*American Journal of Electrical and Electronic Engineering, 2019, Vol. 7, No. 3, 62-68*
Available online at http://pubs.sciepub.com/ajeee/7/3/2
Published by Science and Education Publishing
DOI:10.12691/ajeee-7-3-2

# Driverless Car for Next Generation Commuters - Key Factors and Future Issues

**Arun Agarwal[1,*], Kabita Agarwal[2], Gourav Misra[3], Omkar Pabshetwar[3]**

[1]Department of Electronics and Communication Engineering, Institute of Technical Education & Research, Siksha 'O' Anusandhan Deemed to be University, Khandagiri Square, Bhubaneswar-751030, Odisha, India
[2]Department of Computer Science and Applications, Utkal University, Vani Vihar, Bhubaneswar-751004, Odisha, India
[3]School of Electronic Engineering, Dublin City University, Glasnevin, Dublin 9, Ireland
*Corresponding author: arunagrawal@soa.ac.in

*Received June 26, 2019; Revised August 03, 2019; Accepted August 16, 2019*

**Abstract** In today's world, as the technology is increasing day by day, road accidents are becoming more and more prevalent. Driver error is the most common cause of traffic accidents, and with cell phones, in-car entertainment systems, more traffic and more complicated road systems, it isn't likely to go away. To reduce the human error, there arises a possibility if with use of technology this error can be reduced and driving can be safer. Driverless cars are one of the major topics where transportation and innovation are considered to be perfectly combined for the safety on roads. Every automotive player is trying its best to make it practically possible in whichever it could. Companies developing and/or testing driverless cars include Audi, BMW, Ford, Google, General Motors, Tesla, Volkswagen and Volvo. One of the major ongoing projects is "Waymo" by Google. In this project we designed a prototype of driverless car with basic features using Arduino uno. We have used gmaps to create a map where we used to give the source and destination to get the route then we download the route in Keyhole Markup Language (KML) file format then we go to convertcsv.com site to extract latitude and longitude from the KML file that we just downloaded from the gmaps. We copy the latitude and longitude to our Arduino uno code where we keep the latitudes and longitudes in form of an array. Then we have built an app which uses the mobile Assisted Global Positioning System (AGPS) sensor to sense the current real time position in terms of latitudes and longitudes and send them to things peak cloud and simultaneously displaying them on a real time map. Arduino uno then receives the latest data sent from the mobile to the cloud and to do that Arduino uno uses a Wi-Fi module (esp 8266) to connect to the internet. Then the thingspeak cloud send the data receive from the mobile to the Arduino uno and then using that data we calculate the degree and distance required to move the car according to the latitudes and longitudes stored in the array which we got from the gmap route.

***Keywords:*** *Arduino uno, driverless car, keyhole markup language, wi-fi module (esp 8266), Assisted Global Positioning System (AGPS)*

**Cite This Article:** Arun Agarwal, Kabita Agarwal, Gourav Misra, and Omkar Pabshetwar, "Driverless Car for Next Generation Commuters - Key Factors and Future Issues." *American Journal of Electrical and Electronic Engineering*, vol. 7, no. 3 (2019): 62-68. doi: 10.12691/ajeee-7-3-2.

## 1. Introduction

### 1.1. Motivation

We live in a country where road safety has been a major issue since a very long time. People in INDIA are very careless towards road safety rules and regulations. The National Highway Traffic Safety Administration (NHTSA) estimates that 94% of serious crashes are due to human error or poor choices, such as drunk or distracted driving. Being a concerned citizen of INDIA and as an engineer, our motive was to take up a project which deals with the safety and advanced technology at the same time. Driverless car is one of the innovations which is a perfect combination for road safety and advanced technology. Since, India is not so far behind in the driverless car race as compared to other countries; hence we were inclined to work on such project.

### 1.2. Design Goals

#### 1.2.1. Purpose

India has one of the largest automotive industries in the world and issues related to road safety are becoming more and more concerning everyday due to the increased number of accidents. The future of automotive sector lies in between innovation and automation and the idea of connecting technology with transportation is spreading day by day. Due to this reason, most of the automotive companies are focusing on driverless cars/vehicles.

#### 1.2.2. Scope

The prime focus of innovation these days is to direct human intercession in everyday tasks. Driving security experts predict that once driverless innovation has been completely developed, car accidents brought about by human errors, for example, deferred response time, tailgating, rubbernecking, and other forms of distracted or aggressive driving should significantly be reduced. Automation of vehicles can improve the fuel economy of the vehicle by upgrading the drive cycle. Decreased traffic obstructions and the enhancements in rush hour because of the far-reaching utilization of automated vehicles will convert into higher eco-friendliness.

#### 1.2.3. Applicability

Advanced driver assisted system (ADAS) helps the human driver with directing, braking or accelerating, anyway not in the meantime. ADAS joins rearview cameras and features a vibrating seat advised to caution drivers when they float out of the way. An ADAS that can control and either brake or quicken in the meantime while the driver remains totally mindful in the driver's seat and continues going about as the driver.

An automated driving system (ADS) can play out each and every driving endeavor in explicit circumstances, for instance, leaving the vehicle. In these conditions, the human driver must be set up to re-take control is up 'til now required to be the fundamental driver of the vehicle.

Promotions can play out each driving errand and screen the driving condition in explicit conditions. In those conditions, the ADS is adequately needy that the human driver doesn't have to center.

The vehicle's ADS go about as a virtual driver and do all the driving in all conditions. The humans are travellers and are never expected to drive the vehicle.

### 1.3. Problem Statement

Design a prototype of Driverless car with basic features using central processing unit like Arduino controller

## 2. Literature Survey

### 2.1. Project Specification

The history of driverless extends a way long time back. Experiments have been conducted on driverless cars since many years and they are still going on. The feasibility of driverless cars has gone from “may be possible” to “definitely possible” to “inevitable” to “how did anyone ever think this wasn’t inevitable?” to "now commercially available."

**1920:-**

In 1925, Houdina Radio Control showed the radio-controlled "American Wonder" on New York City boulevards, going up Broadway and down Fifth Avenue through the thick of the traffic obstruction.

**1930:-**

An early portrayal of a mechanized guided vehicle was Norman Bel Geddes' Futurama display supported by General Motors at the 1939 World's Fair, which delineated radio-controlled electric autos that were pushed through electromagnetic fields given by circuits installed in the roadway.

**1950:-**

In 1953, RCA Labs effectively fabricated a smaller than expected vehicle that was guided and constrained by wires that were laid in an example on a research facility floor. The framework started the creative ability of Leland M. Hancock.

In 1957, a full-size framework was effectively shown by RCA Labs and the State of Nebraska on a 400-foot segment of the open parkway at the crossing point of U.S. Highway 77 and Nebraska Highway 2, at that point simply outside Lincoln, Nebraska. A progression of test identifier circuits covered in the asphalt was a progression of lights along the edge of the street. The identifier circuits had the capacity to send driving forces to direct the vehicle and decide the nearness and speed of any metallic vehicle on its surface.[15]

**1960:-**

In 1960, Ohio State University's Communication and Control Systems Laboratory propelled an undertaking to create driverless autos which were initiated by electronic gadgets embedded in the roadway. The leader of the venture, Dr. Robert L. Cosgriff, asserted in 1966 that the framework could be prepared for establishment on an open street in 15 years.

In the mid-1960s, the Bureau of Public Roads considered the development of an exploratory electronically controlled parkway. In August 1961, Popular Science gave an account of the Aeromobile 35B, an air-pad vehicle (ACV) that was designed by William Bertelsen and was imagined to change the transportation framework, with individual driverless drifting autos that could accelerate to 1,500MPH.

**1990:-**

In 1991, the United States Congress passed the ISTEA Transportation Authorization charge, which trained USDOT to "exhibit a computerized vehicle and thruway framework by 1997." The Federal Highway Administration took on this undertaking, first with a progression of Precursor Systems Analyses and after that by building up the National Automated Highway System Consortium (NAHSC). In 1995, Carnegie Mellon University's Navlab venture finished a 3,100 miles (5,000 km) cross country venture, of which 98.2% was self-rulingly controlled, named "No Hands Across America" [16]. In 1996, (presently Professor) Alberto Broggi of the University of Parma propelled the ARGO Project, which took a shot at empowering an adjusted Lancia Thema to pursue the typical (painted) path stamps in an unmodified highway. The Park Shuttle, charged as the world's first driverless vehicle, is a robotized people mover which utilizes fake reference focuses (magnets) inserted in the street surface to check its position. [17]

**2000:-**

In the principal Grand Challenge held in March 2004, DARPA (the Defense Advanced Research Projects Agency) offered a $1 million prize to any group of automated architects which could make an independent vehicle fit for completing a 150-mile course in the Mojave Desert. [19]

In November 2007, DARPA again supported Grand Challenge III, however this time the Challenge was held in a urban situation. In this race, a 2007 Chevy Tahoe independent vehicle from Carnegie Mellon University earned the first spot. Prize rivalries as DARPA Grand Challenges allowed understudies and analysts a chance to inquire about a venture on independent vehicles to lessen the weight of transportation issues, for example, traffic clog and auto collisions that inexorably exist on numerous urban residents. [20]

In January 2006, the United Kingdom's 'Foreknowledge' think-tank uncovered a report which predicts RFID-labeled driverless autos on UK's streets by 2056 and the Royal Academy of Engineering guaranteed that driverless trucks could be on Britain's motorways by 2019. [21,22] Autonomous vehicles have additionally been utilized in mining. In December 2008, Rio Tinto Alcan started testing the Komatsu Autonomous Haulage System – the world's first business independent mining haulage framework – in the Pilbara iron metal mine in Western Australia. Rio Tinto has revealed benefits in wellbeing, security, and profitability. In November 2011, Rio Tinto marked an arrangement to incredibly extend its armada of driverless trucks. [23]

Google started building up its driverless vehicles in 2009, however, did as such secretly, keeping away from open declaration of the program until the not too distant future. [24]

**2010:-**

In 2011, GM made the EN-V (short for Electric Networked Vehicle), a self-governing electric urban vehicle. In 2012, Volkswagen started testing a "Transitory Auto Pilot" (TAP) framework that will enable a vehicle to drive itself at paces of up to 80 miles for every hour (130 km/h) on the highway. Ford has led broad examination into driverless frameworks and vehicular correspondence systems. In October 2010, a lawyer for the California Department of Motor Vehicles raised worries that "The innovation is in front of the law in numerous territories", referring to state laws that "all dare to have a person working the vehicle". [25,26]

The 2014 Infiniti Q50 utilizes cameras, radar, and other innovation to convey different path keeping, crash evasion, and voyage control highlights. One analyst commented, "With the Q50 dealing with its very own speed and changing course, I could kick back and just watch, even on somewhat bending parkways, for at least three miles at a stretch," including that he wasn't contacting the controlling wheel or pedals. [27]

In spite of the fact that starting at 2013, completely self-sufficient vehicles are not yet accessible to people in general, numerous contemporary vehicle models have highlights offering restricted self-sufficient usefulness. These incorporate versatile voyage control, a framework that screens separations to nearby vehicles in a similar path, altering the speed with the progression of traffic; path help, which screens the vehicle's situation in the path, and either cautions the driver when the vehicle is leaving its path, or, less generally, takes remedial activities; and leaving help, which helps the driver in the assignment of parallel parking in October 2014 Tesla Motors reported its first form of AutoPilot. [28] Demonstrate S autos furnished with this framework are fit for path control with self-ruling controlling, braking and speed limit modification dependent on signs picture acknowledgment. The framework additionally gives self-sufficient leaving and can get programming updates to improve aptitudes over time [29]. In April 2016 Volvo declared designs to convey 100 XC90 driverless autos to test them in ordinary driving conditions in China in 2017. [29] In August 2016 Singapore propelled the primary driverless taxi administration, given by nuTonomy. [30]

# 3. Design Scheme

## 3.1. System Design

In this project we have used, Arduino uno, mobile (4G Android), Battery Operation (BO) motors, L293D circuit and many more electronic components to meet our desired goals.

### 3.1.1. Working Principle

We have used gmaps to create a map where we used to give the source and destination to get the route then we download the route in Keyhole Markup Language (KML) file format then we go to convertcsv.com site to extract latitude and longitude from the KML file that we just downloaded from the gmaps. We copy the latitude and longitude to our Arduino uno code where we keep the latitudes and longitudes in form of an array.

Then we have built an app which uses the mobile Assisted Global Positioning System (AGPS) sensor to sense the current real time position in terms of latitudes and longitudes and send them to thingspeak cloud and simultaneously displaying them on a real time map.

Arduino uno then receives the latest data sent from the mobile to the cloud and to do that Arduino uno uses a Wi-Fi module (esp 8266) to connect to the internet. The Wi-Fi module connects to hotspot whose USSID and password is specified in the Arduino uno code and using that connectivity we send a “get channel feed” request. Then the thing speak cloud send the data receive from the mobile to the Arduino uno and then using that data we calculate the degree and distance required to move the car according to the latitudes and longitudes stored in the array which we got from the gmap route.

Then for better visualization we have built an application in python which uses folium library to show the real-time path travelled by the car.

### 3.1.2. Purpose of Components

**Arduino uno:**

Arduino uno consists of a microcontroller A Tmega 328 which performs all the processes and mathematical analysis. The process includes using arduino uno we can connect the internet and through which we can connect to the cloud and receive data and using the data we perform operation on actuators. Arduino has 14 digital pins and 6 analog pins on the Uno.In our project we have used

1. PORT 2 and 3 as Software Serial. This is used for serial communication between the Wi-Fi module (esp 8266) and Arduino uno
   - PORT 2 is used as transmitter
   - PORT 3 is used as Receiver(Rx)
2. PORT 4, 5, 6 and 7 is used to control the rotation of BO(Battery Operation) motors

**Driver circuit (L293D):**

Since Arduino provides a supply voltage of 5V and provide current of 40mA which is very less to drive the 2 BO motors. Henceforth we need a driver circuit (L293D) to supply a current up to 600 mA(per channel) to the BO motors, so that it can run properly

**Wi-Fi module (esp 8266):**

It is used to provide internet connectivity to Arduino uno, this module can access any information that is available in the internet.

**BO motors:**

It is used to drive the wheels of the bot when supplied with the voltage high or low to both pins of BO motor.

## 3.2. Circuit Design

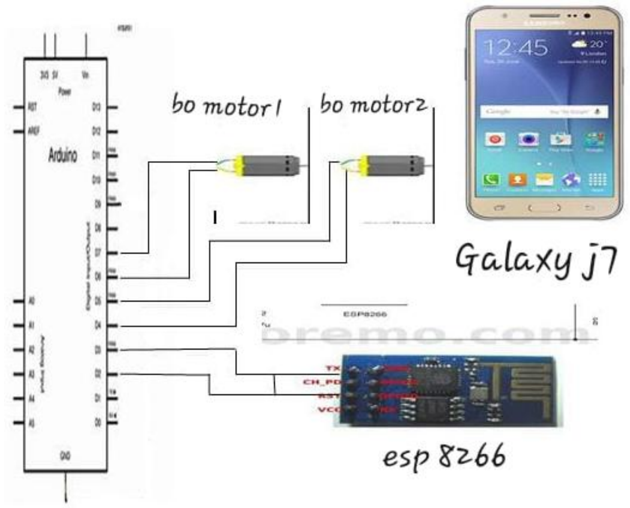



**Figure 1.** Circuit diagram of driverless car

## 3.4. Design Evolution

The first model consist of a bot car, Arduino uno , Bluetooth module , mobile and LCD display where the direction was specified by the user on the mobile in runtime, the serial communication between mobile and Arduino uno was done using Bluetooth module (HC-05). Since the model was not applicable for the real time scenario.

The second model was based on the real world where we get real time values of latitudes and longitudes from the GPS module (NEO_6m). In this model, we have used a bot car, Arduino uno, Wi-Fi module (esp 8266) and GPS module (NEO-6m). In this model, GPS module (NEO-6m) when connected to power supply of 5V, continuously throws NMEA sentences to the serial port of Arduino uno. Then using the Arduino code we extract the current latitudes and longitudes from the NMEA sentences. After getting the latitudes and longitudes from GPS module, we send them to the thingspeak cloud where we actually process the data and then using that we send information to Arduino so that the bot can move.

But in this model the problem was with GPS module (NEO-6m):-

The latitude and longitude that we got from the GPS module(NEO-6m) was inconsistent and were not precise or accurate. To get a fix from a NEO-6m it takes 15 to 30 minutes depending on the factors like weather conditions, etc. The NEO-6m doesn't work inside the tunnels or buildings Due to these problems the model was not feasible.

To avoid these problems with NEO-6m we use mobile where the mobile uses the technology of AGPS to get accurate real time position.

## 3.5. Implementation

We have used gmaps to create a map where we used to give the source and destination to get the route then we download the route in Keyhole Markup Language (KML) file format then we go to convertcsv.com site to extract latitude and longitude from the KML file that we just downloaded from the gmaps. We copy the latitude and longitude to our Arduino uno code where we keep the latitudes and longitudes in form of an array.

Then we have built an app which uses the mobile Assisted Global Positioning System (AGPS) sensor to sense the current real time position in terms of latitudes and longitudes and send them to thingspeak cloud and simultaneously displaying them on a real time map.

To fulfill the industry standards, a precision location fix requires at least three GPS estimations. The expression "Assisted" alludes to how Sprint arranges assets are utilized to give an increasingly robust estimation when just two satellites are visible.

Arduino uno then receives the latest data sent from the mobile to the cloud and to do that Arduino uno uses a Wi-Fi module (esp 8266) to connect to the internet. The Wi-Fi module connects to hotspot whose USSID and password is specified in the Arduino uno code and using that connectivity we send a "get channel feed" request. Then the thingspeak cloud send the data receive from the mobile to the Arduino uno and then using that data we calculate the degree and distance required to move the car according to the latitudes and longitudes stored in the array which we got from the gmap route.

Then for better visualization we have build an application in python which uses folium library to show the real-time path travelled by the car.

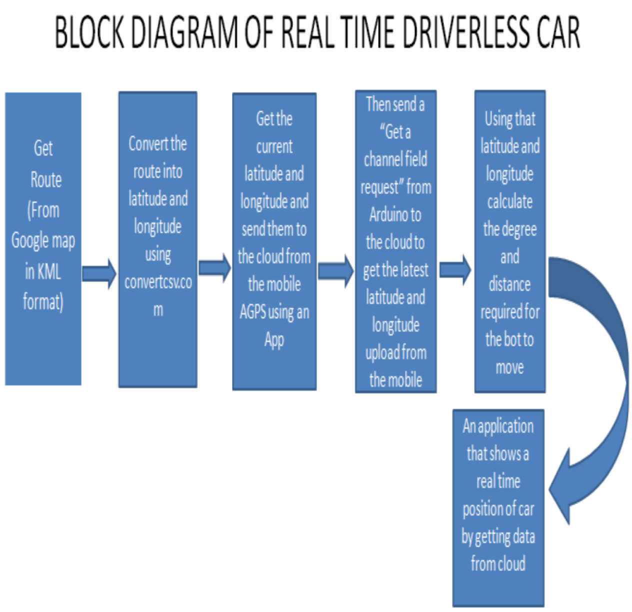
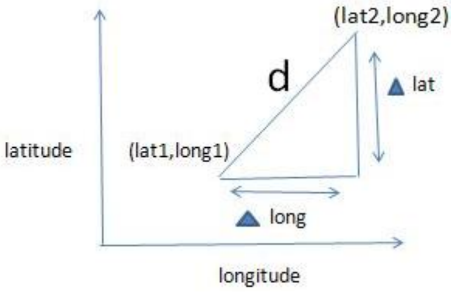



**Figure 2.** Block diagram of driverless car

# 4. Testing, Analysis and Evaluation

## 4.1. Mathematical Analysis




Let x and y be two point in the co ordinate system

$$\Delta_{lat} = \left| latitude\ of\ \ y - latitude\ of\ \ x \right|$$

$$\Delta_{long} = \left| longitude\ of\ \ y - longitude\ of\ \ x \right|$$

$\Delta_{lat}$ and $\Delta_{long}$ is in degree so we convert it into m

1 Degree = 111 km = $111 * 10^{-3}$ m.

So after conversion

$$d = \sqrt{\left(\Delta_{latitudeinmeteres}\right)^2 + \left(\Delta_{longitudeinmeteres}\right)^2}$$

Where d is the distance between x and y in metres.

Then to find angle

$$\tan\theta = \frac{perpendicular}{base} = \frac{\Delta_{lat}}{\Delta_{long}}$$

$$\theta = \tan^{-1}\left(\frac{\Delta_{lat}}{\Delta_{long}}\right).$$

## 4.2. Testing

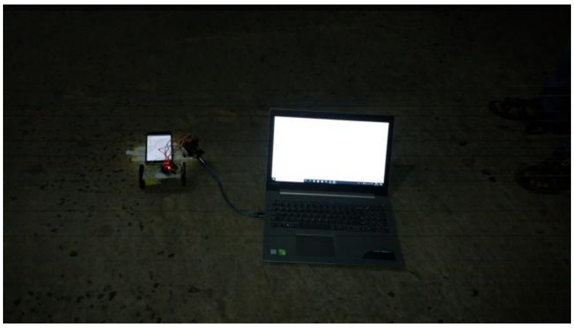


**Figure 3.** The complete setup of Driverless car

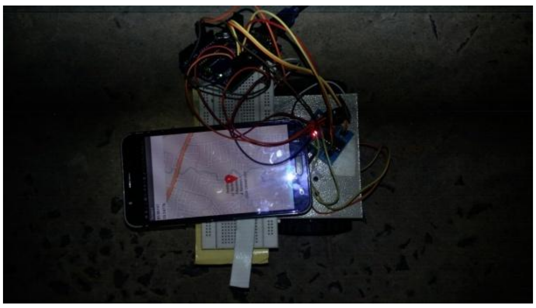


**Figure 4.** Top view of the bot

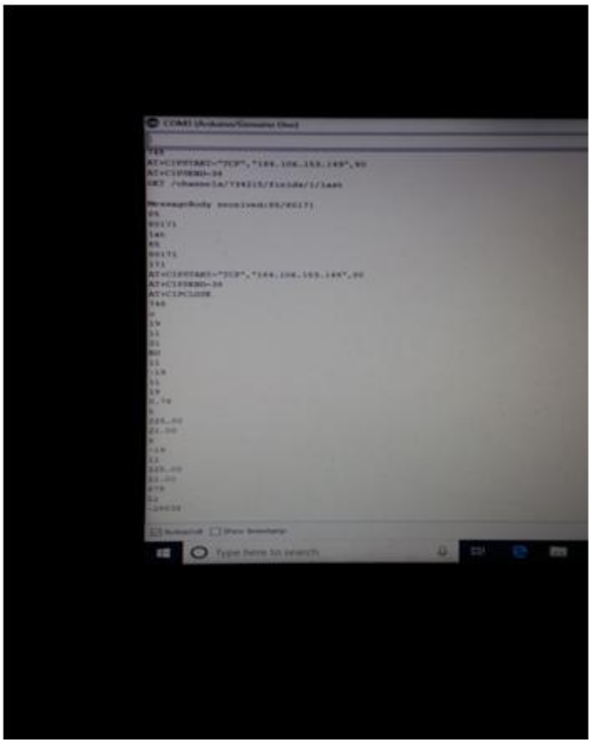


**Figure 5.** Output shown on the serial monitor of arduno

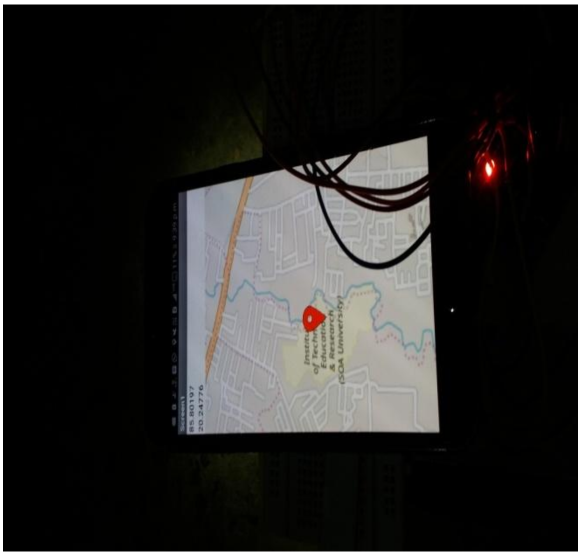


**Figure 6.** The App

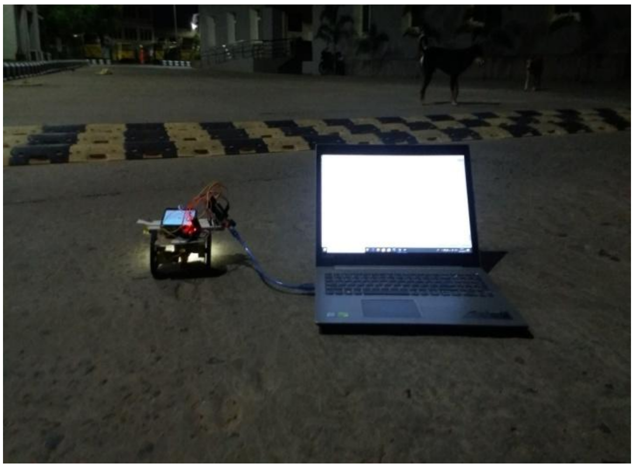


**Figure 7.** The Bot after reaching destination

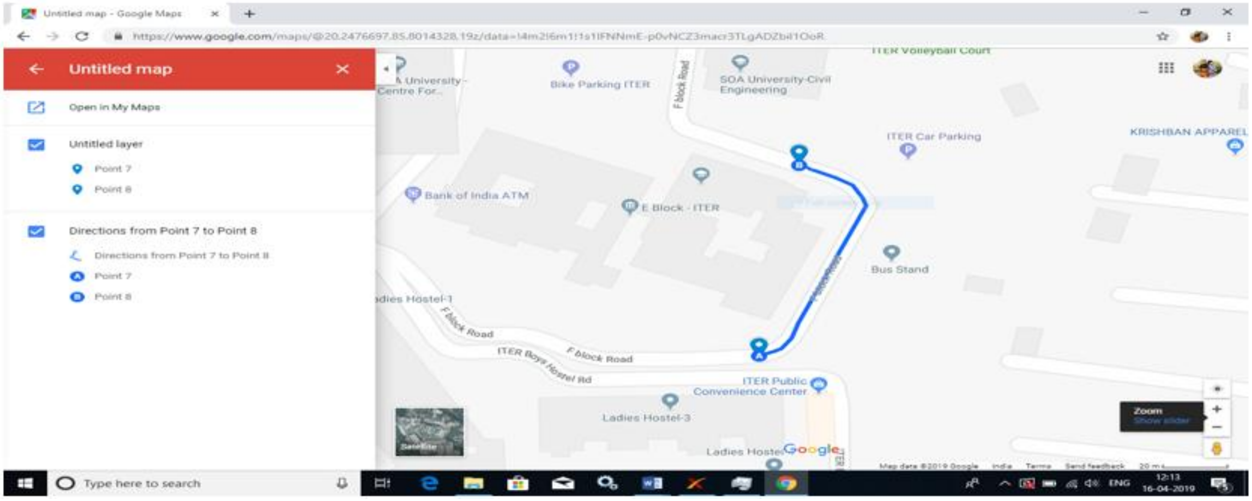



**Figure 8.** The test track from google map

### 4.3. Evaluation


**Figure 9.** The fluctuating data from GPS module

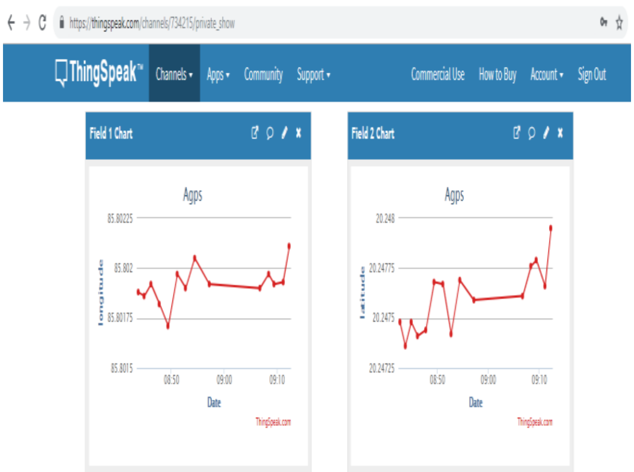



**Figure 10.** The partially stable data from mobile AGPS

## 5. Challenges

Cost is really going to be one of the greatest obstacles confronting driverless cars. The measure of innovative work that should be consistently done will make delivering only one vehicle an extremely expensive procedure. One of the most critical aspects of transitioning to driverless cars is the legal gray area that exists. Something as basic and essential as snow can truly make things confounded in a driverless world. Path dividers vanish under even the most slender layer of snow. This can be a genuine issue when you think about that self-driving vehicles use cameras to follow the lines on the asphalt.

The values of latitudes and longitudes that we got from AGPS are not precise. A lot of time is taken by thingspeak to upload and download the data. A lot of additional noise is added while transmitting and receiving the data from thingspeak. Due to this reason, getting an accurate latitude and longitude is very time consuming.

The first model was not applicable for real time scenario. For real time scenario, we needed the current latitudes and longitudes. So for that, we used the NEO-6m to trace the current latitudes and longitudes. The data provided by NEO-6m was not accurate. Then we used mobile AGPS to get accurate latitude and longitude. But to connect mobile AGPS to our bot car we needed IoT (Internet of things). Sending data from Arduino to the cloud was available from various sources, but receiving a feed was not available anywhere so we had to come up with our own way of getting data from the cloud to Arduino.

## 6. Conclusion

There's a great deal of guarantee and opportunity related with Driverless vehicles, yet there are lot many queries and concerns. The innovation is as still being processed and tried, so workarounds for a portion of the previously mentioned issues may be made starting at yet, however the accurate framework is still in process.

Driverless vehicles are going to be part of things to come, hence they are effectively sent over America's roadways with the prediction that it will be an evolution for drivers and traffic designs, in addition for the transportation business all in all.

Though there are uncertain issues, like, wellbeing, innovation issues, debate concerning obligation, opposition by people to give away the control of their autos, usage of a legitimate system and foundation of government guidelines; risks related to loss of protection and security concerns, but the predicted and potential advantages of driverless cars related to transport cannot be neglected. The robotization of vehicles needs a much more positive aspect and people need to realize the need and potential of it. Though there are many ongoing debates regarding the feasibility of driverless cars, but people need to understand its advantages and give this technology time to prove itself, as good things take time.

## References


[1] Ravi Dhameliya, Kaushik Domadiya, Pratik Miyani, Hiren Savaliya, Pratik Jariwala, "Automatic Power Factor Control Using Arduino uno", *International Journal of Advance Engineering and Research Development (IJAERD)*, vol. 4, no. 4, pp. 2348-4470, April 2017.

[2] Gaurav Tembhurnikar, Ajit Chaudhari, Nilesh Wani, Atul Gajare, Pankaj Gajare, "A Review on Reactive Power Compensation Techniques using FACTS Devices", *International Journal of Engineering and Management Research*, vol. 4, no. 1, pp.2250-0758, February 2014.

[3] T. Rajesh, S. Aravindhan, M. Sowmiya, S. Thenmozhi, "Design of Shunt Active Filter for Reduction of Harmonics", *International Journal of Engineering Science and Computing*, April 2016.

[4] T. S. Rathnayake, K. T. Rukshan, RA. T J. K. Rupasinghe, R.M. Ruwanthika, "Design and Simulation of Single Phase Active Current Harmonic Filter", *International Conference on Circuit Power and Computing Technologies [ICCPCT]*, 2014.

[5] Rahul K. Gargi, Soumyadeep Ray, Nitin Gupta, "Reactive Power Compensation and Power Factor Improvement using Fast Active Switching Technique", *1st IEEE International Conference on Power Electronics Intelligent Control and Energy Systems (ICPEICES*, 2016.

[6] Murad Ali, "Design and Implementation of Microcontroller-Based Controlling of Power Factor Using Capacitor Banks with Load Monitoring", *Global Journal of Researches in Engineering Electrical and Electronics Engineering Type: Double Blind Peer Reviewed International Research Journal*, vol. 13, no. 2, pp. 2249-4596, 2013.

[7] N. Langhammer, R. Kays, "Performance Evaluation of Wireless Home Automation Networks in Indoor Scenarios", *IEEE Transactions on Smart Grid*, vol. 3, pp. 2252-226, 2012.

[8] R. Jiang, R. Lu, C. Lai, J. Luo, X. Shen, "Robust group key management with revocation and collusion resistance for scada in smart grid", *IEEE Globe Communication Conference (Globecom)*, pp. 824-829, 2013.

[9] Hao-wei Yao, Xiao-wei Wang, Lu-sen Wu, Dan Jiang, Teng Luo, Dong Liang, "Prediction method for Smart Meter Life Based on Big Data", *Procedia Engineering*, vol. 211, pp. 1111-1114, 2018.

[10] R. Pereira, J. Figueiredo, R. Melicio, V.M.F. Mendes, J. Martins, J. C. Quadrado, "Consumer energy management system with integration of smart Meters", *Energy Reports*, vol. 1, pp. 22-29, 2015.

[11] M. M Makram, M. M. Mohammed, "On the design of low Phase-Noise CMOS LC-Tank Oscillators", *International Conference on Micro-electronics*, [online] Available: Http//www.colpittoscillator.com, 2008.

[12] L. Robert, Boylestard, Louis Nashelsky, Electronic Device and Circuit Theory, Prentice Hall:Published by Pearson education Inc., pp. 763-767, 2009.

[13] K. Oguchi, S. Maruta, D. Hanawa, "Human positioning estimation method using received signal strength indicator (RSSI) in a wireless sensor network", *Procedia Computer Science*, vol. 34, pp. 126-132, 2014.

[14] B. Mrazovac, B. M. Todorovic, M. Z. Bjelica, D. Kukolj, "Reaching the next level of indoor human presence detection: An rf based solution", *Telecommunication in Modern Satellite Cable and Broadcasting Services (TELSIKS) 2013 11th International ConferenceIEEEVol*, vol. 1, pp. 297-300, October 2013.

[15] Z. Xu, K. Sandrasegaran, X. Kong, Z. Zhu, B. Hu, J. Zhao, C. Lin, "Pedestrain monitoring system using Wi-Fi technology and RSSI based localization", *International Journal of Wireless & Mobile Networks*, 2013.

[16] "Autonomous Cars Will Make Us Safer". *WIRED. 16 November 2009*. Retrieved 20 October 2016.

[17] Bishop, Richard, "Intelligent Vehicle Technologies and Trends. Boston": Artech House. p. 300. ISBN 978-1580539111, 2005.

[18] Albanesius, Chloe, "Google Car: Not the First Self-Driving Vehicle". PC Magazine October 11, 2010.

[19] *Dudley, David.* "The Driverless Car Is (Almost) Here; The self-driving car — a godsend for older Americans — is now on the horizon". *AARP The Magazine. AARP*. Retrieved November 30, 2015.

[20] Thrun, Sebastian. "Toward Robotic Cars." Communications of the ACM 53.4 (2010): 99-106. Computer & Applied Sciences Complete. Retrieved 24 October 2014.

[21] *McCue, Andy (26 January 2006).* "RFID-tagged driverless cars on roads by 2056". *Silicon.com*. Retrieved 20 November 2011.

[22] "Driverless trucks by 2019". *Roadsafetygb.org.uk. Archived from* the original *on 11 May 2012*. Retrieved 20 November 2011.

[23] "Rio Tinto Expands Driverless Truck Fleet". *2 November 2011. Archived from* the original *on 2014-12-20*. Retrieved 2014.

[24] *Harris, Mark.* "How Google's Autonomous Car Passed the First U.S. State Self-Driving Test". IEEE Spectrum. *Institute of Electrical and Electronic Engineers*, Retrieved 2014.

[25] *Jack Carfrae (25 May 2010).* "An automated adventure at the wheel of a driverless BMW – The National". *Thenational.ae*, 2012.

[26] "The driverless car is coming. And we all should be glad it is." by Dan Niel Wall Street Journal, 24 September 2012.

[27] Ulrich, Lawrence, "Feeling a Bit Obsolete in the Driver's Seat". The New York Times. Retrieved 18 December 2013.

[28] Aaron M. Kessler, "Elon Musk Says Self-Driving Tesla Cars Will Be in the U.S. by Summer". The New York Times, 2015.

[29] Korosec, Kirsten, "Volvo Expands Its Self-Driving Car Experiment to China". Fortune. 2016.

[30] Watts, Jake Maxwell, "World's First Self-Driving Taxis Hit the Road in Singapore – Singapore's nuTonomy debuts autonomous cabs, beating the likes of U.S. tech giants Uber and Google". The Wall Street Journal, September 2016.