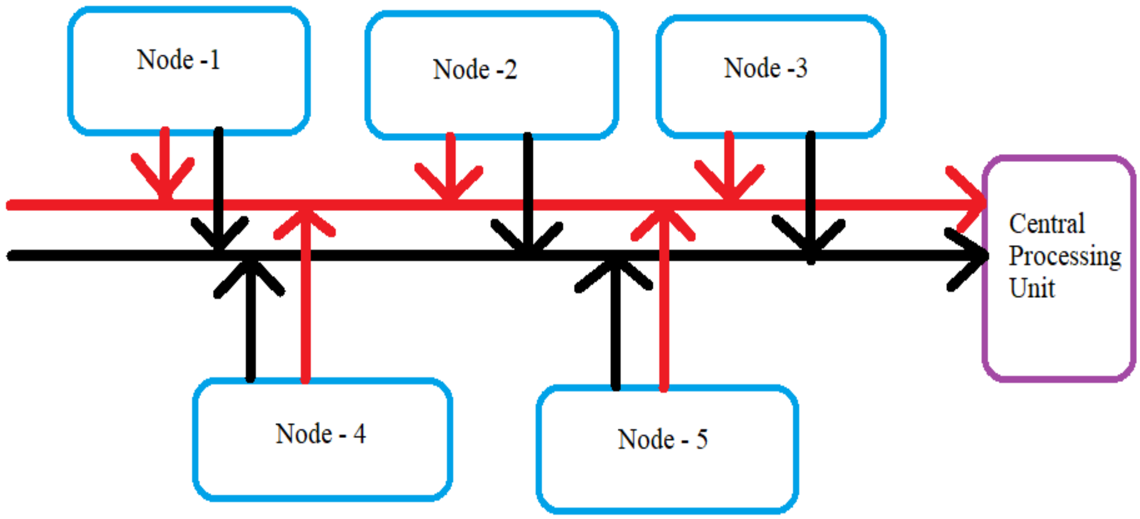

Fig.3.16. CAN Bus Sensor Network Block Diagram

Chapter: 4: Methodology

Self-Driving Mode

The prime concern of this research is to implement drivel less drive system into a vehicle. For this reason we were more focused on the self-driving mode of this system. Using multiple input units we have developed a responsive system which can control the car autonomously. We also have combined multiple decision into an output unit so that maximum percentage of accuracy can be achieved during decision making.

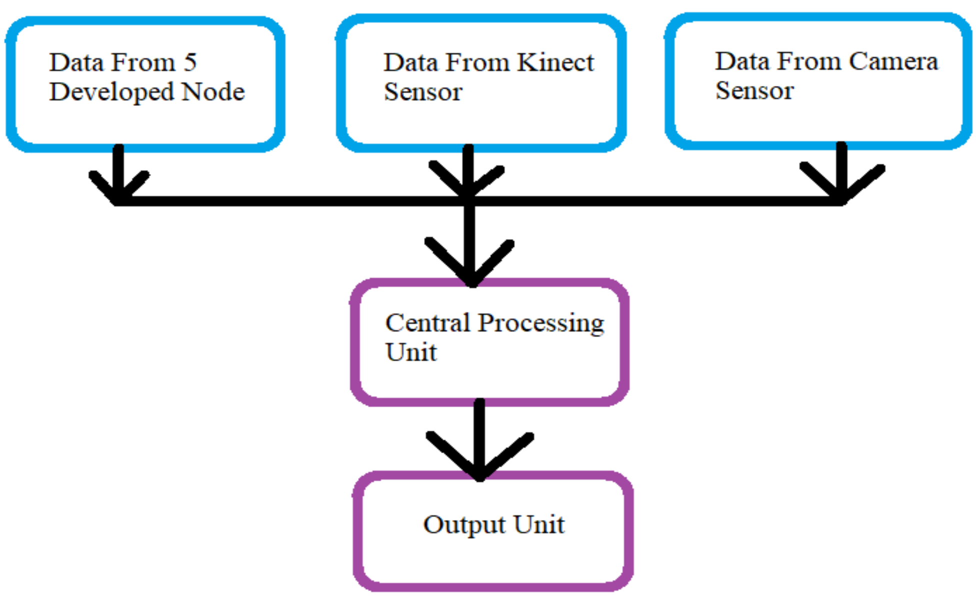

Fig.4.1. Self – Driving System Block Diagram

In the above diagram the self-driving approach has been shown. If we critically analyze the diagram then we can see that the central processing unit is gathering informations from three major sources. They are developed nodes using CAN Bus module, Kinect sensor and camera sensor. Then it will process the data in the CPU. After processing a decision making command will be send to the output unit so that it can command the vehicle about its mobility. As we have earlier discussed about the CAN Bus Node operation so in this part we will focus on the other major sources of data and the total system.

Data from Kinect

As we have mentioned earlier that for depth sensing we have used Kinect sensor into our system. So in this part a Kinect sensor will be placed at the front middle part of the vehicle so that it can cover maximum angle. This Kinect sensor is directly connected with the CPU through USB. Inside the Kinect sensor we have a RGB VGA video camera, a depth sensor and a microphone. So when the sensor is activated then it will through IR light on the obstacles so that it can illuminate subject or obstacle. Then the onboard camera of the Kinect measure the distance IR light travels to each pixels within the chip. After that the unique embedded imaging software uses depth map to perceive and identify objects in real life. Using all these data a 3D mapping plot has been created which will help the CPU to make decisions about vehicle control.

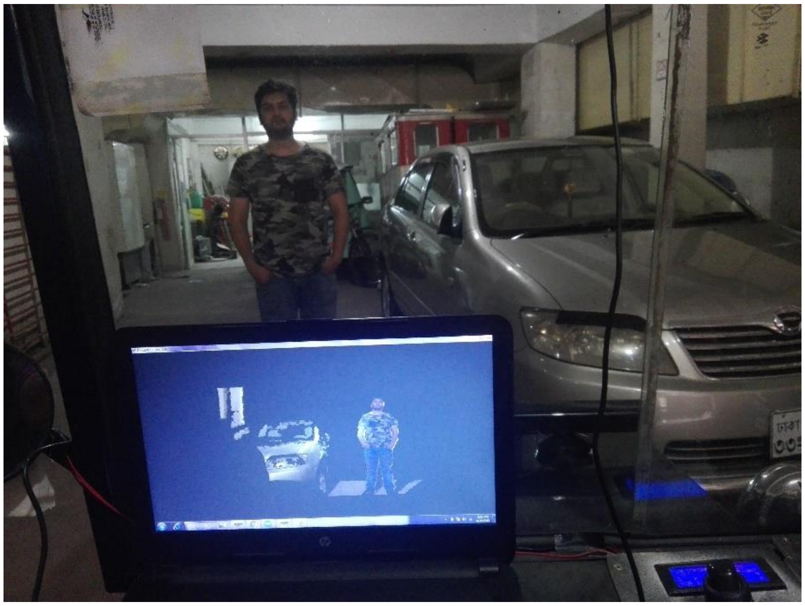

Fig.4.2. Operational view of Kinect sensor

Image processing operation

If we look at figure number 1 we can see that data from camera module is one of the major source of data for decision making. We have developed an image processing system to make precise decision for controlling the car. This system will reduce noise form the image right before processing it in the CPU. Python 3.6 programming language along with Open CV 3.4.1 has been used to fulfil this operation. Tensor flow object detection API is also integrated into the system. The main purpose of this processing operation to detect the lane from the road so that the vehicle can maintain the lane with constant speed. Normally we can get RGB values from an image which stands for red, green and blue. Now if we can convert the RGB values into gray scale image values then we can easily differentiate the element into the image as it will show only black and white values for the different elements of the image. After converting the image into gray scale using Tensor flow object detection API and Open CV we can detect the lane from the road.

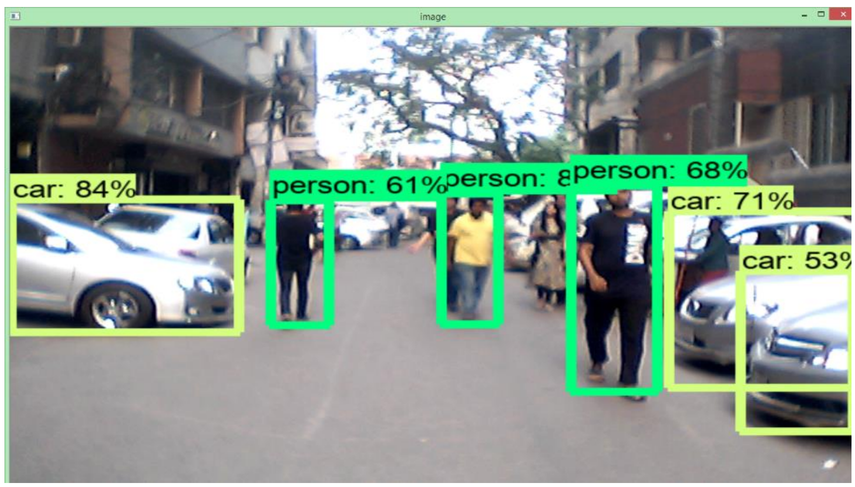

Fig.4.3. Image processing operational view

In our system we are using an onboard laptop as our central processing unit so that it can process all the data smoothly. After collection of data from various source the central processing unit will process all the data to finalize a decision. Then it will send final control command to the output unit.

Output Unit

The output unit is consist of two elements. They are Atmega328p microcontroller unit and relay modules. The microcontroller is connected with the relay modules and the relay modules are connected with the two important part name accelerator and inbuilt electric braking system of motor. Controlling the relay modules we can easily control the accelerator and braking system of the vehicle. Now after getting command from the CPU the microcontroller chip of that output unit turn on and off relay modules which ensures a controlled movement of the vehicle.

Chapter: 5: Experiment and Analysis

For measuring, the performance of the developed system there is no other option is better than experimenting the system in real life scenario. In our case we have also did several experiment to ensure the performance of the system. We have divided the total experiments in two different type. The experiments are as follows

Obstacle Avoidance using Kinect and Sensor Node

For doing, the obstacle avoidance experiment we have selected a road near BRAC University building no.05 situated along Gausul Azam Mosque, Mohakhali. So we have choose a straight path of 50 meter. Therefore, in the obstacle avoidance code we have set three different distance for detecting the obstacles. The distance are 2 meter, 1.6 meter and 1.2 meter. So when we run the vehicle and put the obstacle on 1.2 meter distance from the starting zone, then the car detect the obstacle successfully but it cannot break itself so hit the obstacle. After that, we have increase the obstacle distance and make it 1.6 meter. Then the system detect the obstacle and break itself, but the distance between the vehicle and the obstacle was not safe. After that, we have set the obstacle distance on 2 meter. This time the system detect the obstacle successfully and break itself. The distance between the vehicle and the obstacle was safe enough this time.

No.	Obstacle Distance	Result
1	1.2 Meter	Hit the obstacle
2	1.6 Meter	Break before obstacle but the distance from the obstacle was not safe
3	2 Meter	Break before obstacle with safe distance from obstacle

Fig.5.1. Obstacle avoidance using Kinect and sensor node

Object detection using image processing

For the image processing based object detection we have selected human being, car, tree and animals as test subject. A USB camera has been placed on the upper middle part of the vehicle and it is connected with the CPU. when we drive the vehicle autonomously then the image processing system started detecting the objects to take decision for mobility control. The output of the image processing unit has been shown in the onboard laptop. We have taken 200 still picture from the image processing operation and only one single picture has a false detection. If we calculate, the accuracy based on the 200 taken snap then we say that the image processing based system is 99.5% accurate.

Fig.5.2. Object detection experiment using image processing

Chapter 6: Conclusion and Future Development Scopes

Integrating Autonomous features into the vehicle control system is one of the prime concern for the first line vehicle manufacturing companies these days. As this technology is growing so there are a lot of research work going on based on driverless car control. Making an error less system is the main concern of this kind of research. So going with the flow, we have approached a driverless car control system in this following research paper. From the scratch, a custom designed four-wheeler electric vehicle has been made for the experiment. The Implementation of CAN Bus system make the total data transfer system faster than other system which is a unique feature of our model. We have also used sensor node based obstacle avoidance system to detect obstacle and other material. Kinect sensor has been integrated for depth measurement. The implementation of image processing operations help the model to detect different materials like car, human being, tree etc. In the near future power steering mechanism can be implemented for ensuring the autonomous dynamic movement of the vehicle. The battery units can be improved for more run time. Fast charging method can be implemented in near future for saving time. In this era of technology if we can continue the research related to driverless car operation then we can surly make a significant step towards the future of mobility.

Chapter 7: Codes

7.1. Node-1 & Node-4(Ultrasonic Range Finder & RADAR):

```
#include <mcp_can.h>
#include <SPI.h>

const int SPI_CS_PIN = 10;
MCP_CAN CAN(SPI_CS_PIN);                                   // Set CS pin
unsigned char stmp[8] = {0, 0, 0, 0, 0, 0, 0, 0};

const int anPin = A0;
long anVolt, dist_mm, dist_inches;
//const int pwPin1 = 3;
//long sensor, mm, inches;

const int radarPin = 4;
int motion_flg = 0;

void setup()
{
  //pinMode(pwPin1, INPUT);
  pinMode(radarPin,INPUT);
  Serial.begin(115200);
  while (CAN_OK != CAN.begin(CAN_500KBPS))              // init can bus : baudrate = 500k
```

```
  {
    Serial.println("CAN BUS Shield init fail");
    Serial.println(" Init CAN BUS Shield again");
    delay(100);
  }
  Serial.println("CAN BUS Shield init ok!");
}

void loop()
{
  read_sonar();
  read_radar();
  stmp[0] = dist_inches;
  stmp[1] = motion_flg;
  CAN.sendMsgBuf(0x1B, 0, 8, stmp);
  delay(25);
}

void read_sonar(){
  //sensor = pulseIn(pwPin1, HIGH);
  anVolt = analogRead(anPin);

  dist_mm = anVolt * 5;
  dist_inches = dist_mm/25.4;
   Serial.println(dist_inches);
}

void read_radar(){
  int val = digitalRead(radarPin);

  if((val > 0) && (motion_flg==0))
```

```
  {
    Serial.println("Motion Detected");
    motion_flg = 1;
  }

  if(val == 0)
  {
    Serial.println("Clear");
    motion_flg = 0;
  }
  delay(25);
}
```

7.2. Node-1 & Node-4(Acceleration):

```
#define accelaration_in A0
#define pwm_out         3
int     adc;
//low 175 high 875
void setup() {
  // put your setup code here, to run once:
 Serial.begin(9600);
 pinMode(pwm_out,OUTPUT);


}


void loop() {
  // put your main code here, to run repeatedly:
  adc = analogRead(accelaration_in);
  //Serial.println(adc);
  int pwm = map(adc, 875, 175, 150, 0);
  analogWrite(pwm_out, pwm);
}
```

7.3. ECU (engine control Unit):

```
\
#include <LiquidCrystal.h>
#include <SPI.h>
#include "mcp_can.h"

\
\
unsigned char len = 0;
unsigned char data[4];
unsigned char buf[8];
unsigned long canId;
float Volt = 48.9;

const int SPI_CS_PIN = 10;
MCP_CAN CAN(SPI_CS_PIN);

LiquidCrystal lcd(A5, A4, A3, A2, A1, A0);
void setup()
{
   Serial.begin(115200);
```

```
    while (CAN_OK != CAN.begin(CAN_500KBPS))              // init can bus : baudrate = 500k
    {
//        Serial.println("CAN BUS Shield init fail");
//        Serial.println(" Init CAN BUS Shield again");
        delay(100);
    }
//    Serial.println("CAN BUS Shield init ok!");
    lcd.begin(20,4);
    lcd.print("CARICKSHAW :: ECU");
    lcd.setCursor(0,1);
//    lcd.print("D0 D1 D2 D3 D4 D5 D6");
}
////

void loop()
{



    if(CAN_MSGAVAIL == CAN.checkReceive())
    {
        CAN.readMsgBuf(&len, buf);
        canId = CAN.getCanId();
//        Serial.println("-----------------------------");
//        Serial.print("Get data from ID: 0x");
//        Serial.println(canId, HEX);

//        for(int i = 0; i<len; i++)
//        {
//            Serial.print(buf[i]);
//            Serial.print("\t");
//        }
```

```
//        Serial.println();

     }
     else{
     //  Serial.println("Null Data");
     }

     lcd.setCursor(0,1);
     lcd.print("LEFT");
     lcd.setCursor(15,1);
     lcd.print("RIGHT");


     if(canId == 0x1A){
    // lcd.clear();
     lcd.setCursor(0,2);
     lcd.print("D");
     lcd.setCursor(0,3);
     lcd.print(buf[0]);

     lcd.setCursor(4,2);
     lcd.print("R");
     lcd.setCursor(4,3);
     lcd.print(buf[1]);

     data[0] = buf[0];
     data[1] = buf[1];
     }
      if(canId == 0x1B){
     //lcd.clear();
```

```
    lcd.setCursor(7,2);
    lcd.print("Volt");
    lcd.setCursor(7,3);
    lcd.print(Volt);
    lcd.setCursor(15,2);
    lcd.print("D");
    lcd.setCursor(15 ,3);
    lcd.print(buf[0]);

    lcd.setCursor(19,2);
    lcd.print("R");
    lcd.setCursor(19,3);
    lcd.print(buf[1]);

    data[2] = buf[0];
    data[3] = buf[1];
    }


    Serial.print("Data");
    Serial.print(",");
    Serial.print(data[0]);
    Serial.print(",");
    Serial.print(data[1]);
    Serial.print(",");
    Serial.print(data[2]);
    Serial.print(",");
    Serial.println(data[3]);
    delay(25);
}
```

References:

[1] Yeka Joseph Abueh ; Hong Liu, Message authentication in driverless car, Proc. IEEE Symposium on Technologies for Homeland Security (HST, 2016)

[2] Xin Zhang ; Maolin Chen ; Xingqun Zhan, Behavioral cloning of driverless car using transfer learning, Proc. IEEE/ION Position, Location and Navigation Symposium (PLANS, 2018)

[3] Liudmila P. Kozlova ; Wang Tong ; Olga A. Kozlova, Model of motion control system of driverless car, Proc. IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus, 2019)

[4] G. Amrithanandha Babu; K. Guruvayoorappan; V.V Sajith Variyar; K.P Soman, Design and fabrication of robotic system: Converting a conventional car to a driverless car, Proc. International Conference on Advances in Computing, Communications and Informatics (ICACCI, 2017)

[5] Brian Markwalter, The path to driverless cars [CTA Inside], Proc. IEEE Consumer Electronics Magazine (Volume: 6 , Issue: 2 , April 2017)

[6] Hervé Drezet ; Sébastien Colombel ; Marie-Laure Avenel, Human – Man Interface concept for Autonomous car, Proc. IEEE International Conference on Consumer Electronics (ICCE, 2019)

[7] Takafumi Okuyama ; Tad Gonsalves ; Jaychand Upadhay, Autonomous driving system based on Deep Q learning, Proc. International Conference on Intelligent Autonomous Systems (ICoIAS, 2018)

[8] Xue-Mei Chen ; Yi-Song Miao, Driving Decision-Making Analysis of Car-Following for Autonomous Vehicle Under Complex Urban Environment, Proc. 9th International Symposium on Computational Intelligence and Design (ISCID, 2016)

[9] Weber, M. (8th May,2014). "Where to? A History of Autonomous Vehicles"

[10] Wikipedia,"CanBus,"Google,[Online].Available- "https://en.wikipedia.org/wiki/CAN_bus"

[11] Rosenzweig,J. , Bartl, M.(2015) "A review and analysis of literature on autonomous driving