International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

A Survey on Lane Departure Warning System

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Abstract: ***This paper proposes a B-Snake based lane detection and tracking algorithm. The B-Snake based lane model describes a wider range of lane structures since B-Spline can form any arbitrary shape by a set of control points. Knowing and using the perspective parallel lines, the problems of detecting both sides of lane borders with the problem of detecting the mid-line of the lane are combined together.***

Keywords: Lane detection, Edge detection, B-spline, B-Snake Model, MMSE

1. Introduction

Most traffic accidents were caused by the negligence of the drivers. In order to reduce the number of traffic accidents and to improve the safety and efficiency of the traffic, the researches and companies on Intelligent Transportation System (ITS) have been conducted worldwide for many years. Intelligent vehicle (IV) system is a component of the ITS system, which aims to assist drivers in perceiving any dangerous situations earlier to avoid the accidents through sensing and understanding of the environment around itself.

Safety is the most important considerations in automotive. Many efforts are being taken in this regard. The important features of Intelligent Vehicles are to enhance road safety, decrease traffic jams and increase the efficiency of transportation. The detection of lane border in images of road scenes, gained from a camera mounted on the vehicle, is an important ability for auto-vehicle in outside environment. It is determined the set of lane model control points using a maximum probability method that measures the matching between the model and the real edge image. This formulates the lane detection problem. The main possessions of the lane border detection techniques are: Shadows, casted by trees, buildings, etc. should not affect the quality of lane detection; it should process the painted and the unpainted roads, it should also handle the curved roads as well as the straight roads, it should use the parallel constraint as a guidance to improve the detection of both sides of lane borders in the face of noises in the images, it should produce reliability of the accurate results obtained. The efforts are being taken to modernize the safety in automotive systems with the help of image processing to help the driver in proficient driving. The increasing volume of traffic needs higher levels of traffic safety.

The goal of the Intelligent Vehicle Systems is mainly that of improving driving safety and reducing the driver's capacity and capability. Advance driver assistance system is used for increasing the safety of driving cars which construes traffic situations independently and support the driver. An important part of an advance driver assistance system is the evaluation of image sequences recorded with cameras mounted in a moving vehicle. LDW uses a camera to monitor the distance between the vehicle and lane markings and, if the vehicle drifts towards the lane markers, the system first sounds an audible warning, followed by a selective application of the brakes to help move your vehicle back into its lane.

2. Related Work

The Hough Transform is a widely used method for finding global patterns such as lines, circles, and ellipses in an image by localizing them in a parameterized space. It is especially useful in lane detection because lines can be easily detected. In order to do any kind of lane-edge detection, filtration of the image to smooth out any noise picked up during image capture is the most important. Because noise introduced into an edge detector can result in false edges output from the detector [1]. The approach by [2] describes a stereo vision-based hardware and software architecture namely as Generic Obstacle and Lane Detection System (GOLD) the Generic Obstacle and Lane Detection system (GOLD), to be used on moving vehicles to increment road safety. It allows detecting both generic obstacles (without constraints on symmetry or shape) and the lane position in a structured environment (with painted lane markings) at a rate of 10 Hz. A Catmull-Rom spline based lane model which described the perspective effect of parallel lines was proposed for generic lane boundary. As Catmull-Rom spline can form arbitrary shapes by control points, it can describe a wider range of lane structures than other lane models such as straight and parabolic model. It formulates the lane detection problem in the form of determining the set of lane model control points [3].

According to [4], the structure of the Catmull-Rom Splines has useful properties for shape representation and analysis as following:

1. The splines passing through the control point (the boundary edges of lane can be regarded as the spline model's control points.)
2. Feasibility of forming arbitrary shapes compared with the second or the third polynomials.
3. Smoothness and continuity, which allows any curve to be constituted by a concatenation of curve segments yet, be treated as a single unit.
4. Local controllability, which implies that local changes in shape are, confined to the Catmull-Rom spline parameters local to that change.

In case of [5], a new Catmull-Rom spline based lane model which describes the perspective effect of parallel lines is constructed for generic lane boundary or marking. It is able to describe a wider range of lane structures than other lane models such as straight and parabolic models. The lane detection problem is formulated by determining the set of lane model control points. Using a maximum likelihood method that measures the matching between the model and the real edge image, the results obtained are good and accurate under shadow conditions. Canny edge detector is used to locate the position of pixels where significant edges exist. Two images are obtained that denote the edge pixels and the orientation of gradient by applying the Canny edge detector to a lane image. It is designated in [6] that Kalman filtering approach to the deterministic, least-squares based, velocity snake model. Two types of estimation models are proposed: Batch Mode model, in which the velocity is estimated independently of the contour dynamics and treated as an input to the tracking model, and Real Time Mode, which uses measurements of image velocity and spatial intensities to adjust the expected position and the covariance of the contour's parameters. In [7], a novel real time lane detection method is proposed to detect the lane marking lines based on some ideas such as to create a top view of the road {the region of interest (ROI)}, Filtration using selective oriented Gaussian High pass filter, to use Hough transformation and Kalman filter to a new and fast algorithm for fitting Bezier Splines. In this algorithm, the effects are shown especially when there are a lot of edges of the vehicles ahead or shadows of objects, like trees, telegraph poles, traffic signs etc. It is revealed theoretically and experimentally that the computational cost of this algorithm is much smaller than the existing methods.

A road lane has the characteristics: locally flat, defined by parallel road markings or curb lengthwise and without sharp bends or roundabouts. Almost all the short and isolated edges have been eliminated through length discrimination. The remaining edge lines correspond to long parallel lines that define the lane and curb positions. It should also be noted that the lines due to the arrow remain, while the curb on the left is now represented by two lines instead of one. These lines will be eliminated during lane analysis [8]. As per [9], a cubic B-Snake model is developed for extracting 2D deformable objects from medical images, with an adaptive control point insertion algorithm that is suggested to increase the flexibility of B-Snake to describe complex shape. The problems that exist in other B-spline based model that have to decide beforehand or exhaustively search over a range of value for the number of control points are overcome by this method. Therefore, these methods are less supple to define unknown complex shapes. B-Snake uses far lesser parameters compared to point-based Snake model. As the cubic B-Spline is proposed to be used, deformable curves are represented by four or more parameters (control points).

3. General Framework

Following figure from [1] shows the block diagram of Basic Lane Detection algorithm.

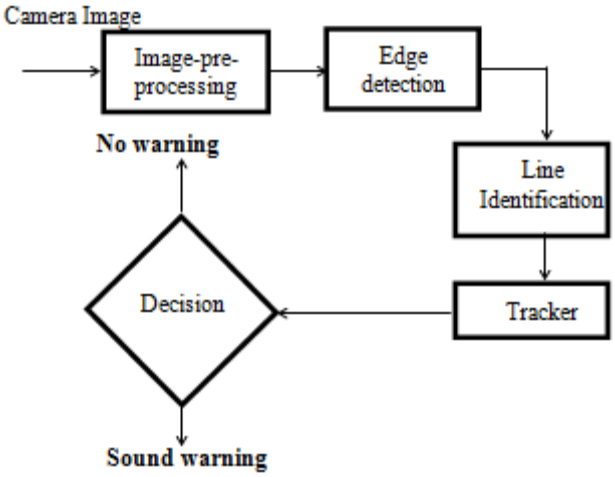

Figure1. Block Diagram of Basic Lane Detection Algorithm

In the fig.1, a high speed camera scans the image of the road scene ahead at regular instants. These images are moved to memory for further processing using the powerful processors such as Blackfinn processors. After then these images go through Edge Detection Techniques which consists of an algorithm which detects the lanes on the road. Then using detection techniques like Hough transform or spline methods, the lines or curves are detected and compared with the current car position. This helps the system in placing a perpetual watch on the car over its position in the lane. This concept also aids in future revolution of automatic driving in highways.

3.1 B-SNAKE Model

Lane model shows an important character in lane detection. The lane modeling ought to create some suppositions about the road's structure in the real world in order to fully recover 3D information from the 2D static image. In this paper, we emphasis on the construction of the 2D lane model by assuming the two sides of the road boundaries are parallel on the ground plane.

In this review paper, a B-Snake based lane model which describes the perspective effect of parallel lines is constructed with dual external forces for generic lane boundary or marking, it is able to describe a wider range of lane structures than other lane models such as straight and parabolic models. In addition, it is robust against shadows, noises, etc. due to the use of the parallel acquaintance of roads on the ground plane. The lane detection problem is formulated by determining the set of lane model control points. Compared to other lane models, there are few advantages for B-Snake lane model with dual external forces:

1. B-Snake can describe much wider range of lane shapes while retains compact representation, since B-Spline has local controllability and can form arbitrary shape. For example, it can describe more complex road shape, such as 'S' or sharp corner turn, just by increasing the number of control points. Other lane model cannot describe those complex shapes, since they use only a single polynomial.
2. With dual external forces, B-Snake model would be robust against shadows, noises, occasional missing and false markings, etc. since the sampling locations for calculating the dual external forces are combined with the knowledge

of parallel lines on the ground plane, the external forces for deformation of B-Snake is not depended on one, but both sides of lane model at a time.

3)The processing time will be reduced since two deformation problems for both sides of lane have been formulated to one deformation problem.

4)This B-Snake lane model is particular suitable for lane tracking application, since the parameters of lane model for the current frame is usually similar to those in the previous frame, i.e. the movements of the control points are smaller.

The B-Snake model is also easy for object boundary tracking application since the parameters of B-Snake for the current frame are usually similar to those in the previous frame, i.e. the movement of the control points is smaller [9].

3.2 Minimum Mean Square Error (MMSE)

Estimation of the position of those control points in the B-Snake model is iteratively developed using the method of Minimum Mean Square Error (MMSE). As MMSE deforms the segments of the B-Spline instead of individual points, it is very robust against local minima. Thus this approach is to minimize (1) the sum of the external forces from the both sides of the road model for achieving accurate position of B-Snake, and (2) the difference of the external forces from the both sides of the road model for achieving suitable parameter. In addition, external forces should be transmitted to each control point when updating B-Snake [9] [10].

4. Applications

As for the applications, Lane Departure Warning systems are designed to warn a driver when their vehicle begins to unintended move out of its lane. Unintentional lane departure can be caused by driver distraction, inattention, drowsiness, or even adverse weather conditions and can result in serious head-on collisions. These systems are designed to minimize accidents by addressing the main causes of collisions: driver error, distractions and drowsiness. In that case, and if the driver did not signal his intent to switch lanes, a warning is issued.

A structure-adaptive B-snake has been designed for segmenting complex shapes from the images. The structure-adaptive capability has been reached by the strategy of adaptively inserting control points during the deformation procedure. This procedure is mainly implemented for the real application of medical imaging areas [11]. It is necessary to develop an appropriate set of in-vehicle detecting and warning systems that can directly improve the driving safety that is there are requirements of hardware such as a camera mounted on the vehicle and the software like image processing algorithm in order to avoid unexpected accidents [12].

Qian Yu and Helder Arau´Jo in [13] describe a fast and robust method for obstacle detection on flat roads or non-flat roads. This method uses the surface normal vectors in 3D space. As proposed in paper [14], using DSP-Based Adaptive Lane Departure Warning System (ALDWS),the system can be applied in highways, tunnels and urban roadways, and works well in sunny, cloudy, and rainy conditions in day or night. Different types of lane markings can be detected, such as solid, dashed, double, etc., by the proposed vision-based detection algorithm. The DSP image processor on ALDWS works with operating frequency of 600MHz and the lane marking detection speed can be more than 35 frames per second with QVGA size. This proposed fast adaptive lane detection algorithm is efficient and robust at both day and night. It is shown in [15] for these driver-assistance objectives that motivate the development of the novel “video-based lane estimation and tracking” (VioLET) system. The system is designed using steerable filters for robust and accurate lane-marking detection. Steerable filters provide an efficient method for detecting circular-reflector markings, solid-line markings, and segmented-line markings under varying lighting and road conditions. They help in providing robustness to complex shadowing; lighting changes from overpasses and tunnels, and road-surface variations. A simple active contour based visual tracking algorithm is presented for outdoor Autonomous Guided Vehicles (AGV) application to develop a simple approach for road-tracking systems which can be used integrate with the existing and low cost hardware. A B-spline function is used to define the initial contour of the image, and then the image processing is performed on this image to extract feature points [16].

According to [17], a virtual lane boundary-based LDWS (VLWS) is proposed to an approach of much longer warning time than the Roadside-Rumble Strip (RRS).VLWS allows the driver to drift beyond the physical lane boundary by adding a virtual lane boundary. Accounting for the driving habit of the driver, lane geometry, and the local driver behavior changes, the virtual lane width is determined using a fuzzy-logic inference method. When the vehicle is predicted to exceed the virtual lane boundary, an alarm is triggered.

It is preferable to use Lane departure warning system based on Machine Vision which is a human decision-make like solution to avoid lane departure fatalities with low cost and high reliability. In this system, a Gauss filter is employed to remove small noises in the incoming picture in the image pre-processing [18]. Using embedded technologies to develop a portable lane departure warning system could bring about certain advantages, such as compact size, low-power and low-cost. The external efforts can also be made to develop a portable lane departure warning systems in various popular consumer devices, such as digital cameras, cell phones, and PDAs [19].

In [20], Adaptive Cruise Control (ACC) is a driver convenience system adding headway time control, which maintains distance to the preceding vehicle within a preset headway time, to conventional cruise control that maintains preset speed if there is no preceding vehicle. The Lane Keeping System (LKS) is a driver convenience system which assists a vehicle in maintaining its driving lane. These two systems have been developed as two separate systems (Bishop, 2005). It is shown in [21] that the algorithm uses a combination of scan boundary lines and Hough transform to fit a hyper bola pair model. The lanes are detected using Hough transformation with restricted search area and then cast into a hyperbola pair model. The algorithm uses noise

and shadow removal technique to eliminate disturbances that would cause inaccuracies. It is presented a new multi camera approach to Lane Departure Warning (LDW). Upon acquisition, the captured images are transformed to a bird's-eye view using a modified perspective removal transformation. Then, camera calibration is used to accurately determine the position of the two cameras relative to a reference point [22] [23]. It is developed a structure adaptive knot point insertion strategy in order to adaptively approach a complex contour without apriority fixing of the number of control points [24].

Natan Peterfreund explains that a new Kalman-filter based active contour model for tracking of non-rigid objects in combined spatio-velocity space in his research work [25]. As [26] proposes Region of Interest (ROI) Segmentation with Image Thresholding the phases of algorithm. An area of the image that may contain a road sign is known as "region of interest". Generally the road signs are produced on white with red colour for better visibility which is therefore thresholding the area with pure red and white colour is essential. Xiaodong Miao, Shunming Li, Huan Shen proposes in [27] a Canny approach to obtain edge map from the road image acquired from monocular camera mount on vehicle, a matching process to normalize the candidates of road line, a searching method used for reinforce potential road lines while degraded those impossible one, a linking condition to further enhance the confidence of the potential lane lines, a K-means cluster algorithm employed to localize the lane lines, and a on board system is designed for experiment under various conditions on the roadway. Also, computation cost is inexpensive and the system's response is almost real time**.**

Watershed transform is used to separate the intersecting objects in the frame. It finds the watershed rigid lines, catchment basin in image by considering it as surface where light pixel as high and dark pixel as low. The advantages of the method the boundaries of each region are continuous [28]. As per [29], a unique method of lane center detection via vehicle motion trajectories is proposed. The vehicle trajectories are detected from the feature point trajectories and the lanes are extracted rapidly and high accurately by using an incremental cluster.

5. Conclusion

This review paper shows the lane detection warning system which is a mechanism designed to warn a driver when the vehicle begins to move out of its lane in that direction on freeways and arterial roads. The Hough Transform, B-Snake methods etc. are the techniques used for lane detection to warn the driver from lane departure.

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