Autonomous Car Using Full Mapping GPS System

Thesis submitted to the Department of

Electrical and Electronic Engineering

BRAC University

In partial fulfillment of the requirements for the degree of

Bachelor of Science

In

Electrical & Electronic Engineering

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Declaration

We hereby declare that the Thesis Titled "**Autonomous Car Using Full Mapping GPS System**" is submitted to the Department of Electrical and Electronic Engineering of BRAC University in partial fulfillment of the Bachelor of Science in Electrical and Electronic Engineering. This is our original work and was not submitted elsewhere for the award of any other degree or any other publication.

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ABSTRACT

Our project is an Autonomous Car using full mapping GPS, which is based on a Laptop computer to generate the path coordinates and an Android phone to obtain the GPS data and used the mobile camera as the obstacle detection image processing unit. An Arduino is used as the brain of the system. The car which we made features electric motor driving of each of the two front wheels via independent controllers and has full drive-by-wire control of the throttle, steering and braking system. Nowadays the traffic has increased by quite a huge number. In this situation due to excessive number of vehicle accidents occurs rapidly. Driver issue is also a great problem. Our target by creating Autonomous Car is to increase efficiency by reducing manpower, reducing the possibilities of accidents and to ensure the safety of the passengers as well as the pedestrians. But the best part of our project (Autonomous Car) is to serve the applications for military purpose where the situation is inconvenient, dangerous or impossible to have human operator present. Already some country used many types of Autonomous vehicle or Unmanned Ground Vehicle (UGV) for military purpose and other important work. There are many Driverless or Autonomous Vehicles already exist and are perfectly used in many challenging field work. Actually this is the future and we are researching on it. Generally, our vehicle will have a set of sensor to observe the environment, and will either autonomously make a decision about its behavior or pass the information to a human operator at a different location who will control the vehicle trough teleportation.

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1 INTRODUCTION AND BACKGROUND

1.1 Introduction

About 1.24 million People are killed in roads every year throughout the world. In Bangladesh, according to BUET accident research centre the death toll every year is 10-12 thousand and countless number of people are injured or become disabled destroying so many lives and families. The national loss has been estimated around Taka 5,000-7,000 Cores every year. Almost 30% of the national healthcare budget is used behind road crash victims incurring a financial loss to our economy equivalent to 2% of our national GDP .Autonomous system is a solution of this problem. Here are some ways through which driverless car will change the world as follows:

Safety - No matter what we like to believe, humans are no good at driving. The 1.24 million people killed every year on roads worldwide are proof of that. Unlike us, driverless cars will never drive drunk and will not be able to speed, take reckless chances or race their mates away from traffic lights. They will never doze off, lose concentration or send a text message at the wheel. They will never get angry, frustrated or competitive. In short, they will be a lot, lot safer than we are.

Congestion – There are more people and cars on this little island than ever before, and they're all in a traffic jam between where you are and where you need to be. Driverless cars can travel in convoys, inches apart, without any needless dabs of the brake pedal to filter backwards through traffic and create mysterious, pointless hold-ups.

Cost – Buying, insuring and maintaining a car is expensive. So why not let someone else do it? The future of driverless cars is likely to include sharing schemes, smart taxi firms and affordable leasing options – cars will be more productive, more of the time, rather than spending 99 per cent of their lives motionless outside your house.

Imagine the following scenario: a customer uses a Smartphone app to request an autonomous shared vehicle, it arrives at your door and drops you to your destination, and the vehicle then either moves on and picks up another customer or parks itself and recharges.

Parking - No longer will it be our problem to find a space – our car will handle it. Once we arrive at our destination we will hop out at the front door and leave the car to slink away and wait for us to summon it later with our Smartphone. No more parking tickets, no more dented bumpers, no more endlessly driving in circles waiting for a neighbor to leave. This will free up urban road space for wider pavements

Free time – Think of the time we waste driving a car. So many hours a week, thousands of hours a year. Sure, some of that is enjoyable – the windy country road on a summer's day – but the vast majority is a tedious, grinding chore. Why not do some work instead and let the car drive itself? Or read a book, watch a film, chat with family?

The motor/vehicle industry has experienced unrest in the course of the most recent decade with advances, for example, driver help frameworks and cross breed/electric drive frameworks created in the fields of mechanical autonomy and hardware advancing into an industry overwhelmed by fossil fuelled vehicles with constrained insight. This upheaval then again, is a long way from being done with electric vehicles still yet to make critical progress in the business sector and mechanical usefulness constrained to helper frameworks used to help the driver and make up for their shortcomings. Car racing has seen the improvement of numerous propelled advances all through the historical backdrop of vehicular transport, be that as it may, there has been minimal traverse with automated innovations as the centre of most rivalries is in the streamlining of innovation, driver skill and team organization.

1.2 Motivation

The advancement of the Autonomous Car is essentially roused by the immense potential for examination into control frameworks, data preparing calculations and tactile procedures that are made conceivable by making of this vehicle as an exploration stage. This exposition portrays the formation of such a stage, and also a little extent of the conceivable systems that can be produced and tried to encourage the field of versatile mechanical technology. The vehicle we made is only a prototype model which has space for only one person.

But customary vehicles dashing is thought to be at the cutting edge of innovation and has seen huge mechanical advances which have separated down to more ordinary transportation frameworks and it is in this way expected the same will apply in the field of self-ruling driving. We are influenced by Google-Car, one of the best projects of the world using the top level technology. The Google Self-Driving Car is a venture by Google that includes creating innovation for independent autos. The product driving Google's autos is called Google Chauffeur. Lettering in favor of every auto recognizes it as a "self-driving auto".

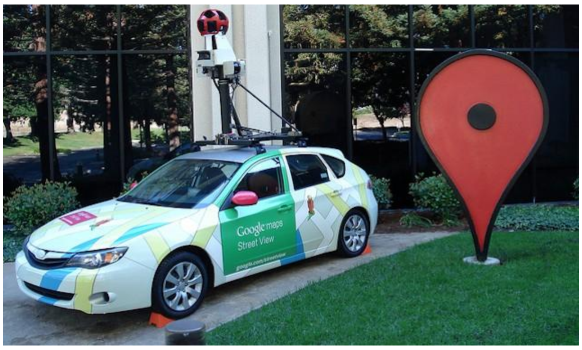


Figure: Google Car

Research into autonomous driving has noteworthy business potential as it speaks to the following unrest in the productivity of all transportation frameworks. Self-governing trains are now genuinely ordinary, especially in corner operations, for example, Unmanned Ground Vehicle (UGV) for military purpose and other important work. Some of them are mentioned below:

Figure: Oshkosh Ground TerraMax Autonomous Vehicle (The ability of military vehicles to better protect occupants with modern design and high-tech materials) - UK and TexasOshkosh Ground TerraMax Autonomous Vehicle (The ability of military vehicles to better pro

1.3 Literature Review

Research into self-sufficient vehicles started in the 1980s with activities, for example, the EUREKA Prometheus Project in Europe and the United States' Autonomous Land Vehicle Project. The DARPA Grand Challenges in 2004 and 2005 saw groups of self-governing vehicles contending to explore a desert domain whilst the 2007 Urban Challenge required route of a street based course and adherence to movement conventions. In Europe, the VisLab Intercontinental Autonomous Challenge in 2010 required a self-governing drive taking after a pioneer auto from Italy to China. These rivalries saw gigantic improvement of the field, with cutting edge advancements effectively getting to be accessible for car use. Self-governing driving innovation is developing quickly and is well on its approach to discovering business use in years to come. Google as of late uncovered that their armada of self-sufficient autos had voyage 140,000 miles on US open streets without human intercession. Locally, Rio Tinto arrangements to have 150 independent trucks supplied by Komatsu working in their Pilbara mining operations by 2015

In the course of the most recent decade driver help frameworks have step by step gotten to be standard in new autos however most flow offerings are of restricted refinement. Versatile voyage control using a laser sensor was initially offered by Toyota in 1998, with frameworks intended to pre-empt potential accidents getting to be accessible on Mercedes-Benz models in

2002. Most frameworks are insignificantly obtrusive and have are outlined just to enlarge the inadequacies of the human driver.

The eventual fate of this innovation holds noteworthy guarantee for enhancing street wellbeing and is exemplified by exploration at Daimler, which offers novel usefulness, for example, the location of risky circumstances in roundabouts.

As of late innovations have developed and examine into the capability of self-sufficient autos in dashing has started, with activities, for example, Stanford University's independent Audi TTS, which has possessed the capacity to execute and also prepared hustling drivers. This undertaking is specifically noteworthy as its points in utilizing electronic control frameworks to drive "at the breaking points" of the auto's mechanical capacities are like our task. A modern suite of route sensors are utilized and have seen the auto drive mind boggling, long (20km) race courses.

2 SYSTEM DESIGN

2.1 Overview and Requirements

The scope of the control system required for this project consists of everything from a user-interface to physical actuation of the car and consists of a significant body of work. As we can see from figure, our system is based on mainly two parts: Electrical and Mechanical. The whole process is controlled by linking Arduino with a Smartphone and laptop. We got the GPS using Smart Phone then used the GPS to locate our current location of the car. Then comes the Laptop part, we used Google EarthPro to create the path of our desired destination. Google EarthPro chose the shortest path for us then we save the KMP file and extract the KMP file into XML, and the converting process was done by the Arduino. Followed by the previous extraction of XML file, Arduino get the coordinates (the coordinates are broken into small part) and send the coordinates to the mechanical part which includes a digital potentiometer, a motor controller, steering motor & another motor. Now, in the mechanical part there are some simple steps to breakdown process. Firstly the signal from Arduino comes into the digital potentiometer, from which we control the voltage to change the speed of the car. The digital potentiometer sends required instructions to the motor controller. Motor controller controls the whole process of the motor of the car like rpm, turning, speed etc. Another motor controller is used for the steering movement. This motor controller which controls the steering movement is directly linked with the Arduino.

We used gyro censor for the direction purpose. It works like a compass to control the desired direction of our vehicle. Several other sensors have been used too. This includes IR sensor and Sonar sensor for obstacle detection.

2.2 Block Diagram

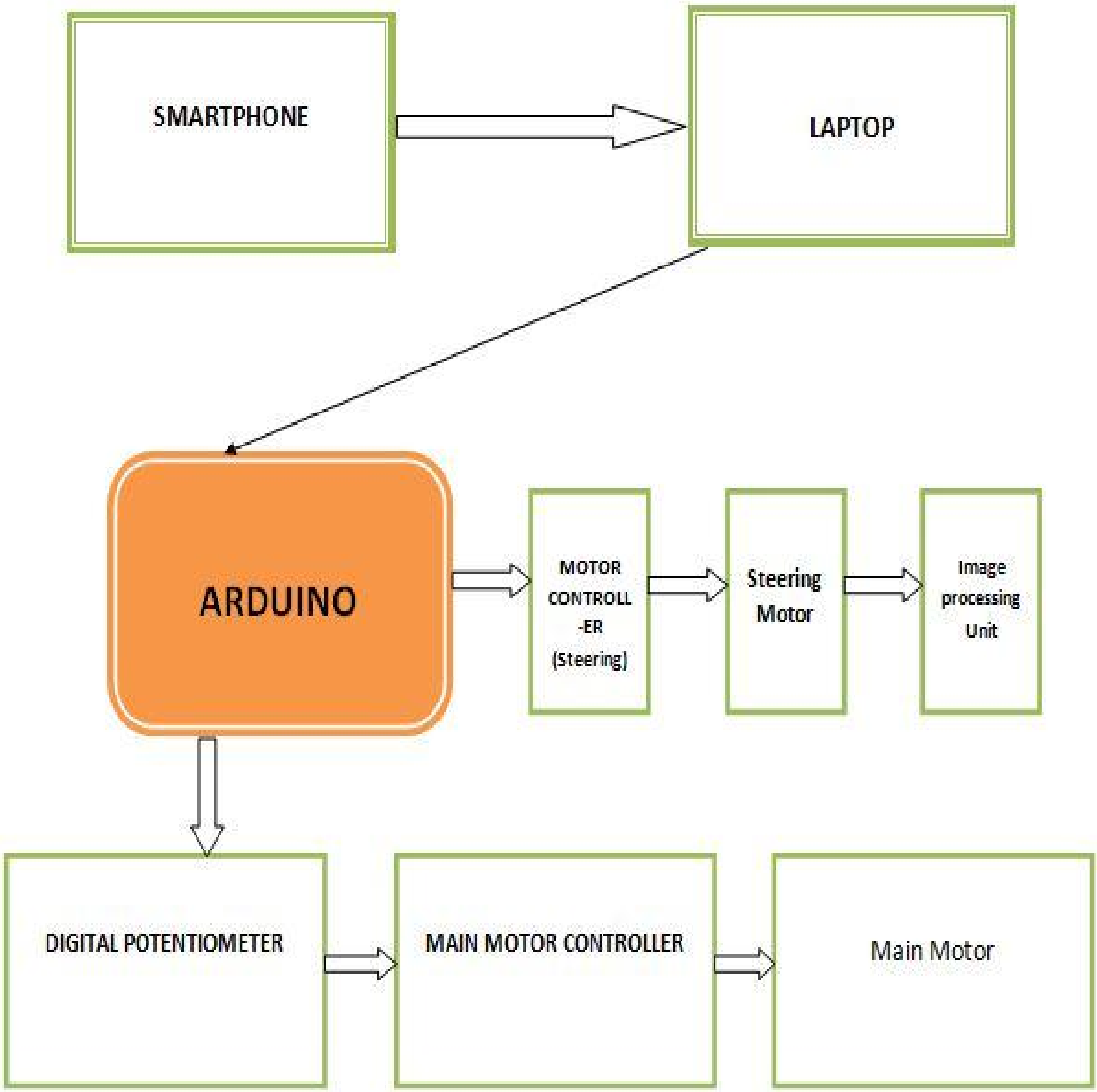


Figure: Block diagram of the system

2.3 Hardware Framework

Driver help frameworks, for example, that actualized in 2011 on the UWA BMW X5 vehicles are normally fixated on moderately capable smaller scale controllers (e.g. the Eyebot M6) and exist as separated implanted frameworks. Be that as it may, whilst such frameworks are minimized and powerful, they are not perfect for the improvement of a stage for experimentation in which critical future extension is normal. An overview of different self-sufficient vehicle activities demonstrated that standard x86 structural engineering PCs are generally utilized as a part of such applications, with advantages including a lot of preparing power and simplicity of reconciliation with off-the-rack peripherals. On the other hand, in this occasion, the auto does not have the space for a full measured PC and in addition an imperative existing in the measure of force ready to be drawn from the DC-DC converter situated in the low-level framework. Two promptly accessible options were examined, the first being the Arduino which is a microcontroller-based units for building advanced gadgets and intuitive articles that can sense and control objects in the physical world. Besides, a Laptop Computer in light of an Intel Core i5(second gen) processor with 8GB of RAM and a glimmer HHD was viewed as and at last utilized all through the lion's share of testing and outline of this vehicle. The Computer demonstrated amazingly valuable amid testing as the PC can be cooperated with effortlessly, permitting code changes on the fly and testing autonomous of the auto's frameworks. Furthermore, we additionally utilize an Android Phone for GPS and utilized the telephone as a deterrent recognition picture preparing camera. By utilizing a standard PC framework, interconnection of peripherals is rearranged fundamentally as particular interfacing equipment is not required. The base station takes the type of a typical Windows tablet with a substantial physical crisis stop catch associated and controlled by means of a USB port.

2.4 3D Modeling

Rather than hurrying into a silly choice of beginning the handy work promptly, legitimate arranging also, certain progressions of methodology must be conceptualized already. Thus, we have made a three dimensional programming model of the autonomous car.

Utilizing the Auto CAD software we could outline the whole autonomous car structure and the mechanical frameworks included. It is fundamental to assemble a three dimensional model before actualizing it as it will give us the pith of the autonomous car and what it may resemble. More significantly, it will give us a thought whether the autonomous car is faceable to be put into generation some time recently making basic blunders. In doing as such, we could assess the unpredictability, potential outcomes and the delicacy of the undertaking before going top to bottom into the pragmatic work. The product that we have utilized is the Auto CAD software. Auto CAD is a sort of software with which we can make a three dimensional model of any functional usage taking into account its criteria. Not just that, we will have the capacity to see the configuration from any point and make sense of what changes ought to be if fundamental and what issues we may face amid usage. The following are a few photos of the product plan.

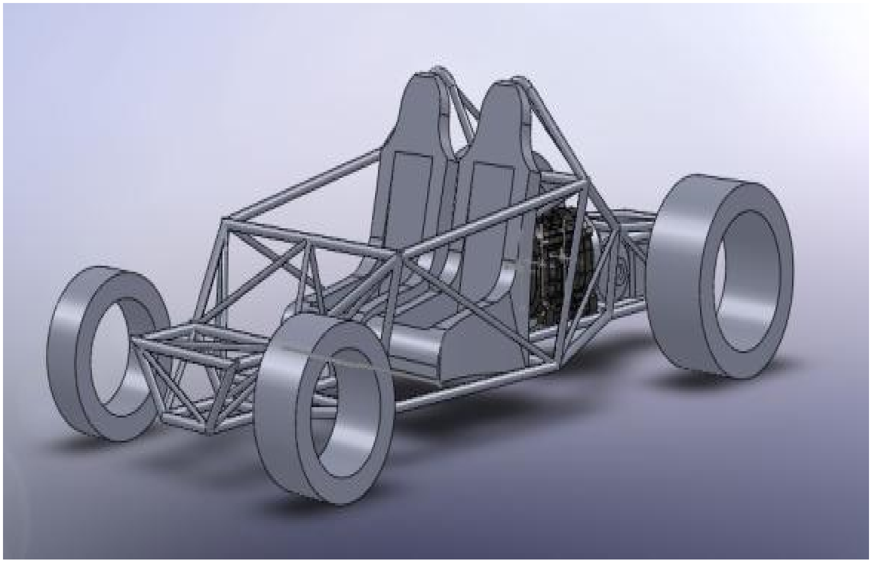
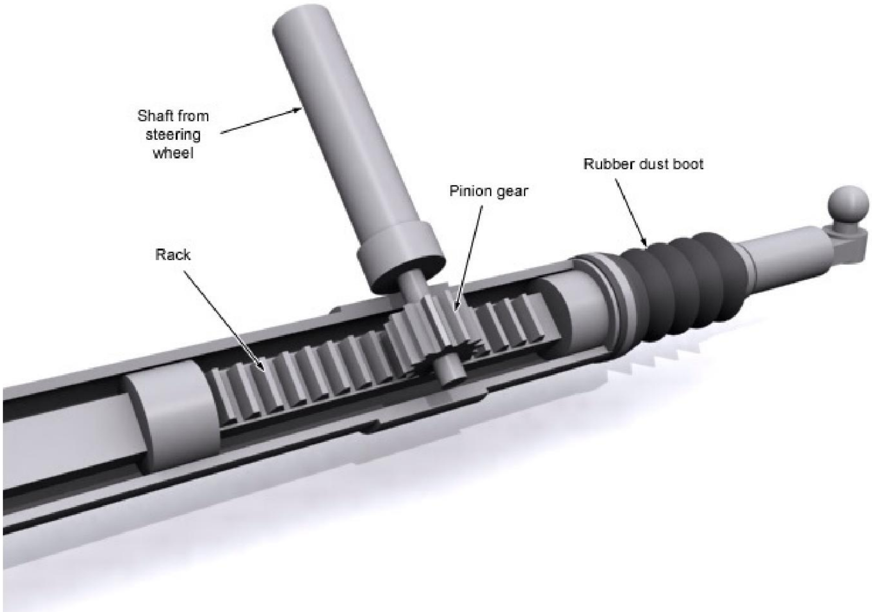


Figure: Autonomous Car (3D Model)



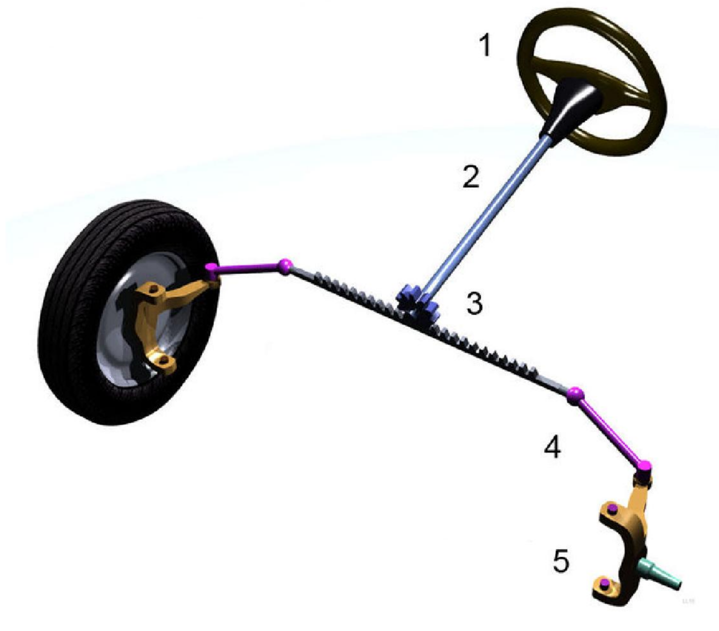


Figure: Steering (3D Model)

3 STEERING CALCULATION AND DRIVING

3.1 Navigation

The autonomous car navigates based on driving through the mapped waypoints in grouping, with closed loop control frameworks controlling the heading and speed required keeping in mind the end goal to finish the way effectively. At the point when autonomous driving is begun, the car drives from its present position towards the first waypoint and proceeds with the way until the last waypoint is reached, and soon thereafter the car brakes to an end and turns off the autonomous mode. A waypoint is considered to have been come to when the car’s current position is inside of a sure separation of the waypoint, the waypoint span.

In ideal condition, the measure of a waypoint would be entirely little; in any case, the utilization of a bigger point improves the probability that the car can effectively achieve the point. Two essential classes of direction era are found in versatile mechanical technology Sliding Mode Path Following includes the pre-era of the way to be driven and the utilization of controllers with a specific end goal to keep minimize the sidelong deviation from the vehicle's present position to the way focus whilst dynamic way taking after consistently recalculate the direction based upon the vehicle's present area and thought of the surroundings ahead.

The calculations introduced here are of the recent assortment and powerfully decide the direction taking into account thought of a little partition of the way forward. This methodology fits circumstances in which the way may need successive update because of snag or street edge shirking and it is normal future work will extend the calculation to give such insight.

3.2 Simple Steering Algorithm

The basic aim of steering is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears. One of the fundamental concepts is that of caster angle – each wheel is steered with a pivot point ahead of the wheel; this makes the steering tend to be self-centering towards the direction of travel.

As our vehicle is an autonomous one the steering needs to move autonomously with the synchronization of the direction. We had difficulties to adjust the behavior of the steering. We computed the steering values and steering ratio using the steering law:

$$T = a + b \int_C \frac{ds}{W(s)}$$

Where, T is the average time to navigate through the path

C is the path parameterized by s

W(s) is the width of the path at s,

a and b are experimentally fitted constants.

In general, the path may have a complicated curvilinear shape (such as a spiral) with variable thickness W(s).

If the path is a straight one of constant width W, the equation reduces to

Where A is the length of the path

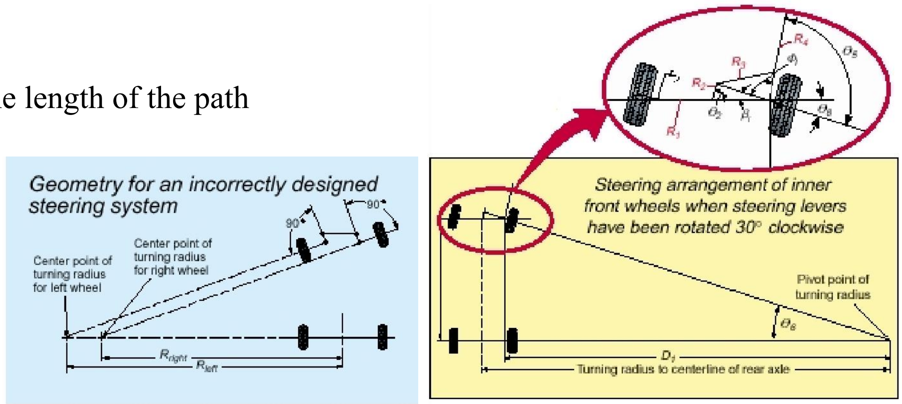


Figure: Steering Motor Working Principle (1)

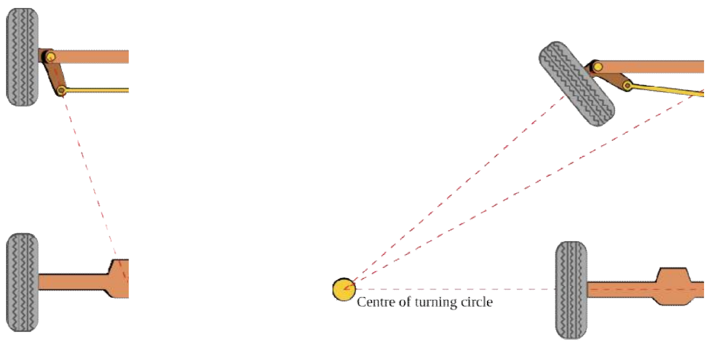


Figure: Steering Motor Working Principle (2)

At first, simple algorithm in view of exploring in an immediate line from the present position to the following waypoint in the guide was executed. The car's direction is ascertained every time upgraded position estimation is gotten and a vector from the present position to the following waypoint is set up. The bearing connected with this vector is then ascertained and utilized as the set point for the guiding control circle, meaning to take the auto on the briefest way to the following waypoint. Estimation of the car's current heading is contrasted and the heading required by the direction and a guiding controller yield registered in the customary manner of a feedback controller. The yield to the drive-by-wire framework adequately sets a 35 front-wheel controlling point and influences the present heading of the vehicle and in addition its yaw-rate.

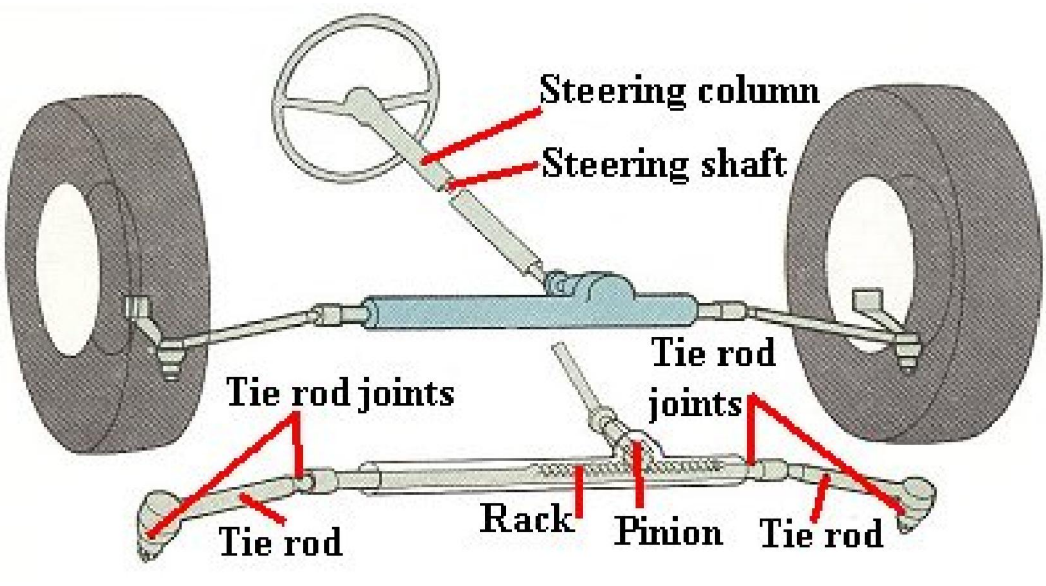


Figure: Steering Mechanism

In these comparisons, the value β is termed the vehicle slip point and ψ the yaw edge. In this execution the controller addition, KP, is set to the opposite of the slant got from the adjustment of the drive-by-wire controller, bringing about a 1-1 relationship between the heading blunder and the wheel edge δ f.

This outcomes in the wheels guiding straightforwardly in the coveted heading of go at zero speed, which a slight underestimation is given the non-linearity of the vehicle slip point with the wheel edge.

Amid testing it was found that the sure guide courses of action brought about the auto touching base at a waypoint on a point from which it was not physically conceivable to achieve the following waypoint without driving around the waypoint and endeavour to achieve it once more. In conclusion, it was distinguished that better way arranging would empower the utilization of littler waypoints which because of the size required keeping in mind the end goal to guarantee soundness in this calculation prompted "cut-corners" on the inner parts of bended segment.

3.3 Existing Hardware and Modifications

Not at all like different tasks in the zone of automated vehicles, the fundamental centre in this undertaking was not to make the vehicle and its supporting foundation as advanced as could be allowed by utilizing top of the line innovation like parallel PCs and Android Phone, picture handling camera work (utilizing Android Smartphone) et cetera, however rather as it is expressed that make such a vehicle as cheap, simple to construct, and simple to adjust as could be allowed. The fundamental issue similarly as the equipment is concerned is along these lines to utilize standard gear like standard microcontrollers, a pre-assembled body for the vehicle and so on., and to attempt to abstain from utilizing specific (and subsequently costly) equipment wherever it is doable. This section portrays the subtle elements of the equipment utilized as a part of this project. It begins with a short depiction of the model vehicle that was utilized as a fundamental chassis.

4 CIRCUIT DESIGN AND SET-UP

4.1 Arduino:

Arduino is an open-source prototyping stage in view of simple to-utilize equipment and programming. Arduino boards can read inputs. We can advise our board what to do by sending a set of directions to the microcontroller on the board. To do as such we utilize the Arduino programming dialect (based on Wiring) and the Arduino Software (IDE),based on Processing.

Throughout the years Arduino has been the brain of a large number of projects, from regular items to complex experimental instruments. An overall group of engineers, and experts - has assembled around this open-source platform, their commitments have indicated an extraordinary measure of available information that can be of awesome help to amateurs and specialists alike. We utilized Arduino Mega as the head of our framework.

The Arduino Mega is a microcontroller board. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller. It can be simply connected to a computer with a USB cable or powered with an AC-to-DC adapter or battery. Reason for choosing Arduino is that our system architecture requires a large number of pins, for which the Arduino Mega is a good option.

Figure: Arduino Mega

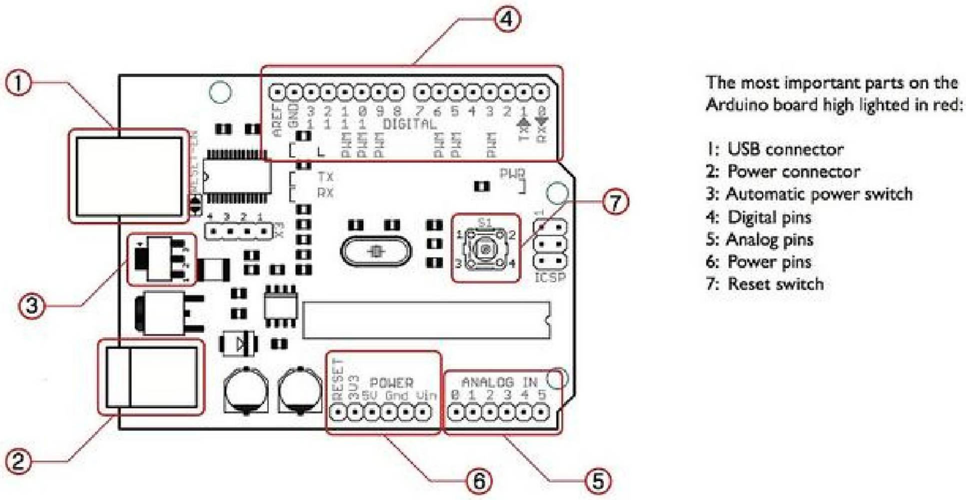


Figure: Pin Configuration of Arduino

Summary of Arduino Mega Microcontroller:

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 *(of which 6 provide PWM output)*
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega 328) *of which 0.5 KB used by bootloader*
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Arduino is the head of our system. It receives the GPS data we obtained from the mobile phone and the coordinates of the path our vehicle will travel from the XML file we got from Google Earth. It sends the necessary instructions for the speed control, navigation to the Digital Potentiometer. We connected the Arduino with computer via USB and used the Arduino coding Software to provide the desired instructions to the main board.

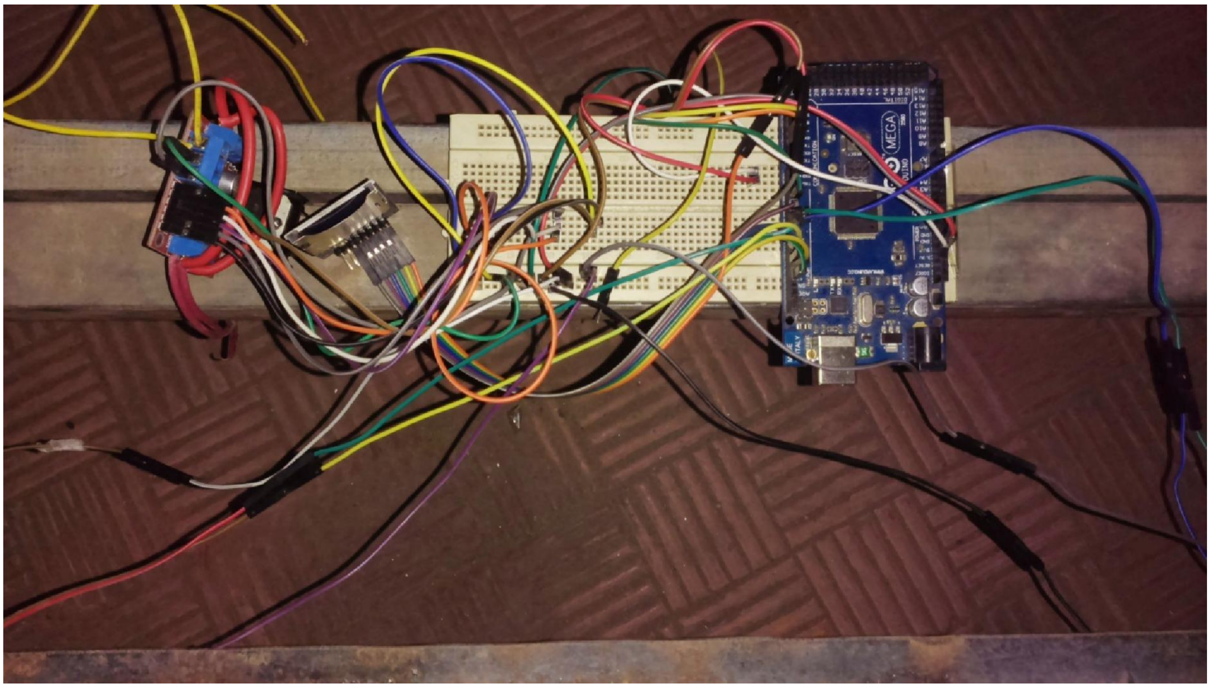


Figure: Connection with Arduino

4.2 Sensors

Sensor also called transducer is a device which converts one form of energy into another form such as a microphone convert sound into an electrical form or a light sensor give output according to the intensity of light. Sensors are the key components for perceiving the environment. A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena.

The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. In short, a sensor is a device that detects and responds to some type of input from the physical environment such as light, heat, motion, moisture, pressure and used to switch voltages or currents.

We used various sensors to overcome the problem of obstacle detection, direction, road edge detection. These sensors enabled us to roam our vehicle safely and more accurately. The sensors we used are:

1. Gyro Sensor
2. IR Sensor
3. Ultrasonic Sensor
4. Image Processing Unit (Camera of Smartphone).

4.2(a) IR Sensor:

This Sensor module deals with the rule of Reflection of Infrared Rays from the occurrence surface. A consistent light emission beams is transmitted by the IR LED. At whatever point a reflecting surface comes before the Receiver, these beams are reflected back and caught. Whenever a retaining surface comes before the Receiver, these beams are consumed by the surface and in this manner not able to be caught. So it can be said, this device emits and/or detects infrared radiation to sense a particular phase in the environment. Generally, thermal radiation is emitted by all the objects in the infrared spectrum. The infrared sensor detects this type of radiation which is not visible to human eye.

Basic Block diagram:

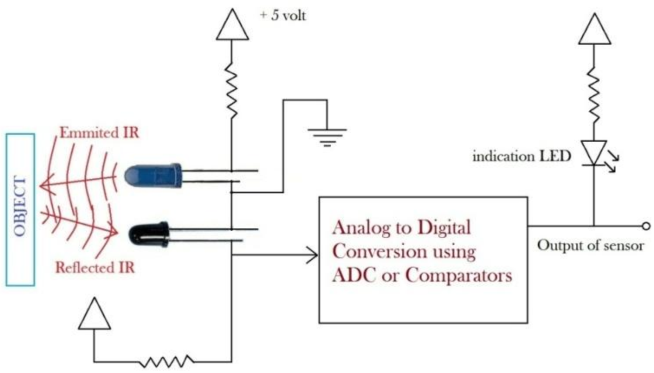


Figure: IR Sensor block diagram

Advantages

- Easy for interfacing
- Readily available in market

Disadvantages

- Disturbed by noises in the surrounding such as radiations, ambient light etc.

Working Principle:

The basic idea is to make use of IR LEDs to send the infrared waves to the object. Another IR diode of the same type is to be used to detect the reflected wave from the object. The diagram is shown below.

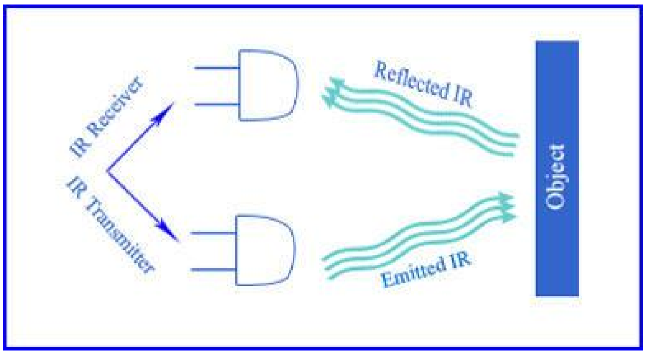


Figure: IR sensor working principle

When IR receiver is subjected to infrared light, a voltage difference is produced across the leads. Less voltage which is produced can be hardly detected and hence operational amplifiers (Op-amps) are used to detect the low voltages accurately.

Measuring the distance of the object from the receiver sensor:

The electrical property of IR sensor components can be used to measure the distance of an object. The fact when IR receiver is subjected to light, a potential difference is produced across the leads.

IR LED

An Infrared light-emitting diode (IR LED) is a sort of electronic device that emanates infrared light not noticeable to the bare eye. IR LED is used in this circuit to transmit infrared light.

The wavelength and color of the light delivered rely on upon the material used as a part of the diode. Infrared LEDs use material that creates light in the infrared part of the spectrum, which is, just underneath what the human eye can see. Distinctive infrared LEDs may create infrared light of varying wavelengths, much the same as diverse LEDs deliver light of diverse colors.

Figure: IR LED

Since the human eye can't see the infrared radiations, it is impossible for a person to recognize whether the IR LED is working or, much the same as a typical LED. To defeat this issue, the camera on a mobile phone can be used. The camera can demonstrate to us the IR beams being radiated from the IR LED in a circuit.

Photo-Diode:

A semiconductor diode that, when presented to light, produces a potential difference or changes its electrical resistance can be termed as Photo-diode. Photo-diode usually used to catch reflected light of IR LED.A Photo diode is a converse one-sided silicon or germanium pn junction in which an increment of reverse current can be observed when the intersection is presented to light. At the point when no light is episode on the pn junction of photo-diode, the reverse current is to a great degree little which is known as dark current.

Figure: Photo Diode

At the point when light is incident on the pn junction of the photo-diode there is an exchange of energy from the occurrence light to the atoms in the junction. This will make all the more free electrons. These extra free electrons will result an increase of reverse current.

This electrical energy can be recorded as voltage drop fluctuations by using a series resistor as a part of the outer circuit and taking voltage readings across it.

Analog to digital converter:

It is known that the output of the Photo diode is an analog voltage. As microcontroller does not acknowledge the analog voltage so we have to change over the analog voltage to digital before we feed it to the microcontroller. Comparator and ADCs can be used to convert the voltage.

Function of Comparator:

The comparator circuit takes two analog inputs, compare them and produce the logical output high “1” or low “0”.

V0 = High when V+ > V-

V0 = Low when V+ < V-

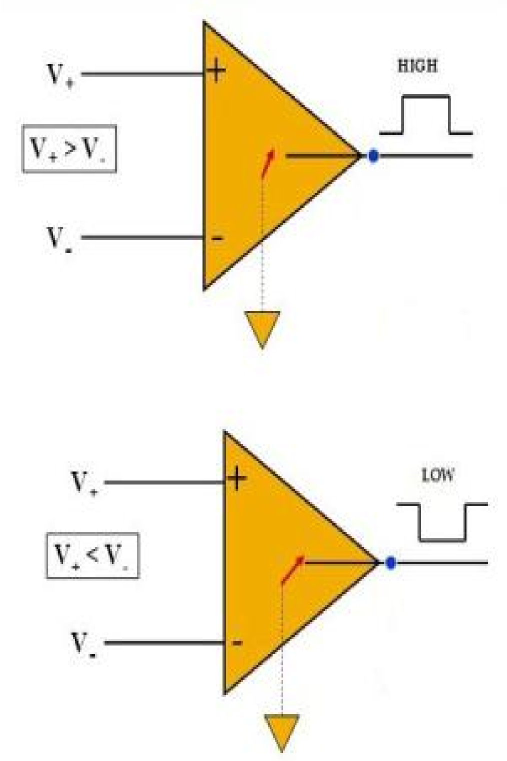


Figure: Function of Comparator

Applications

- Thermography – According to the black body radiation law, it is possible to view the environment with or without visible illumination using thermography
- Heating – Infrared can be used to cook and heat food items. They can take away ice from the wings of an aircraft. They are popular in industrial field such as, print dying, forming plastics, and plastic welding.
- Spectroscopy – This technique is used to identify the molecules by analyzing the constituent bonds. This technique uses light radiation to study organic compounds.
- Meteorology – Cloud heights; calculate land and surface temperature is possible when weather satellites are equipped with scanning radiometers.
- Photobiomodulation – This is used for chemotherapy in cancer patients. This is used to treat anti-herpes virus.
- Climatology – Monitoring the energy exchange between the atmosphere and earth.
- Communications – Infra red laser provide light for optical fiber communication. These radiations are also used for short range communications among mobiles and computer peripherals.

Moreover this sensor works as follows:

- Line Follower sensor
- Obstacle Avoidance Robot
- Edge avoiding robot
- Anti-falling robot
- Light/Fire sensing

4.2(b) GYRO SENSOR

Inertial sensors make the measurement of the internal state of the vehicle. A major advantage of the inertial sensors is that they are non-radiating and non-jumpable and may be packaged and scaled from the environment. This makes them partially robust in the harsh conditions. The most common application of inertial sensors is in the heading gyro. Integration of the gyro rate information provides the orientation of the vehicle. A gyro is the device return an output proportional the rotational velocity. Gyro sensor can sense rotational motion and also can sense change in orientation. In other word gyro sensor can be defined as the sensing device that can detect motion effectively. Gyro sensors, also known as angular velocity sensors, are devices that sense angular velocity.

Angular velocity is the change in rotational angle per unit of time. Angular velocity is generally expressed in deg/s (degrees per second). Our Human eye can detect motion but there are some motion that human eye have difficulty sensing. This is where the Gyro sensor comes to work.

Good quality gyro sensors have: 1 .Zero or constant bias

2. Small noise variance.

Types Of Gyro Sensor:

Gyro sensors come in various types. Different types of Gyro Sensor are plotted by size and performance in the following diagram.

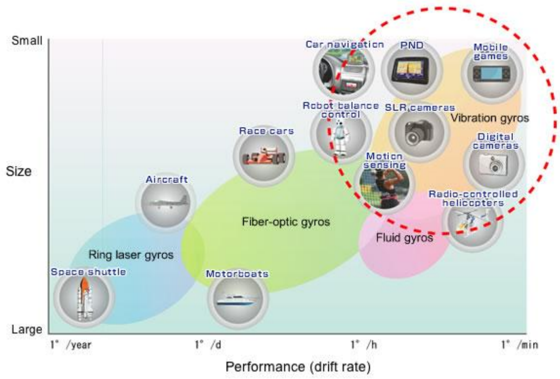


Figure: Types of Gyro Sensor

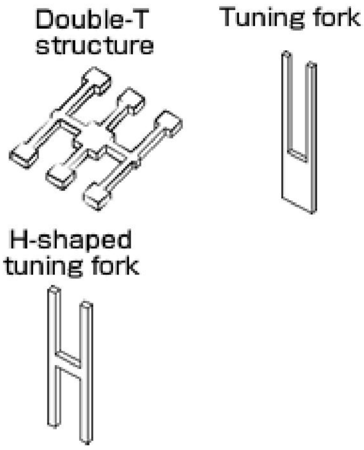
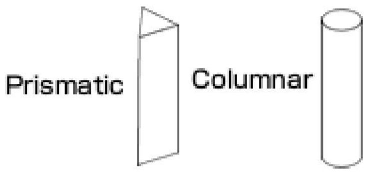
The miniature, high accuracy gyro sensors are becoming very essential now days. In recent time Gyro sensor can be found in camera shake detection system for compact video and in still cameras, motion detection for video games and also in vehicle electronic stability control also known as anti-skid system among other things. In coming days Gyro sensor is expected to extend in areas such as vehicle driver safety and support systems and also in robotics in terms of motion control.

Elements of Gyro sensor:

Gyro sensors sense rakish speed from the Coriolis power connected to a vibrating component. Therefore, the exactness with which precise speed is measured varies essentially relying upon component material and difference in structure. Here, we quickly depict the primary sorts of components utilized as a part of gyro sensors.

Gyro sensor manufacturer are utilizing an assortment of materials and structures with an end goal to devise reduced, high-precision gyro sensors that have great attributes, including

- Scale factor
- Temperature-frequency coefficient
- Compact size
- Shock resistance
- Stability
- Noise characteristics

	Material	**Sample Structure**
Piezoelectric transducer	Crystal 	
	Ceramic	
Silicon transducer	Silicon	Si MEMS

Working procedure of Gyro sensor: Earlier it was mentioned that Gyro sensors sense rakish speed from the Coriolis power connected to a vibrating component. Now the working procedure is explained using a double-T structure crystal element.

Gyro sensor applications:

There are mainly three applications for gyro sensors

- Angular velocity sensing
- Angle sensing
- Control mechanism

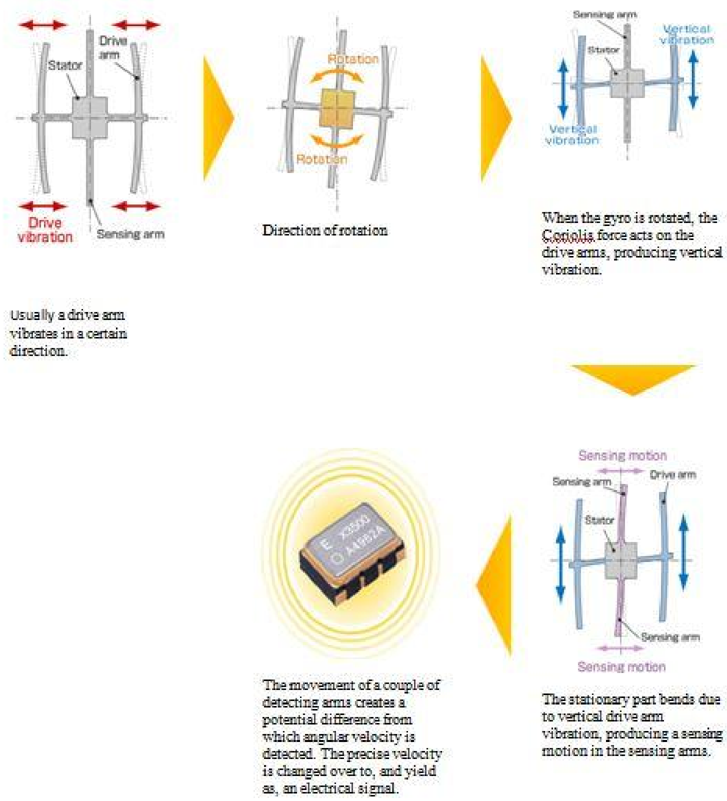


Figure: Gyro sensor working principle

Angular velocity sensing:

Gyro sensor detects the amount of angular velocity produced that means it can be used to measure the motion. For example:

Angle sensing:

Gyro sensor detects angular velocity created by the sensor's own movement. Angles are detected via integration operations by a CPU. The angle moved is sustained to and reflected in an application. For example: Car navigation systems, Game controllers

Control mechanism:

Gyro sensor detects vibration produced by external factors, and transmits vibration data as electrical signals to a CPU. It can be utilized as a part to correct the orientation or balance of an object. For example: Camera-shake correction, Vehicle control.

4.2(c) SONAR SENSOR

SONAR stands for Sound Navigation and Ranging, was initially developed for underwater application. The Sonar Sensor is a compact high performance ultrasonic rangefinder that transmits ultrasonic waves into the air and identifies reflected waves from an object. There are numerous applications for ultrasonic sensors, for example, in intrusion alarm systems, programmed entryway openers and reinforcement sensors for vehicles. Joined by the fast improvement of data handling innovation, new fields of use, for example, factory automation equipment and car electronics are increasing and should continue to do so. The sensor automatically calibrates itself when powered up.

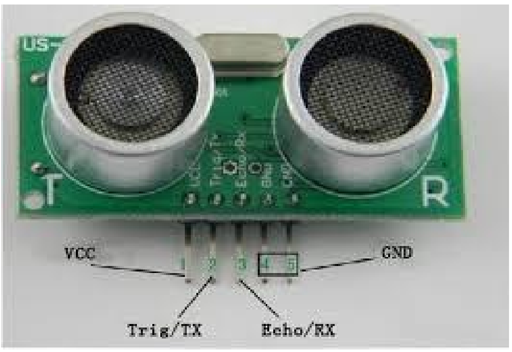


Figure: Sonar Sensor

Utilizing its remarkable piezoelectric ceramic fabricating innovation created over numerous years now days we have ultrasonic sensors which are minimized but have superior. Sonar is an ultrasonic sensor that uses electrical and mechanical energy transformation to measure the distance from the sensor to the target object. It consists of a transmitter and receiver which are available as separate units or embedded together as a single unit.

This sensor consists of four pins: (1) VCC-connect to the 5v DC.

(2)Trigger- Pulse input that triggers the sensor.

(3)Echo-Indicates the reception from the target.

(4)Gnd- Ground.

Working: A sonar sensor work through 6 steps.

Step 1: Make a "Trig" pin of the sensor high for "10 micro second". This indicates a sensor cycle.

Step 2: 8*40KHz pulse will be sent from the transduces of the sensor, after which time the "Echo" pin of the sensor will go from low to high.

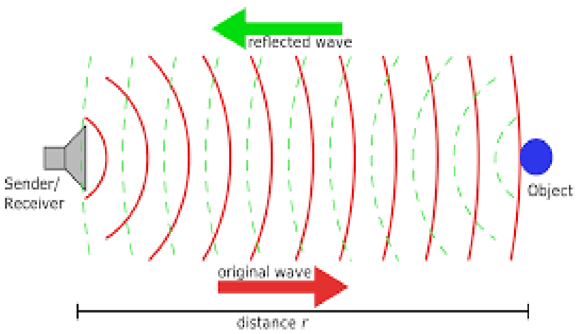


Figure: Working Principle of Sonar sensor

Step 3: The 40 KHz sound will bounce off the nearest object and return to the sensor.

Step 4: When the sensor detect the reflected sound wave, the echo pin will go low.

Step 5: The distance between the sensor and the detected object can be calculated based on the length Of the Echo pin is high.

Step 6: If no object is detected, the Echo pin will stay high for 38ms and then go low.

CHARACTERISTICS OF ULTRASONIC WAVES

Ultrasonic waves are sounds which cannot be heard by humans and are normally, frequencies of above 20 kHz. The basic characteristics of ultrasonic waves will be explained below.

Wavelength and Radiation

Velocity of wave propagation is communicated by multiplication of frequency and wavelength. The Velocity of an electromagnetic wave is 3×108m/s, however the speed of sound wave propagation in air is as moderate as around 344m/s (at 20°C). At these slower speeds, wavelengths are short, implying that higher determination of distance and course can be acquired.

Reflection

With a specific end goal to recognize the vicinity of an object, ultrasonic waves are reflected on objects. Since metal, wood, solid, glass, elastic and paper, and so forth reflect roughly 100% of ultrasonic waves; these items can be effortlessly identified. Material, cotton, fleece, and so on are hard to distinguish in light of the fact that they retain ultrasonic waves. It might frequently be troublesome, additionally, to recognize items having substantial surface undulation, as a result of irregular reflection. On account of the higher determination, it is conceivable to get higher estimation made substantial precision. The surface measurement of the ultrasonic gadget can be effectively to get exact radiation.

EFFECTS OF TEMPERATURE

Velocity of sound wave propagation “c” is expressed by the following formula.

c=331.5+0.607t (m/s) where t=temperature (°C) That is as sound speed fluctuates as indicated by circumferential temperature, it is important to confirm the temperature at all times to gauge the distance to the object precisely.

ATTENUATION

The quality of ultrasonic waves spread into the air constrict relatively with distance. This is brought on by diffusion loss on a spherical surface due to diffraction phenomenon and absorption loss, that energy is absorbed by medium.

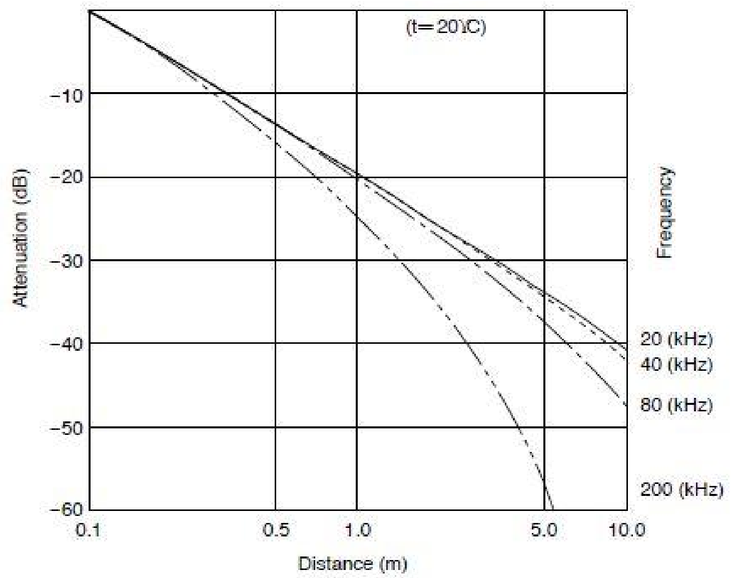


Figure: Attenuation Characteristics of Sound Pressure by Distance.

As shown in Fig, the higher the frequency of the ultrasonic waves the bigger the attenuation rate and the shorter the distance the wave reaches.

OPERATION PRINCIPLE

At the point when voltage is connected to piezoelectric ceramic, mechanical distortion is created by volt-age and recurrence. Then again, when vibration is connected to piezoelectric ceramic, an electric charge is created.

By applying this principle, when an electric signal is added to a vibrator, built of 2 sheets of piezoelectric ceramic or a sheet of piezoelectric ceramic and a metal sheet, an electric sign is transmitted by flexure vibration. As a converse impact, when a ultrasonic vibration is added to the vibrator, an electric signal is delivered. As a result of these impacts, piezoelectric ceramic are used as ultrasonic sensors.

ELECTRICAL CHARACTERISTICS:

SOUND PRESSURE CHARACTERISTICS

Sound pressure level (S.P.L.) is unit indicating the volume of sound and is expressed by the following formula: S.P.L. =20log P/ Po (dB)

Where “P” is Sensor sound pressure (Pa) and “Po” is reference sound pressure (20µPa)

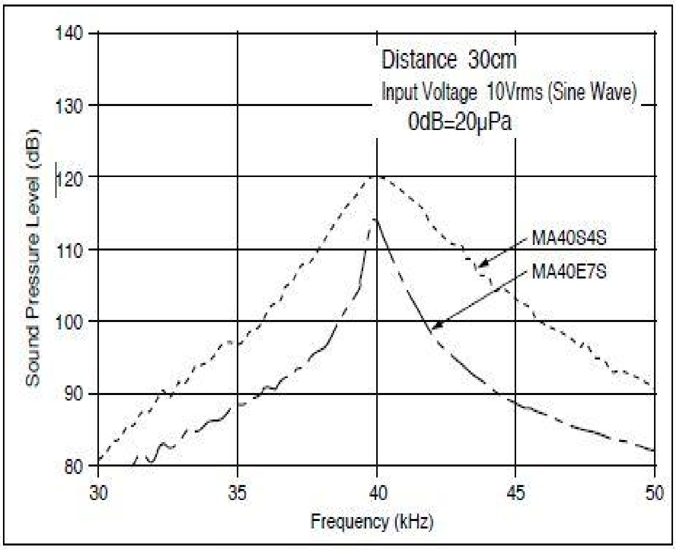


Fig. Sound Pressure

SENSITIVITY

Sensitivity is the unit indicating the sound receiving level and is expressed by the following formula.

Sensitivity=20log S/So (dB)

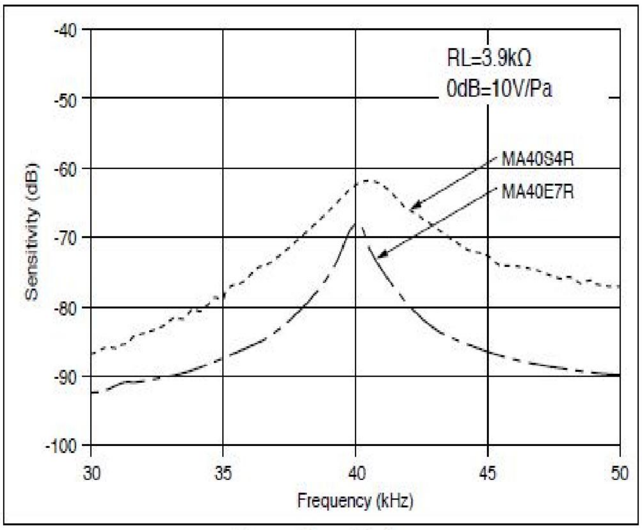


Fig. Sensitivity

Where “S” is Sensor voltage (V) and “So” is reference sound pressure (V/Pa)

RADIATION

Let us assume that ultrasonic sensor is installed on a table. Then, the relationship between angle and sound pressure (sensitivity) is measured. In order to express radiation precisely, the angle in which the sound pressure (sensitivity) level attenuates by 6dB compared with the front is called the half attenuation angle with an expression of θ1/2.

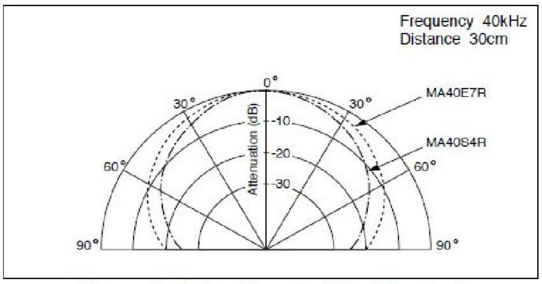


Fig. Radiation Characteristics (Receiver)

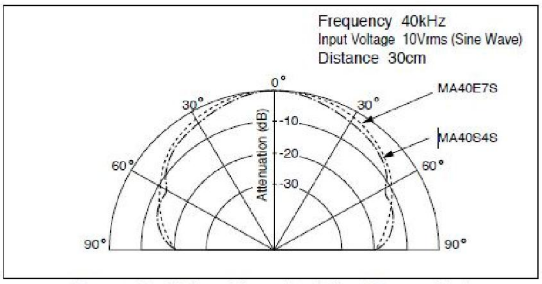


Fig. Radiation Characteristics (Transmitter)

APPLICATION FOR DISTANCE MEASURING

The standards of measuring distance and is known as the "pulse reflection method" which makes the most of it conceivable to the quantity of reference pulses. This technique is utilized to gauge reflection time up to the object between transmitting and receiving pulse of the ultrasonic wave. The relationship between the distance up to the object L and the reflecting time T is expressed by the following.

L=C • T/2 where C is the velocity of sound.

That is, the distance to the object can be found out by measuring the reflection time included in coming to the object.

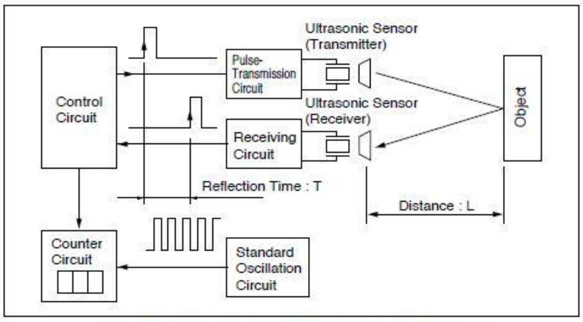


Fig. 15 Principles of Measuring Distance

4.3 Motor Controller (L298N)

The L298N H-bridge module can be used with motors that have a voltage of between 5 and 35V DC. With the module, there is an onboard 5V regulator, so if our supply voltage is up to 12V we can also source 5V from the board. The L298 chip is the greater sibling to the L293 chip (a prominent little motor driver IC), however the L298 handles current flow. Furthermore, it can handle more voltage - exactly what our requirement for the autonomous car. One of the first realizations in mechanical autonomy is that making something move isn't a simple task. None can take a "brain" circuit and join it to a motor and anticipate that anything will happen. The motor will essentially say "HAH!" at the tiny output signal from the brains, stay still.

What the mind needs is an implementer. Muscle, something to persuade the motor to do things the way the brains need it to be finished. There are numerous approaches to reinforce ("buffer") a sign so it's sufficiently solid to drive a huge burden like a motor. Transistor, Hbridge circuits, buffer- chips, and committed motor driving chips are all suitable applicants, with their own advantages and impediments.

Figure: Motor Controller (L298N)

We're utilizing the well-demonstrated L298 for this configuration, as it has basically every one of the components we would need in a decent motor driver, counting thermal shutdown, implying that it will back off and stop if over-burden (as opposed to dissolving down in a calamitous way!). Including a low-drop out controller gives us a chance to tap off 5V for any other hardware we might need to drive, and the pointer LEDs are dependably extremely helpful when observing the practices of our circuit. We're very satisfied on how well the Compact L298 Motor Driver turned out, and we trust it's as useful to anyone in our plans as it has been for us!

Implementation of Motor-Controller:

To control the course of the spin of DC engine, without changing the way that the leads are joined, we can utilize a circuit called a H-Bridge. An H extension is an electronic circuit that can drive the engine in both headings. H-scaffolds are utilized as a part of a wide range of uses, a standout amongst the most well-known being to control engines in robots.

It is called an H-span on the grounds that it utilizes four transistors joined as a part of such a route, to the point that the schematic outline resembles a "H."

The L298 can control the rate and course of DC engines and stepper engines and can control two engines at the same time.

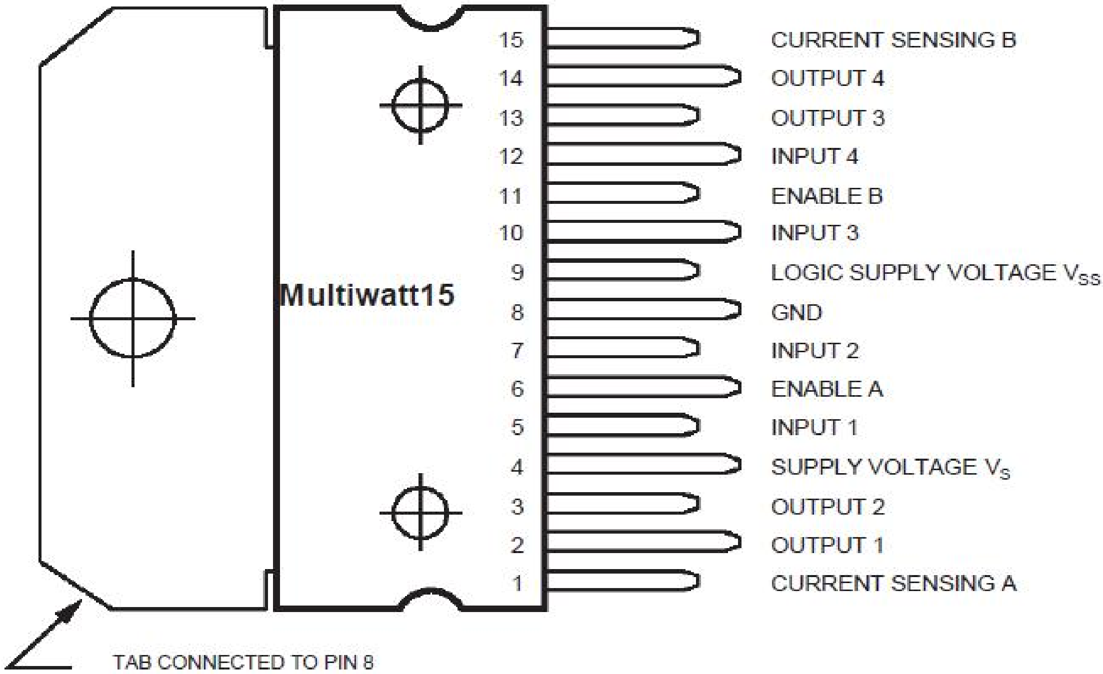


Figure: L298 Pin configuration

4.4 Digital Potentiometer

Mechanical potentiometers have been utilized following the most earliest days of devices and give a helpful system for the alteration of the yield of different sensors, power supplies, or for all intents and purposes any gadget that requires some sort of alignment. Timing, frequency, contrast, brightness, gain and counterbalance alterations are only a couple of the potential outcomes. On the other hand, mechanical pots have dependably experienced various issues including physical size, mechanical wear out, wiper contamination, resistance float, affectability to vibration, temperature, humidity, the requirement for Screwdriver access, format inflexibility, and so on.

Digital potentiometers maintain a strategic distance from all the inherent issues connected with mechanical potentiometers and are perfect substitutions in new outlines where there is either a microcontroller on the other hand another digital device to give the important control signals. Physically controlled advanced potentiometers are likewise accessible for the individuals who don't have any on-board microcontrollers. Not at all like mechanical pots, digital pots be controlled powerfully in dynamic control applications.

We instructed the digital potentiometer by coding the Arduino. Doing this enabled us to control the voltage into the motor controller which decides the speed and torque of the motor. It also helps us to stop the vehicle by dropping the potential difference in the motor. In a word, the digital potentiometer acts as a speed controller.

4.5 Smartphone

Our autonomous car is controlled using an Android application that conveys over Bluetooth. The application converses with the on-board microcontroller (Arduino), driving the motors and parsing information from the sensors. We got the exact location data using the phone's GPS. Nowadays every smart phone is equipped with built in GPS technology. A brief description of how GPS works is given below:

4.5(a) GPS:

The Global Positioning System (GPS) is a network of about 30 satellites orbiting the Earth at an altitude of 20,000 km. Any device with be it a SatNav, mobile phone or handheld GPS unit, can receive the radio signals that the satellites broadcast. Wherever we are on the planet, at least four GPS satellites are 'visible' at any time. Each one transmits information about its position and the current time at regular intervals. These signals, travelling at the speed of light, are intercepted by your GPS receiver, which calculates how far away each satellite is based on how long it took for the messages to arrive. Once it has information on how far away at least three satellites are, your GPS receiver can pinpoint your location using a process called trilateration.

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use trilateration to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map. A GPS receiver must be locked on to the signal of at least 3 satellites to calculate a 2-D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3-D position (latitude, longitude and altitude).

Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

Figure: Working Principle of GPS

We obtained the current location using our smart phone’s GPS and then we used the coordinates from the Google Earth to run the car according to the desired path.

Another Major role of the Smartphone in our project is to process the images to detect the obstacles and the edges of the roads. To do this, we used an Android application named “Carduino”. This app detects the road edge & obstacles using the cell phone’s camera. The camera used as an image processor unit.

The Carduino app has two modes of operation: 1) Auto drive

2) Manual drive.

We used the auto-drive feature to drive our car. This app communicates with the main microcontroller using a Bluetooth module (HC-05).

4.5(b) Bluetooth module (HC-05):

This economical Bluetooth module permits the Arduino Mega to effortlessly correspond with the smart phone. Whatever is being sent by means of a serial connection with the Bluetooth module is being transmitted remotely to whichever device is right now joined with the Bluetooth module.

On the HC-05, there is likewise a pin that shows whether there is an active connection right now, which we used to bring and transmit information from the Arduino, just when that is fundamental. Layout of the Carduino app is shown in the figure below:

Figure: Bluetooth Module (HC-05)

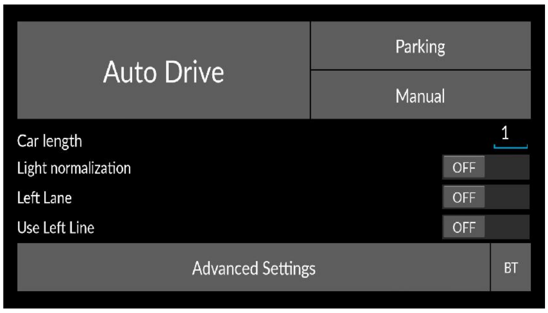


Figure: Carduino App

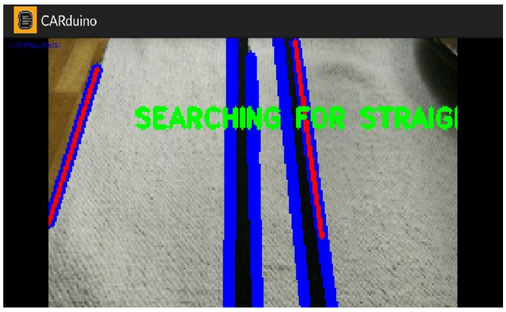


Figure: Image processing (In Carduino)

Figure: Autonomous Car Driving

5. Result Analysis

5.1 Results

There were so many problems we faced during testing the Autonomous car. Our work was more of a prototype. While the car receiving the GPS, we used an Android phone to get the GPS. But there is always an error and some fluctuation occurs. We stored the coordinates of our desired destination path and when the car was running through this path, some problem occurred due to the fluctuation of GPS reading, because the car always compare between its current position(GPS position) and the coordinates of the path. Also the GPS not respond or showed the position as quickly as we need. It took time to update and also sometimes The GPS unable to find the current location. There is some problem regarding the steering control. When to move and how much to move, sometimes the car could not make the decision, though the steering motor works perfectly. When the car did not receive the perfect current position, then the problem regarding steering movement occurs. Due the necessity of reducing the car's power so substantially for testing on campus, the speed control system was not able to be fully tested. It was observed that at low speeds some oscillation resulted due to the significant time-lag introduced into the control system as a result of the lack of available torque even when already moving. It is expected that with increased torque and better tuning this control system will operate in the required fashion.

Our sensor for obstacle detection worked properly. The control frameworks actualized in this venture have given fruitful operation amid testing and have seen the production of a system for control of the vehicle and enhancing comprehension of the prerequisites for more propelled calculations. The overhauled direction era calculation demonstrates significant promises as the basis for more advanced methods and future work on this project will encompass optimization of driving behaviors so that regular useable performance can be achieved in the near future.

5.2 Problems Faced during implementation and it's Solution:

As our project focuses on autonomous driving, implementation was not very easy task. We faced quite a few problems during our thesis work.

Firstly, our main problem was to integrate the GPS data with the microcontroller. It couldn't be done by any direct method. We got the coordinates of the desired path from Google Earth Pro, but the format was unreadable by the Arduino. We had to convert the coordinate data using XML editor and make it readable for the Arduino.

Another problem we faced was obstacle detection. As this is an autonomous vehicle, it is a must for us to ensure the obstacle detection system is working correctly. We used Ultrasonic sensors and IR sensors for this purpose. Though we couldn't be as precise as we wanted to be, still it helped us to have a safer driving of our car.

Direction and navigation of the car was regulated by a gyro sensor. It was tough to synchronize the gyroscope with the microcontroller and get the desired angles of rotation as we have a unidirectional system. The rotation process is more or less accurate. While trying to create the path, in Google EarthPro there are many bugs. Sometimes they don't create the shortest or exact path we wanted, what they supposed to do. In this situation we need to create the path manually. There are images given bellow:

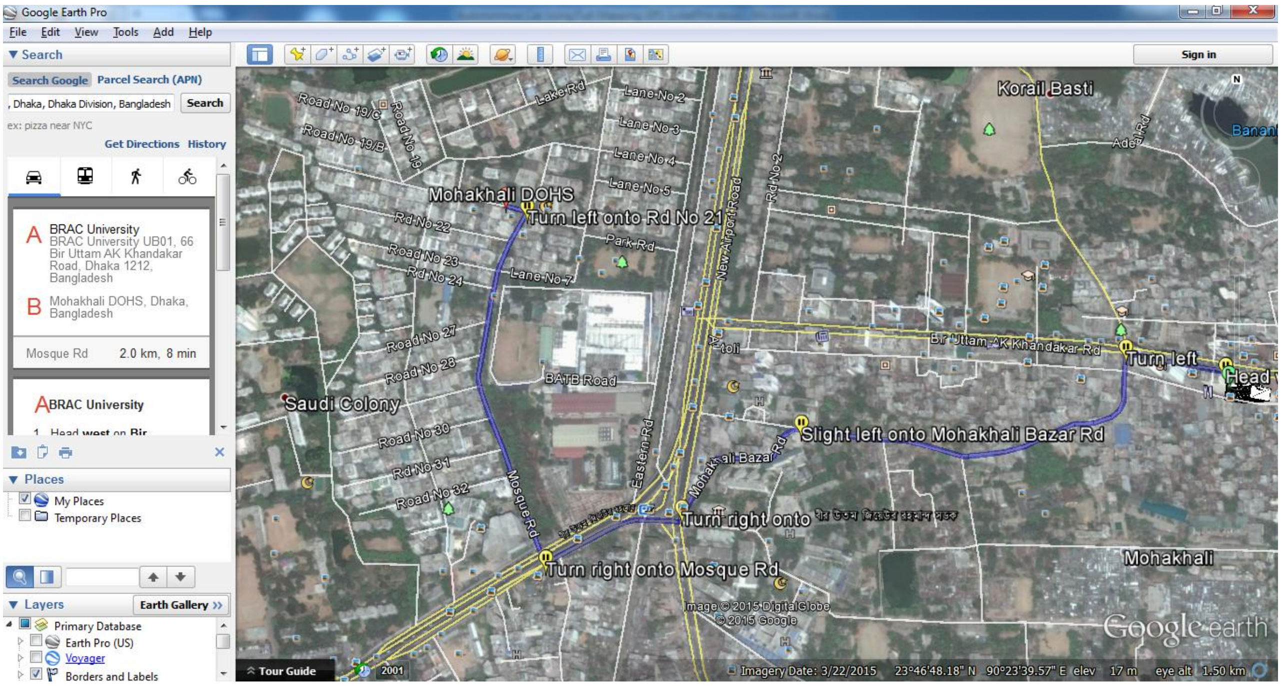


Figure: Wrong Path (BRAC University to Mohakhali DOHS)

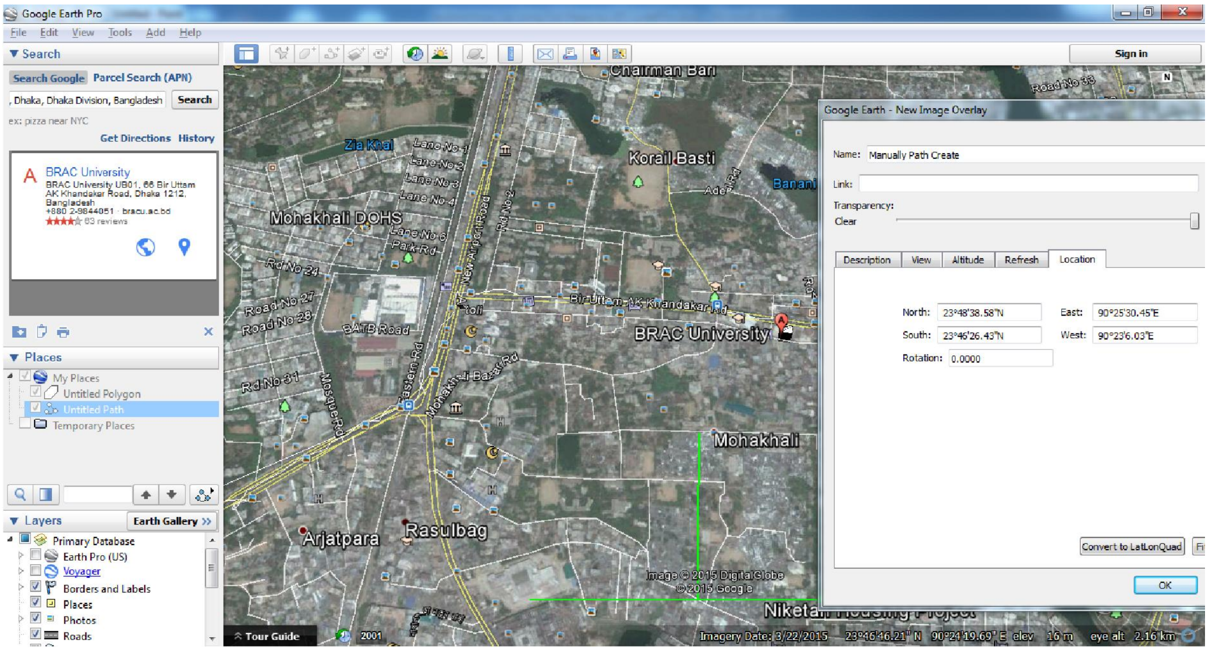


Figure: Manually created Path

Sometimes we get paranoid, when after trying so many times the car didn't run. We faced major problem while working with GPS and coordinate selection. We also faced problem with Motor Driver, some motor driver burn while working. We made a successor graph to understand the successor rate properly. The graph is provided bellow:

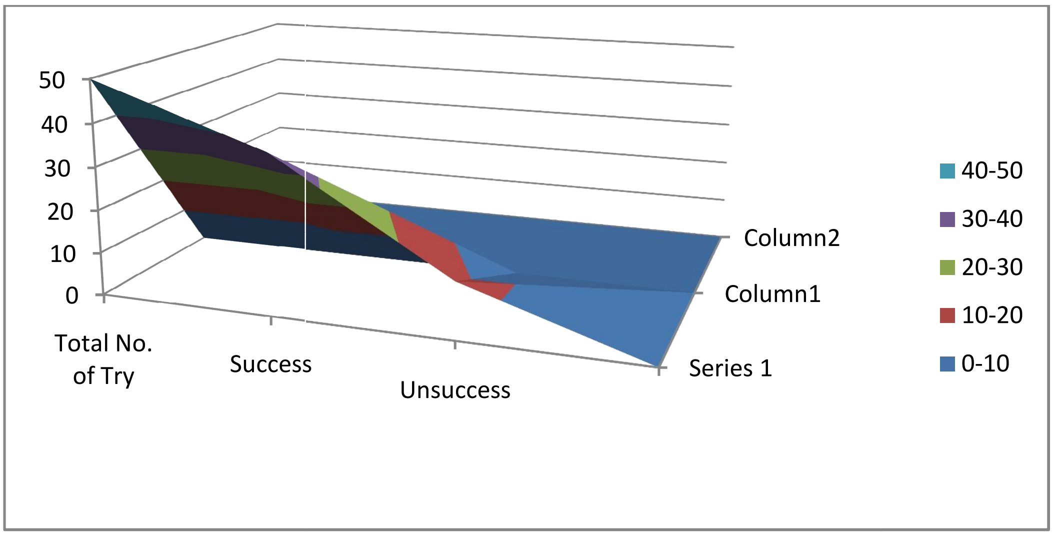


Figure: Success Rate

6. Conclusion & Future Scope:

With the rapid development of technology, autonomous driving is now a very promising feature of the motor vehicle industry. Specially in Bangladesh this kind of autonomous research has not been developed much. Autonomous vehicle can be a big step in the technological advancement of our country. This project shows significant promise as a platform for the development of autonomous driving technology and it is anticipated that with development of the underlying systems completed future work will focus on refining and improving the methods presented here. If our government and private investors have the willingness to grant fund this field of research, it would be a very propitious sector.

Though, it is difficult to implement this project with a limited budget. To obtain precise and accurate results LASER sensors are required. These kinds of sensors are pretty much expensive, which is a drawback. In future works, if the laser sensor named “LIDAR” is used, surely the results will have very less errors. Further improvements in the hardware platform will give better results in obtaining GPS data accurately and synchronizing simultaneously with the Arduino.

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Appendix

Code Implementation using Arduino Software:

(a) Motor Test

```
int motorSpeed = 2;

char ch;

String str;

int n;

void setup() {

  // put your setup code here, to run once:

  Serial.begin(9600);

  n = 0;

  analogWrite(motorSpeed, 0);

}

void loop() {

  // put your main code here, to run repeatedly:

  while (Serial.available()){

      ch = Serial.read();

      str+=ch;

      delay(2);

  }

  if(str.length() >0){
```

```
    n = str.toInt();
    Serial.println(n);
    str = "";
    analogWrite(motorSpeed, n);
  }
}
```

(b) Motor Speed with L298N

```
int motorL = 2;
int motorLF = 3;
int motorLB = 4;
char ch;
String str;
int velocity;

void setup() {
  Serial.begin(9600);
  velocity = 0;

  pinMode(motorLF, OUTPUT);
  pinMode(motorLB, OUTPUT);

  analogWrite(motorL, 0);
  digitalWrite(motorLF, LOW);
  digitalWrite(motorLB, LOW);
}
```

```
void loop() {
 while (Serial.available()){
    ch = Serial.read();
    str+=ch;
    delay(2);
 }
 if(str.length() >0){
   velocity = str.toInt();
   Serial.println(velocity);
   str = "";
   analogWrite(motorL, velocity);
   digitalWrite(motorLF, HIGH);
   digitalWrite(motorLB, LOW);
 }
}
```

(c) Gyro Code

```
#include <VirtualWire.h>
 #include "Wire.h"
 #include "I2Cdev.h"
 #include "MPU6050.h"
int val;

 MPU6050 mpu;

 int16_t ax, ay, az;
 int16_t gx, gy, gz;
```

```
void setup() {
  // put your setup code here, to run once:
 Wire.begin();
   Serial.begin(9600);
   mpu.initialize();

   vw_setup(2000);      // Bits per sec
}

void loop() {
  // put your main code here, to run repeatedly:

mpu.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);
    val = map(ay, -17000, 17000, 0, 179); //the accelarometer y axis reading is mapped to 0-
179 values & stored in val variable
    Serial.println(val);
}
```

(d) Main Code

```
#include <NewPing.h>
#include <SPI.h>
#include <SD.h>

double distanceL;
double distanceR;
NewPing sonarLeft(8,9,200);
```

```
NewPing sonarRight(6,7,200);
int motor = 2;
int motorFrwd = 3;
int motorBack = 4;
int steering = 44;
int steeringLeft = 45;
int steeringRight = 46;
File myFile1,myFile2;
void setup() {
 // put your setup code here, to run once:
 pinMode(motor, OUTPUT);
 pinMode(motorFrwd, OUTPUT);
 pinMode(motorBack, OUTPUT);
 pinMode(steering, OUTPUT);
 pinMode(steeringLeft, OUTPUT);
 pinMode(steeringRight, OUTPUT);

 analogWrite(motor, 0);
 digitalWrite(motorFrwd, LOW);
 digitalWrite(motorBack, LOW);

 analogWrite(steering, 250);
 digitalWrite(steeringLeft, LOW);
 digitalWrite(steeringRight, LOW);
 delay(100);
```

```
analogWrite(steering, 250);
digitalWrite(steeringLeft, HIGH);
digitalWrite(steeringRight, LOW);
delay(1000);

analogWrite(steering, 150);
digitalWrite(steeringLeft, LOW);
digitalWrite(steeringRight, HIGH);
delay(1000);
Serial.begin(9600);
delay(100);

if (!SD.begin(4)) {
 Serial.println("initialization failed!");
 return;
}
myFile1 = SD.open("long.txt", FILE_READ);
myFile2 = SD.open("latt.txt", FILE_READ);
if (myFile1) {
 Serial.println("long.txt:");
 // read from the file until there's nothing else in it:
 while (myFile1.available()) {
  Serial.write(myFile1.read());
 }
 // close the file:
 myFile1.close();
```

```
  } else {
    // if the file didn't open, print an error:
    Serial.println("error opening long.txt");
  }
  if (myFile2) {
    Serial.println("latt.txt:");
    // read from the file until there's nothing else in it:
    while (myFile2.available()) {
      Serial.write(myFile2.read());
    }
    // close the file:
    myFile2.close();
  } else {
    // if the file didn't open, print an error:
    Serial.println("error opening latt.txt");
  }
}

void loop() {
  // put your main code here, to run repeatedly:

  analogWrite(steering, 256);
  digitalWrite(steeringLeft, HIGH);
  digitalWrite(steeringRight, LOW);
  delay(1000);
```

```
  analogWrite(steering, 256);
  digitalWrite(steeringLeft, LOW);
  digitalWrite(steeringRight, HIGH);
  delay(1000);

//  distanceL = sonarLeft.ping()/US_ROUNDTRIP_CM;
//  distanceR = sonarRight.ping()/US_ROUNDTRIP_CM;
//
//  if(distanceL<50 && distanceR<50){
//    analogWrite(motor,0);
//    digitalWrite(motorFrwd,LOW);
//    digitalWrite(motorBack,LOW);
//    delay(1000);
//  }else if(distanceL<50){
//    analogWrite(steering,100);
//    digitalWrite(steeringLeft,LOW);
//    digitalWrite(steeringRight,HIGH);
//    delay(500);
//    digitalWrite(steeringLeft,HIGH);
//    digitalWrite(steeringRight,LOW);
//    delay(500);
//  }else if(distanceR<50){
//    analogWrite(steering,100);
//    digitalWrite(steeringLeft,LOW);
//    digitalWrite(steeringRight,HIGH);
//    delay(500);
```

```
//    digitalWrite(steeringLeft,HIGH);
//    digitalWrite(steeringRight,LOW);
//    delay(500);
//  }
//  Serial.print("Left: ");
//  Serial.println(distanceL);
//  Serial.print("Right: ");
//  Serial.println(distanceR);
//  delay(100);
}
```