

# Self-driving car with anomaly detection

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## Abstract

The main idea of this project is a self-driving car that drives normally on the road and takes a different decisions including slowing down when detecting road anomalies as well to avoid car damages that might occur if passed by a road anomaly on a high speed. Also Anomalies detection should result in reducing vehicle accidents in general and car damages. So we propose a sensor based self-driving car with a dual camera for self-driving and the detection of road anomalies. We aim to help the self-driving car achieving higher safety by detecting road anomalies using Gyroscope, Accelerometer, GPS sensor and using a dual camera that will help the car to know the depth map between the vehicles in front of it. The car will behave like normal drivers behave when passing by road anomalies as it slows down its speed to avoid car damages. Our car will contain a device which will collect the data of the sensors readings and it will detect the road anomalies and saves its location to alert the vehicles that will pass on this location later. Also our car will have a dual camera that helps the car to behave according to depth map distance between our car and the other cars. Also we will use Support Vector Machine algorithm to classify the readings of the road conditions from the sensors and use CNN to classify the images we of the road lanes and train the algorithm on them.

## 1 Introduction

### 1.1 Background

Technology evolution is developed every day. Now science fiction becomes true as we invented a Self-Driving car. The main idea behind this creative invention is that the car which is operated by a computer is somehow could be safer and improve safety conditions. It's hard at first to convince people that having a Self-Driving car is safer, they cannot imagine how can I trust a machine to keep me safe? Actually, majority of accidents are caused by human error. On the other hand, a Self-Driving is purely analytical that it acts exactly like a smart computer there is no emotions involved and there will not be any distraction while driving because computers simply are faster and smarter to take the right action than our mind. As a result, a future full of self-driving cars will be

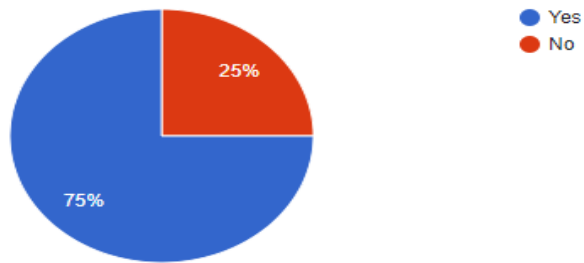
a safer one. A Self-Driving car contains a variety of sensors to perceive the surroundings areas, lanes and objects. These sensors also identify appropriate navigation paths and take the lead in driving during the whole ride. A Self-Driving car. Road accidents are the worst thing that could ever happen while driving, although they happen quite a lot. A study was proven that a Self-Driving car decreases the rate of road accidents and could save over half a million lives each decade [1]. When driving with a high speed on an unfamiliar road this may cause accidents due to road anomalies that are not seen. A speed bump is one of the road anomalies that considered to be a device that is designed to slow down vehicles to improve safety conditions. A speed bump is a double-edged weapon, as it can cause the vehicle to flip over and lead to an accident if it was not seen by drivers and traversed by a high speed. A Self-Driving car has the ability to detect road anomalies such as speed bump and pothole on any road which are sometimes difficult to be detected or seen by drivers therefor a Self-Driving car has the ability to maintain safety for drivers. A Self-Driving car is considered to be an eco-friendly as it is a clean vehicle that reduces air pollution and moves with electricity [2]. Our project idea is to implement a Self-Driving car that will be able to detect the road anomalies and drive automatically by itself deciding the right actions to be taken to avoid any crash and take the whole control of the car. The main purpose behind that is to improve safety on roads and somehow decrease the rate of road accidents.

## 1.2 Motivation

According to studies from National Conference of State Legislatures (NCSL), it's obvious that self-driving and autonomous vehicles in general is begging to take a huge place in the market, also car and technology companies have been discussing this topic for years as it promises of life changing safety and ease. Due to statistics from NCSL, it's proven that the number of states considering legislation related to autonomous vehicles has been increased each year as since 2012 41 states and D.C. have considered legislation related to autonomous vehicles. Also twenty nine states including Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Michigan, Mississippi, Nebraska, New York, Nevada, North Carolina, South Carolina, Tennessee, Texas, Utah, Virginia, Vermont, Washington and Wisconsin have enacted legislation related to autonomous vehicles. It's also proven that in 2017, 33 states have already introduced autonomous vehicles legislation and in 2018, 15 states already enacted 18 autonomous vehicles related bills. Studies also show that bus drivers are more exposed to health risks cause of repeatedly riding over speed bumps which makes speed bumps count as a death hazard [3]. Due to these studies that shows that accidents are happening a lot , that road anomalies can be common reasons of car crashes , vehicles accidents, and car damages and that self-driving idea is becoming something that is being used in the streets these days, We propose a self-driving car that behaves according to road state and surrounding vehicles state.

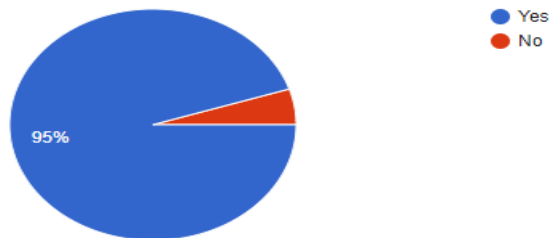
هل تعتقد ان المطب الصناعى يزيد معدل الامان؟  
Do you think that speed bump improve safety?

60 responses



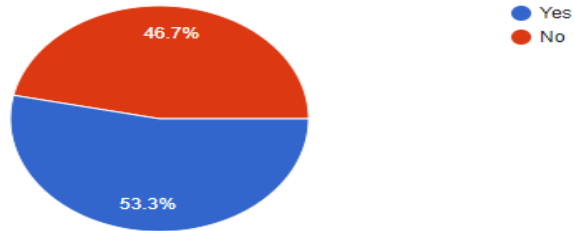
هل ترغب بجهاز استشعار بالسيارة يقوم بتنبيهك قبل ان تمر على المطب الصناعى؟  
Would you like a sensor device in your car to alert before passing by a speed bump?

60 responses



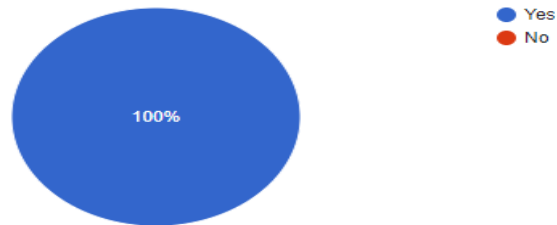
هل كنت مشتت الذهن اثناء القيادة و تسببت في سلوك غير طبيعي بسبب استخدام الموبيل\الراديو .. الخ ؟  
Have you ever been distracted while driving & causing abnormal behavior due to using phone/radio..etc?

60 responses



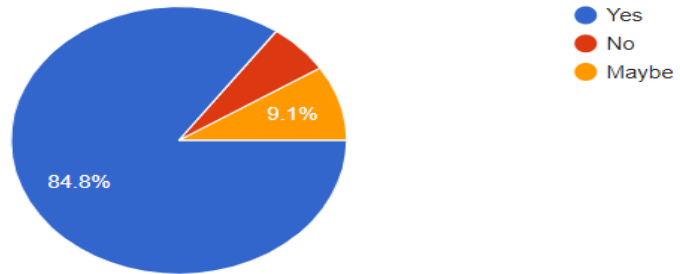
هل تصميم المطب الصناعى الغير محترف طويل\عريض او زاوية خطأ يسبب ازعاج للسائق؟  
Does poor-designed speed bump that are too tall/wide or with incorrect angle may disturb drivers?

60 responses



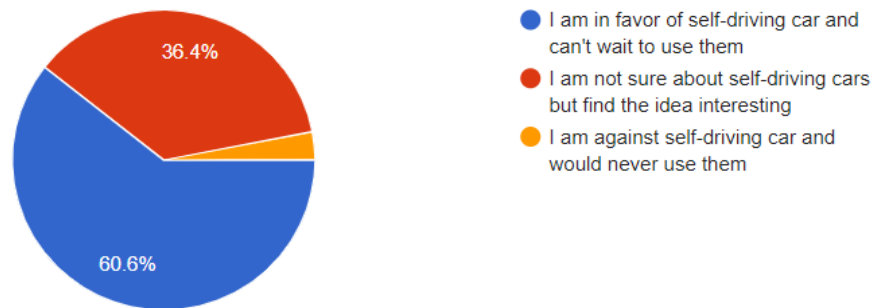
## Do you like to be given a chance to try self-driving car ?

33 responses



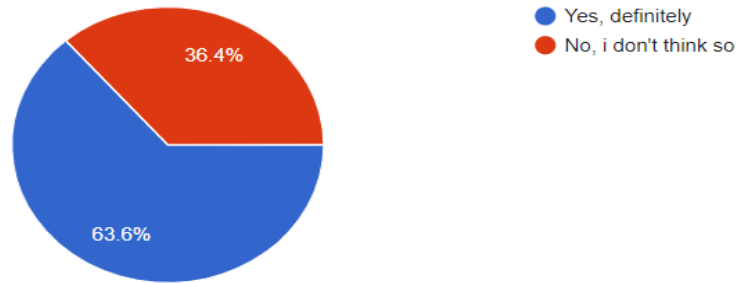
## What's your opinion about self-driving car

33 responses



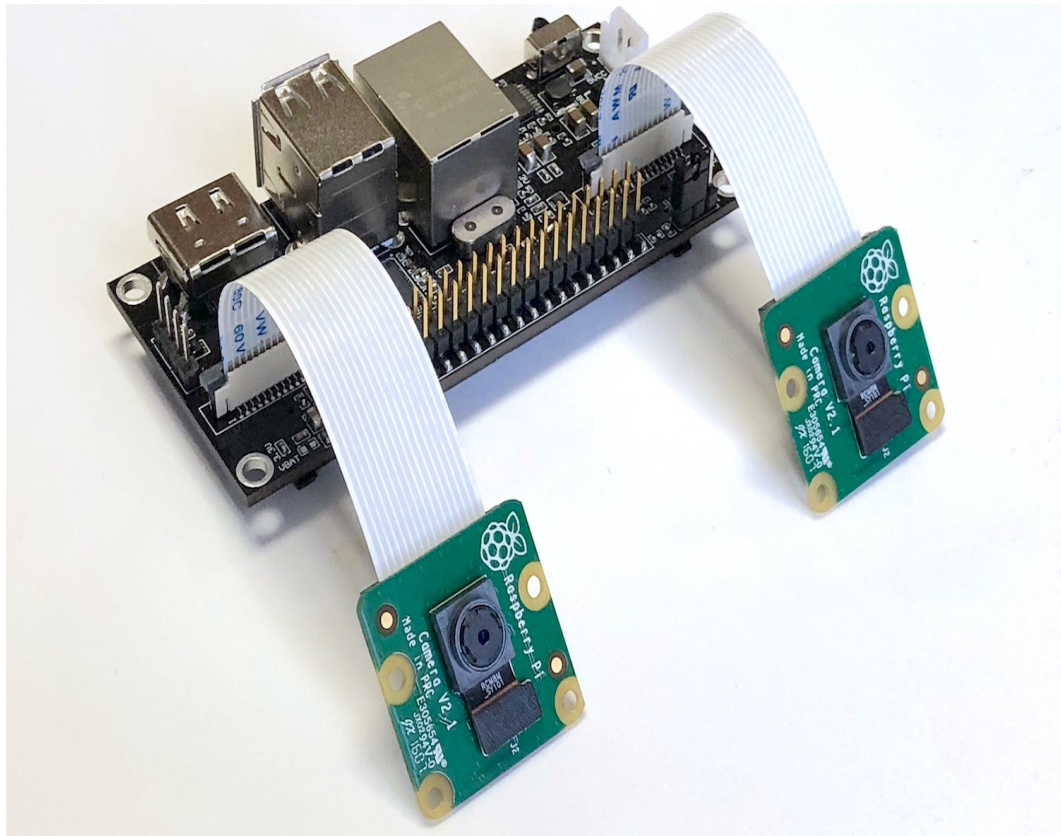
## Do you think that self-driving (autonomous) cars are safer than normal cars

33 responses



### 1.3 Problem Definition

We have some challenges that this project will solve. Our car will be a full self-driving car that takes different decisions based on road condition as it will slow down the speed or change lanes automatically if it passed by a bump or an anomaly using Gyroscope, Accelerometer and GPS to detect these anomalies, also it takes decisions based on the surrounding vehicles condition by detecting the depth map between the vehicles in front of it and moves , brakes or change lanes based on the distances between the vehicles in front of it using stereo vision cameras. We will focus on developing an autonomous car with these functions as it will be a good addition in the self-driving field and help autonomous vehicles to achieve more safety to the vehicles themselves.



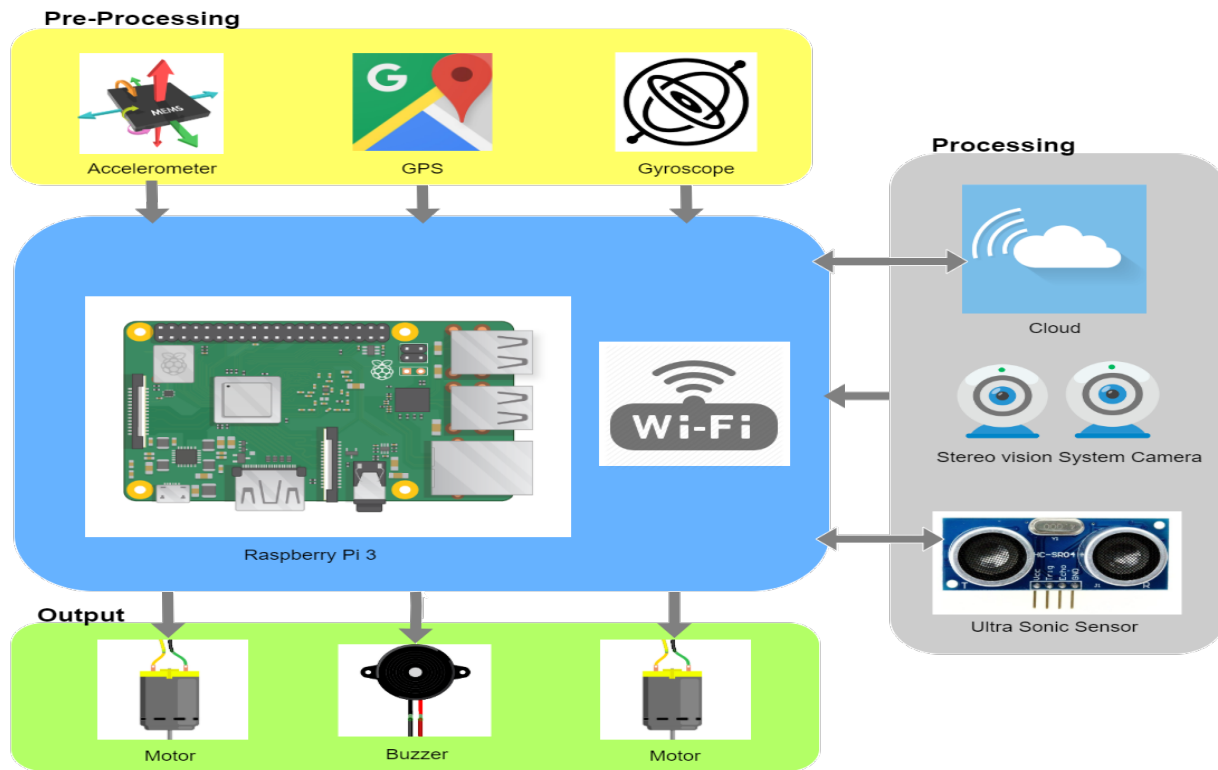
## 2 Project Description

Developing a self-driving car that takes multiple decisions based on certain conditions.

### 2.1 Scope

- The Car will detect the distance between the vehicles in front of it.
- The Car will detect speed bumps.
- The Car will detect potholes.
- The car will change lanes or brakes based on road condition and cars going with it.
- The car will save road anomalies coordinates and alert other devices when they pass on same location later.

## 2.2 Project Overview



Reprocessing:

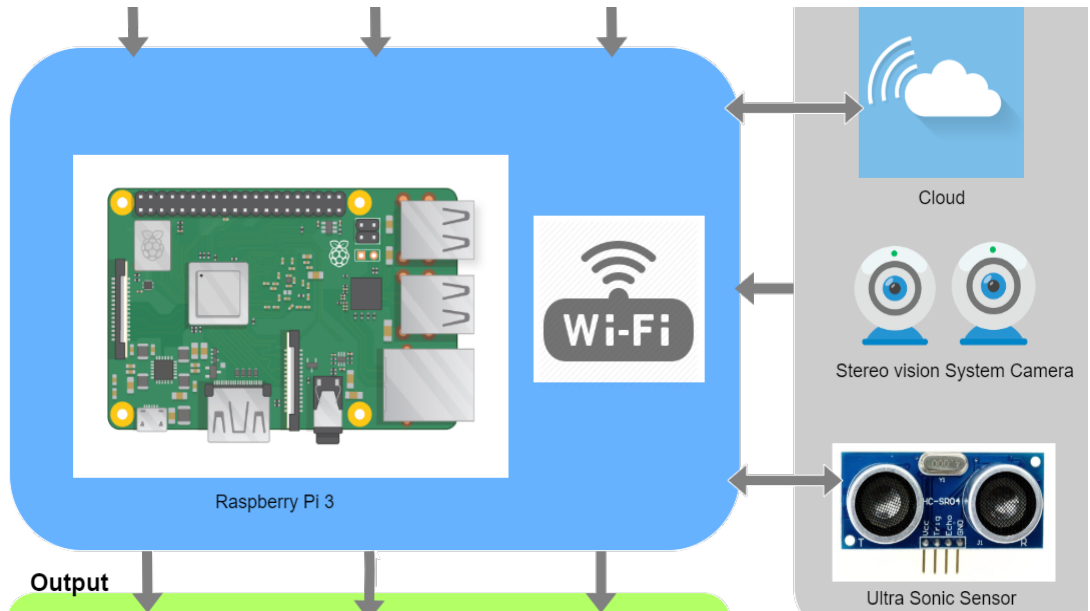


## Pre-Processing



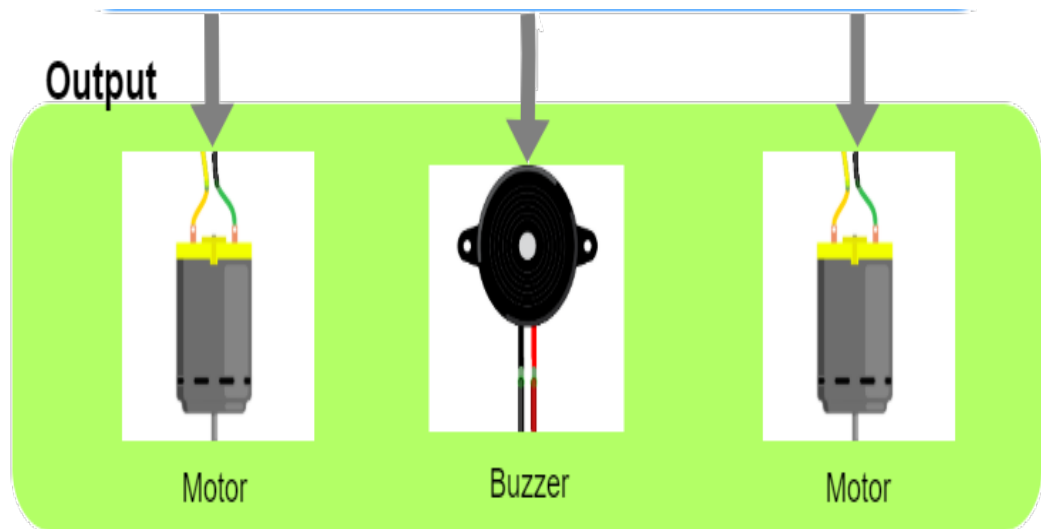
- Get sensors reading (Accelerometer, Gyro GPS , ultra sonic)
- Filtering the readings from the sensors to remove the noise
- Getting images from stereo vision camera

## Processing



- Uses SVM as a better algorithm than KNN to classify sensors reading according to comparison between KNN and DTW[4] in the driving behavior classification that proved that KNN achieved higher accuracy.
- Uses CNN to classify images from dual camera.
- Bumps and holes locations will be stored in cloud to use it later.
- Uses ultrasonic to help sensors reading in anomalies data.
- Uses stereo vision to measure distance between vehicles and obstacles through disparity map.

Output



- Car alerts the driver that there is an anomaly through buzzed
- Car slows down or changes lane before any detected anomaly.
- Car avoids crashing with any obstacle in its way using stereo vision

### 3 Similar System Information

In this system[5], an approach on captured images using ant colony optimization on Canny for edge detection then applying few processes on them which are (1) Resizing image , converting the image to grayscale , separating the background , Reducing the noises on the image, applying canny edge detector then Ant colony

optimization. These processes with the help of the algorithms used helped the system on capturing a clean images of only road lanes to classify them which helped in achieving high accuracy in detecting road lanes.

The paper[6] discusses the evolution in computer vision and how it has grown that now it is easy to develop a self-driving car using deep learning. YOLO (You Only Look Once) which is a real-time CNN method that was used to implement this project. This method is implemented to detect other objects from images. They also used a road lane detector which detect road track from the video frame. After collecting this information, they are passed to the controller which integrate both of the data (objects and lanes) to help the self-driving car to make it 's own right decision-making process.

Another Similar system[7], is a developed a sequential end to end learning method to estimate left and right ego lanes directly and separately without any post processing. In this system point detection problem was redefined as a region segmentation. Also they constructed an extensive dataset that is suitable for deep neural network training by collecting different road conditions, annotating ego lanes and augmenting them. It was mentioned also it was mentioned that higher accuracy of ego lanes estimation was achieved when more iterations on the algorithm were done. Also Grand Theft Auto 5 video game was used during dataset collection of roads to collect some types of ego lanes dataset.

[8] A device which is a smartphone that uses a three axis accelerometer of an android based smart phone and the GPS of the phone to record and analyze the driver behavior and road conditions that could be hazard. The device purpose is to alert the drivers and increase their awareness to maximize their safety. The device is not only identifying potholes but also bumps, rough, uneven and smooth roads using only the accelerometer. Undefined classification algorithms are used to predict driver's overall skill derived from some driving conditions like lane changes and steering control. Also it was mentioned that using a multiple axis classification method for bumps increased the bump and pothole classification accuracy. They also obtained an 85.6 percent accuracy for road anomaly classification.

[9] There are two Aims in this paper, the first one is automated driving during traffic jam, the second one is (to make dynamic destination) following another car that is familiar with its destination by continuously receiving its direction/location. So in this paper vehicles are smart enough to take intelligent decisions in as little time as possible and vehicles can determine the distance from another vehicle/obstacles. Also in this project there are many sensors used for example: ultrasonic sensors are used to avoid obstacles, GPRS module to gets the route and move in this path and most importantly mobile robot is used in this project to be as a small demo for vehicle and to put all the hardware components on it. All these things are made only to make the driver more relaxed while driving his own vehicle.

Detection of potholes using mobile sensing system(Android)[10], this paper collects 90 percent data from real world. It is such a layer in navigation system to helps users to detect the pothole with limited hardware and software resources. The aim of the project is to make an automated system without any interaction

of humans, detection of potholes and report to government to repair roads as necessary. In the proof of concept, accelerometer was used at the beginning then microphone was also used from android smartphone to recognize the sound when the vehicle passes on a pothole. Some algorithms were used in this system like z-thresh, z-diff, STDEV and then the most important algorithm the g-zero. The system reached an 90 percent accuracy and above.

Li, Chaocheng amp; Wang, Jun amp; Wang, Xiaonian amp; Zhang, Yihuan in [11] creates a new algorithm called path planning. This algorithm used to determine the shortest trajectory in dynamic environment while there are complex multi obstacles in this path. Also this algorithm is generating online trajectory. In case of nearby collision, the self-driving car take the right decision to avoid this collision by taking any other suitable lane.

This paper[12] analysis the greatest technology and artificial intelligence in the future and how humans will benefit from it. They implemented a self-driving car prototype using deep neural network/CNN on a raspberry Pi 3 model B. they had the ability to make their own data set and collect these data and information. They made an oval artificial path outdoor with an 8 shaped traffic signs and using the camera they took images as data. The steps were to train these data and then move on to the test experiment. According to the output or final result the self-driving car prototype makes it 's own decision and take the right action to move forward/backward/stop etc..

### 3.1 Similar System Description

In the past years there are many projects and papers related to our proposed project but most of them have different conditions of collecting the data set, different software and hardware components and also with different algorithm so each paper has it's own accuracy and its own results depending on things used in it. Also all of the projects /papers didn't put road anomalies in considerations when designing the autonomous vehicles or algorithms to help self-driving cars .SVM algorithm was used in some projects to work on data from sensors readings like gyroscope and accelorometer which affect the accuracy and increase it be 95.36 percent, also CNN was used in classifying images with high accuracy so these two algorithms are what are we are using in these two fields of our project.

### 3.1.1 Comparison with Proposed Project

Points of comparison	Self-driving and driver relaxing vehicle	Real-Time Self-Driving Car Navigation Using Deep Neural Network	Real-time Pothole Detection Using Android Smartphones with Accelerometers	Our Proposed System
Sensors	GPS GSM <u>UltraSonic</u> Compass	Raspberry Pi 3 Arduino UNO Camera RC Scale <u>Adafruit Driver</u>	Accelerometer Microphone	Gyroscope Accelerometer GPS Ultrasonic Stereo Vision (External sensors)
Algorithms	Not Mentioned	CNN	Z-thresh Z-diff, STDEV G-zero	SVM CNN
Accuracy	Not mentioned	Not mentioned	Above 90%	----

## 4 Project Management and Deliverable


### 4.1 Tasks and Time Plan


Task Name	Start Date	End Date
Information Gathering	15/9	30/9
Survey and Proposal	1/10	8/10
Proposal Presentation	9/10	9/10
Data Set Collection	1/10	8/10..
Implementing Prototype	1/10	8/10
SRS Document	1/12	15/2
SRS Evaluation	16/12	16/12
SDD Document	10/2	28/2
Implementing Device	1/10	1/3
Validation and Testing	2/3	6/3
Final Presentation	20/5	20/5

## 4.2 Budget and Resource Costs


Item	Quantity	Cost
Arduino Uno Board	1	145LE
ESP32S	1	275LE
Arduino battery connector	1	20LE
MPU6050 - ORIGINAL	1	95LE
2WD ROBOT CAR	1	175LE
BATTERIES	1	90LE
L298N Motor Driver	1	65LE
BLUETOOTH HC-05(ZS-040)	1	125LE
Wires	1	30LE
StereoPi	1	2707LE
Total Cost		
3727LE		

### 4.3 Supportive Documents


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 ResearchGate

**Dataset request** [Report message](#) [Block user](#)

 **Sara Fouad** 4 days ago

Dear ms Semiha,  
I hope everything is fine with you today ...  
This is Sara Fouad; Senior Student, Computer science Fourth Year  
Kindly I am requesting to send us your dataset of this paper "Estimating driving behavior by a smartphone" this dataset will help us in our graduation project as your paper is such a useful reference Thus, I am asking for your permission to send us the dataset  
Really appreciate your understanding and assistance in this matter ...  
Best Regards,  
Sara Fouad

 **Semiha Makinist** to you 10 minutes ago

Hello Sara,  
Thank you for good wishes.  
I don't have its dataset now, because I don't work in that job. I will ask my teacher for you. I hope he sends it to me.  
Good work,  
Best Regards,



## Data-set Request Add label



**Mahmoud Mahm...** 5 days ago

to wodoo2474, jiadiyu, yzh... ^



**From** Mahmoud Mahmoud  
Ahmed Fathy Ali Hassanein •  
mahmoud1611910@miuegypt.edu.eg

**To** wodoo2474@sjtu.edu.cn  
jiadiyu@sjtu.edu.cn  
yzhu@sjtu.edu.cn  
mlli@sjtu.edu.cn  
yingying.chen@stevens.edu

**Date** Oct 1, 2019, 18:58

[View security details](#)

Dear Doctors,

I'm a computer science senior student at Misr International University and im working with my team on a graduation project that is related to the paper you have published earlier in 2015 that's name is "Abnormal Driving Behaviors Detection and Identification Using Smartphone Sensors".

I kindly want to ask you if we can have the dataset of the sensors features that you have collected using the mobile sensors to identify the patterns of the driving behaviors as it will really help us and save us some huge time collecting these data by ourselves.

Thanks in advance.

Best Regards.



12:35 .ll 21.0 KB/s

51



## Graduation Request Inbox



**Omar Omar Ismail Mohamed...** Oct 8

Dear Mr.Ahmed , we are senior student at misr international university faculty



**Ahmed ABDELRAHMAN** 6 days ago

to me ▾



Dear Omar,

It seems to me that you have a nice applicable GP idea.

I will forward your proposal to the responsible person in Valeo Egypt.

I wish you all the success .

Best Regards,  
**Ahmed Abdelrahman**

Principal Firmware Engineer  
Testing and Tooling Excellence, CDV  
☎ +20-2-35328042



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## 5 References

- [1]<https://www.forbes.com/sites/danielaraya/2019/01/29/the-challenges-with-regulating-self-driving-cars/344833a6b260>
- [2]UCSUSA 'https://www.ucsusa.org/resources/vehicles-air-pollution-human-health.V4RMkZMrJE4' Jul 18, 2014
- [3]National Conference Of State Legislature 'http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx' 10/9/2019
- [4]Hamdy, Aya Atia, Ayman Mostafa, Mostafa-Sami. (2017). Recognizing Driving Behavior and Road Anomaly using Smartphone Sensors. *International Journal of Ambient Computing and Intelligence*. 8. 22-37. 10.4018/IJACI.2017070102.
- [5] Daigavane, Manoj Bajaj, Preeti. (2010). Road Lane Detection with Improved Canny Edges Using Ant Colony Optimization. 76 - 80. 10.1109/ICETET.2010.128.
- [6]Nugraha, Brilian Su, Shun-Feng Fahmizal,. (2017). Towards self-driving car using convolutional neural network and road lane detector. 65-69. 10.1109/ICACOMIT.2017.8253388.
- [7]Kim, Jiman Park, Chanjong. (2017). End-To-End Ego Lane Estimation Based on Sequential Transfer Learning for Self-Driving Cars. 1194-1202. 10.1109/CVPRW.2017.158.
- [8]Fazeen, Mohamed Gozick, Brandon Dantu, Ram Bhukhiya, Moiz Gonzalez, Marta C.. (2012). Safe Driving Using Mobile Phones. *Intelligent Transportation Systems, IEEE Transactions on*. 13. 1462-1468. 10.1109/TITS.2012.2187640.
- [9]Q. Memon, M. Ahmed, S. Ali, A. R. Memon and W. Shah, "Self-driving and driver relaxing vehicle," 2016 2nd International Conference on Robotics and Artificial Intelligence (ICRAI), Rawalpindi, 2016, pp. 170-174. doi: 10.1109/ICRAI.2016.7791248.
- [10] Mednis, Artis amp; Strazdins, Girts amp; Zviedris, Reinholds amp; Kanonirs, Georgijs amp; Selavo, Leo. (2011). Real Time Pothole Detection Using Android Smartphones with Accelerometers. 1 - 6.10.1109/DCOSS.2011.5982206.
- [11]Chaocheng Li, Jun Wang, Xiaonian Wang and Yihuan Zhang, "A model based path planning algorithm for self-driving cars in dynamic environment," 2015 Chinese Automation Congress (CAC), Wuhan, 2015, pp. 1123-1128. doi: 10.1109/CAC.2015.7382666
- [12]T. Do, M. Duong, Q. Dang and M. Le, "Real-Time Self-Driving Car Navigation Using Deep Neural Network," 2018 4th International Conference on Green Technology and Sustainable Development (GTSD), Ho Chi Minh City, 2018, pp. 7-12.