Autonomous Vehicle Lane Detection Using Machine Learning

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Abstract— Lane detection is a critical component of autonomous vehicle (AV) technology, enabling vehicles to navigate safely within their designated lanes. This paper provides an overview of the current state-of-the-art techniques and challenges in lane detection for AVs. By analyzing various approaches and methodologies, including object detection and deep learning algorithms, the paper highlights the complexities involved in accurately detecting lanes under diverse environmental conditions and driving scenarios. Furthermore, it discusses the technical issues, advantages, and challenges associated with lane detection, emphasizing the need for robust systems that can adapt to dynamic road conditions. The proposed system architecture and implementation details are also presented, aiming to enhance the capabilities of AVs and ensure their safe integration into society.

Index Terms—Self-driving cars, Autonomous vehicles (AVs), Lane Detection.

I. INTRODUCTION

As per the World Health Organization's yearly testimony on traffic-related injuries, Road accidents claim the lives of 1.35 million people every year [1]. The majority cause of these crashes are the result of human error [4] [8]. These errors can be induced by excessive speeding, driving while intoxicated, or distractions while driving (like talking on mobile phones, messaging, chitchatting with others). Other faults include the reluctance to use seatbelts, helmets, or additional necessary safety gear [2]. These numbers demonstrate the necessity for widespread acceptance and advancement of self-driving vehicle (AV) technology. Tesla Model 3, a level 2 autonomous vehicle, was launched to the market in 2019 [7]. An autonomous vehicle is one that operates independently of human control and is capable of sensing its environment. An autonomous vehicle is also referred to as a self driving vehicle or a driverless vehicle [4].

There are numerous advantages towards adopting autonomous technology, such as a reduction in road pollution, an increase in reliability, improvement in traffic flow and reduction in congestion that eventually improve the quality of life for individuals. By the year 2022, it is estimated that, a sophisticated speed adaption systems and completely automated AVs will be available without driver backup by 2030, according to author [3].

II. CHALLENGES INVOLVED IN USING AVS

Hacking for malicious purposes: Self-driving vehicles can be programmed for recreational or criminal objectives. Increased vehicle travel: By enhancing convenience and comfort, autonomous vehicles have the potential to enhance vehicle travel and thus collision exposure. Costs of ownership and operation: Most optional vehicle equipment, including remote starting, adaptive cruise control, active lane assist, safety cameras, and navigation systems, now cost several thousand dollars [6]. Table I shows the summary of the pros and cons of AVS.

Benefits:-

1] Accidental damage: Autonomous vehicles are an effective way to reduce traffic deaths and injuries.

2] Reduced Expenses: Accurate autonomous driving can reduce fuel consumption and improve component efficiency.

Drawbacks:-

1] Law: AVs may be limited by the legal definition of their responsibilities.

2] Security risk: Due to their current computer-controlled functions, antivirus software may be more susceptible to network hacking.

III. LITERATURE REVIEW

Lane detection is crucial for autonomous vehicles (AVs), allowing them to navigate safely within traffic lanes. Several studies have addressed challenges in this area. Wang and Zhou proposed a lightweight deep learning model for recognizing traffic signals. Yuan et al. developed VSSA-NET for traffic sign recognition, while Zhu et al. employed object suggestion techniques. Raja Muthalagu introduced a method for detecting safe driving regions, and Roy presented an approach for detecting emergency vehicles using YOLO-V3. Additionally, Ioana Koglbauer focused on adapting AEB systems for different road conditions. These studies highlight the importance of ongoing research in advancing AV safety and efficiency.

IV. PROPOSED METHODOLOGY

Object and lane detection is a task in computer vision that involves identifying the presence, location, and type of one or more objects in a given photograph. It is a challenging problem that involves building upon methods for object recognition. The project aims to build a prototype of an autonomous car using Raspberry Pi as a processing chip. An HD camera is used for image processing which will provide necessary data from the real world to the car. The car is capable of reaching the given destination safely and intelligently thus avoiding the risk of human errors. Many existing algorithms like lane detection, object detection are combined together to provide the necessary control to the car. We will implement road sign detection, for lane detection car will autonomously give steering predictions and as a result will be able to drive on a given road condition. In this way with the help of advanced technology the car can achieve object detection and lane detection autonomously. The main objective of this work is to develop a perception algorithm for self-driving cars which is based on pure vision data or camera data. The work is divided into two major parts. In part one of the work, we develop a powerful and robust lane detection algorithm which can determine the safely drive-able region in front of the car. In part two we develop and end to end driving model based on CNNs to learn from the drivers driving data and can drive the car with only the camera data from on-board cameras. Performance of the proposed system is observed by the implementation of the autonomous car that can be able to detect and classify the stop signs and other vehicles. In this work, the frames read from the video are given as an input to the system and the raw images are go through the following processing steps.

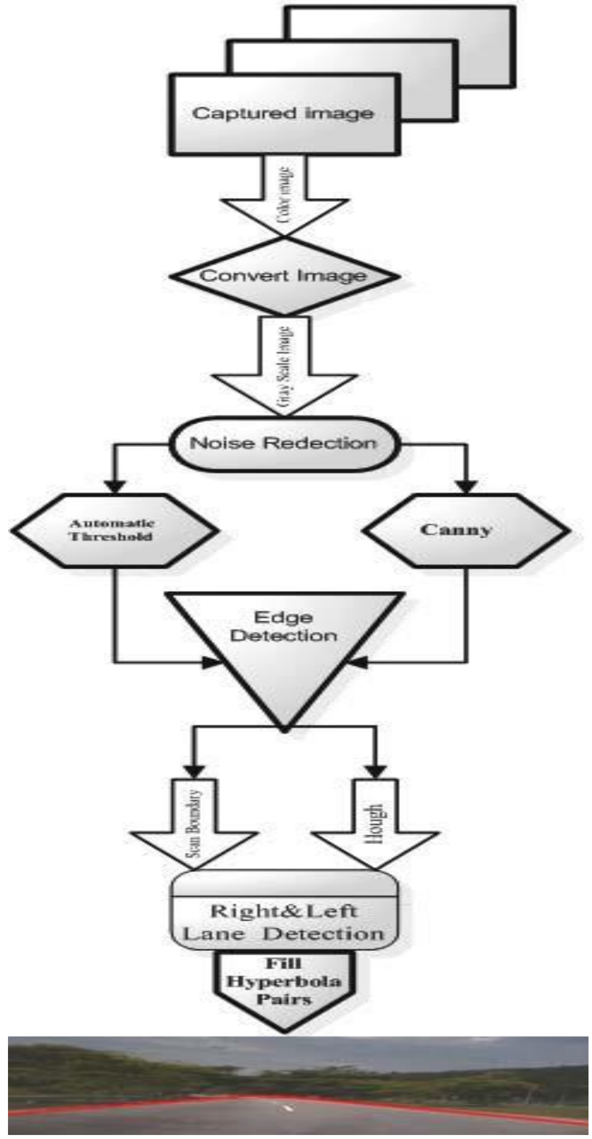


Fig.no:1.1 Algorithm over view

Step 1:- Pre-processing and color segmentation on the image that includes loading the raw image, converted the raw image from its original RGB color space to HSL (Hue Saturation Lightness) and split into its individual color bands of H, L and S. It is used to detect objects or parts of the image that are in a specific color.

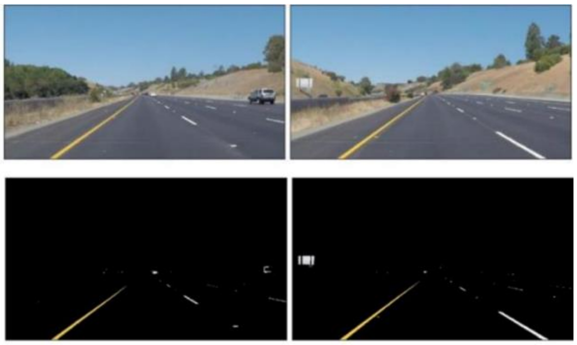


Fig.no:1.2 Input raw image and output color segmented image from pre-processing

Step 2 :- The Canny edge detector classifies a pixel as an edge if the gradient magnitude of the pixel is larger than those of pixels at both its sides in the direction of maximum intensity change, the result after applied the 'Canny' edge detector over the gray scaled image. The Canny edge detection algorithm yields good edge detection results. The detection of the edges for the lane markings may be heavily affected by present noise in the image, so it is required to remove the noise after the edge detection by filtering.

Fig.no:1.3 Edge detected output from the canny edge detector after noise removal

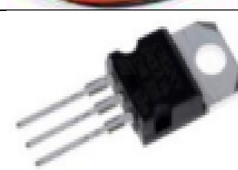
Step 3 :- A smoothing filter is used to smoothen the gradient, and only the prevailing gradients are detected in this edge detection algorithm. The noise removed edge detected image. After the edge detection, the lines can be extracted from these edges.

Step 4 :- The Hough transform is used to convert the lines into a parameter space as a point, it helps to detect the lines by associate a line in the image as a single point in the parameter space. The slope for the lanes is determined with linear regression after the most dominant Lines are found.

Fig.no:1.4 The result of the minimalistic lane detection approach

V. IMPLEMENTATION DETAIL

Table 1.1: Used Hardware List

1.Raspberry Pi: Model 4 (2gb) Ram LDDR4 5V DC 3A	
2.Webcam: 1080p (HD) Depending on Brand	
3.Motor: 5V (DC)	
4.Battery: Lithium Ion/Lithium poly 12V	
5.Voltage Regulator: 12V to 5V	

Block Diagram:

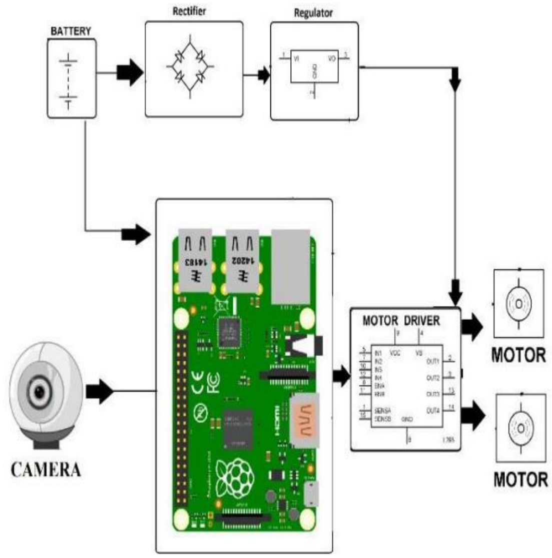


Fig.no:1.5 System Flow

VI. CONCLUSION

In summary, autonomous vehicles have the potential to transform transportation, addressing many of today's challenges. Entrepreneurs believe that by 2030, these vehicles will be reliable, affordable, and widely accessible, bringing significant savings and advantages. However, we should be cautious of overly optimistic predictions influenced by industry insiders. This article has examined the current state of autonomous vehicle technology, focusing on sensor technologies and past research. These advancements are expected to improve safety, reduce pollution, and promote fairness. Yet, infrastructure alone won't suffice; future smart cities must adapt to accommodate autonomous vehicles. Moreover, ongoing research is crucial for further progress. By outlining system architecture and strategies, this article aims to contribute to the advancement of autonomous vehicle technology. With collaboration and understanding, we can fully harness the benefits of autonomous vehicles for society's wellbeing.

REFERENCES

[1] Chen, Z.; Chen, K.; Chen, J. Vehicle and Pedestrian Detection Using Support Vector Machine and Histogram of Oriented Gradients Features. In Proceedings of the 2013 International Conference on Computer Sciences and Applications, Wuhan, China, 14–15 December 2013; pp. 365–368.

[2] Raja Muthalagu1, Anudeep Sekhar Bolimera2, Dhruv Duseja3, Shaun Fernandes4 ,"OBJECT AND LANE DETECTION TECHNIQUE FOR AUTONOMOUS CAR USING MACHINE LEARNING APPROACH ",Transport and Telecommunication, 2021, volume 22, no. 4, 383–391 Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia DOI 10.2478/ttj-2021-0029

[3] Shuvendu Roy,Md. Sakif Rahman,"Emergency Vehicle Detection on Heavy Traffic Road from CCTV Footage Using Deep Convolutional Neural Network",2019 International Conference on Electrical, Computer and Communication Engineering (ECCE), 7-9 February, 2019

[4] S. Wang, J. Cheng, H. Liu, F. Wang, and H. Zhou, “Pedestrian detection via body part semantic and contextual information with DNN,” IEEE Trans. Multimedia, vol. 20, no. 11, pp. 3148–3159, Nov. 2018.

[5] W. Ouyang, H. Zhou, H. Li, Q. Li, J. Yan, and X. Wang, “Jointly learning deep features, deformable parts, occlusion and classification for pedestrian detection,” IEEE Trans. Pattern Anal. Mach. Intell.,vol. 40, no. 8, pp. 1874–1887, Aug. 2018.

[6] Z. Cai, M. Saberian, and N. Vasconcelos, “Learning complexity-aware cascades for pedestrian detection,” IEEE Trans. Pattern Anal. Mach. Intell., vol. 42, no. 9, pp. 2195–2211, Sep. 2020

[7] J.-G. Wang and L.-B. Zhou, “Traffic light recognition with high dynamic range imaging and deep learning,” IEEE Trans. Intell. Transp. Syst., vol. 20, no. 4, pp. 1341–1352, Apr. 2019

[8] Y. Yuan, Z. Xiong, and Q. Wang, “VSSA-NET: Vertical spatial sequence attention network for traffic sign detection,” IEEE Trans. Image Process., vol. 28, no. 7, pp. 3423–3434, Jul. 2019

[9] Y. Zhu, C. Zhang, D. Zhou, X. Wang, X. Bai, and W. Liu, “Traffic sign detection and recognition using fully convolutional network guided proposals,” Neurocomputing, vol. 214, pp. 758–766, Nov. 2016.

[10] S.M. Easa, M. Diachuk, Optimal speed plan for the overtaking of autonomous vehicles on two-lane highways, Infrastructures 5 (2020),

Infrastructures 2020, 5(5), 44; https://doi.org/10.3390/infrastructures5050044.

[11] Ioana Koglbauer, Jürgen Holzinger, Arno Eichberger & Cornelia Lex,"Autonomous emergency braking systems adapted to snowy road conditions improve drivers' perceived safety and trust", Traffic Injury Prevention, available @ https://www.tandfonline.com/doi/pdf/10.1080/15389588.2017.1407411?needAccess=true

[12] JungEun Lee, GyoungEun Kim and ByeongWoo Kim" Study on the Improvement of a Collision Avoidance System for Curves", Appl. Sci. 2019, 9, 5380; doi:10.3390/app9245380 www.mdpi.com/journal/applsci.

[13] Raja Muthalagu et.,al "OBJECT AND LANE DETECTION TECHNIQUE FOR AUTONOMOUS CAR USING MACHINE LEARNING APPROACH" Transport and Telecommunication, 2021, volume 22, no. 4, 383–391.