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Automated Driving Car using RPI Board and CNN Algorithm

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Abstract

Self-driving vehicles will provide more than a luxury in this era. In this study, we are implementing an upcoming technology in Machine learning and neural networks called Autonomous cars or self-driven cars. It provides relief to humans from travelling stress and helps reduce traffic congestion and accidents.This study produces a successful model that navigates through the traffic and tackles all the obstacles placed in its path. This self drive car is implemented using Machine Learning algorithms and Convolutional neural networks in a way that provides complete automation to the driver. This car performs the following functions: self-parks, avoids traffic congestion, follows lane markings, avoids obstacles and detects vehicles and moves accordingly based on its distance from other vehicles.Previously, designs were made in such a way that all these functions were implemented in separate vehicles. But this car design integrates all these functions in a single model which increases its effectiveness, efficiency and reduces the cost of building it separately.

Keywords: *Autonomous car, CNN, image processing, ultrasonic sensor*

INTRODUCTION

Driving has become an integral part of people’s life, since they rush around trying to get their errands done. The accidents and errors encountered while driving due to various factors like use of cell phones, traffic problems and carelessness are few of the major issues to be tackled. Since the number of accidents is increasing rapidly over time, necessary measures have to be taken in order to overcome these human errors and help mankind. To overcome this problem, self-driving cars or autonomous car was introduced which drives to the destination given without any human help. Autonomous cars or self driven cars provide humans with a luxury that lessen the commuting burden. It will eliminate accidents caused due to negligence of drivers, intoxication and various other factors. It provides comfort to those who have to commute long distances without facing the hurdles of traffic.

The main self-governing vehicle "Linrrican Wonder" was presented in 1925, which was a radio-controlled driverless vehicle. It went on New York City lanes, from Broadway down to Fifth Avenue. In 1926, the Linrrican Wonder sent Radio driving forces through radio receiving wires which got the radio motivations and sent the sign to circuit-breakers which worked little electric engines that direct every development of the vehicle. Yet, first real independent and genuinely self-sufficient autos were created during the 1980s with the assistance of Carnegie Mellon University and ALV extends in 1984 and a short time later in 1987 by Budeswer University Munich's EUREKA Prometheus Project and Mercedes-Benz.

Autonomous car aims at travelling from one point to the destination without any human interfering and to mainly avoid the obstacles present in front of it or near it. It helps in improving traffic conditions, provides relief to humans from daily travels, increases productivity of customers who would otherwise waste their time and energy in travelling back and forth, provides safety to those who are intoxicated and tired.

To understand exactly what an autonomous car does, The National Highway Traffic Safety Administration (NHTSA) explains various levels:

1stDegree Automation (no Automation): The driver is in complete control of all functions of the car like brake, throttle, steering, etc.

2ndDegree Automation (Function specific Automation): The driver has the control of the car but little control over few automatic functions like dynamic break during emergencies, cruise control, and lane keeping.

3rdDegree Automation (Combined Function Automation): The driver is freed of two primary control functions and one or two functions are automated.

4thDegree Automation (Limited Self Driving Automation): The driver has control over few small functions where the rest of the functions are automatic.

5thDegree Automation (Full Self Driving Automation): The car is entirely automatic and has control over all the functions and can completely drive it.

At this stage, Level 3 and Level 4 automobiles are being designed. However, it comes with its own challenges which need to be overcome in order to fully depend on this self driving car.

ANALYSIS OF RELATED WORKS

This study [1] used a reflexive neural network to run the autonomous car which converts the images into commands to drive it. The simulation data used to train the neural network was taken from Grand Theft Auto. The data set containing the necessary instructions was verified on connecting the neural network to the car system containing a camera input and the specific steering value, where the resulting average error rate was only 1.9%. This neural network was connected to a RC car system which provided a camera input and receives steering angle and throttling value.The designed car could successfully navigate 98 of the 100 laps in response to various obstacles placed in front of it. It consisted of aCNN network for image processing, a multi layered network for steering, a deep layered network for steering and additional networks for braking. It used python and Keras' API to implement the neural network.The camera was used to provide images to the system and the existing steering angle as the input which was used to find the throttle. It consists of four modules: In Steering processing network, CNN provides a specific steering angle based on the input provided by the camera. It consists of series of layers that help in pattern detection.With merging network, the merged network provides the combined output of the previously described networks. It has a deep layered network of six layers.With Anti-collision network, this network is independent of the other networks and its main purpose is to make sure that the brakes are applied when an object comes in front of it.

The technology used in this [2] provided a solution to overcome monitoring of parking spaces using vision based automated parking. The current parking system just provided the number of parking spaces available and not the actual feasible parking space. Hence, this automated system was designed that could self-park based on the available spaces.Coordinates systems was used to detect available car parking spaces to indicate the regions of interest and a car classifier. This paper shows that the initial work done here has an accuracy that ranges from 90% to 100% for a 4 space car park. The work done showed that the utilization of a dream based vehicle leave the board framework would most likely recognize and demonstrate the accessible vehicle park spaces. Sensors alongside a camera were introduced to give accessible parking spots. In view of the info video, Haar-like highlights decided the nearness of a vehicle inside the parking spot. The object classification was done using a tool called OpenCV. Two sets of input images are necessary to train this algorithm. One set called the positive images contain the object to be detected and another set called the negative images do not contain the object to be detected. Once this data was analyzed, coordinate system was used to detect the coordinate of the car parking spaces with the help of a marker tool of OpenCV.This was used to determine the number of parking spaces available and the best place for the car to park in the list of available spaces.

This system was designed[3] using advanced technologies where the data streams included IMU, GPS, CAN messages and HD video streams of the driver's face, driver's cabin, the forward path and the instrument cluster. It implements "naturalistic driving study", which is not restricted by experimental design and which collects audio, video and other elements of driving over a large period of time and to use this collected data to help the autonomous car. The aim of this paper is to understand the data being collected throughout from vehicles in order to design, implement and run the autonomous system, inform the providers of insurance of safety measures, and enlighten the educational institutions on how to use these autonomous cars in order to reduce the burden of mankind. It aims at understanding human behaviour in a semi-automated system for a period of 1 year and using those reactions to drive the autonomous car. It uses AI to inspect the driving experience through the collection of data and to use human expertise to understand how to react in difficult situations.

In this study [4], it is stated that the project mainly focuses on the input which will be the video/image data which is continuously captured with the help of a webcam interfaced to the Raspberry Pi.

It detects the object and tracks that object by moving the camera in the direction of the detected object. The Raspberry pi offers better size but less speed. Accuracy of both systems is similar even if the FPS rate is very different. In this framework we can utilize the foundation subtraction by utilizing the fixed camera by producing the frontal area cover. It contrasts the casing and typical one with foundation pictures or model which has contain the static piece of the scene, everything is considered as the foundation part of pictures as a rule. In this background subtraction can done with the raspberry pi camera.In this system, the image taken by the camera was sent to the raspberry pi, to which the camera was connected using an USB port. The input image was executed on the Raspbian OS software followed by the execution of the python code. The signals generated after the code is executed, is sent to the car. The car then detects objects and the path to the destination effectively and starts driving towards it. Its components include

Raspberry pi, Pi camera, Motor driver, ultrasonic sensor module, raspbian OS, python, OpenCV.

According to this study, [5] there are two sub-systems that are used to build this project. That is Image processing sub-system and obstacle detection subsystem. Camera is attached to image processing sub-system which captures the image. To detect the road lane mainly image processing is used here. To detect the obstacle in front of car and also calculate the distance between the obstacle and the car, obstacle detection sub-system is used. These are captured with help of a webcam interfaced to the Raspberry Pi. It is convenient to use Raspberry Pi as it has very less software glitches and provides overall performance. System takes out thedata from the image and generates the command about turn. Generated commands are forward to obstacle detection subsystem. If adequate distance is available to move car forward the command from Raspberry pi is forwarded to motor driver else this command are rejected. It is significant to detect the lane from the image of road and check their position in the form of pixel coordinates for the settlement of turn. To perform the lane detection action it is significant to convert image into gray scale. The white pixels from the region of interest are considered only. Position of lane on the road is given by the count of this image. The region of interest is slide vertically with respect to speed of car. Ultrasonic module provides the distance between two objects. Arduino's serial communication gives us stop command to the vehicle and also results about the distance.In this project, the main aim is at the development of self-driving vehicles for convenient transportation without a driver. Cars that drive themselves will improve road safety, accessibility, fuel efficiency and increase productivity.

METHODOLOGY

The proposed project design mainly focuses on developing autonomous self-driven RC car. We do this by developing an RC car with a RPI board, camera and other multiple sensors. A basic RC car is assembled with DC motors, which receives the inputs from RPI board.The image of the road is taken from the RPI camera to the board via USB port.

The camera sends high quality video to the board which acts as input to the machine learning algorithms which decides the movements of the RC car.

There are three main divisions to bring about this: lane detection algorithm, convolutional neural network and ultrasonic sensors. Signs and ultrasonic sensors which give us the distance between the obstacles, we decide the next movement of the RC car.

A threshold distance is set between the obstacles and the car as 20cm. If the distance is below 20cms, the car stops no matter what. If the distance is more than 20cms and the CNN algorithm recognizes a stop sign, the RC car comes to halt. If both the outputs pass the threshold value, then the lane detection algorithm gives the RC car the steering angle. To make a left turn if necessary, the output voltage for the left server motor is reduced. To make a right turn if necessary, the output voltage for the right server motor is reduced.To make a halt, we stop the output voltage for both server motor.

The algorithm used to detect stop sign is HAAR cascade. It is a classifier which detects the object that it has trained for. It is done by superimposing positive image over a set of negative images.

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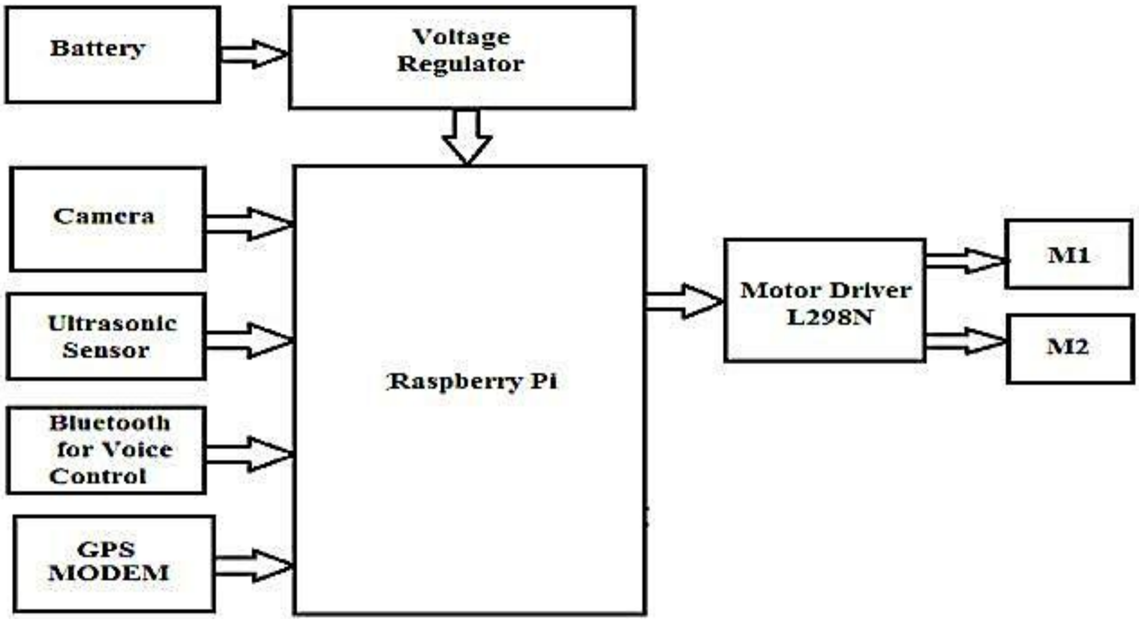

Figure 1: *Block diagram of autonomous car.*

Using CNN, we take inputs from the RPI camera which sends real-time video to the RPI board. These videos are divided into frames and fed into the algorithm.Once the CNN has been trained with the training Dataset, it can interpret the traffic signals. The CNN consists of three main layers: input layer, hidden layer and output layer. The first layer is the convolutional layer where the input is given. Here the image input is always in the matrix form that is, a filter is applied to an image and the pixels are recorded into matrix form. In the hidden layers, the image undergoes through many filters and becomes a linear pixel array. The output is according to the linear pixel array.

We then detect the road or lane from Open CV library. Here we take the real time video frames from the RPI camera as the input for the algorithm. First we convert the image into BW image by adding a gray scale which gives us a filtered image frame. Next this filtered image to plot the Hough lines on the lane marking. Using Hough lines conversion we can plot the perfect lane markings or we can detect the edges of the road. To find the curve or turns on the road, we divide the Hough line plotted image into three major ratios: 2:2:5. Next we draw imaginary Hough line on to the centre of the image which depicts the straight line. Next we calculate the angle of the plotted Hough line with respect to the imaginary plotted Hough line. This angle gives us the perfect steering ratio for the RC car to make a turn. We use the white-line markings on the side of the roads as our base lane for the lane detection algorithm.

Ultrasonic sensor module is used to calculate the distance between the obstacle and our RC car. The ultrasonic sensor which is placed in front of the RC car emits a low frequency ultrasonic waves which hit the obstacle in front of us and rebounds back to the sensor. The sensor captures the rebounded ultrasonic waves and calculates the distance between the obstacles using the formula:

Distance= (speed*time) /2

Using output of lane detection algorithm which gives us the steering angle, Haar cascade algorithm gives us the stop

RESULTS AND DISCUSSION

The main objective behind the development of an autonomous car is to reduce the cost of separate functions by integrating all of them into one model.

To achieve the implementation of this model, the major components used are: a Raspberry Pi with SD card pre-installed with Raspbian OS, a breadboard to connect together all the components, an L293 or SN755410 motor driver, Jumper cables to connect everything up, one or two DC motors rated for 6v, 4x AA batteries and holder, HC-SR04 Ultrasonic Sensors,2 Resistors, RPI Camera to capture images.

The following algorithm depicts the exact working of our autonomous model:

- Live feed is taken from the RPI camera.
- This input is fed to the RPI board connected to the breadboard.
- The input video is then converted into a number of frames and each frame is fed into the algorithm.
- Each picture then goes through the Haar cascade algorithm and checks for stop sign.
- If yes, the car stops.
  Else, the algorithm checks the distance between the car and the obstacle via the ultrasonic sensor.
- If detected, then the car stops.
  Else, the pictures are fed into the CNN algorithm which tells the car to follow the lane rules.

The motors are controlled by the RPI and L2D9 chip. RPI gives command to the L2D9 chip. The above algorithm shows the working of our car model. Once the car has started, the RPI camera gives continuous inputs of pictures which are fed to the RPI board to take respective decisions. These video inputs are divided into frames and then fed to the algorithm. The Haar cascade algorithm is used to determine the start and stop signs in implementation of such models. If the obstacle is right in front of the car, then the algorithm gives stop sign. If not then the Haar cascade algorithm checks the distance between the car and the obstacle with the help of the ultrasonic sensor. IF the obstacle is detected the car stops or else it is given a command to continue moving by following the lane rules.

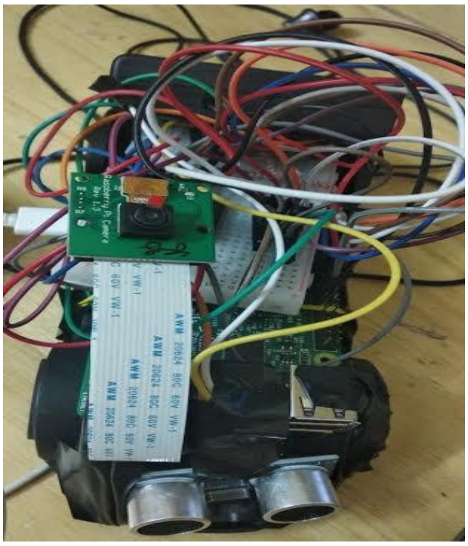

Figure 2: *Working model of autonomous car.*

The above figure shows the working model of the autonomous car. In order to be able to function efficiently, the car has to be trained with data sets so that it becomes capable of taking its own decisions in the time of crisis.

CONCLUSION

The autonomous car was once implemented into the market to be utilized by users which provided a lot of advantages. It provides safety to the needy so that number of accidents can be reduced. Self-driving vehicles can help the general population who can't drive themselves, for example, the old or debilitated. Open, moderate, and advantageous self-driving vehicles could build the complete number of kilometres driven every year. Other industries such as health care, restaurant, military, fire brigade etc., can make use of self-driving technology for their benefits. Hospitals can implement this technology to their ambulances which will help those people who are on the verge of death to the hospital as fast as possible.

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