World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Review Article)

Check for updates

Review on self-driving cars using neural network architectures

Srinivas Rao P, Rohan Gudla *, Vijay Shankar Telidevulapalli, Jayasree Sarada Kota and Gayathri Mandha

Department of Computer Science and Engineering, ACE Engineering College, Hyderabad, Telangana, India.

World Journal of Advanced Research and Reviews, 2022, 16(02), 736–746

Publication history: Received on 08 October 2022; revised on 15 November 2022; accepted on 18 November 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.16.2.1240

Abstract

A self-driving automobile is one that can sense its environment and navigate obstacles like traffic and other vehicles on its own with little to no human intervention. Although it has been debated and worked on for a very long time, Tesla was able to produce this cutting-edge technology, which is currently being used in the automotive sector. These cars started to appear in other markets in recent years as both private and public transportation (taxis etc.). In this product development, numerous businesses are involved, including Waymo, UBER, Nissan, and Nvidia. With this kind of vehicle, the efficiency, safety, and ability to reduce human error in all aspects of automobile transportation are all improved, and driving is made as safe as possible. This kind of system can revolutionize transportation for those with disabilities and support independent travel for the blind. In this article, the development of self-driving automobiles is briefly discussed. The deep learning techniques used for self-driving automobiles are thoroughly discussed in this review article. It focuses on current techniques for lane recognition, path planning, and traffic sign detection. Additionally, it covers the experimental findings related to each of the aforementioned techniques.

Keywords: Self Driving; Convolutional Neural Network (CNN); Computer Vision; Autonomous Driving; Neural Network; Deep Learning

1. Introduction

A vehicle that can sense its surroundings and move safely with little to no human intervention is referred to as a self-driving automobile or an autonomous vehicle [1].

Japan's Tsukuba Mechanical Engineering Laboratory created the first semi-autonomous vehicle. With funding from the US Defense Advanced Research Programs Agency, Carnegie Mellon University's Navlab and ALV projects led to the development of a seminal autonomous vehicle in the 1980s. In 1997, the National Automated Highway Systems study was successful. Honda started leasing a limited ''number of 100 Legand Hybrid Ex Sedans in Japan in March 2021. These cars were outfitted with "Traffic Jam Pilot'' driving technology, which enabled drivers to legally take their eyes off the road, and Level 3 automated equipment.

Any transportation device's main objective is to move people from one place to another via one or more specific places in any fashion that is physically possible. This is confounded by the dizzying array of variables that affect which mode of transportation is most efficient, including cost, dependability, comfort, safety, flexibility, convenience, and environmental impact. The world is currently being led by automation, which has enabled humans to have access to anything with a simple tap thanks to objects that can sense their environment and operate autonomously or in response to remote user commands.

* Corresponding author: Gudla Rohan

Department of Computer Science and Engineering, ACE Engineering College, Hyderabad, Telangana, India.

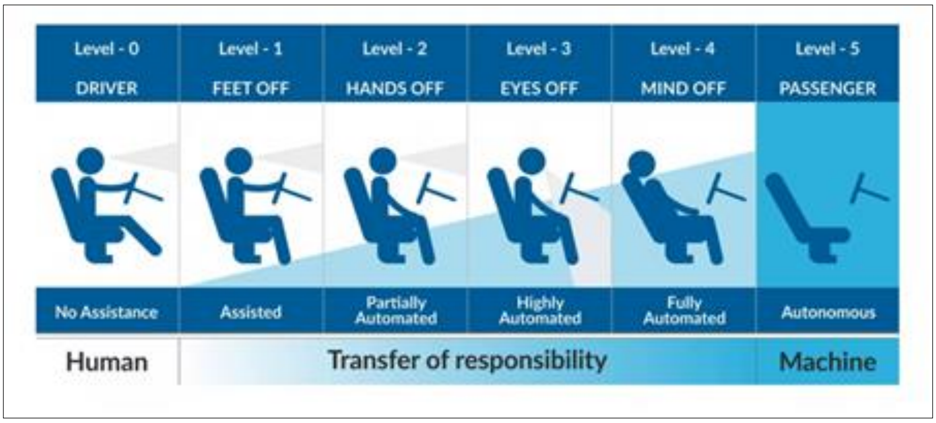
Information created by these clever Devices enable several businesses chances and customer-targeted offers services. several technological developments that Of course, software is the reason behind self-driving automobiles. and algorithmic creativity.

New tracking and planning algorithms enable safer and more comfortable driving, and the software infrastructure to simulate and analyze enormous volumes of data in data centers have all played a significant role in the development of self-driving vehicles. Incredible advancements in machine learning have improved our capacity to perceive the environment. Figure 1 illustrates the degree of automation in a self-driving automobile. The driver completes every work during the zero phase, hence there is zero automation. While the driver controls the vehicle in the initial phase, driver assistance elements may be incorporated into the vehicle's design.

In contrast, only the driver's notification of the system's start and the destination are necessary in the second scenario, leaving no room for the driver to make any additional decisions. In the third phase, conditional automation, most businesses are attempting to reach that degree of automation, with the exception of the USA, where drivers are still required to monitor the surroundings.

It is exceedingly challenging to reach the fourth and fifth levels of automation.

Customers who desire the versatility and independence of fully equipped level 5 cars will have to wait longer.



(Source:https://sae.org)

Figure 1 levels of driving automation

2. Self-driving car development

The rise and development of artificial intelligence (AI) and the internet economy have accelerated the development of autonomous vehicles. One of the greatest inventions since the microchip is today thought to be artificial intelligence (AI) and machine learning (ML). Artificial intelligence used to be a fantastical idea from the realm of science and machine learning, but nowadays it's a part of everyday life for people.

One of the amazing uses of machine learning technology is artificial intelligence (AI) in automobiles, sometimes known as self-driving or autonomous vehicles.

Automobiles equipped with machine learning immediately adapt to changing road conditions while simultaneously learning new situations. On-board computers can make split-second decisions even faster than experienced drivers by continuing to analyze a stream of visual and sensor inputs. Autonomous vehicles, self-driving vehicles, and AI in automobiles all have similar foundations to other sectors.

You have an output as well as input characteristics. An autonomous vehicle, also referred to as a robotic vehicle or a driverless vehicle or self-driving vehicle, can perform all of the functions of a traditional car that relate to human transportation. As an autonomous vehicle, it is capable of sensing its environment and navigating on its own. However, a human driver is not required to perform any mechanical functions of the vehicle. The information is interpreted by an autonomous vehicle using technologies such a radar, GPS, LEDAR, and computer vision advance control system. Autonomous vehicles can travel across uncharted regions by updating their map based on sensor information.

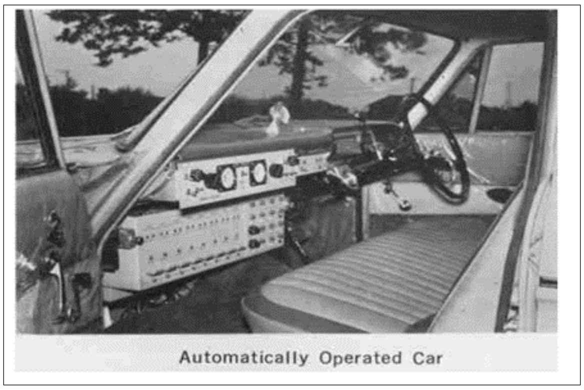
There is a growing market for autonomous vehicles. Many businesses and research institutes are now investing in this area. Giants like Google, Nissan, Audi, General Motors, BMW, Ford, Honda, Tesla, Apple, Toyota, Mercedes, Nvidia, and Volkswagen have all contributed to the research and development of autonomous vehicles.

Due to its strong computer foundation, Google, an online corporation, is among the top companies developing self-driving vehicles.

The basic goal of the autonomous decision system is to generate some decisions for the self-driving automobile, such as path planning, navigation, obstacle avoidance, and so on. As an illustration, while planning a journey, the autonomous decision system first determines a global path based on the destination location and current position. Next, it determines a local path for the self-driving car by merging the knowledge about the neighborhood supplied by the environment perception system with the global path.

3. The history of self-driving cars

Over the past ten years, the idea of autonomous or self-driving vehicles has gained popularity. But it appears that the concept of creating a vehicle that could navigate itself without human input dates back to the Middle Ages. The self-propelled cart seen in Leonardo da Vinci's drawings was intended to be driven by coiled springs with programmed steering and brakes. Clearly, technology has come a long way since then.

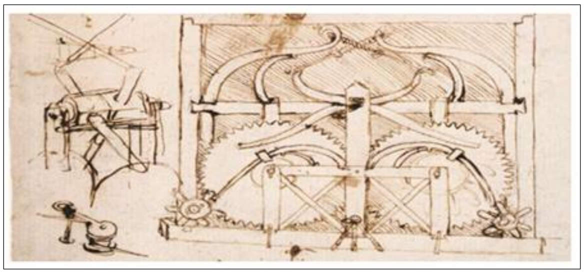


(Source:https://www.truebil.com/)

Figure 2 1977. Tsukuba Mechanical Engineering Lab, Japan, 1977. computerized driverless car achieved spe

An Idea is Born

Francis Houdina's radio-controlled car invention in 1925 is the first known effort to really develop a driverless car. The "Phantom Auto," as it was called at the time, was guided by radio signals given from a vehicle following closely behind. A decade or so later, an industrialist by the name of Norman Bel Geddes developed the idea for an automated highway system that would use electric circuits embedded in the pavement to manage automobiles. Despite successful testing, this prototype didn't catch on because of the significant financial commitment needed. A comparable autonomous vehicle and road system was also developed at the same time by the Transport and Road Research Laboratory in the UK. It was successfully tested and is expected to significantly decrease traffic accidents and boost road capacity.But because the government was reluctant to provide funding, the project was abandoned.



(Source:http://www.leonardodavincisinventions.com)

Figure 3 Leonardo da Vinci's self-propelled cart

3.1. Taking a New Course

The Tsukuba Mechanical Engineering Laboratory in Japan created a concept in 1977 that focused on making the automobile intelligent rather than on improving exterior road technology. The technology consisted of a computer that analyzed the surroundings using images from an inside camera. This car, which could go at 20 mph, was regarded as the first standalone autonomous vehicle.

Then, in the 1980s, a German aerospace engineer with support from Mercedes Benz developed the VAMOR prototype, a self-driving car that could travel at high speeds. It was developed using a Mercedes van, and it was controlled by a computer software that provided information from built-in cameras and sensors.

3.2. The Dream Expands

A number of institutions and automakers engaged in the Eureka Prometheus Project, the greatest research and development effort into self-driving automobiles, which began in 1987 in Europe and was inspired by this accomplishment. In order to show the autonomy of their twin robot cars, VaMP and VITA-2, Ernst Dickmanns and his colleagues drove them on the Paris motorway for 1000 km at 130 km/h.

Similar initiatives were also being conducted in America at the same time. One prominent example was the Navlab self-driving automobile system, which in 1995 traveled over 3000 miles using a supercomputer, a GPS sensor, and camera equipment.

The DARPA Grand Challenge, which offered a $1 million prize to anybody who could create an autonomous vehicle that could go 150 miles over the Mojave Desert, was announced in 2000. Sadly, nobody was able to complete this task.

(Source:https://commons.wikimedia.org)

Figure 4 2014. Google self driving car

3.3. The Current Self-Driving Scenario

However, Google revealed in 2010 that they had been creating and testing a technology that would aid in reducing the amount of accidents through autonomous driving. This team included several of the engineers that worked on the automobiles in the DARPA competition. Since then, Google has driven its self-driving vehicles more than a million miles and fought for legislation to legalize them in four US states. Self-driving cars are now picking up and dropping off passengers in Boston, Phoenix, and Pittsburgh. Nvidia and Volkswagen recently revealed a self-driving chip that links artificial intelligence to hardware that is ready for manufacturing. This is anticipated to enhance self-driving car performance and introduce appealing features like digital assistants.

Although very sophisticated driver assistance technologies like Tesla's Autopilot and Cadillac's Super Cruise are evidence of how far autonomous car technology has evolved, it remains to be seen if authorities will permit the unrestricted use of self-driving cars around the world.

4. Theory behind the self-driving car deep learning methods

Within the field of artificial intelligence during the past ten years, deep learning has shown to be an excellent method. Many issues, including image processing [2], speech recognition [3], and linguistic communication processing [4], are solved using deep learning techniques. Deep learning has the genuine capacity to overcome several difficulties in the field of self-driving automobiles since it can automatically modify the initial signal's features layer by layer as it learns robust and efficient feature representation.

Four different types of deep neural networks, which are the most popular deep learning techniques used in self-driving vehicles, are discussed in order to provide a clear introduction to the applications of deep learning in this sector.

4.1. Convolutional Neural Network

Convolutional Neural Networks (CNN) are by far the most often used deep neural network topologies. They typically have an input layer, one or more convolution and pooling layers, a complete connection layer, and an output layer at the top [5].

Although the particular architectures of convolutional neural networks may vary, the convolution layer is the fundamental element of these networks. Specifically, a neighborhood region of the input picture is convolved with the convolution kernel (i.e., filter matrix).

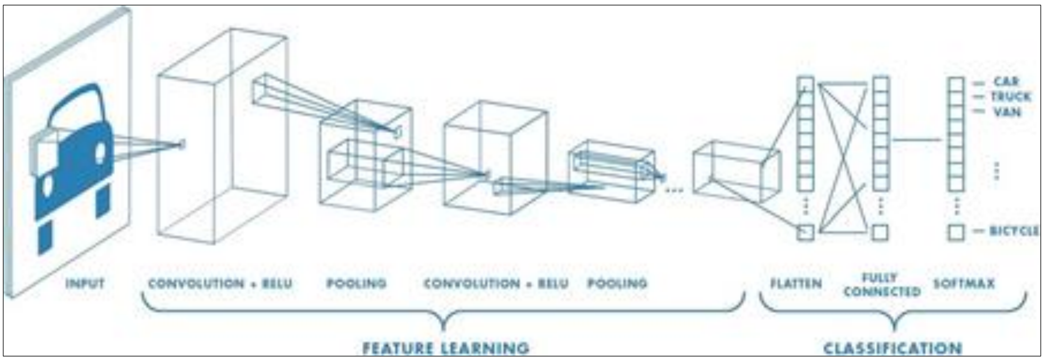


Figure 5 Convolution neural network architecture for self driving car

$$y_j = \sum w_{ij} * x + b_j ,$$

Where x is the input feature map and y is the output feature map, the operator stands for a two-dimensional discrete convolution operation; w stands for the filter matrix; and b is the bias parameter. Most of the time, the convolution kernel is started as a small three by three or five by five matrix. The convolution kernel is continuously changed during the network training process through learning, and it finally acquires a low-cost weight.

Recent image classification challenges including computer images and general images have shown amazing results using the convolutional neural network. Many self-driving car technologies may be simply developed to enable convolutional neural networks for obstacle detection, scene categorization, and lane identification since they rely on picture feature representation.

The application of this kind of neural network for image processing is due to its high precision in the convolution function's ability to extract distinguishing characteristics from photos. It employs many hidden layers and a 2D input to extract high-level characteristics. Based on the spatial arrangement of the input pixels, it analyzes the input and finds interesting patterns within the pictures. CNN is simple to implement since no preprocessing is needed. They are utilized in AVs for pedestrian recognition and path planning.

4.2. Recurrent Neural Network

In order to create a more accurate picture of the world for the self-driving car, which relies on data from the perception of a constantly changing environment, it is crucial to store and track all pertinent information that has been acquired in the past. This issue will be effectively handled by Recurrent Neural Network (RNN), which is particularly adept at capturing the temporal dynamics of video snippets. Through a feedback loop, the recurrent neural network preserves the memory of its hidden state across time and represents the reliance between this input and the prior state [6]. Long Short-Term Memory (LSTM) is a unique type of Recurrent Neural Network that regulates input, output, and memory state to identify long-term dependencies [7].

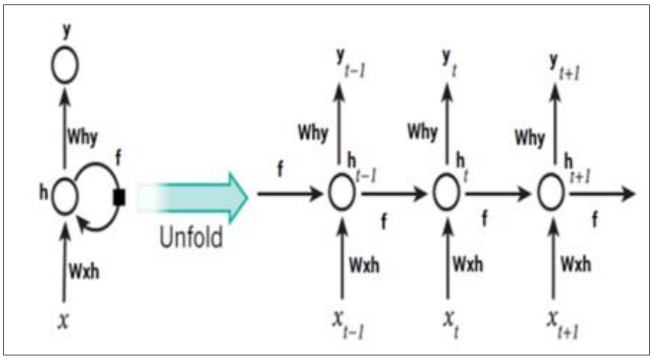


Figure 6 RNN working principle

4.3. RCNN

For object detection, neural networks of this kind are employed. As the number of repetitions of the item fluctuates, standard CNN, which is used to recognise an object inside an image, uses up a lot of space. Each object's borders and labels are found using a selective searching technique by RCNN, which then draws a boundary box around each one. In order to determine the bounding box's precise coordinates, a linear regression model is eventually applied. RCNN is employed in AVs for the detection of pedestrians, objects, and traffic signs [8].

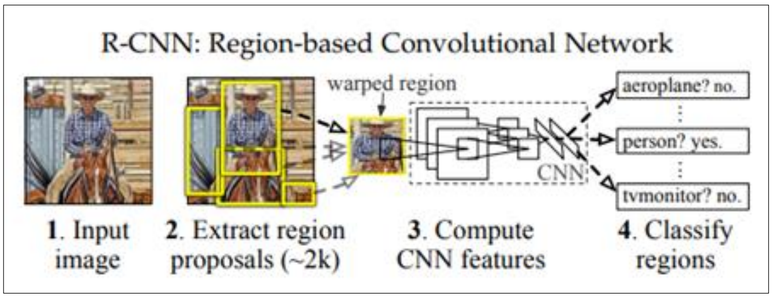


Figure 7 RCNN working principle

4.4. SLAM

SLAM mostly uses readings from LiDAR or RADAR sensors to estimate the relative location of static objects in an environment. By serving as an odometer, RADAR-SLAM can calculate velocity and even carry out localisation using map data. LiDAR-SLAM or Visual SLAM tracks the characteristics of successive photographs while estimating the relative orientation and translation using a monocular or stereo camera. Motion Control, Path Planning, and occasionally even pedestrian recognition are carried out by AVs using SLAM [9].

Modern autonomous vehicles often employ Bayesian Simultaneous Localization and Mapping (SLAM) algorithms, which combine information from several sensors and an offline map to produce cutting-edge position estimations and map updates. Google is developing SLAM with detection and monitoring of other mobile devices (DATMO), which also deals with issues involving vehicles and pedestrians.

Roadside real-time locating system (RTLS) beacon systems can be used by more straightforward systems to help in localization. Typical sensors include IMU, GPS, and stereo vision. Neural networks are used in machine vision for visual object identification.

When a person starts driving, the best possible coincidence occurs at some point in one of the few situations.

Every other check of more than a thousand kilometers was successfully completed without assistance from a person.

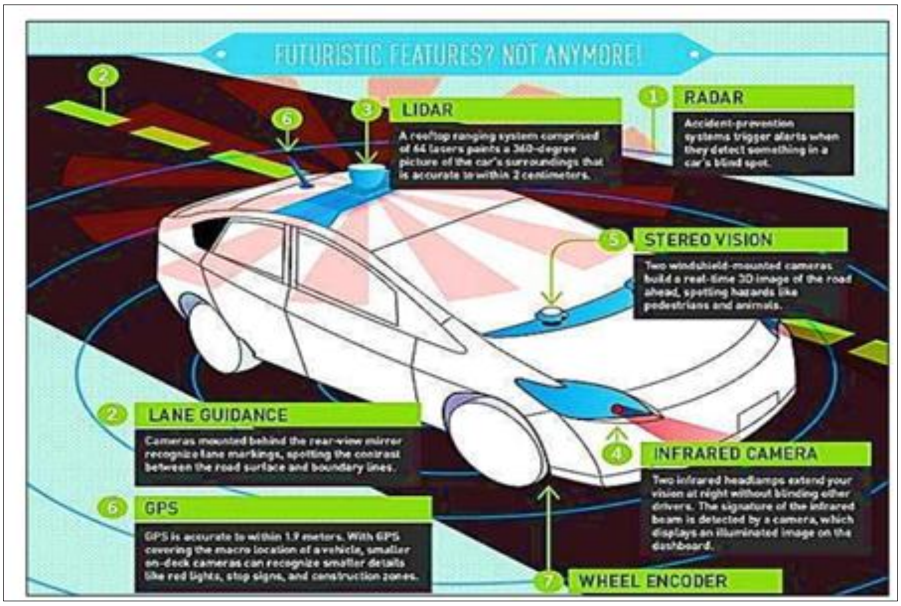


Figure 8 AN overview of futuristic self driving car

4.5. K-Means

Unsupervised method that creates predetermined clusters from unlabeled or unclassified samples. It iteratively seeks to reduce the total sum of distances between cluster centroids and their data points by assigning each cluster a centroid [10].

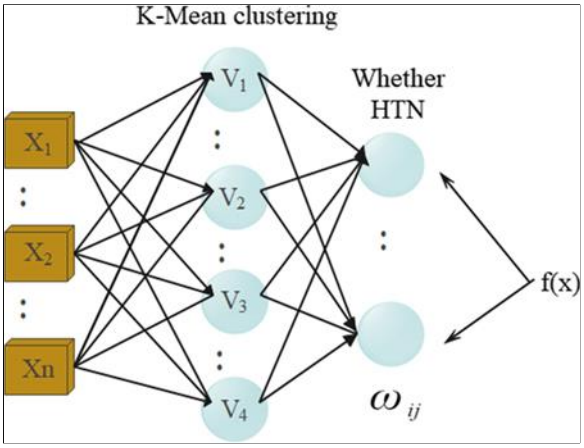


Figure 9 K-Means working principle

4.6. YOLO

Joseph Redmon created a CNN-based algorithm for the Darknet framework that is effective for real-time object identification. Following that, YOLOv2, YOLOv3, and YOLOv4 were developed as a series of object detectors for computer vision. Object identification and classification are handled by this one-stage detector in a single network run. YOLO-based models are practical and quick to implement [11].

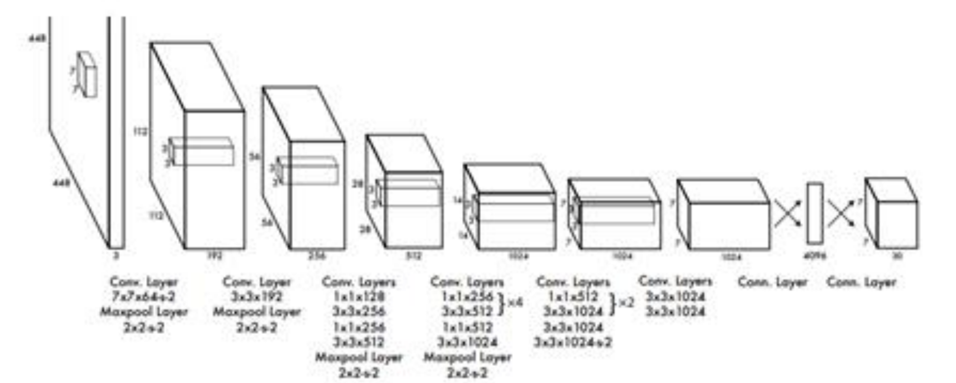


Figure 10 YOLO framework

5. Overview of Application

In today's culture, automated cars are more common. Lane detection, path planning, and traffic sign detection are all essential components for self-driving automobile operation.

This essay focuses on a review of all current techniques applied to these tasks to improve the effectiveness and performance of autonomous vehicles and self-driving automobiles.

5.1. Detection of Lanes

Techniques for detecting lanes using image processing

There are two methods for detecting lanes. The beginning steps for both strategies thresholding and warping are the same [12].

5.1.1. Thresholding

The video's BGR-formatted picture is transformed into an HSV format. The primary application of HSV is color-based picture segmentation, which is employed to distinguish the road from its surroundings. Thresholding turns the image into a binary image, where the path's color is recognised as white and the remaining area is shown in black.

5.1.2. Warping

By altering the perspective of the image, warping was formerly utilized to obtain the top view. The coordinates of the picture are sent to an OpenCV library function to do the task. When a road is straight, the fundamental goal of warping is to transform a rectangular shape.

5.2. Detection of Canny Edge

Canny edge employs a multi-stage method to find sharp edges in images by spotting significant gradient changes.

To find actual edges, hysteresis thresholding is employed. Edges with gradient intensities above the maximum value are recognised as edges, while those with gradient intensities below the minimum value are eliminated. Based on connectedness, the edges between the highest and minimum values are categorized.

5.2.1. Sliding Window Algorithm

A horizontal slice and a fixed-size, rectangular section are both cut out of the input picture. By using a fitting function, the best fit curve on the line is produced. To calculate the curvature, the values of the left and right edges are recorded and then subtracted from one another.

Without utilizing edge positions, the first method only provides an approximation of the turning value, and the offset value cannot be calculated. Both roads with and without lanes are treated using the second strategy. A second method may be used to measure offset value. Therefore, the second strategy is more precise than the first one.

5.3. Detecting Lanes Using Deep Learning

Systems for lane detection mostly rely on convolutional image processing methods. Data-driven feature extraction is used to reduce the impact of environmental influences.

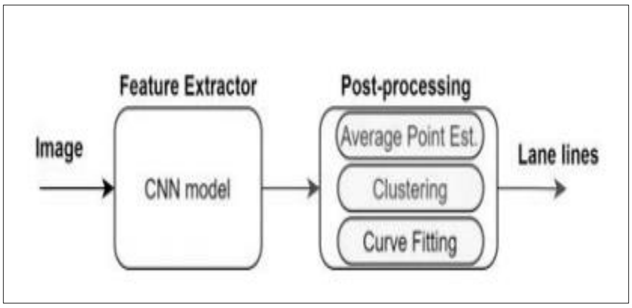


Figure 11 Overview of CNN model for lane detection

The main goal is to use a deep convolutional neural network to extract lane information under various environmental conditions. From the input picture, a tiny image patch is chosen, and prediction is run on each image patch. The three convolutional layers of the proposed system. Three of the layers are fully linked, and one is the greatest pooling layer. The output is a binary classification result, with the input being an image patch with a size of 16 by 64 pixels [13].

At the pre-processing level, the patches with poor lane marking confidence values are eliminated. The group of points with the same lane border is subjected to the Euclidean distance and angle clustering procedure.

5.4. Path Planning

In autonomous driving, path planning is crucial.

Path planning may be done using a variety of techniques, including Genetic Algorithms, Particle Swarm Optimization, and others.

The path planning problem for self-driving cars in complicated situations, however, is not well suited to and efficient for these conventional and standard planning methods.

NMPC (nonlinear model predictive controller) is intriguing due to its significant benefits in maximizing performance in roadways without lanes.

5.4.1. Simulator experiments

The static and dynamic tests were performed using an LG SVL simulator. the suggested system's ability to avoid obstacles while traveling using two different methods: simulating a static barrier in front of the position of the car in the same driving lane while emulating a lateral moving obstruction in front of the vehicle (i.e., a traveler crossing the street). the separation from the obstruction to the vehicle and the vehicle's deceleration are evaluated. The simulator and the ROS platform are integrated, supplying a car model that can be manipulated using ROS the common instructions and simulations for sensors in the use of GPS, LiDAR, and cameras for autonomous vehicles.

5.4.2. Simulation result

The car was able to maintain a safe distance from all artificial obstacles during the test. In the static obstacle testing, the car started a lane shift at 14 meters from the obstacle.

A moving obstacle that simulates a pedestrian crossing the street is used in the moving obstacle testing. All lines are closed and the vehicle must come to a complete stop if the obstacle's motion is latitudinally to the road.

5.5. Traffic Sign Detection

Traffic sign classification using CNN and Computer Vision

Deep learning is used for image detection on traffic signs, while OpenCV is used for image processing. The dataset being utilized is GTSRB - German Traffic Sign Detection Benchmark. Kaggle uses the well-known dataset GTSRB to model traffic signs. More than 50000 photos in 40 different classes make up this data collection, which may be used for testing, validation, and training. Training sets, validation sets, and testing sets are created from the data set. Additionally, the dataset is quite varied. The network type being utilized is a convolutional neural network (CNN). The first limitation was the high and difficult-to-access processing power needed to train the network [14].

6. Conclusion

The potential for fully autonomous cars to improve transportation is enormous. For many potential consumers, however, the confidence necessary to embrace new technologies has not yet materialized and may need to be developed gradually. According to the survey poll findings, the majority of the public may be hesitant to fully automate their lives.

Improved educational procedures that are more closely aligned with preferred learning techniques may also be helpful.

Eventually resulting in the introduction of completely autonomous vehicles.

Today's vision specialists are concentrating on creating autonomous vehicles that can drive themselves. Autonomous vehicles contribute to fewer traffic collisions and a more ecologically friendly world. The most recent deep learning techniques for lane recognition, path planning, and traffic sign detection in autonomous cars are described in depth in this article. The experimental outcomes of the aforementioned techniques are also discussed.

Compliance with ethical standards

Acknowledgments

We would like to thank our guide Mr. P. Srinivas Rao for his continuous support and guidance. Also, we are thankful to our project coordinator Mrs. Soppari Kavitha and we are extremely grateful to Dr. M. V. VIJAYA SARADHI, Head of the Department of Computer Science and Engineering, Ace Engineering College for his support and invaluable time.

Disclosure of conflict of interest

We have no conflicts of interest to disclose. All authors declare that they have no conflicts of interest.

References

[1] Hu, Junyan; et al(2020), "Cooperative control of heterogenous connected vehicle platoons: An adaptive leader following approach", IEEE Robotics and Automation Letters, 5(2): 977-984.

[2] Zhao, B.; Feng, J.; Wu, X.; Yan, S. A survey on deep learning-based fine-grained object classification and semantic segmentation. Int. J. Autom. Comput. 2017, 14, 119–135.

[3] Zhang, Z.; Geiger, J.; Pohjalainen, J.; Mousa, A.E.D.; Jin, W.; Schuller, B. Deep learning for environmentally robust speech recognition: An overview of recent developments. ACM Trans. Intell. Syst. Technol. 2018, 9, 49.

[4] Sun, S.; Luo, C.; Chen, J. A review of natural language processing techniques for opinion mining systems. Inform. Fus. 2017, 36, 10–25.

[5] R. Chauhan, K. K. Ghanshala and R. C. Joshi, "Convolutional Neural Network (CNN) for Image Detection and Recognition," 2018 First International Conference on Secure Cyber Computing and Communication (ICSCCC), 2018, pp. 278-282, doi: 10.1109/ICSCCC.2018.8703316.

[6] Yu, Y.; Si, X.; Hu, C.; Zhang, J. A review of recurrent neural networks: LSTM cells and network architectures. Neural Comput. 2019, 31, 1235–1270.

[7] Gers, F.A.; Schmidhuber, J.; Cummins, F. Learning to forget: Continual prediction with LSTM. In Proceedings of the 1999 the 9th International Conference on 'Artificial Neural Networks (ICANN99)', Edinburgh, UK, 7–10 September 1999; Volume 2, pp. 850–855

[8] Y. Qian, H. Zheng, D. He, Z. Zhang and Z. Zhang, "R-CNN Object Detection Inference With Deep Learning Accelerator," 2018 IEEE/CIC International Conference on Communications in China (ICCC Workshops), 2018, pp. 297-302, doi: 10.1109/ICCChinaW.2018.8674519.

[9] H. Lategahn, A. Geiger and B. Kitt, "Visual SLAM for autonomous ground vehicles," 2011 IEEE International Conference on Robotics and Automation, 2011, pp. 1732-1737, doi: 10.1109/ICRA.2011.5979711.

[10] D. Liu, Y. Wang, T. Chen and E. T. Matson, "Application of Color Filter Adjustment and K-Means Clustering Method in Lane Detection for Self-Driving Cars," 2019 Third IEEE International Conference on Robotic Computing (IRC), 2019, pp. 153-158, doi: 10.1109/IRC.2019.00030.

[11] J. Redmon, S. Divvala, R. Girshick and A. Farhadi, "You Only Look Once: Unified, Real-Time Object Detection," 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 779-788, doi: 10.1109/CVPR.2016.91.

[12] Vighnesh Devane, Ganesh Sahane, Hritish Khairmode, Gaurav Datkhile, Lane Detection Techniques using Image Processing, ITM Web of Conferences 40, 03011 , ICACC-2021.

[13] Tesfamchael Getahun, Ali Karimoddini, and Priyantha Mudalige, A Deep Learning Approach for Lane Detection, 2021 IEEE Intelligent Transportation Systems Conference (ITSC), Indianapolis, USA. September 19-21, 2021.

[14] AnuraagVelamatia, Gopichand G, Traffic Sign Classification Using Convolutional Neural Networks and Computer Vision, Turkish Journal of Computer and Mathematics Education, Vol.12 No.3(2021), 4244-4250.

[15] S. Albawi, T. A. Mohammed and S. Al-Zawi, "Understanding of a convolutional neural network," 2017 International Conference on Engineering and Technology (ICET), 2017, pp. 1-6, doi: 10.1109/ICEngTechnol.2017.8308186.

[16] M. Kaur and A. Mohta, "A Review of Deep Learning with Recurrent Neural Network," 2019 International Conference on Smart Systems and Inventive Technology (ICSSIT), 2019, pp. 460-465, doi: 10.1109/ICSSIT46314.2019.8987837.

[17] R. Girshick, J. Donahue, T. Darrell and J. Malik, "Region-Based Convolutional Networks for Accurate Object Detection and Segmentation," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 38, no. 1, pp. 142-158, 1 Jan. 2016, doi: 10.1109/TPAMI.2015.2437384.

[18] Wang, S., Zhao, Z. Risk decision analysis of commercial insurance based on neural network algorithm. Neural Comput & Applic (2022). https://doi.org/10.1007/s00521-022-07199-0.