

Development of Intelligent Driver Assistant System for Cognitive Cars

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Abstract

Automation in vehicles is essential in present day's road conditions. Many of the accidents are happening due to wrong behaviour, drowsiness and human inattention. The vehicle drivers are expected to be more attentive during their driving period. As a normal human being, it is usual that sometimes there may be a lapse in attention due to many environmental factors. Therefore, automation in cars is really required to overcome many uncertainties faced in real-time scenarios. This paper explores various automation techniques used in vehicles. Cognitive cars proposed in the paper, functions based on machine learning Algorithms. These cars travel from source to destination without any human intervention. The main objectives included in the paper are lane detection, obstacle detection, road signs detection and traffic lights detection. In near future cognitive cars will be preferred for the modern communities due to its intelligent features and increased safety aspects. It will be an asset of the future generation.

Keywords: Cognitive Cars, Adaptive Cruise, Behavioural Cloning, Reinforcement Learning

1. Introduction

Cognitive cars are expected to play a major role in the automotive industry. Various attractive features are included in the cognitive cars such as parking assist, lane detection, object detection and pedestrian movements etc. Fully automated cars use different Artificial Intelligent (AI) Technique. The automated highway is the main requirement for implementing this proposed vehicle. These types of highways are already in practice for

public use to increase the safety aspects, to check the traffic violations and toll collections etc. Fully automated cars require more facilities in the automated highways with sophisticated hardware, software algorithms [6] and AI technologies. These automated highways will be implemented by following structured protocols [8,14].

On account of mechanized driving, one of the key usefulness is "finding drivable free space", which tends to utilize Artificial Neural Networks (ANN). With the development of the cognitive car vehicle innovation, the cognitive car vehicle promoting stage will give the fantastic capacity of accuracy customized publicizing proposals and carry incredible changes to current promoting modes. To enhance the safety and reliability of cognitive cars, control systems should use relative velocity of the car. Differentiating the measured distance between cars with respect to time, we will obtain relative velocity. As already mentioned, lane detection is one of the objectives of the cognitive cars. This paper includes end to end learning of how the car detects lane and moves accordingly. The complete developed model can assist and guide the vehicle with the help of front view camera information. It helps to maintain the lane discipline, obey traffic rules and object detection and other safety aspects.

2. Literature Review

The development of Autonomous vehicles started in the year 1920 [9]. Researchers were involved in developing innovative technologies for driver assistance systems. Much of the research is focussed on development of Artificial Intelligence and Machine Learning algorithms for autonomous vehicles [1, 2]. Safety aspects are given much importance during the development phase of autonomous vehicles [3,5]. Recognising traffic signals are the integral part of this system [4,7]. Lane detection has been implemented with various algorithms[10]. Researcher shows interest in developing radar sensors for implementing various safety aspects[11]. In this paper artificial intelligent methods integrated with image processing techniques are used for the development of driver assistance systems.

3. Development of Cognitive Car

3.1 Real Time Implementation

The development of Cognitive Car is to implement the simulation idea in real-time using Raspberry pi. A hardware module was developed with required sensors and actuators. The developed Hardware module was shown in figure 1

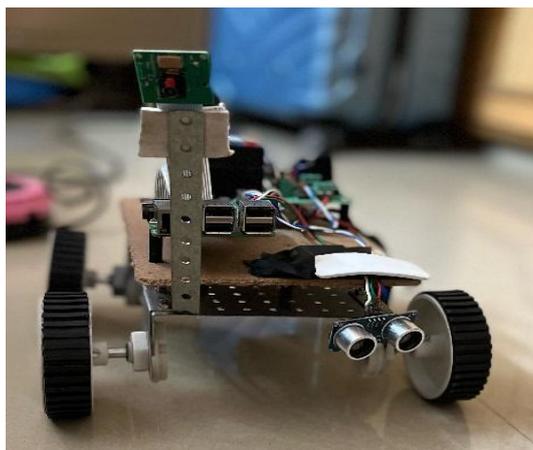


Figure 1. Cognitive Car

3.2 Hardware Description

The integration of sensor, camera with the controller is one of the challenging tasks in this research because the real time data has to be captured and processed. The hardware components are picked with utmost care. Table 1 shows the major list of hardware's used in the paper. The specifications were also tabulated. Ultrasonic sensor and Raspberry pi are described in details.

Table 1. Hardware Specifications

Name of the Hardware	Specifications
Ultrasonic Sensor	450 cm - Max Sensing Range
Camera	5 MP Resolution 25x23x8 (LxWxH) mm- dimensions
DC Motors	12 VDC - Operating voltage 200 - Rated RPM
Raspberry Pi	ARM processor 4 GB RAM Wireless connectivity

3.2.1 Ultrasonic Sensor

As mentioned earlier ultrasonic sensors are widely used in automotive applications. It usually measures the distance between the car and the object. Ultrasonic sensor sends sound waves through input pins; the sound wave hits the object and will be reflected back to the

source. The reflected sound wave will be received by the echo pin. The time taken by the sound wave to reach the echo pin will be measured and then distance is calculated. Based on the above logic the distance at which the object is located will be determined.

3.2.2 Raspberry Pi

The proposed method includes image processing for lane detection and traffic light detection. Raspberry pi is a low cost computer which is compatible with cameras and other interfacing devices. The memory ranges from 256 MB to 1 GB RAM. It has 4 USB ports along with an HDMI port. Its speed ranges from 700 MHz to 1.2 GHz. It supports python programming and OpenCV. Various computing algorithms and real time image processing techniques can also be implemented with fun ways of learning.

The other major components are Pi Camera, H Bridge and DC Motors. The Pi Camera is a gadget which is used to capture real time images with good clarity; it is connected to Raspberry Pi using a flexible elastic cord. It has a resolution of 5 megapixels and has a lens. The H Bridge is used to control DC motors in clockwise and anticlockwise direction. The DC motor's input pin is connected to H Bridge which is then connected to Raspberry Pi. This connection is done to make the DC motor move in forward as well as reverse direction. A DC motor is an electrical motor which is used to convert electrical energy to mechanical energy. It operates under direct current and acts like an actuator. The prototype of cognitive cars movement is achieved by the help of H Bridge, DC motors and the control signal from Raspberry Pi.

4. Methodology

The prototype model is developed by using two algorithms namely Behavioural Cloning and Reinforcement Learning. Behavioural cloning model is developed by training the real world data and the Reinforcement Learning Algorithm uses the simulated environment for training the model.

- **Behavioural cloning:** Using manual driving we will capture human skills of driving and this is programmed in a computer. When the human performs actions, his or her actions are recorded and given to the computer. This record acts as input to the computer and the computer will output certain rules and car moves accordingly.

- **Reinforcement Learning:** Here the car acts and the environment returns reward to the car. Car acts as agent and environment is lane or track, this algorithm is based on Markov Decision process has parameters like S, A, P and r

where,

S= state or images captures

A= action taken by the car based on the images

P= transition probability

r= reward given to the car i.e., positive reward will be given if the car moves in track and negative reward will be given if it moves out of the track.

These algorithms are shown in the figure 2 below:

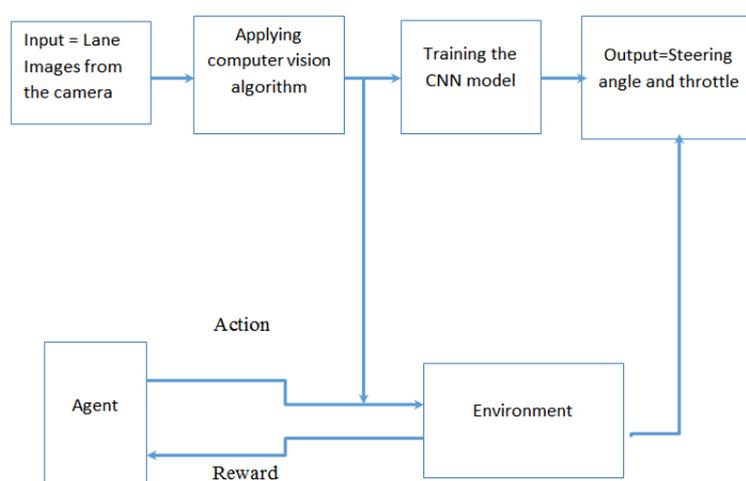


Figure 2. Algorithm flow diagram

5. Results and Discussion

The prototype will be able to demonstrate Lane Detection, Object Detection, Road Signs Detection and Traffic Light Detection. The average response times of all the modules are three to four seconds. The response time may be increased by using dedicated computers suitable for executing machine learning and deep learning algorithms

5.1 Lane Detection

Input video will be given to the car. Based on input video the car will move and it will take appropriate actions as shown in figure 3. H-bridge will be connected to DC motors and there will be separate files for each of the modularity. Main module will be connected to a

take an alternative way as shown in figure 5. There are four pins in the ultrasonic sensor. That is Vcc, Gnd, Echo and Trigger. Echo pin acts as input and sends ultrasonic sound waves and trigger pin acts as output and receives the electrical signal. It measures the time taken for emission and transmission of sound waves. And it detects the distance it is traveling by doing little math. This transmission and emission is done using a reinforcement learning algorithm.

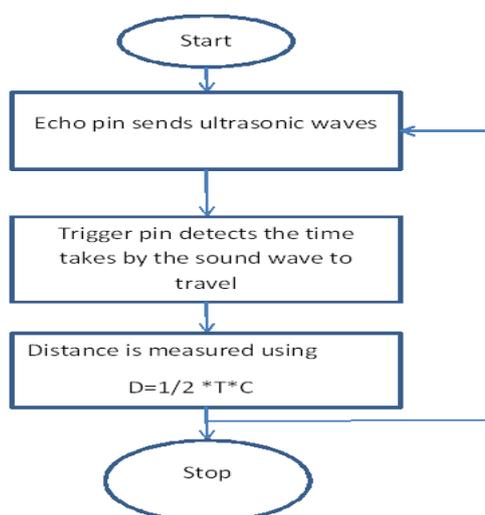


Figure 5. Object Detection Flow Diagram

Ultrasonic sensor will detect an object [13]. It measures the distances between object and car and once the car detects the object it will stop, and it will take an alternative way. As shown in figure 6.

```

File Edit Shell Debug Options Window Help
stop
27.386000000000003
stop
back
right
stop
44.099999999999994
stop
Traceback (most recent call last):
  File "/home/pi/deepcar.py", line 44, in <module>
    for x in range(0, len(lines)):
TypeError: object of type 'NoneType' has no len()
>>>
  
```

Figure 6. Object Detection in hardware

5.3 Road Sign Detection

Once the camera captures the road signs like stop, forward, left, right, U-turn etc. The car recognizes the signs and takes the appropriate action and the signs will be displayed in the

output window as well, which is shown in Fig 5.5. First we have to pre-process the image. Images are first converted to grayscale and equalized. Pictures will have small ranges of blackness and whiteness values meaning shades are very close together. So we are standardizing light and normalizing the values (0-1). When we equalize the image we take off the shades and spread them apart. So it has a greater range of values making it easier for the computer to pick up contrast. This is called Pre-processing. CNN pick up the feature of different groups of road signs, and then use this information to sort new images to classes. This is done using reinforcement learning. So if values in the pictures match, that value will be added to the feature map. This is called pooling. After polling images will be flattened. Every node in the first layer will be connected to every node in the second layer. They work together to predict the class of image going through the part of the program.

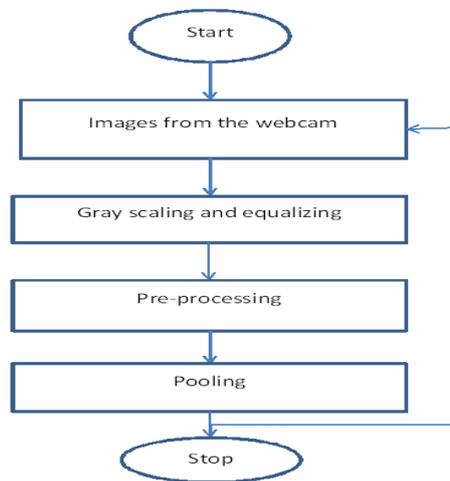


Figure 7. Road Sign Detection Flow Diagram

Once the camera captures the road signs like stop, forward, left, right, u turn etc. [11,12] The car recognizes the signs and takes the appropriate action and the signs will be displayed in the output window as well, which is shown in figure 8. Road sign detection system is trained using the open data set available in “kaggle”.

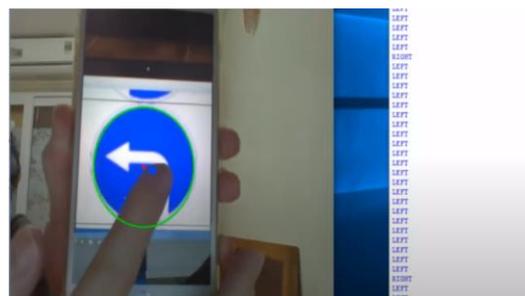


Figure 8. Road Sign Detection in hardware

5.4 Traffic Light Detection

Once the camera captures the red light, the car stops. When it detects yellow light, it displays a pause and when it detects green the car displays forward and the car starts moving forward as shown in Figure 9 below. Open cv2 works fine for traffic light detection problems. IR sensors can be used in case of emergency. For map construction and traffic light detection we can use the offline phase. We have to integrate the previous maps for recording, direction and similar other properties of traffic lights. To find the 3D coordinates of traffic light in the data we are using a semi-automatic process to filter the irrelevant images. This is done using reinforcement learning. Using the online phase previous images are projected to images which are shown in the camera. This is done to filter the predictions produced by a deep detector.

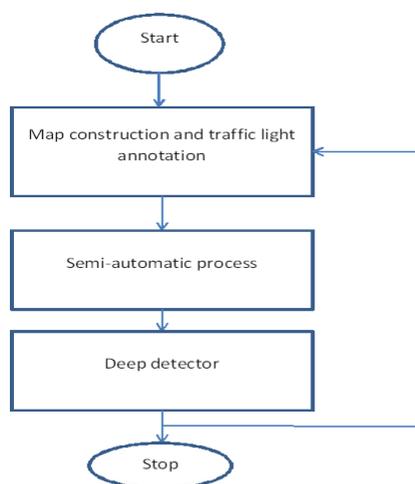


Figure 9. Traffic Light Detection Flow Diagram

Once the camera captures the red light, the car stops. When it detects yellow light, it displays pause and when it detects green the car displays forward and the car start moving forward as shown in figure 10 below.

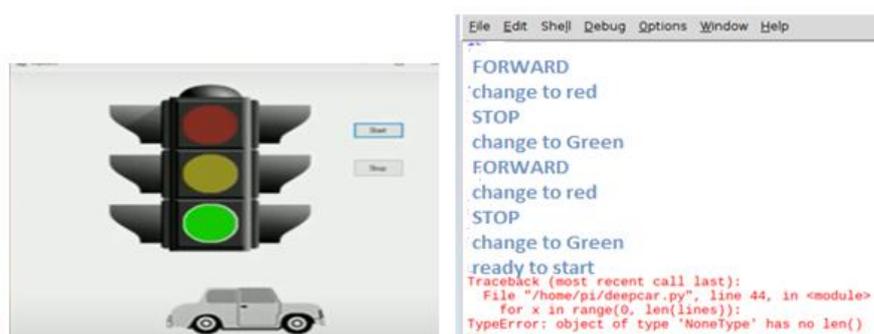


Figure 10. Traffic Light Detection in hardware

6. Conclusion and Future Scope

Using machine learning and along with hardware components we have developed the model which is working as per expectation. With the help of image processing and machine learning we have developed this prototype. There are advantages like increased safety, reduced accidents, reduced pollution, cost effective, eco-friendly and helpful for physically challenged people but also it must overcome certain social barriers. In future we can add camera belts which will capture images in 360 degree more sensors and central ECUs. IMU sensors can be incorporated into the vehicle for object detection. Using the map generated implementing A* algorithms such that the car can take the shortest path. Autonomous vehicles will play a major role in the society. The prototype developed in this research definitely yields a path to implement latest technologies and further improvements.

References

- [1] Vinayak Pujari, Dr. Yogeshkumar Sharma and Mr. Sanket Ambre, “Artificial Intelligence in Automobiles: An Overview”, Contemporary Research in India, Special issue (2021): 45-51
- [2] Gonzalo De-Las-Heras, Javier Sánchez-Soriano and Enrique Puertas “Advanced Driver Assistance System (ADAS) Based on Machine Learning Techniques for the Detection and Transcription of Variable Message Signs on Roads” Sensors (2021): 1-18
- [3] Tomasz Dudek and Kamil Pędzwiatr (2021) Safety and the Use of Smart Driver Assistance Systems, European Research Studies Journal, Volume XXIV, (2021):651-665.
- [4] Ziyue Li, Qinghua Zeng and Yuchao Liu “An improved traffic lights recognition algorithm for autonomous driving in complex scenarios” International Journal of Distributed Sensor Networks (2021): 1-17
- [5] Swaroop Balaji, R Sivaprakash S Sabareesh and M Sivasundar (2020) Development of Advanced Driver Assistance Systems for Indian Cars, 3rd International Conference on Advances in Mechanical Engineering (2020) 1-6
- [6] Liyong Wang, Peng Sun, Min Xie, Shaobo Ma, Boxiong Li, Yuchen Shi, and Qinghua Su “Advanced Driver Assistance System(ADAS) for Intelligent Transportation Based on the Recognition of Traffic Cones” Advances in Civil Engineering. No 2020 (2020): 1-8

- [7] Ruturaj Kulkarni, Shruti Dhavalikar and Sonal Bangar “Traffic Light Detection and Recognition for Self Driving Cars Using Deep Learning” 2018 Fourth International Conference on Computing Communication Control and Automation (ICCCUBEA)
- [8] Sanju Meena & Om Prakash “The Study on Automated Highway Systems”, Imperial Journal of Interdisciplinary Research (IJIR) No.3. (2017): 959-962
- [9] Keshav Bimbraw, “Autonomous Cars: Past, Present and Future A Review of the Developments in the Last Century, the Present Scenario and the Expected Future of Autonomous Vehicle Technology” Autonomous Vehicle Technology. (2015) 191-198
- [10] Takiyaldin Al Smadi “Real-time lane detection for driver assistance system”. Circuits and Systems, No. 5 (2014): 201-207.
- [11] M. Li et al., "A High Performance Low Cost CMOS Radar for Advanced Driving Assistance Applications," 2012 International Conference on Connected Vehicles and Expo (ICCVE), 2012, pp. 197-200, doi: 10.1109/ICCVE.2012.43.
- [12] Miao, X.D., Li, S.M. and Shen, H. “On-Board Lane Detection System for Intelligent Vehicle Based On Monocular Vision”. International Journal on Smart Sensing and Intelligent Systems, No. 5 (2012): 957-972.
- [13] Alessio Carullo and Marco Parvis, “An Ultrasonic Sensor for Distance Measurement in Automotive Applications”, IEEE SENSORS JOURNAL, No.1. (2001): 143-147
- [14] Smiley, A.; Brookhuis, K.A. Alcohol, drugs and traffic safety. In Road Users and Traffic Safety; Transportation Research Board: Washington, DC, USA, 1987; pp. 83–104.