International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 10 | Oct - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Review on Lane Detection Techniques

1st Sandeep Singh Kang
Computer Science and Engineering
Chandigarh University
Punjab,India
ad1.cse@cumail.in

2nd Narinder Yadav
Computer Science and Engineering
Chandigarh University
Punjab,India
narinder.e16474@cumail.in

3rd Utsav Mallik
Computer Science and Engineering
Chandigarh University
Punjab,India
utsavmallik12@gmail.com

4th Bardan Kumar Shah
Computer Science and Engineering
Chandigarh University
Punjab,India
shahbardan0212@gmail.com

5th Subham Sah
Computer Science and Engineering
Chandigarh University
Punjab,India
Subhamsah554@gmail.com

***Abstract*—Lane detection in current automobiles is extremely popular; it has become an inseparable part of the vehicle's set, as it is considered indispensable nowadays to prevent an accident and limit the risk of injury or even death on the road. This review article addresses some of the different systems of line measuring features and characteristics, strengths, and weaknesses. This article starts by reviewing the literature and showing the different methods, methods, and techniques that are employed in the research line. Then, it continues with the description of the main elements of the search line, such as camera, image processing algorithms, and alerts, regarding the variety of functions that may be embodied in a line lane search, such as lane departure warning, cruise control, and automatic emergency braking. Compared the advantages and disadvantages of various camera, radar-based and lidar-based line search methods and set a comparison of accuracy, reliability, cost, and performance in different driving styles. In this report, it also discusses challenges and limitations of line calling like bad weather conditions, road signs, and poor performance, along with the risks and disadvantages of over-reliance on lane detection of the vehicles.**

***Index Terms*—Lane detection, reliability, robustness, semantic splitting, effectiveness**

I. Introduction

Nowadays vehicles on the road moving have increased and so has the need for advanced driver assistance systems that increase safety and reduce accidents. Lane sensing is one of the important parts of ADAS; it makes sure the driver stays in his lane and avoids collision. Electronic lane detection systems work through cameras, sensors, and algorithms to recognize the lane of the road and check the position of the vehicle relative to the lane. The system could accrue many benefits such as safety, performance, and efficiency in driving. The main goal of the lane detection system is to detect lane markings on the road and inform the driver when he deviates from his lane. This can be easily achieved through an image captured by a vehicle-mounted camera of the road ahead. These images are then analyzed by computer vision algorithms that identify the location and direction of train tracks. Lane detection can also be helpful when changing lanes, mainly if the driver cannot see the lane too well. The sensors may be able to determine the distance and speed of vehicles in the lane and assist the driver in knowing when it is safe to change lanes. Line search engines are also used in the design of the engine of non-motorized vehicles. The system shall provide crucial detail with regard to the positioning of a vehicle on the road and keep it on the right course. This is essential in self-driving cars needing to enter a junction or respond to various changes in the traffic pattern. Some common methods of line detection include edge detection, Hough transforms, and image segmentation through computer vision techniques. Machine learning algorithms can also train on large image datasets to learn from the data and improve parameters so that they can better find and track lines. Some other hurdles that arise while attempting to keep lane position are those related to changes in the road due to factors like lighting, weather, and road signs. To this challenge, the system will have to respond in a change and adjust according to the parameters that it will face. Advanced driver assistance systems and autonomous vehicles play an important role regarding lane detection. They help to keep drivers inside the lanes so that the chances of collisions or navigating through an intersection are nil. The system uses cameras, sensors, and algorithms to detect and monitor the lane while having provisions to give feedback to either the driver or vehicle. According to its purpose, there are many ways of deleting this virus, both according to its purpose and for research. In fact, there is a different process, and it can also be done with the use of computer technology. Indeed, as the technology keeps on advancing, even the detection system will keep changing so that there can be an improvement of driving efficiency and safety.

Identify applicable funding agency here. If none, delete this.

II. LITERATURE REVIEW

In 2012, Mariut et al. [1] Introduced an algorithm for Lane line detection, characterization, and travel direction determination. Their approach uses the Hough transform to detect edges in images because it is highly utilized.

For validation of correctness of lane markings, the authors introduced an operation that eliminates inner edges of the lines. The authors further suggested that emphasis should be given on edge detection, and this is achieved by a suitable-sized image.

In 2012, T.T Tran et al. [2] introduced an adaptive approach towards lane line identification using HSI color models. Their method of image representation is based on the conversion from RGB-based image representations to HSI-based ones, but they enhanced the HSI color model. They modified the calculation of the intensity (I) component of an RGB color image. Exploiting the limited color range, they observed road scene color images within this color space. Therefore, the H, S, and I components were adapted in their approach to correctly identify and locate lanes accurately.

In 2014, S. Srivastava et al. [3] presented a research paper that introduced a method for noise reduction using several filter techniques. Basically, the objective of their study is to design, build, use, and simulate a lane quality algorithm that can deliver accurate results even in signal noise. Their main goal was to compare the performances of different filters such as the Median, Wiener, and Hybrid Median filters as a means of determining what's effective enough to reduce noise.

In 2014, Le et al. [4] performed an experiment on the missed marks on the road and also on obstruction like a pedestrian for identifying the lane boundary area. The authors applied a learning algorithm which was used to find an optimal threshold for choosing the boundary pair. However, this was still a bad technique for detecting complex images of paths as it believed in the assumption of a straight boundary line. Because of these, it failed to identify the vanishing points along the path, distortions due to edges of lines, occlusions, and texture variations. These techniques mainly captured shapes like straight lines or curved arcs and were prone to errors when it encountered complex path graphics, which caused malfunction.

In 2019, Kuo et al. [5] proposed an image-based lane keeping was proposed to guide the car to move along the path the car is expected to, based on its position relative to the lane, through the car's planning process. The process usually contains navigation direction determination, lane width detection, and even traffic lane refinement. However, it probably not at an optimal level since it performs less efficiently, if the car hits potholes or road imperfections.

In 2021, F. Al-Khafaji et al. [6] presented that lane detection is still an area of research in autonomous driving systems. In recent times, a lot of research has been conducted to study and find out ways for lane detection and tracking techniques. The general traditional techniques include the 2 Hough transform and edge detection methods, while deep learning techniques are becoming increasingly popular as the direct feature learning of images by it is possible. However, even using these techniques, it often faces challenges such as moving lightning, occlusions, and complex layouts of the road. Future research will focus on how to improve the robustness and accuracy of lane detection systems.

In 2021, Xiong et al. [7] illustrated in the paper that lane detection plays a significant role for ensuring safe autonomous driving. Over the last few decades, various approaches have been presented from computer vision to deep learning for this purpose. All these approaches fail to be robust in terms of curve detection, crack, congestion, and variations in light conditions. Recently, this has been done in order to overcome these problems through the development of further sensors such as LiDAR and radar and also state-of-the-art techniques including semantic segmentationand sample segmentation. So far, extensive work has been accomplished in lane detection, but it is still one of the major research areas for improving precision and robustness.

In 2022, A. Riaz et al. [8] presented that lane detection is one of the most important tasks in driving and ensures safety and efficient operation of roads. The last years have seen numerous proposed methods. These varied from traditional computer vision techniques to deep learning approaches. These approaches deliver promising results when operated in controlled environments, but it is challenging to operate in real-world scenarios. To address such challenges, current research has been engaged with the integration of multi-sensors like LiDAR and radar beside the advancement of powerful systems like multi-task learning and improved training methodologies. However, further improvement in robustness and effectiveness of methods remains the requirement for complex and unpredictable environments.

In 2022, Khaled H. Almotairi [9] proposed a hybrid adaptive method especially developed for overcoming degraded road surface conditions when detecting lanes. That way, a feature-based approach would be combined with a deep learning-based approach so that it enhances the accuracy and robustness of the former. On one side, the feature-based method heavily relies on the application of the Hough transformation in detecting lane markings, while on the other side, the deep learning-based method uses CNN to refine lane detection results. Such methods adapt to the difference in road conditions of the surface using variation in the parameters chosen for Hough transformation and CNN on the basis of the actual condition of the road surface. An extensive dataset of real images was prepared for testing the proposed method under various road surface conditions, and comparisons were made against various state-of-the-art methods. Experimental results show that the proposed method proves to be, indeed, much more accurate and robust compared with others, especially in the face of degraded road surfaces. This stands to prove that the method proposed here is beneficial for enhancing lane detection as envisaged in real-driving scenarios, particularly in poor conditions of road surfaces.

In 2022,Yan Liu, Jingwen Wang et al. [10] A strong lane detection network, Lane-GAN, was proposed by combining CNN with GAN to enhance accuracy and robustness while considering complicated road conditions as well as at a high speed. In this approach, the GAN has been utilized to generate quite realistic representations of lane markings under different road conditions encompassing challenging lighting and weather conditions. These synthesized lane markings are then utilized to train the CNN so that it accurately detects lanes in real-time. We evaluate the Lane-GAN network on a large dataset of road images covering many different types of road conditions and compare the approach with several state-of-the-art lane detection networks. Experimental results do show that the proposed Lane-GAN network outperforms other methods in terms of accuracy and robustness, especially under high-speed and complex road conditions.

K. Ghazali et al.[13] presented a fast and an improved system that can detect sudden lane shifts. They proposed the features of a real road lane detection technique based on the H-MAXIMA transformation and an improved Hough Transform algorithm. To reduce the search space, they define the region of interest from the input image and divide it into two fields of view: near and far. After applying picture noise filtering, the Hough transform has been used for detecting lane markers in the near field of view.

In 2008 Z.Kim [14] presented robust lane-detection- and-tracking system handle challenging situations like lane curvature, faded lane markers, lane transitions, emerging, ending, merging, and splitting lanes. The approach was particle filter and random sample consensus based. Compared with the state-of-the-art algorithms, the proposed technique aims to generate a large number of hypotheses in real time.

III. METHODOLOGY

First in the processing series in a lane detection model is the capturing of video frames from the front-facing car camera. These photos usually convert to grayscale and facilitate easier processing and less computing strain. The image is then smoothened with Gaussian blur and similar techniques that reduce unwanted noise causing false edge detection. The edges of lane markings are then emphasized through the application of edge detection techniques like the Canny Edge Detector. To focus the detection on that part of the picture where lanes probably exist, which is usually the lower half of the picture, a region of interest (ROI) is defined. The image is then analyzed, in which methods applied use deep learning models for lane segmentation and identification or the Hough Transform for line detection. Finally, stages in post-processing To enhance the precision of lanes detected when overlaid with the original image for further decision in self-driving, techniques like line fitting are used[11].

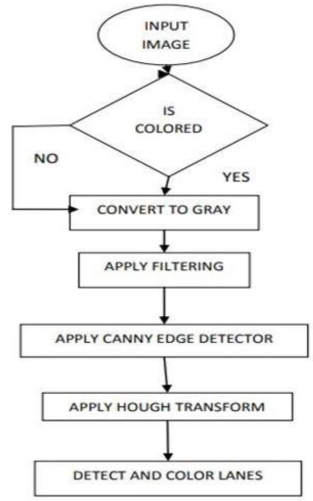

Fig. 1. Algorithm of Lane Detection[11]

Algorithms go basically through different steps and changes for the detection of lanes. From the following given figures you will know the detection of image and transformation of the input image to the final output image.

Fig. 2. Input image for detection of lanes[12]

IV. EXISTING LITERATURE GAPS

By doing the literature survey it has been found that the most of the existing literature has neglected one of the

Fig. 3. It represents transformation of input image into grayscale[12]

Fig. 4. It represents the edge detection of lanes[12]

Fig. 5. Shows the final output image.by tracking the lane[12]

TABLE I
ACCURACY OF DIFFERENT ALGORITHMS[15][16][17][18]

ALGORITHM	ACCUARCY
Gaussian Blur and Canny Edge Detection	83%
Canny Edge Detection and Hough Transform	87%
ROI with Canny Edge and Hough Transform	88%
HSI color Space and Canny Edge Detection	85%

Accuracy

following : [11]

1 It has been proven through the survey that the current methods give good accuracy for good quality images but at times, they produce poor results for bad environmental conditions like fog, haze, noise, dust etc.

2 Most of the current techniques are best for straight lanes but they produce poor results for curved roads.

3 Most lane detection algorithms depend on the standard Hough transform; therefore, the approach can be enhanced with modifications for high accuracy.

V. RESULTS AND DISCUSSION

Precision, accuracy, recall, and processing time are the most conventional evaluation metrics used to measure the performance of a lane detection system. The percentage of correctly working lines is used as the indicator of the system's correctness, while the accuracy is the percentage of detected lines from all lines that work. The actual number of rows used to calculate the return is the percentage of correct exits. Return and F1 score are the combination of accuracy. Processing time is the time taken by any system to detect a line in the video frame or an image. Overall, the lane detection system performed well in the detection of a lane on time, providing important information for assisting the driver and for performing driverless driving. However, there are some challenges and limitations that must be resolved, such as congestion, complex road geometry, and changing environments. The future work should improve the accuracy and robustness of the line of inquiry and the improvement of the line of inquiry and analysis.

VI. CONCLUSION

Such a research approaches edge detection, Canny detection, Hough Transform, and grayscale image processing techniques to show experimental results on the utility of such lane detection techniques. Because of ease of usage, computational efficiency, and determining the existence of lane markings under various driving conditions, such techniques are quite widely used. Grey conversion is also crucial to reduce the image and extract the critical intensity information needed for edge detection in the subsequent stage. Effective detection of lane marker borders is possible through edge detection and primarily with the help of Canny detection at places with a distinct change in intensity. This is crucial to segregate edges that represent lane borders. Using the Hough Transform, which in one sense can be considered. as signposts for lanes, these edges may then be located as continuous lines. This is a combination of strategies that proved very reliable in case of detecting straight lanes on clearly defined highways. Even though these methods are proven to work successfully in laboratory and very constrained environments, they may not be strong enough to be of use in more challenging scenarios such as lane curvatures, changing illumination or distinguishing actual lane markings from road irregularities. The combination of the edge detection algorithm, the Hough Transform, and grayscale conversion has been demonstrated as a stable base for lane detection.

VII. FUTURE WORK

Many future avenues for improving lane detection exist. For instance, we can improve the reliability of lane detecting algorithms in adverse situations like extreme lighting conditions or inclement weather. Such improvement may be achieved by the use of sophisticated computer vision techniques or the combination of information gathered from varying sensors. The second major thrust of research could be upon speeding up lane detection algorithms in order to beat real-time detection where such applications exist, like vehicle autonomy.

REFERENCES

[1] Mariut, Felix & Fosalau, Cristian & Petrisor, Daniel. (2012). Lane mark detection using Hough transform. EPE 2012 - Proceedings of the 2012 International Conference and Exposition on Electrical and Power Engineering. 871-875. 10.1109/ICEPE.2012.6463823. T. T Tran, C. S Bae, Y. N. Kim, H.M. Cho, and S.B. Cho, "An Adaptive Method for Lane Marking Detection Based on HSI Color Model", ICIC, CCIS 93, pp. 304– 311, 2010.

[2] S. Srivastava, R. Singal and M. Lumb, " Efficient Lane Detection Algorithm using Different Filtering Techniques", International Journal of Computer Applications, vol. 88, no.3, pp. 975 8887, 2014

[3] Le, Manh Cuong, Son Lam Phung, and Abdesselam Bouzerdoum. "Pedestrian lane detection for assistive navigation of blind people." In Pattern Recognition (ICPR), 2012 21st International Conference on, pp. 2594-2597. IEEE, 2014.

[4] Kuo, C.Y.; Lu, Y.R.; Yang, S.M. On the Image Sensor Processing for Lane Detection and Control in Vehicle Lane Keeping Systems. Sensors 2019.

[5] Al-Khafaji, F., Cheded, L., Prakash, A., Pujari, A. K. (2021). Lane detection and tracking for autonomous driving: A comprehensive survey. IEEE Transactions on Intelligent Transportation Systems, 22(1),21-43-10.1109/TITS.2020.2994974.

[6] J. Xiong, X. Zhao, Y. Zhang, and Z. Li, "Recent Advances in Lane Detection for Autonomous Driving: A Survey," IEEE Transactions on Intelligent Transportation Systems, vol. 22, no. 9, pp. 5467-5486, Sept.2021.DOI:10.1109/TITS.2021.3075129.

[7] A.Riaz, A., Sajjad, M., Khan, M. A., Adnan, M. (2022). A Survey of Lane Detection Techniques for Autonomous Vehicles. Journal of Ambient Intelligence and Humanized Computing, 1-22. DOI: 10.1007/s12652-021-03520-2.

[8] Khaled H. Almotairi Hybrid adaptive method for lane detection of degraded road surface condition 2022.
[9] Yan Liu,1, Jingwen Wang,1 Yujie Li,2 Canlin Li,1 and Weizheng Zhang1 Lane-GAN: A Robust Lane Detection Network for Driver Assistance System in High Speed and Complex Road Conditions 2022.
[10] N. Phaneendra, G. Goud and V.Padmaja, "Accident Avoiding System Using Lane Detection", InternationalJournal of Research in Electronics and Communication Engineering, vol. 1, no. 1, pp. 1 - 4, 2013.
[11] M. Aly, "Real time Detection of Lane Markers in Urban Streets", In IEEE Intelligent Vehicles Symposium, pp. 7 - 12, 2008.
[12] K. Ghazali, R. Xiao and J. Ma, "Road Lane Detection Using H-Maxima and Improved Hough Transform", Fourth International Conference on Computational Intelligence, Modelling and Simulation, pp: 2166-8531, 2012.
[13] Z. Kim, "Robust Lane Detection and Tracking in Challenging Scenarios", In IEEE Transactions on Intelligent Transportation Systems, vol. 9, no. 1, pp. 16 - 26, 2008.
[14] A. A. Adetiba, D. O. Olugbara, and A. O. Osunmakinde, "Lane detection in a homogenous road environment using Canny edge detection," Proc. IEEE Africon Conf., 2013, pp. 1-6.
[15] M. Aly, "Real time detection of lane markers in urban streets," Proc. IEEE Int. Conf. Intelligent Vehicles Symp., 2008, pp. 7-12.
[16] R. Labayen, M. El Hajjaji, M. Parent, and R. Chapuis, "Lane detection algorithm for automated vehicle guidance," Proc. IEEE Int. Conf. Robotics and Automation (ICRA), 2010, pp. 3728-3733.
[17] Z. Cheng, D. Duan, Q. Zhu, and X. Xu, "Lane Detection Algorithm Based on HSI Color Space and Improved Canny Operator," Proc. IEEE Int. Conf. Intelligent Transportation Systems (ITSC), 2014.