The State of the Art in Development a Lane Detection for Embedded Systems Design

Narathip Thongpan, and Mahasak Ketcham

***Abstract*—**The embedded systems are particularly important in vehicle intelligence system, mainly due to new innovation of technological that fast and easy installation. The embedded systems application for traffic application such as their lane detection and tracking, real-time vision on vehicle, and a driver assistance system (DAS). The most in the several fields of image processing has applied in traffic applications in a lane detection. In this paper, presents the state of the art in development a lane detection in between since 2003 - present used in vehicle intelligent system for specific traffic applications. However, the lane detection approach based on the image processing of their feature-driven, area-driven, vision-driven and model-based. Furthermore, we discriminate between the cases study of mobile camera, digital camera, video camera or input data methods (Image or Video). Based on this categorization of processing tools, we present technique systems that have been deployed for operation. Thus, in summary of the paper provides the state of the art in lane detection and their operation in traffic applications. The lane detection focuses on new techniques, namely automatic lane finding and tracking such as their , adaptive ROI initialization, adaptive land-mark ROI, Traffic Sign Recognition (TSR), finding the local adaptive threshold , tracking and fitting the lane-marks and Inverse Perspective Mapping (IPM). It attempts to compile the differences in the requirements and the constraints of these new techniques so the applied to embedded systems and future trends ,Thus for example, automatic driver, advanced driver assistance systems (ADAS), real-time traffic sign recognition system, android-based smart phone application, and embedded system design.

***Keywords*—**Intelligence system, Lane detection, Tracking, Embedded system, Driver assistance system, Automatic lane finding

I. Introduction

EMBEDDED systems are particularly important in vehicle intelligence system, mainly due to new innovation of technological that fast and easy installation. The embedded systems application for traffic application. In the recent years, intelligent vehicles became an important part of the service robotics.

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The embedded systems application for traffic application. In the recent years, intelligent vehicles became an important part of the service robotics. Besides routine tasks for the service robotics, such as localization and navigation, intelligent vehicle must solve many specific tasks. Although fully autonomous intelligent vehicle does not exist, there are many support systems nowadays for which vehicles are closer to the vision of self-piloted vehicle[1]. The application of image processing techniques to the analysis tool of image or video of traffic offers considerable improvements over the existing methods of traffic data collection and road traffic monitoring.

Moreover, they provide wide area monitoring allowing analysis of traffic and turning movements[2]. Normally, lane detection is used for local lane marking(or boundaries) in the given road images , road video, and can help to estimate the geometry of the road ahead, as well as the lateral position of the ego-vehicle on the road. Lane detection is used in intelligent cruise control systems, for lane departure warning, road modeling, and so on. Automating driving system may help reduce this huge number of human fatalities. The road detection algorithm is one of the key technologies of the system. Thus, lane detection is a key problems in driver assistance system. In this paper, the proposed to detect the lane marking lines based on generating a top view of the road, the region of interest (ROI) [3, 4]. However, the most of these algorithms were focused on lane detection on new technique applied to embedded systems.

In addition, in application for lane detection and tracking an implementation in FPGA platform. The implementation is A real-time versatile roadway path extraction and tracking of a Lane Departure Warning (LDW) system, which requires high-performance digital image processing as well as low-cost semiconductor devices, appropriate for the high volume production of the automotive market. the proposed algorithm is specifically designed to be completely embedded in FPGA[5].

Furthermore, Motivated by the state of the art , in this paper present adaptive technique based lane detection and tracking algorithm for the application of driver assistance systems . The main lane detections of our method are the following:1) Automatic lane finding and tracking, 2)Adaptive ROI initialization and Adaptive land-mark ROI, 3)Traffic Sign Recognition (TSR), 4) Finding the local adaptive threshold, 5) Tracking and fitting the lane-marks, 6) Inverse Perspective Mapping (IPM), and 7) Extreme learning machine (ELM).

Moreover, the design and implementation of an automatic lane detection avoidance assistance system in a prototype

http://dx.doi.org/10.15242/IIE.E0814541

vehicle in embedded system. Thus, the topic of lane detection applied in embedded system for curvy roads and traffic signs is a topic of the trend current research.

II. Lane Detection Techniques

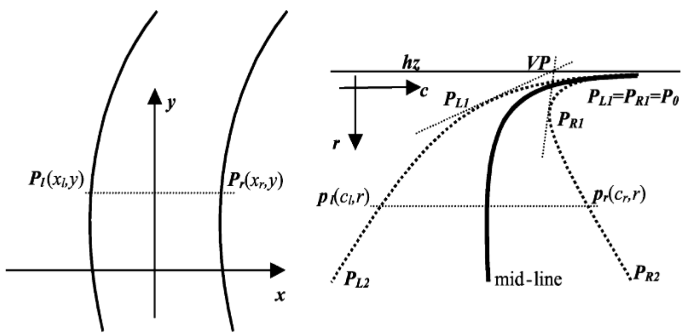
In this paper, were focused on lane detection on new technique, Therefore, the several approaches have been proposed to details of each step are described in the following:

A. Lane finding and Tracking

This stage is concerned with detecting lanes. Each of the steps will be discussed in detail in the following subsections:

1) B-Spline snake Fitting

Lane model plays an important role in lane detection. The lane modeling has to make some assumptions about the road's structure in the real world in order to fully recover 3D information from the 2D static image.[6]



(a) (b)

Fig. 1. Parallel lines on ground plane and image plane.

This Fig.1. The right side of road is the shifted version of the left side of road at a distance, D = (x_r - x_1); along the x axis in the ground plane. Here, x_r and x_l are the x coordinates of the two correspondence points, P_l (x_l,y) and P_r (x_l,y).

In [6] a set of control points to describe the mid-line of the road by B-Spline. The mid-line of lane model can be deformed by the external forces $E_{M\_sum}(s)$, which is the sum of the dual external forces calculated from both the left and the right sides of lane model, $E_L(s)$ and $E_R(s)$.

$$E_{M\_sum}(s), = E_L(s) + E_R(s) \qquad (1)$$

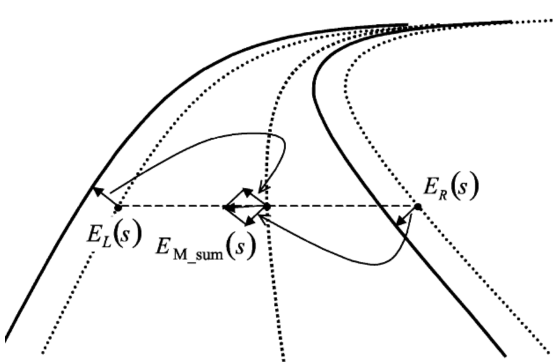
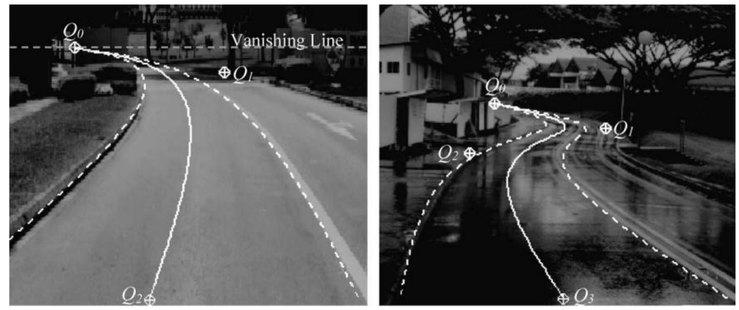


Fig. 2 Example on the external forces of the mid-line of lane model. Solid lines are the real road edges, while dash lines are the lane model.



(a) 3 point control (b) 4 point control

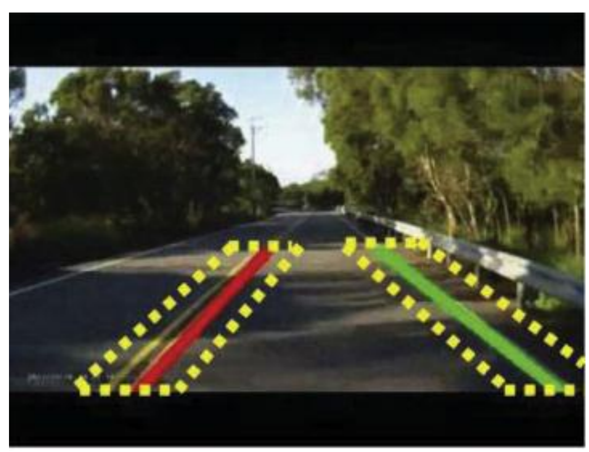
Fig. 3 B-Spline snake based lane model

2) A vanishing point detection

A vanishing point detection location is vitally important for the rest of the task. Although a few pixels variation in the vanishing point position does not significantly influence the system performance, the detected vanishing point has to correspond to the lanes. Most of the vanishing point detection algorithms are based on the Hough transform.[7]

B. Adaptive ROI initialization

Normally, in .[8] the road area is always located in front of the automobile and is not far from the vehicle when it is moving forward. A region of interest (ROI) is a portion of an image that can filter or perform some other operation on.[4] This is the reason why your ROI is selected on the bottom side of the image. The adaptive ROI used the cue that the lane-mark may not shift too much between two adjacent image frames and construct a table to label the blocks that are occupied or close to the lane model from the previous frame. The result is shown in Fig. 4 Adaptive ROI.



(a) lane model from the previous frame

F	F	F	F	F	F	T	T	F	T	T	T	F	F	F	F
F	F	F	F	F	T	T	T	F	F	T	T	T	F	F	F
F	F	F	F	F	T	T	F	F	F	T	T	T	F	F	F
F	F	F	F	T	T	T	F	F	F	F	T	T	T	F	F
F	F	F	F	T	T	F	F	F	F	F	F	T	T	T	F
F	F	F	T	T	T	F	F	F	F	F	F	T	T	T	F
F	F	F	T	T	F	F	F	F	F	F	F	F	T	T	T
F	F	F	T	T	F	F	F	F	F	F	F	F	F	T	T

(b) lane-mark ROI table

Fig. 4 Adaptive ROI: (a), (b)

C. Adaptive land-mark ROI (Lane mark fitting)

The road both lane mark on the left and right should be parallel and have a distance criterion between each other.[8]

1) Straight-line fitting

Lane mark analysis process is finished, then obtain the coordinates of all lane-mark edges, which call the continuous set S_k. To decrease the computation time, for straight line fitting. Lane model is established by the top and bottom points for each left and right lane mark edges by using Eq. (1)

$$d_{k\to ij} = \frac{\left|(x_j - x_i)y_k + (y_i - y_j)x_k + x_i y_j - x_j y_i\right|}{\sqrt{(x_j - x_i)^2 + (y_j - y_i)^2}} \quad (1)$$

An accumulator is used to calculate the number of edge points that are fitted to the candidate lane model.

2) Curved-line fitting

In the curved-line fitting step, we use a quadratic function to approximate the lane-mark as a kind of parabola. The quadratic function should be in the form of

$$y = ax^2 + bx + c \quad (2)$$

D. Traffic Sign Recognition (TSR)

Traffic Sign Recognition (TSR) is an important component of Advanced Driver Assistance Systems (ADAS). The traffic signs enhance traffic safety by informing the driver of speed limits or possible dangers such as icy roads, imminent road works or pedestrian crossings. In this paper, the present a three-stage real-time Traffic Sign Recognition system, consisting of a segmentation, a detection and a classification phase to details of each step are described in the following[9]: The TSR result is shown in Fig. 5.

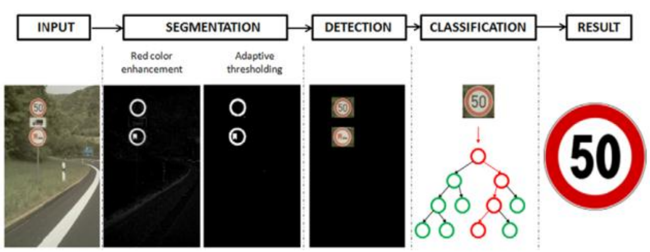


Fig. 5 Three stage approach proposed for Traffic Sign Recognition (TSR)

1) Segmentation

Potential ROIs are extracted in the segmentation phase. We implement the red color enhancement[10], the chromatic filter[11] and introduce the morphological filters. After applying one of these filters, the image is threshold using an empirically determined threshold or the adaptive threshold. [9]

(a) Original. (b) Enhanced. (c) Chromatic. (d) Top-hat. (e) Bottom-hat.

Fig. 6 Image segmentation for TSR

2) Detection

In this paper, were focus on the detection of speed limit and warning signs. The traffic signs there are circular and another for the triangular.

The HOG descriptor is used, as it is fast to compute and robust to changes in illumination and scale. A further reason for choosing HOG over other features is that when using undirected gradients classifier.[9]

3) Classification

Traffic signs detected is identified using the tree classifiers. For an extensive evaluation of the tree classifiers. However, the particularly adapted for the traffic sign classification. This improvement weights the feature vectors to focus the Nearest Neighbor comparison in the tree classifiers on the interior of the sign. However, the performance of each of these three stages is compared to the state-of-the-art techniques. The classification step was also put to the test at the live German Traffic Sign Benchmark Challenge[12], where our approach was ranked 3rd in terms of accuracy and proved to be suitable for embedded systems as it runs in real-time and is resource efficient. [9]

E. Inverse Perspective Mapping (IPM)

In the Euclidean space, define two kinds of description of traffic scene, i.e. the world coordinate system W and the image Coordinate system I. The coordinate transformation relationship from I to W can be shown in Fig. 1. [3, 13]

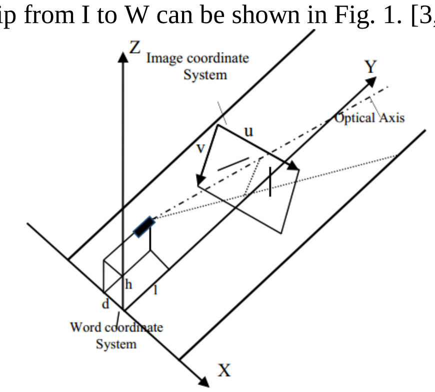


Fig. 7 Schematic diagram of IPM

Assuming that the coordinates of mounting position of the camera in the world coordinate system is (w, l, h), For images processed by IPM transform operation, The IPM processing result respectively is shown in Fig. 8.

(a) Original image. (b) Result of IPM

Fig. 8 Result of IPM algorithm

III. Conclusion

In this paper, we proposed provides lane detection in traffic applications. The lane detection focuses on new techniques of lane finding and tracking such as their , adaptive ROI initialization, adaptive land-mark ROI, Traffic Sign Recognition (TSR), finding the local adaptive threshold , tracking and fitting the lane-marks, and extreme learning machine (ELM). It attempts to compile the differences in the requirements and the constraints of these new techniques so the applied to embedded system.

Moreover, future work for example, automatic driver, advanced driver assistance systems (ADAS), real-time traffic sign recognition system, android-based smart phone application, and embedded system design.

IV. Future Development of a Lane Detection for Embedded System Design

In summary, this paper provides a review of Lane detection, In the future challenges of the intelligent vehicles. All these advanced assistance control systems have in common that they were first developed for robots. Therefore intelligent vehicles are considered as robotic applications. Applications developed for intelligent vehicles require[1]: 1) Knowledge of vehicle state - position, kinematics and dynamics of the vehicle, 2) Knowledge of environment state, 3) Knowledge of driver and passengers' state, 4) Communication with roadside infrastructure and other vehicles and 5) Access to digital maps and satellite data. Moreover, future work for example, advanced driver assistance systems (ADAS).Thus, applications developed for intelligent vehicles has device as follow:

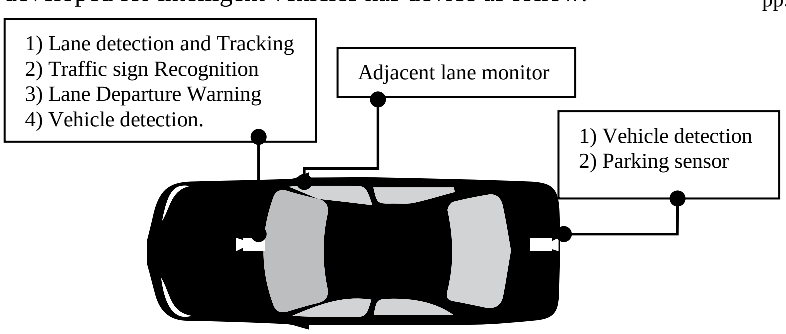


Fig. 9 Model of advanced driver assistance systems

Acknowledgment

Thank you for Dr. Mahasak Ketcham, Department of Information Technology Management, Faculty of Information Technology, King Mongkut's University of Technology North, Thailand for valuable advice and comment on this proposed work.

References

[1] F. Duchoň, P. Hubinský, J. Hanzel, A. Babinec, and M. Tölgyessy, "Intelligent Vehicles as the Robotic Applications," *Procedia Engineering,* vol. 48, pp. 105-114, // 2012.

[2] V. Kastrinaki, M. Zervakis, and K. Kalaitzakis, "A survey of video processing techniques for traffic applications," *Image and Vision Computing,* vol. 21, pp. 359-381, 4/1/ 2003.

[3] J. Deng., J. Kim., H. Sin., and Y. Han., "Fast Lane Detection Based on the B-Spline Fitting " *International Journal of Research in Engineering and Technology (IJRET)* vol. 2, pp. 134-137, 2013.

[4] T. Poomvichid. and M. Ketcham., "A Lane Detection for the Driving System Based on the Histogram Shapes," in *International Conference on Systems and Electronic Engineering (ICSEE'2012)*, Phuket (Thailand), 2012, p. 5.

[5] R. Marzotto, P. Zoratti, D. Bagni, A. Colombari, and V. Murino, "A real-time versatile roadway path extraction and tracking on an FPGA platform," *Computer Vision and Image Understanding,* vol. 114, pp. 1164-1179, 11// 2010.

[6] Y. Wang, E. K. Teoh, and D. Shen, "Lane detection and tracking using B-Snake," *Image and Vision Computing,* vol. 22, pp. 269-280, 4/1/ 2004.

[7] Y. Wang, N. Dahnoun, and A. Achim, "A novel system for robust lane detection and tracking," *Signal Processing,* vol. 92, pp. 319-334, 2// 2012.

[8] P.-C. Wu, C.-Y. Chang, and C. H. Lin, "Lane-mark extraction for automobiles under complex conditions," *Pattern Recognition,* vol. 47, pp. 2756-2767, 8// 2014.

[9] F. Zaklouta and B. Stanciulescu, "Real-time traffic sign recognition in three stages," *Robotics and Autonomous Systems,* vol. 62, pp. 16-24, 1// 2014.

[10] A. Ruta, Y. Li, and X. Liu, "Real-time traffic sign recognition from video by class-specific discriminative features," *Pattern Recogn.,* vol. 43, pp. 416-430, 2010. http://dx.doi.org/10.1016/j.patcog.2009.05.018

[11] S. Maldonado-Bascon, S. Lafuente-Arroyo, P. Gil-Jimenez, H. Gomez-Moreno, and F. Lopez-Ferreras, "Road-Sign Detection and Recognition Based on Support Vector Machines," *Intelligent Transportation Systems, IEEE Transactions on,* vol. 8, pp. 264-278, 2007. http://dx.doi.org/10.1109/TITS.2007.895311

[12] J. Stallkamp, M. Schlipsing, J. Salmen, and C. Igel, "The German Traffic Sign Recognition Benchmark: A multi-class classification competition," in *Neural Networks (IJCNN), The 2011 International Joint Conference on*, 2011, pp. 1453-1460.

[13] C. Wang and Z.-k. Shi, "A Novel Traffic Stream Detection Method Based on Inverse Perspective Mapping," *Procedia Engineering,* vol. 29, pp. 1938-1943, // 2012.