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Lane Departure Warning System

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ABSTRACT
A lane departure warning system is one of the emerging systems for reducing traffic accidents. LDWS is a system designed to warn a driver when the vehicle begins to move out of its lane boundaries on roads. Different techniques to implement LDWS have been surveyed. Implementation of LDWS on different platforms is studied.

General Terms
Lane detection algorithm, collision warning, object tracking

Keywords
Lane departure warning system

1. INTRODUCTION
Today, road safety is an important issue in the world. Thousands of car accidents occur every year. This may lead to loss of many lives. These collisions on roads cause many fatalities every year. The influence of traffic density and the speed of driving play an important role on the driver's perception of the road. It is often observed that if traffic on roads is less, lanes and traffic signboards may be ignored by drivers. The system called Driver Assist System (DAS) which alerts the driver about the lanes and signboards can be of great assistance. It can prevent accidental changes of lane due to the lack of driver's concentration. Lane departure warning systems monitor the position of the vehicle with respect to the lane boundary. When vehicle leaves lane unintentionally, the system delivers a warning to the driver.

From the falling cost of camera technology, many automobile manufacturers are starting to equip their vehicles with video cameras positioned at various places around the body of the vehicle. These cameras will capture images of lanes on roads and image processing techniques can be used for preprocessing. 1-D or 2-D Gaussian smoothing can be used to reduce noise in the captured image. Edge detection methods can be used to filter out unnecessary background information and to detect edges of lanes.

2. PLANE DEPARTURE WARNING SYSTEM IMPLEMNTATION
The system is to be developed to work on roads. These roads will have high contrast road markings showing the lane that the vehicle is to travel in. The primary work is to detect lane markings and to find out whether the vehicle lies within lane boundaries

2.1 Algorithms for lane detection
In order to detect whether the vehicle is departing from its lane, through the image processing, first thing need to be done is to determine positions of lane markings in the image plane. Detecting lane markings use a series of feature-based approaches to do lane markings recognition.

Line gradient estimation method is one method to detect lane [7]. Lane markings have higher gray values compared to road surface, regardless of its color (white, yellow or other). Statistics of gray scale is used to find out threshold value of lane marks. The comparison with threshold value will differentiate lane and road surface. Line gradient can be calculated using equation 1.

$$G_i = -P_{i-1} + 2 * P_i + P_{i+1} \qquad \text{.... (1)}$$

Here, *Gi* is the line gradient value of position i in the image, P*i* is the pixel value in the image's region of interest. Maximum value of *Gi* is found to detect the edge of every lane mark i. To identify whether the region between boundaries is a lane mark or not, an important parameter called continuity is considered. The average pixel value is used to identify if there is continuity between the region of left boundary and right boundary. After finding the edge of one lane mark, the middle position of a lane is found. Recursive Least Square method and the middle positions are used to build the lane model. Then distance between vehicle and left and right lanes is calculated and compared with threshold distance value to find out whether vehicle is within lane boundaries or moving out.

Another method for lane detection is Hough transform [1][2]. It requires less computational time to detect a lane marking over the entire frame. It is more commonly used for detection of lines in an image. But this algorithm can also be used to detect any arbitrary shapes, for example circles, ellipses, and so on. The underlying principle of the Hough transform is that every point in the image has an infinite number of lines passing through it, each at a different angle. The purpose of the transform is to identify the lines that pass through the most points in the image, i.e. the lines that most closely match the features in the image. To do this, a representation of the line is needed that will allow meaningful comparison in this perspective. A second line is drawn from the origin to the nearest point on the line at right angles. The angle that this second line makes to the origin is recorded, as is the distance from the origin to the point where the two perpendicular lines meet. These values are known as "theta" (θ) and "rho" (ρ). The line-to-point mapping is illustrated in Figure 1.

For implementation on an image, the Hough Transform is often performed after edge detection step.

Gradient method gives reasonably good performance in many cases. But work is carried out on roads with clear lane markings. The problem arises when clear lane marks are not available or lane makings are worn out.

Lane detection algorithms can detect lanes only when lane markings are visible. When lane marks are not available, vehicle tracking algorithms can be used. One way is to use L-K optical flow tracking [1]. Camera fixed with vehicle captures images of lanes when available. The front-view images captured are converted to their corresponding top-view images via a homography.

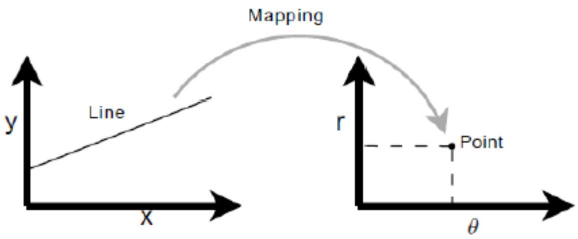

Figure-1 Mapping of a line to the Hough space

Then the L-K optical flow tracking is used based on these converted images. It tracks points from frame to frame to find the vehicle's heading angle and thus its lateral position by evaluating the relationship between these tracked features.

There are some challenging scenarios that need to be dealt with in real time, such as lane curvature, worn lane markings, lane changes, and splitting, merging, ending, emerging lanes. Gradient method cannot distinguish false intensity bumps caused by leading vehicles and road markings/textures from weak lane markings. Thus, robust algorithm can be used called random sample consensus i.e. RANSAC for lane detection together with particle filtering technique for lane tracking [6]. In this algorithm, the image is rectified. Possible lane marking pixels in the rectified image are detected. Then, the detected lane-marking pixels are grouped into lane-boundary hypotheses. Finally, a probabilistic-grouping algorithm is applied to group lane-boundary hypotheses into left and right lane boundaries. Due to separate generation of left and right boundary hypotheses, it is possible to deal with various scenarios such as on/off-ramps or an emerging lane.

One more problem is that the lanes to be detected are considered in good lights. In the presence of shadows or changing lighting conditions robust algorithm is needed to be used. The system can be designed using steerable filters for robust and accurate lane marking detections [2]. Steerable filters can provide an efficient method for detecting circular reflector marking, solid-line marking, and segmented-line marking under varying lighting and road conditions. It helps to provide robustness to lighting changes from overpasses and tunnels and road surface variations, complex shadowing. Curvature detection is made more robust by incorporating both lane markings and lane texture and vehicle state information. Another method for lane detection in presence of shadows or low illumination conditions is to use local gradient features [3]. In this method, firstly, video frames are extracted and processed for detecting lane markers. Then, vertical gradient of the lane is computed and is used for feature extraction. Spectrum match plot is then used to locate points on the adjacent lanes.

The regular and time consuming modular algorithms can be taken and carry them out into hardware realization. Lane detection can be done using a modified global edge detector (GED) [5]. Vertical shifter based GED can be used that speeds up in circuit communication [4].

2.2 Platforms used for implementation of LDWS

Various platforms like FPGA, ARM, DSP can be used to implement LDWS. Each of these has its own advantages and disadvantages.

FPGA is more advantageous compared to other commercially available hardware platforms such as microprocessors, DSP due to its features such as re-configurability, flexibility. It takes less time for computation compared to others, due to its parallel nature. Thus computation is fast. Design time to market is less with low cost. LDWS can be implemented on different FPGA platforms. For example, Altera embedded with NIOS II processor [4] or Xilinx platform embedded with microblaze or picoblaze processor. Spartan 6 or Spartan 3 FPGA can be used for implementation.

FPGA implementation of vision based LDWS can be done with the help of system generator [2]. In system generator development process, first algorithm for proposed model is made in MATLAB Simulink. Algorithm to be used in HDL is identified and then co-simulation is performed. This is implemented on FPGA. Hardware/software co-simulation is performed.

Real time processing of image is difficult with the help of FPGA due to resource constraints. Digital signal processors (DSP) supports real time processing [7]. Thus, DSP based embedded system can be used to implement vision based LDWS. Processed image can be transmitted through DSP after decoding from analog format to digital format. The DSP with high computing performance executes the recognition and estimation algorithm.

Many LDWS systems are still implemented on personal computer based platform. Thus, they lack flexibility for easy deployment and capability of product commercialization. Due to the enhancement of embedded calculating technology, the low-cost and high-flexibility advantages of embedded system technology in various other fields can be exploited. Hence, LDWS can be built using Advanced Risc Machines (ARM) [4]. This gives portable system with properties compact size, low power consumption and low cost, can widely be deployed to various popular consumer devices.

3. RESULTS

We have implemented Gaussian smoothing algorithm using MATLAB. Original image of lane on the road is shown in Figure-2. First, this image is converted from RGB to gray using a MATLAB command as shown in Figure-3.

Figure-2 Image of lane on road

Gaussian smoothing is then applied and the result is shown in Figure-4. It reduces noise in the original image. After Gaussian smoothing operation, sobel operator based edge detection is performed to find out edges in that image and to remove unnecessary background information. Its result is shown in in Figure-5. Lane detection algorithm is applied to this image for detecting lanes.

Figure-3 Result of RGB to Gray conversion

Figure-4 Result of Gaussian smoothing

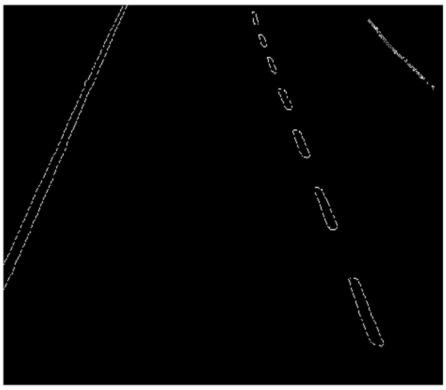

Figure-5 Result of edge detection

4. CONCLUSION

We have surveyed different algorithms for lane detection and lane tracking, such as gradient algorithm, Hough transforms, RANSAC with particle filtering. We have gone through various problems to be dealt with during lane detection like worn lanes, lane curvature, emerging lanes, shadow and light problem. RANSAC algorithm provides solution for most of these problems, thus it is more beneficial compared to others.

We have seen that LDWS can be implemented on different platforms such as FPGA, DSP, ARM. FPGA implementation gives fast computation, requires less power but real time processing of image is difficult with FPGA. DSP supports real time processing of image. ARM based embedded system gives portable system. Depending on designer's requirements, appropriate platform can be chosen.

5. REFERENCES

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