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Road Lane Line Detection in Smart Cities using Image Processing Technique

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***Abstract*— In light of growing metropolitan traffic, safety when driving has grown more and more persuasive. The majority of fatalities on the roads are caused by drivers leaving their lanes while following the required laws. Many of them are a consequence of the driver's disrupted and drowsy attitude. Lane discipline is essential for both driving and protecting pedestrians on the road. The proposed research seeks to detect lane markings in order to produce a safe and advanced traffic system. The proposed device's capabilities include displaying lane line locations to the driver on any exterior display to more complicated programs such as recognizing lane changes within the near future so that injuries caused on the roadways may be avoided. The proposed strategy aims to detect markings for lanes on the roadway by providing a video of the road using computer vision technology to reduce the incidence of accidents. The proposed system was installed in automobiles and cabs to reduce the number of accidents caused by careless driving along the road. In addition, the efficiency of motorists in transportation-related sectors can be tracked in order to detect and report driver irresponsibility and lack of focus on the roads.**

***Index Terms*— Lane detection, image processing, hough transform, canny, edge detection, traffic, road, driver.**

I. INTRODUCTION

Among the most important challenges has become traffic accidents. The majority of accidents are caused by the driver's irresponsibility. Rushing and irresponsible driving might endanger other motorists and passengers on the roadways. A lot of crashes can be avoided if dangerous driving circumstances are identified promptly and various drivers are reminded. Most highways now utilise camera and speed detectors to monitor and catch cars who exceed the permitted speed limit. That is a crude technique, but it has limitations. though motorists slow down at approaching the speed detection devices, they may not be noticed even though they already exceeded the permissible speed. In 2020, failing to stay in the appropriate lane or going off the road was responsible for over 7% of fatal collisions in the United States [1].
In 24% of all deadly collisions, the driver was not travelling in the proper lane. This is the most critical preceding event in car crashes. One of the most prevalent types of car accidents is a lateral effect incident. Side effect crashes occur whenever vehicles switch lanes or join onto the roadway irresponsibly. These incidents occur mostly as a result of the approaching automobile driver moving into the back mirroring the blind-spot of the vehicle in the to

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riding-assistance systems in order to increase safety while driving [2, 3]. The vehicle's imaging system recognizes the lane markings on the road and determines the automobile's direction and positioning in relation to the lines [4]. Lane detection is a critical function in a lot of applications because lanes provide critical data, such as a region of interest, for further processing [5]. Lanes typically show up in images as distinct, straight-line characteristics, particularly on highways, or as curves that smaller straight lines can roughly mimic [6]. The widely used linear HT (Hough Transforms) based lane detection algorithm is frequently performed using the line detection technique [7-8]. The HT map is a parametric representation of the edge points[9,10]. Each edge pixel has two steps, where P(x,y) is:

$$\rho = x\cos\theta + y\sin\theta \qquad (1)$$

where ‘ρ’ denotes the angle formed by the perpendicular to the x-axis and the distance of the perpendicular from the origin O to a line passing through (x,y). Then the 2-D array is used to aggregate the data, and its peaks correspond to the image's straight lines [11,12]. In order to find straight lines, array accumulation analysis is used for peak identification [13]. Due to trigonometric computations and other factors, the standard Hough transform requires a lot of computing time. It is inappropriate for direct use in lane identification because to the multiplication operations performed on each pixel in the edge map, which requires real-time processing. Hierarchical pyramidal methods were put out as a way to increase the parallelism of the HT computing process.

The organizational structures screen applicants for promotion to the upper hierarchy levels by using a threshold of accumulation spaces [14]. Each candidate who passes the conditions is subjected to another rigorous HT calculation using eqn (1). As a result, while hierarchical approaches [15] speed HT by running in parallel the operation, additional costs for re-computing HT at every level occur. These higher computation expenses are problematic in applications that are embedded such as lane detection in automobiles, where computing hardware is limited. A revised approach is provided in this work that will speed up the HT process in a computationally efficient manner and make it suitable for real-time lane recognition. The approach recommended is employed for straight lane recognition and has been shown to provide results in smart cities. It employs a modified or revised Hough Transform method. A Driving Video Recorder (DVR) is integrated in the recommended manner without impairing the DVR's functionality in smart cities.

II. Related Work

A road image is usually classified into two types: organized and unstructured. Localization of road boundaries or road markers is one of the most regularly used tactics for organized roadways. Several approaches were used to locate the road markers or boundaries, including color cues, Hough Transform-based steerable filters, and the Spline model. The drawback of these systems is that they operate only consistently on well-structured roadways with obvious borders or markers [16]. Techniques based on segmenting the road employing the color cue have been given; however, they fail to work well for an overall road image, particularly when the pavement has minimal color contrast with the surrounding area.

The Adaboost-based region segmentation and boundary identification constrained by geometrical projection were used to determine the "drivable" road area for unstructured or organised roads that had no discernible borders or markers. But training an area classifier needs a large number of different types of road images that might be tough. While the opposite visual flow approach provides adaptable road segmentation, it suffers on chaotic roads when the camera is unstable and optical flow estimate is not trustworthy enough [17]. FARS, which began activities in 1975, has data on a census of fatal traffic collisions in each of the fifty states, the United States District of Columbia, and Puerto Rico. A collision requires a motor vehicle moving on an open highway and lead to the demise of a driver, travellers, or non-motorist within a month after the incident to be covered by FARS. The numbers in this report were compiled using the 2004 FARS data file, which was created in June 2005. This report includes the 2003 final counts that have been updated. The 2005 report will include the 2004 final counts that have been revised. Data for GES are gathered from all police-reported crashes in a nationally representative probability sample [18].

The Federal Motor Carrier Safety Administration's (FMCSA) safety goal is to reduce the number and extent of big truck deaths and collisions. Many on-board safety features for trucks and buses have been tested and evaluated by the FMCSA in recent years in order to enhance both the security and safety of drivers everywhere. The FMCSA has started taking steps to engage closely with the trucking industry to create voluntary, vendor-independent requirements to encourage the voluntary adoption of these technologies within trucking fleets. The referred document’s goals are to convey a better understanding of how on-board safety systems work and to shed light on the advantages of employing them in terms of efficiency and safety [19].

The majority of efforts to use ITS technologies to address intersection safety issues are focused on signalized intersection situations. Several cutting-edge options for cooperative vehicle collision avoidance systems and driver aid systems have been created and tested. Current findings on unsignalized junctions mostly focus on modelling crash frequency, predicting crashes, analysing collision severity, and simulating motorist and bike behaviour. Real-world crossovers lacking pedestrian signal management are not often taken into consideration in system layouts or results. Furthermore, contemporary RTK-enabled DGPS (Differential Global Positioning System) receivers for communication, ultrasonic detectors, laser scanning devices, and photographic sensors, as well as their pairing, are required for reliable real-time automobile condition identification [20]. These technologies are used to improve intersection safety. Still, in a complex situation where certain functionality level consistently necessitate high system creation costs, a trade-off between efficiency and cost has to be considered when implementing such technologies in order to achieve an ideal efficiency and security level.
The majority of the circumstances awareness metrics that forms the basis of the assurance for safety at signalized crossings is the automobile's positioning state, that broadly speaking comprises coordinates location, velocity, attitude, and directions. It provides a comprehensive account of the vehicle's dynamical motion. This knowledge motivated the proposed research to create unique and reasonably straightforward methods for resolving vehicle conflicts by directing or regulating vehicles with the outcomes of dynamic state prediction. Satellite-based navigation has been regarded as an especially promising technique for finding cars. Despite the fact that high-precision position requires costly DGPS technological advances, a multi-sensor fusing system, whereby a low-cost GPS (Global Positioning System) gadget is augmented by other sensors and mapping citations, reduces the cost-efficiency difference. By applying data fusion processing to improve the GPS receiver's output frequency and continuity, the aiding sensors help the positioning system. Reference data from road plans enhances precision by modifying errors in estimation according to previous knowledge of the layout of the roadways [21]. Lane-level location has been an important trend in automobile location and navigation, with numerous consequences for system layout and algorithm creation. Many studies have proposed new approaches to this problem, regardless of the day and at night. Some studies attempt to boost the quantity of sensors installed on automobiles in order to enhance the performance of recognising obstacles in the perspective of the driver. Vehicles and pedestrian both employ two camera systems, multi-layer RADAR, and CAN-bus sensors. Several cameras and multi-range RADARs are used to identify a variety of obstacles.

III. Methodology

A two-dimensional convolution to blur images and eliminate noise, the Gaussian smoothing operator is utilized. It is similar to the mean filter in this sense; however, it utilizes an unusual kernels which replicates the form of a Gaussian hump. This kernel has distinct distribution properties. The initial stage in canny edge detection is to eliminate noise from the initial image prior attempting to identify and recognize any edges. The Gaussian filter blurs and removes superfluous features and noise. The Gaussian smoothing shall be performed using normal convolution techniques when an appropriate 5x5 mask is created. A convolution mask is substantially less in size than the individual picture. The kernel traverses the picture matrix, pushing one square of pixels at a time. The filter employs the following distribution to achieve convolution. Since the matrix's weight is dispersed outwards from its center. In order to ensure any noise in its outermost rows and columns is removed. The margins are areas with high intensity contrasts or a shift in intensity from one element to the next. Edge police work drastically decreases the amount of information in an image and filters unnecessary information while preserving the essential structural elements. The smart edge detection algorithmic application is also known as the best edge detector. The goal of Canny is to improve the image's numerous edge detectors. Low error rates and the ability to filter undesirable data from useful data should be the major criteria. The second condition is to keep the variance between the transformed image and the original one as small as feasible. Many gripping reflexes are disqualified by the third criteria. The smart edge detector will reduce noise. In areas of the picture with significant spatial derivatives, the gradient is accentuated. The algorithm monitors these locations and inhibits any component that isn't being targeted as much as it can. The gradient array is currently being physically shrunk to eliminate streaking and cut the edges.

A. Gaussian filter

The Gaussian filter is used for eliminating noise. The initial step in canny edge detection is to eliminate any noise from the initial image prior attempts to discover and identify any edges. Unwanted detail and noise are blurred and eliminated using the Gaussian filter. By constructing an adequate 5x5 mask, the convolutional technique is employed to achieve Gaussian smoothing. A convolution mask is significantly smaller than the picture. As a consequence, the mask is moved over the picture, and each pixel square is computed separately. The Gaussian filter's goal is to minimize image noise. The cv2.GaussianBlur function requires the following three inputs:

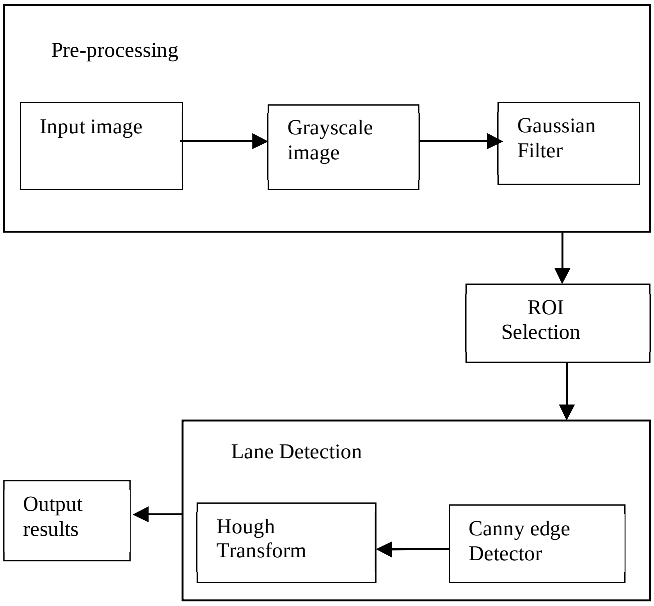


Figure 1System architecture of the proposed system

- The image parameter defines normalisation in order to decrease noise.
- 'ksize' defines the size of the kernel that will be used to convolute the image. The noise reduction is accomplished using this kernel convolution. The Gaussian Kernel is used to normalize the image.
- The standard deviation is specified by the 'sigma' parameter. The standard deviation measures the variance of the image's pixels. The ideal pixel spread would be consistent, with a standard deviation of zero.

B. Canny edge detection

The smart edge detection technique is the best edge detector. Cranny's purpose is to enhance the image's multiple edge detectors. The first requirement must have a low rate of errors and retain details while eliminating out unwanted data. The second requirement is to keep the original and processed images as similar as feasible. The third criterion removes the many edges from both the initial and modified images. Taking the guidelines as a reference, the astute edge detector initially calms the image in order to muffle the noise. Following that, it discovers the picture gradients to highlight places with high spatial contrast components. Every pixel beyond them is suppressed by the algorithm. The img option specifies the image that will be used for edge detection. It detects the intensity of pixels that have altered in certain regions of an image. Canny edge detection uses the horizontal and vertical gradients of pixels to detect edges in images. The cv2 is made up of three parameters.

- Threshold-1 parameter eliminates edges with gradients with a value less than this threshold.
- Threshold-2 parameter establishes the threshold value for an edge to be regarded as valid.
- If there is a gradient between the two thresholds, it will be taken into consideration as another gradient that is above threshold-2.

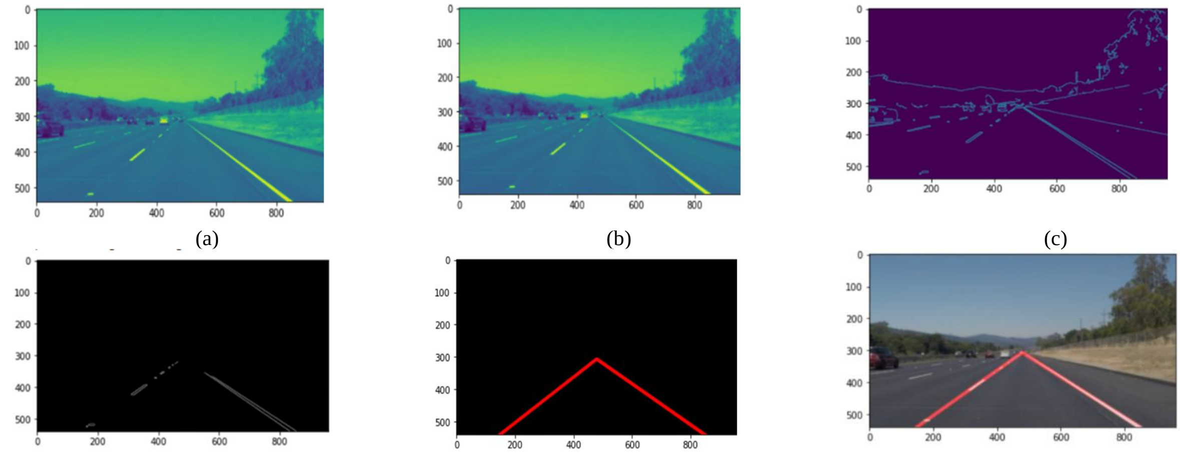
Remove the spots that don't belong in the area of interest. The zone of focus for the car's camera is limited to the two lanes directly in front of it and nothing beyond. Extraneous pixels are removed by defining a polygon region that is relevant and eliminating those pixels that belong within the polygon.

C. Hough Transform

The Hough transform hunts out faulty elements inside a specified class of patterns by employing a voting procedure. This vote is performed in a parameterized space from the objects that candidates are calculated as local maxima in the accumulator space. The algorithms determine the lines that signify lane lines after identifying edges in the region of interest. The process of transformation takes a "x vs. y" line and changes it to an angle in "gradient vs. intercept" space. The image's points will match to lines in Hough space. A line intersection corresponds to a line intersection in Cartesian space. Using this approach, one can discover lines in a smart city implementations from the pixel values of the fuzzy edge detection.

IV. Result

The system of road lane line detectors is implemented in the proposed model of the smart city automation process. The driver uses their eyes to choose where to go when they drive a vehicle. The guide for where the vehicle should be directed is the lines on the road that indicate lane locations. One of the primary goals in developing a self-driving automobile is to use an algorithm to recognise lane lines. Road detection ROI must be adjustable. The horizon will shift when moving up or down a steep incline is no longer determined by the frame's proportions. Additionally, this is to be considered when there is heavy traffic. This proposed method is heavily reliant on image processing, and the importance of route characterization in self-driving automobiles is tremendous. A single image from the evaluation set is chosen and included in the proposed model's implementation. The image selection is critical since the model's execution demands an image input for processing. If the procedure goes well, the output is also generated. If the output obtained for the testing image is same, the resultant image is forwarded to the next phase that requires additional development.
The concepts of Open CV tools for line detection using the Hough Transform and Canny Edge Detection were used in developing the proposed system. The accuracy of the algorithm is 93.8%. For bigger frame sizes, the proposed algorithm runs at a speed of around 0.17 s/frame. With the same precision, the speed was significantly increased. For lower frame sizes, the accuracy percentage is 92.2%. The speed is around 0.065 s/frame. Each frame is 640/480 split by 0.17 seconds to demonstrate how to normalise speed to pixels per second.



(a) (b) (c)

(d) (e) (f)

Figure 1 a) Grayscale image (b) Gaussian Filter (c) Canny Edge Detector (d) Region of interest (e) Hough Transform (f) Final output

V. Conclusion

Self-driving cars are now safe and will get easier if people's perceptions of their safety do not change in smart cities. People can only enjoy the pleasure of autonomous driving when they believe in it and decide to give it an opportunity. The advancement of self-driving cars appears to be crucial in the field of transportation. Although autonomous automobiles were the initial concept, radio waves, cameras, sensors, and other features will be developed in the near future. This will enhance traffic flow and safety by allowing for faster reactions and fewer errors. Since we implement our models in modules, it is simple to update the algorithms, and work on changing the implementation of the model may continue in the future. Considering the test cases, the pickle file of the model is required in the necessary places so that it may be quickly copied onto goods. By providing an alternate scenario in which roadways can be recognised in the dark or at night, one can improve driving after dark. In daylight, the Color detection and selection procedure work incredibly well. While adding shadows will make some noise, it won't be as demanding of a test as driving at night or with poor visibility at the time of heavy fog can be done using the Julia tool. This system can also be implemented as lane change alarm apps, and cameras mounted in self-driving cars, etc.

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