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Self Driving Car Using Image Processing and Neural Networks

[1]Anirudh.J, [2]Chaitra.B, [3]Ayush.V, [4]Anup Ranjan Sabat, [5]Aushij Singh

[1,3,4,5]UG Student, [2]Professor
[1,2,3,4,5]School of Computing and Information Technology, Reva University,
Bengaluru, Karnataka, India
[1]anirudhjeevan1999@gmail.com, [2]chaitra.b@reva.edu.in, [3]ayush.v.gowda@gmail.com,
[4]ranjananup76@gmail.com, [5]aushijsingh.suryavanshi@gmail.com

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Abstract

The main idea behind the entire self driving car is to make the travelling between any given places easier, safer and hassle free. The amount of self driving cars that are being developed around the world is increasing at a rapid rate. We have made it possible by using hardware such as RaspberryPi, Arduino Uno, L293H motor drivers, car chassis kit and PCB. The software which we are using are Arduino IDE and Raspbian OS. OpenCV and Neural Interface are some of the packages that are used. The car that we are developing can perform the following features stop sign detection, lane detection, traffic light detection and changing the lane if an object is present in front of it. The self driving car can should be used everywhere as this car reduces the amount of pollution that is happening around the world.

Keywords: *Self Driving Cars, Raspbian OS, Arduino IDE, OpenCV, Neural Networks, Haar cascade*

1. Introduction

Rushing around, trying to make mistakes, worrying about the stuff to buy from the nearest grocery store has become part of our daily life. Driver error is one of the most common causes of traffic accidents and it's not likely to go away with cell phones, in car entertainment systems, more traffic and more complex road systems, as the number of injuries rises by the day. Taking over the human errors and helping mankind has become significant. All of this could end with self-driving cars that only need to know the destination and then let the passengers carry on working. This will not only prevent injuries, but will also provide self-relief for limited day-to-day driving tasks for small things.

Self-driving vehicles are developments in automotive technology. Since many years, some people are using their private cars because of inconvenience of public transportation. The traffic issue was arising due to such a large number of vehicles on roads. Traffic laws are designed to address this traffic problem. However, disobeying these traffic laws causes accidents and there would be maximum accidents due to errors made by human. To reduce these accidents and to improve safety transporta tion we require Self-Driving Cars. Self-Drive technology is one of the most necessary innovation in the automotive industry. If we will able to implement this technology and have total control over it, then it can result in large benefits for both individuals & society. In future Self-Driving Cars will consist of maximum number of cars on the roads due to its benefit to the society. Millions of people have lost their lives or have become disabled worldwide as a consequence of traffic accidents. This project aims to build a safe Self-Driving car that could benefit millions of people every year. Unfortunately, in the next coming years the number of lives lost each year will likely be doubled if there are not much Self-Driving cars on roads. To avoid such problems, we have to move towards Self-Driving Cars.

A scaled down version of self-driving system using a RC car, Raspbian OS and Open Source software. The system uses a Raspberry Pi, Arduino Uno with a camera and image processing as inputs for lane detection with a processing computer that handles steering, object recognition (stop sign) and distance measurement.

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2. Related Work

1. Self-Driving Car research analysis requires several fields that need to be discussed more deeply. Such as Neural Networks, Computer Vision, Lane Detection, Traffic light, Stop Sign Detection. All of them are fusion of several spheres of research. This paper discusses the "Implementation of Lane Detection Algorithm for Self-Driving Car using Python Language" [4] whose result shows this algorithm needed to add some method that can change the parameters during day and night adaptively and accordingly to its driving environment.

2. Self-driving cars have been one of the most anticipated technologies in the area of Artificial Intelligence and Neural Network research, which could be the greatest technological revolution of the near future. There are several technologies making up a self-driving vehicle - image processing, computer vision, machine vision, laser, radar, GPS, etc. There are already several relatively low-cost RC-car based prototypes, such as MIT's Race Car and U Penn's F1/10 race car. Emboldened by these positive results, in this paper, "Real-Time Self-Driving Car Navigation Using Deep Neural Network" [5], using neural networks we developed a self - driven car to detect lanes, Stop Sign and Traffic Lights.

3. In this paper, "Self Driving Cars: A Peep into the Future" [1], how self-driving cars (otherwise called a driver less vehicle, auto, an independent vehicle, automated vehicle) are vehicles that are equipped for detecting their conditions and exploring without human information. Self - driving vehicles route increase expanding significance in different developing application regions. They utilize an assortment of systems to distinguish their environmental factors with the assistance of different sensors on-board, and PC vision. All through the previous decade, we have seen perhaps the best walk in car innovation with the emphasis on self-ruling autos. As of late self-driving autos are coming up in the news, however the specialists have been trying different things with self-driving vehicles for more than 4 decades.

4. The generation-x of millennia's had started a new race, of which little has been heard so far. A race that might take over unprepared all the drivers of the present millennia's and future ones of this planet. This assumes the control of the steering wheel will be given not to another person, but to an electronic "brain". The implementation of powerful computation units has become more and more of a necessity in automotive safety and in the beginning of autonomous driving. The goal of this paper, "Smart traffic sign detection on autonomous car"[2] is to build a prototype of a self - driving car which can detect traffic signs by combining intelligent cameras with radar sensors, information being processed by open computer vision software.

5. The presence of traffic lights in urban environments should not be ignored by researchers that are advancing their driving assistance systems or working in the field of autonomous driving. In order to achieve this goal Mahesh & Satish Kumar have proposed in their paper, "Real Time Traffic Light Detection by Autonomous Vehicles using Artificial Neural Network Techniques", [3] which calls for the development of a self - driven car that can detect the presence of a traffic light, classify the traffic light accurately and guide the autonomous vehicle to take the correct and essential action with respect to the detected traffic light.

3. Methodology

1. Software And Hardware Requirements

- Raspberry Pi
- Arduino Uno
- Raspicam 2
- Raspbian OS
- Arduino Uno
- Haar Cascade
- Open CV
- L298H BRIDGE

• L298H BRIDGE

The L298h bridge has 6 pin header that is mainly used to connect the DC motors of the car. The left side DC motors of the car is connected to the left side of the Edge Bridge and vice-versa. The edge bridge is mainly used to control the speed of the car. A 6 male to female jumper wire is taken and the wire is connected from the L298h edge bridge to the Arduino Uno.

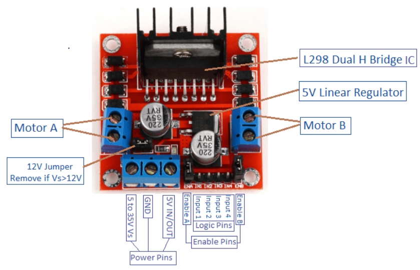

Figure 1: L298HBRIDGE

• ARDUINO UNO

The Arduino Uno is a microcontroller which has 20 digital input/output digital pins. The other side of the male to female jumper wire is connected to Arduino Uno. The Arduino Uno is powered with help of the custom built PCB. Based on which pins we connect the left side and right side motors we have to give the same pin numbers in the Arduino IDE.

Figure 2: ARDUINO UNO

- **RASPBERRY PI 3B+**

The Raspberry PI 3B+ with 1.2GHz 64 bit quad core processor. This is a model which has both Wi-Fi and Bluetooth capabilities. When we connect the Raspberry Pi to the internet we get the Raspbian operating system. A Raspicam is placed on the Raspberry Pi. With help of the Raspicam we take all the images. All the required code for the self driving car is done on the Raspbian OS.

Figure 3: RASPBERRY PI 3B+

- **ARDUINO IDE**

In the Arduino IDE the complete coding for the movement of the car is done here. The pin numbers that we mention in the Arduino IDE should be the same pin numbers that we connect in the car from the L298H Bridge to the Arduino board.

Figure 4: ARDUINO IDE

- **OPENCV**

OpenCV is an open source computer vision and a machine learning software library, it is one of the main libraries that is used for image processing. The main use of the OpenCV library is that with help of this library we can do lane detection and stop sign detection.

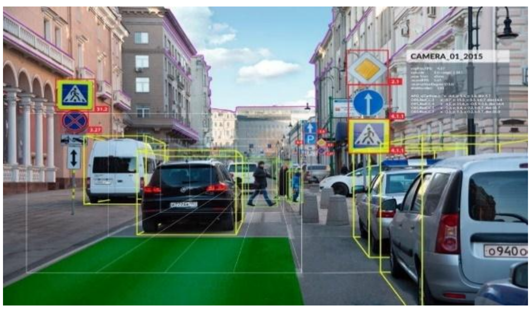

Figure 5: OPENCV

- **HAAR CASCADE**

Haar Cascade is a machine learning program which is generally used for neural networks. The Haar Cascade compares the positive and negative samples of the image captured by the camera. The software that is used for comparing the images is known as Cascade Trainer.

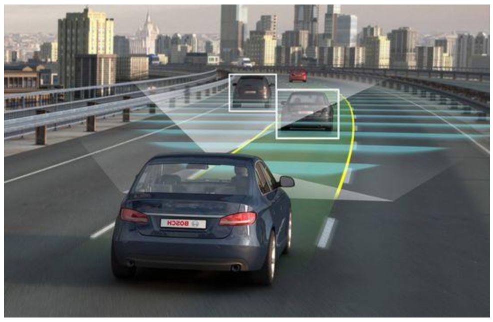

Figure 6: HAAR CASCADE

- **RASPICAM 2**

This is used to display the feed live in front of the car and to capture photos of the stop signs and road lane over which the Raspberry-Pi later processes this. The Raspberry-Pi is linked via a 15 cm ribbon cable. It supports 1080p30, 720p60, and VGA90 display mode.

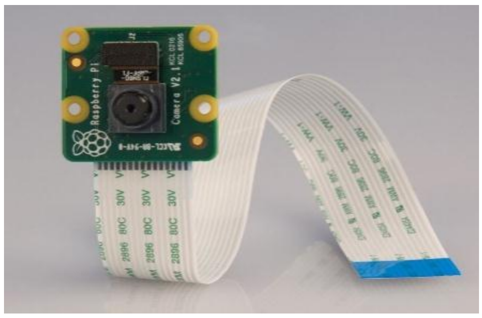

Figure 7: RASPICAM2

2. System Design and Implementation

The fig that has been showed below is the basic idea about how the Self driving Car is going to work. Firstly what happens is that when we turn on the car the car turns into an autonomous car and when the car moves in the desired lane if it encounters an object present in front of it the car automatically changes the lane. Secondly what happens is that when the car encounters a stop sign the camera present on top of the car compares with images that we have already placed in the memory if both the images match then the car stops else it doesn't. Explaining briefly the raspberry-pi and the Arduino Uno which are the central controller would be mounted on the car, whereas the pi-camera module would be placed on the car roof. The motor-driver ICs are responsible for motor operation and therefore movement of the car. The pi-camera module mounted on the car's roof serves as an eagle eye vision that is used to detect any obstacle in front of the

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car and take actions accordingly. If there is an obstacle in front of the car and it is within the specified distance from the vehicle, the raspberry-pi orders the motor driver ICs to avoid supplying the power to the wheel and changing of lane takes place to avoid the obstacle. The next step is to follow lane and stop sign detection, for these we use the image processing principles. HAAR cascade classifier was used in Open CV for detection of the stop signs. As we know, Open CV offers a detector along with classifier. We uploaded both positive and negative images of the data (stop sign) to successfully trigger the HAAR-cascade. The positive image would be the image of the target data to be identified and the negative image would be the area of interest of the pictures, thus defining the stop signs. The area of concern is primarily the stop sign bounding enclosure. Using the fundamentals of machine learning, the module is trained on feeding the required and correct data. When the training is completed, the lane monitoring, stop sign decisions are carried out during the run on the track with the use of neural networks to provide the vehicle with undisturbed motion.

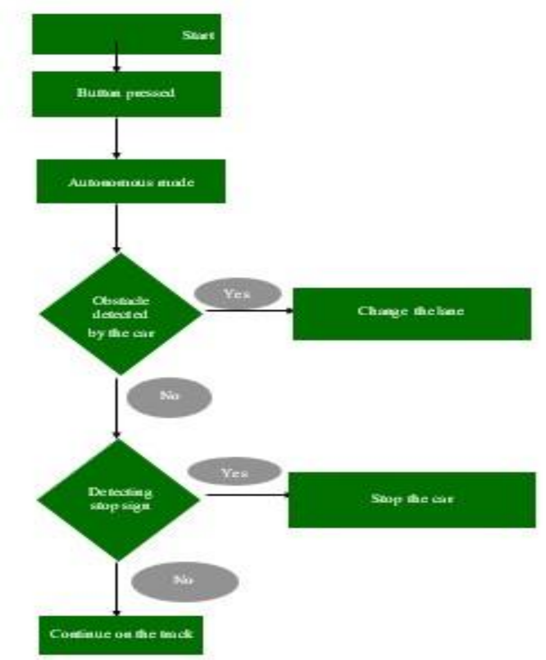

Figure 8: Flowchart of the basic working of self driving car

3. Software Implementation

- **Stop Sign Detection**

The detection of Stop Sign by self-driving car is implemented by using OpenCV as the software engine and Raspberry Pi as the hardware component respectively. Haarcascade algorithm is a machine learning algorithm used for detecting the stop sign. Firstly we create a stop sign and take all the possible positive samples of the stop sign. We need to also take the negative images of the stop sign and then we compare both the. For cascading training we use a software called as cascade trainer. In the cascade trainer we add all the positive images. The cascade trainer is used to crop the stop sign so for all the positive images and is saved in a folder. Using the cascading trainer we compare the cropped positive images and the negative images after comparing is done we get an xml file. The xml file is transferred to Raspberry Pi. A specific distance is measured from the car to the stop sign at which the car should stop. With the help of the equations y=mx+c we have to calculate the value of the slope and the y intercept. Later on we have to program the Arduino Uno such that the car has to stop at the distance that has been calculated so both the left and the right motors we have enabled it to zero. We have also specified a delay in the Arduino IDE to basically stop the car for the required number of seconds. With the help of a decimal value the Raspberry Pi and the Arduino Uno communicate on when to stop the car.

- **Lane Detection**

Lane detection is one of the most important features that a self-driving car should follow. Firstly what we should do is that is the image that we receive from the camera is in BGR color space and we should convert this to RGB color space. Next we have to create a region of interest so that the car can move in the specified lane and this can be done by making 4 points. Later on depending on how our track is made we can do the calculate all the 4 points. Next what we should do is perform perspective wrap or also known as bird's eye view. We use cv2.getperspective and cv2.wrapperspective to perform bird's eye view with given x and y points. We convert the given image into grey scale image as it will be helpful in canny edge detection. So next what we do is that we do canny edge detection. Canny edge detection is a method by which we can detect the edges and with help of Gaussian filter we reduce the noise and remove the unwanted details. Using the concept of histograms, we find the exact lane positions and we also use the concept of region of interest. The car is made is made to run in the center of the track. The Raspberry Pi and the Arduino Uno is connected via cables and the link is between them on what action to perform according to the decimal numbers.

- **Changing of Lanes the Self Driving Car**

Changing the Lane from one lane to another should be done depending on the speed or whether there is a vehicle present in front of it. In this project we are changing the lane when a vehicle is present in front of it. Firstly what we do here is we take all the positive images as well as negative images of the vehicle present in front of self driving car. Crop all the positive images using the cascade trainer and save it in a file. Using the cascading trainer we compare the cropped positive images and the negative images. This creates an xml file which should be

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transferred to Raspberry Pi. Next we have to calculate the distance at which the car should change the lane when it encounters another car. So as we are using the Arduino IDE to change the lane so before it changes the lane it stops and then changes the lane and it comes back to the same lane. A given amount of delay is specified to the car for which it has to stop and then change its lane. The pi-camera module plays a major role in changing of lane using image processing as it creates a trajectory path which the self-driving car should follow in order to avoid collision with the object. When it comes to changing of lanes both longitudinal speed and lateral lane change decision need to considered.

4. Experimental Results

The car equipped with the core device like Raspberry Pi, interfaced with a camera will stream the video as a local host to the Computer. Commands are sent serially to the Arduino to run the car, based on the identification such as pedestrians, vehicle or road signs. Since Raspberry Pi does the process of streaming video to the machine, therefore the control commands are sent from the Raspberry Pi to the Arduino for operation of the vehicle. Hence while driving, the camera interfaced with the vehicle also observes some of the parameters of the lane detection with the help of image processing, if it detects these parameters it is recorded and the car shifts by the parameter by helping the vehicle follow the lane accordingly. The vehicle is tested under different circumstances to overcome its system errors and to bring about its optimistic use in the society.

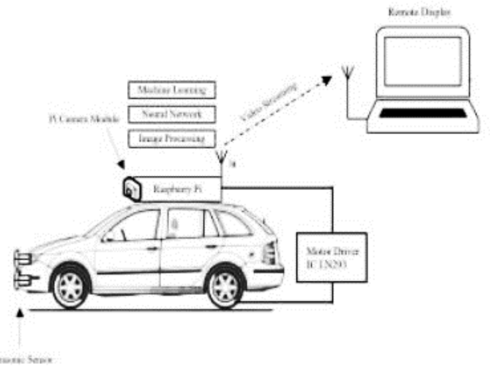

Figure 9: Block Diagram

5. Future Enhancement

Automation of Vehicles will change the lives of everyone who use a vehicle. It'll improve the quality of life, it will increase roadway safety, and it will overall improve a significant portion of the transportation sector. Cars today have proven that level 1, 2, where the car can do some automated functions, but the motive force always has to pay attention. There are already vehicles on the market at level 2 automation i.e. vehicles with an autopilot feature that monitors safe distances and changes lanes if necessary to keep speed. Reaching the highest level 5, will rely upon a lot of external factors. And these completely autonomous vehicles will take several decades to reach the overall public. Moreover the car manufacturers are trying to incorporate connected self-driving vehicles that are completely independent of infrastructure in level 5.Conclusively, it is about trying to grant roads the appropriate catalyzing capabilities of self-driving vehicles so that they'll reply to new needs. The final goal is to carry out more efficient use of infrastructure, improve the protection and luxury of users, and pave the way for the revolution in self-driving cars.

6. Conclusion

In this paper it explains the various components of the hardware and their assemblies. The program will recognize the traffic sign, and stop sign. It uses camera to measure the exact location of the car on the lane, where the roadside is, and even in the absence of traffic signs, to suggest a new route. A novel approach is described in details based on OpenCV to assess the rough, marked or unmarked road edges. In the automation industry, the Self-Drive car will certainly prove to be a blessing and would be compared to other conventional techniques. They may be used to patrol and capture offender's photos. The accidents caused by the carelessness of the goods carrier vehicles will be minimized, because they would not need any drivers, which will ensure improved logistical flow. Public transport buses would be regulated more because of minimal errors. Thus, because of greater autonomy and efficiency, a Self-Drive car of this nature can be practical and is highly beneficial for better regulation in the section of the goods and movers of people. The use of this Self-Driving Car is for agricultural, military, transportation, civil, defense, and commercial use. Self-Drive car provides the non-drivers with autonomous independence, eliminates driving discomfort and tedium. The algorithm described in the paper was implemented with success on a small Self-Driving car.

7. Acknowledgement

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