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FPGA Based Lane Deviation System Using System Generator

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Abstract— This paper describes a novel Driver Assistant System based on real-time video to track lines and road signs with minimal hardware and software requirements. The given system was designed to use low cost cameras and processing power of an on-board commodity laptop. Using vision based solution in intelligent vehicle application often needs large memory to handle video stream and image process which increase complexity of hardware and software. In this project, we present a FPGA implement of a vision based lane departure warning system using system generator. By taking video frames, the line gradient of line is estimated and the lane marks are detected. By analysis the position of lane marks, departure of vehicle will be detected.

Keywords: Sobel edge detecter, Hough transform algorithm, Xilinx system generator, Xilinx 14.1,Lane departure

I. Introduction

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 on roads with minimal traffic density, drivers tend to ignore lanes and traffic signboards. It is also observed that on roads with heavy traffic density, drivers pay more attention in ensuring a safe drive and less on the signboards. Driver Assist Systems that alert the driver about the lanes and signboards can be of great assistance lane change can prevent accidental changes of lane due to the lack of driver concentration. The alerts about the signboard can give the driver an opportunity to look at the signboards and pay attention to the same during driving.

The technologies of finding the lane marks are needed by the lane departure warning system. Compared with other technologies, a vision based LDW system is a human decision-makeø like solution to avoid the accident caused by lane departure with low cost and high reliability. In such systems, one camera is installed in the interior of the vehicle, and the environment is sensed to supply useful information.

The Driver Assist System (DAS) in an automobile is a key component of the Active Safety (AS) system. The main focus in AS is to prevent an accident from happening. Although the term DAS refers to a wide range of systems and functions, the system discussed in this project focuses on the development of lane detection and tracking system. A video based system is all among many available sensors system meant for this application.The main advantage of a video based system is that the amount of data with single camera can capture is much more than what an array of others sensors can do. Another advantage is that with nominal amount of code change, the functionality of the system can be extended.

In this project, the detection of lane is proposed using Hough Transform and Hough Lines, since it requires less computational time to detect a lane marking over the entire frame. The camera is fixed on the interior of the vehicle, its countinusly capture the image at 15 frame per second. From that image we take out the interested region and perform the image techniques. Using sobel edge detecter find the edge of the image and perform the hough transform for finding the lines.

II. Related Works

The following are the few papers and books that were referred to, in the process of doing this project. Following are some of the literature that has somehow contributed for understanding of the Sobel edge detection,Hough transform techniqe and Lane detection and warning system.

The image processing algorithms has been limited to software implementation which is slower due to the limited processor speed, So a high speed processor for edge detection is required which was not possible until advancements in VLSI technology. The work presents FPGA based architecture for Edge Detection using Sobel convolution kernels. Sobel is chosen due to its property of less deterioration in high levels of noise[1]. The edge detection is nothing but find the discontinuities in gray level images. Edge play major role in finding the machine vision It consider two orientation i.e. 0 and 90.In this paper the design and the practical implementation of a driver steering assistance have been described. The system will warn the driver if the driver loses attention during normal driving, an input output hybrid automation framework

describes the switching behavior[2]. Here they will consider the worst displacement at front part of the vehicle on the lane with respect to central line possibility to prove the boundedness of vehicle state against the on and off switching of automatic control.In this paper, the model of vision based lane departure warning system and realization is described first, Then the method of lane detection is illustrated, which is based on three steps: preprocessing of image, binary processing and dynamical thresholding choosing and linear parabolic model fitting, After that the solution of how to perform the departure decision making is proposed and demonstrated. Image acquisition cell is made from video decoder. Divide the image with two parts from that we have to take the interested part and process it[3]. For binary processing choose the threshold value from histogram. Disadvantage of this paper is that the lane detection is not accurate because of noise.

In this paper, a vision-based lane detection approach capable of reaching real time operation with robustness to lighting change and shadows is presented. The system takes the front view using a camera mounted on the vehicle then applying few processes in order to detect the lanes. This paper contain the overall idea of finding the lane of road according to varying the weather condition[4]. The process take place for finding the edge of an image is Image capturing, Gray scale conversion, Noise reduction, canny edge detector used in this paper. This paper presents a FPGA based architecture for Sobel edge detection operator. Main use of Edge detection is in the artificial intelligence system. It founded the application in forensic science and also in digital multimedia for creating image dazzling effect. So a dedicated processor for edge detection has been required which was not possible until advancement in VLSI technology. Today more complex system can be integrated on a single chip providing a platform to process real time algorithm on hardware. Sobel is chosen due to its property of less deterioration in high levels of noise.

In this paper, The system is designed using steerable filters for robust and accurate lane marking detections.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 complex shadowing then lighting changes from overpasses and tunnels and road surface variations. Curvature detection is made more robust by incorporating both visual cues (lane markings and lane texture) and vehicle state information[6].It Capture the complete vehicle context including vehicle surround, vehicle state, and driver state. By capturing the complete vehicle context,its open the possibility of developing driver assistance systems focused on the driver and his or her intended actions.

In this paper a lane departure detection method is studied and evaluated using the full vehicle dynamics software CARSim. The road curvature was estimated and compared to the vehicle trajectory curvatures. The given algorithm takes account of the steering dynamics and uses the Time to the Lane Keeping (TLK) as a second risk indicator in order to reduce false alarms and integrate the driver corrections. Stability conditions of the fuzzy observer are expressed in terms of linear matrix inequalities (LMI) using unmeasurable premise variables[7]. The aim here is that only one sensor is used and no knowledge on the path road is needed. To reduce false alarms and integrate the driver corrections the algorithm take account of the steering dynamics and use the time to the lane keeping to anticipate lane departure detection and avoid false alarms.

III. Overview

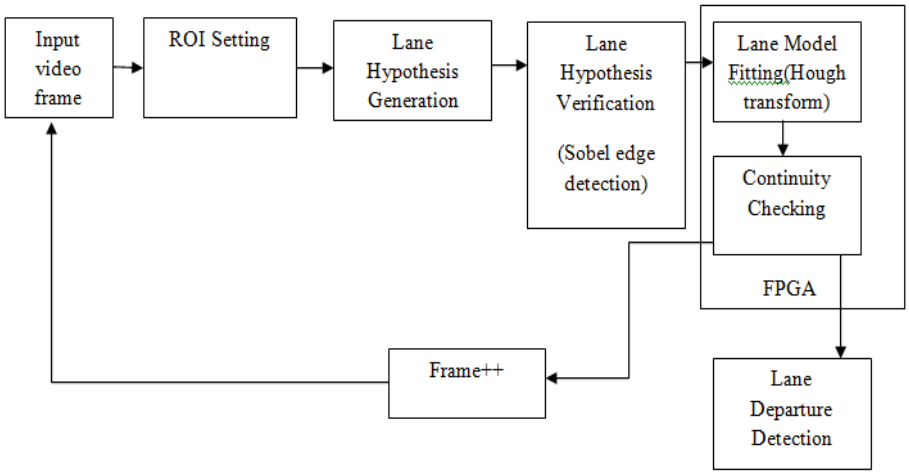


Fig 1. Lane deviation warning system

Nowadays the advent of fast platforms has given a more significant role to image processing. There is no wonder any more that there are image processing units embedded in such small platforms like cell phones and cameras, however the demanding nature of the image processing algorithms is still putting a barrier to realize a wide range of existing advancements in theory into the world of real time implementation. On the other hand the great amount of resources

available on the FPGAs besides the flexibility to test and prototyping an ASIC that it offers, has made FPGA an ideal choice for realizing image processing algorithms in the real time and autonomous drive is no exception.

Using system generator the proposed system is implemented in matlab 2012a simulink with help of system generator configure the simulink in to FPGA VIRTEX 5 Board.

. The system should be able to identify and track the present lanes. The system should be robust against shadows, jerks movements and other changes in the road surface. The proposed system should be able to detect the shifting of lanes and should be able to notify the lane departure. The following methodologies are adopted to develop the system.

Creation of Input Video Stream The video containing different road segments under different lighting conditions is captured. The captured video sequence is collated to form a short sequence but with many features from different conditions.

Definition of Lane Marker Positions The lane markers and their likely places are defined in the system on the basis of their angle with the reference image plane. These range of angle are defined considering the position of the camera in the vehicle and the vehicle relative position to the lane.

Lane Detection and Departure Warning The lane change is detected by identifying the change in lane angles. The direction of movement and the likelihood of departure are estimated. The crossing of lane markers triggers the lane departure warning system.

Xilinx Virtex 5 LX50T The FPGA circuit board is a complete ready-to-use digital circuit development platform based on a Xilinx Virtex 5 LX50T. The largest on-board collection of high-end peripherals, contain Gbit Ethernet, HDMI Video, 64-bit DDR2 memory array, and audio and USB ports make the Genesys board an ideal host for complete digital systems, contaning embedded processor designs based on Xilinx's MicroBlaze. Genesys is compatible with all Xilinx CAD tools, contaning ChipScope, EDK, and the free WebPack, so designs can be completed at no extra cost.

Input video The 15 Frame/ seconds video is captured using camera which has 14.0 Megapixel. The video is converted from MPEG(Moving picture expert group) format to AVI(Audio Video interleave) format using Leawo video convertor software, and give this video as input to the system.

Region of interrest and edge detection In order to reduce processing time while keeping a good performance, region of interest (ROI) is first initialized, and a Sobel operator with non-local maximum suppression (NLMS) is used to find edge-pixels inside the ROI.

Lane hypothesis generation The goal of lane hypothesis generation is to find candidate lane-mark regions inside regions of interest (ROI). Candidate lane-mark regions are identified based on hypothesized lane-mark edges, which are selected based on edge-link features including length, orientation, and width of edge-link pairs.

Lane hypothesis verification In lane hypothesis generation,lane-mark edge features like edge-orientation, edge-pair width, and edge-lenght are checked to filter out noise edges and select candidate lane-mark edges.In lane hypothesis verification, The lane-mark colors are checked inside regions enclosed by candidate lane-mark edge-pairs.

Lane fitting and continuity checking After color verification, edges that belong to lane-marks can finally be decided. Before lane departure detection, lane position and continuity of lane should be provided. Lane position is figured out by fitting straight line model based on lane-mark edge-points using Hough transform. Two parameters ø and ρ should be estimated to fit the straight line model. Their values are finally determined by max-voting in the Hough parameter space. After finding the line continuity, its check for the line parameters values. Lane color parameter **c** and lane continuity parameter **t** can provide further information on lane types. So that more detailed information from the given parameters can be included when lane departure warning instructions are generated.

IV. Edge Detection

Edges are considered to be most important image attributes that provide valuable information for human image perception.The advent of artificial intelligence systems and forensic science the process of edge detection has achieved the most needed status. Edge detection is a very complex process affected by deterioration due to different level of noise.

A number of operators are defined to solve the problem of edge detection. They behave good in one application but poorly in other. In early processes, the edge detection was mainly performed on software due to its large hardware requirement and also the application-specific integrated circuits have not gain that much advancement. But todays researches on programmable devices make it possible to implement edge detection algorithms on these devices whose

design turn-around time varies from few hours to few days. During the recent years field programmable gate arrays (FPGA's) have become the dominant form of programmable logic device. In comparison to previous programmable devices like programmable array logic (PAL) and complex programmable logic devices (CPLD's), FPGA's can implement far larger logic functions. FPGA's supports sufficient logic to implement complete systems and sub-systems. FPGA exploit the increasing capacity of integrated circuits to provide designers with reconfigurable logic that can be programmed on application-specific basis. This suddenly increases flexibility in both the design process and the final artifact by permitting one board-level design to perform many functions, or to be upgraded in the field. In this project a FPGA implementation of Sobel edge detection algorithm has proposed. The choice of Sobel edge detection operator is motivated by the fact that they incorporate both the edge detection as well as smoothing operator so that they have good edge detection capability in noisy conditions.

V. SOBEL EDGE OPERATOR

The operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One convolution kernel is simply the other rotated by 90°.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig 2. Sobel Edge Detection Operators

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one convolution kernel for each of the two perpendicular orientations. The X and Y kernels can be applied separately to the input image to produce separate measurements of the gradient component in each orientation (call these *Gx* and *Gy*). These can be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given as:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

Typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

which is much faster to compute.

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \arctan(Gy/Gx)$$

VI. Line Detection

When images are to be used in different areas of image analysis such as object recognition , it is important to reduce the amount of data in the image while preserving the important, characteristic, structural information. Edge detections makes it possible to reduce the amount of data in an image. However the output from an edge detector part is still a image described by it's pixels. If the lines, ellipses and so forth could be defined by their characteristic equations, the amount of data would be reduced even more. The Hough transform was originally developed to recognize lines , and has later been generalized to cover arbitrary shapes .This worksheet explains how the Hough transform is able to detect (imperfect) straight lines.
Lines can be represented uniquely by two parameters. Often the form in Equation 1 is used with parameters a and b.

$$y = a \cdot x + b \qquad (1)$$

This form is, however, not able to represent vertical lines. Therefore, the Hough transform uses the form in Equation 2, which can be rewritten to Equation 3 to be similar to Equation 1. The parameters and r is the angle of the line and the distance from the line to the origin respectively.

$$r = x \cdot \cos ø + y \cdot \sin ø \qquad (2)$$
$$y = -\cos ø/\sin ø \cdot x + r/\sin ø \qquad (3)$$

The Hough space for lines has therefore these two dimensions; ø and r, and a line is represented by a single point, corresponding to a unique set of parameters (øo, ro). The line-to-point mapping is illustrated in Figure 3.

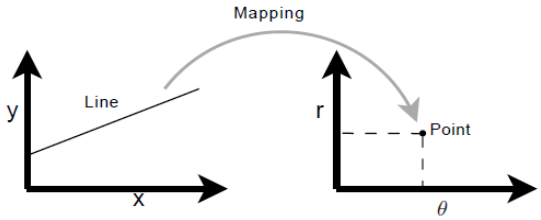
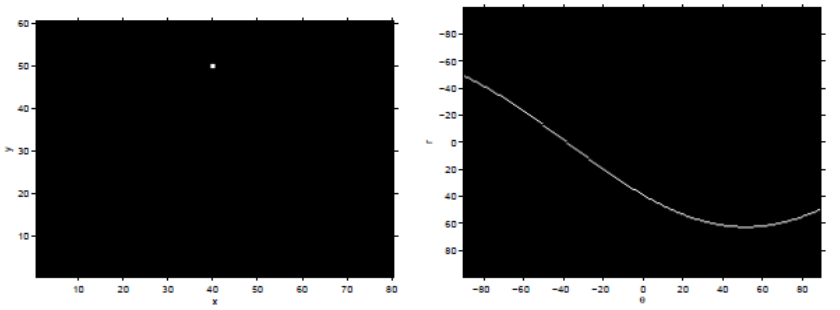


Fig 3. Mapping of one unique line to the Hough space.

An important concept for the Hough transform is the mapping of single points. The idea is, that a point is mapped to all lines that can pass through that point. This yields a sine-like line in the Hough space. The principle is performed for a point p0 = (40, 30) in Figure 4.



(a) Point p_0. (b) All possible lines through p_0 represented in the Hough space.

Fig 4**.** Transformation of a single point (p0) to a line in the Hough space. The Hough space line represents all possible lines through p0.

VII. System Generator Development

1)Make the algorithm for proposed model in matlab simulink
2)Identify the algorithm to be implemented in HDL
3)Perform the co-simulation
4)Implement on FPGA(Optimization)
5)Hardware/software co-simulation

VIII. Result Analysis

Using sobel edge detecter find the edge of a static image and perform the boundry trace algorithm to find out the angle of intersection at different climate conditions**.**

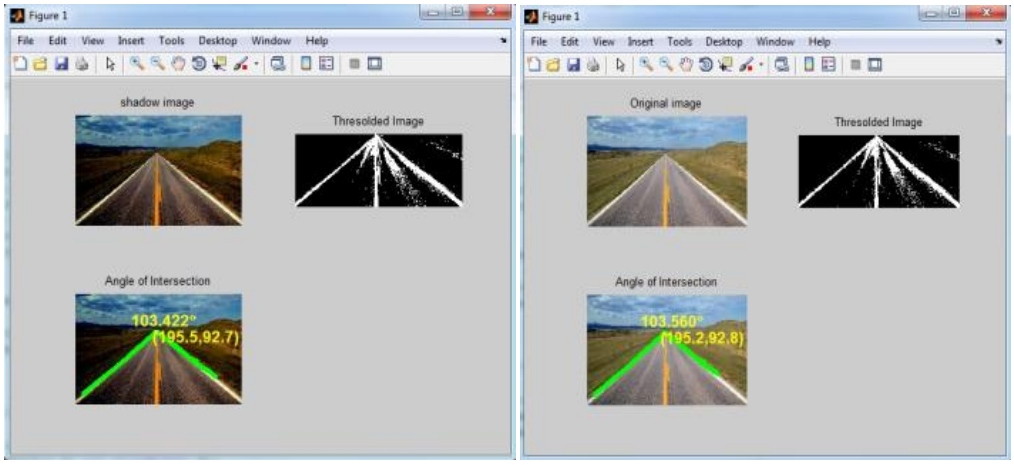


Fig 5. Simulation Result

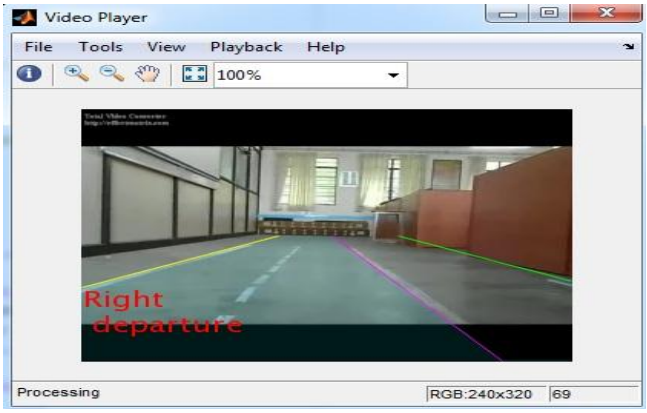


Fig 6. Lane departure warning

IX. Conclusion

There are many challenging problems in studying real traffic scenes within a complex background. In this paper, a successful development of a video processing based driver assist system is reported. The system works quite well under most test conditions. It is able to detect the lane marking irrespective of the lane in which the vehicle is present and under different lighting conditions. Here we haven't deal with the real world images and also in the real time. So in future a real time video capturing technique can be incorporated along with image processing being done on the real world images.

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