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Design and Implementation of Traffic-Scene Understanding System for Autonomous Vehicle

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***Abstract*— In this paper, vision based scene understanding algorithm is designed for autonomous driving system. Integrated algorithm is composed of lane detection and lane type/position recognition part, road marking recognition part, traffic sign recognition and traffic light recognition part. Visual recognition result is delivered to vehicle control part for generating steering angle and speed value. Through the field test in the autonomous driving platform, we found that proposed system shows robust performance in real road and traffic environment.**

***Keywords*— Traffic-scene understanding, autonomous vehicle, HOG, SVM, lane detection**

I. Introduction

Vision based scene understanding under the road environment is essential sensing technology for autonomous vehicle or ADAS system[1, 2]. For example, high-level visual information parsing such as multi-lane detection, traffic sign recognition is impossible to be processed using reflection based active sensors (Radar, Lidar)[3].

In this paper, we proposed integrated visual processing algorithm architecture for autonomous driving system. At first, multi-lane is detected for lane position detection and in the same time, ego lane's lane type is recognized for acquiring further lane position cues[4]. Within ego lane's detected area, road marking is detected and recognized[5]. Traffic sign and traffic light detector searches possible candidate areas based on sliding window scheme and classifies TSR/TLR type[6].

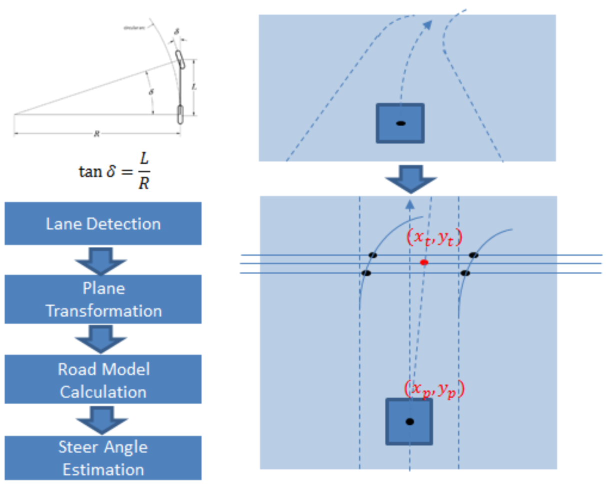


Fig.1. Example process from lane detection to steering angle estimation

Visual recognition results is used to make a control value such as steering angle as shown in Fig.1. Compared to lane departure warning system, the robustness of lane following algorithm in autonomous vehicle is critical. For that reason, we considered complicated steering angle estimation process under the severe miss-detection sequences.

This structure of this paper is described as follows. The integrated road scene understanding algorithm is described in Section II. Finally, section III gives implementation result and concluding remarks.

II. Algorithm Design for Traffic Scene Understanding

An overview of a vision-based traffic scene understanding system is presented in Fig.2. First, lane is utilized as an important visual cue in the proposed system. ROI area of road marking is defined within ego-lane area and lane type recognition is used to estimate vehicle's lane position.

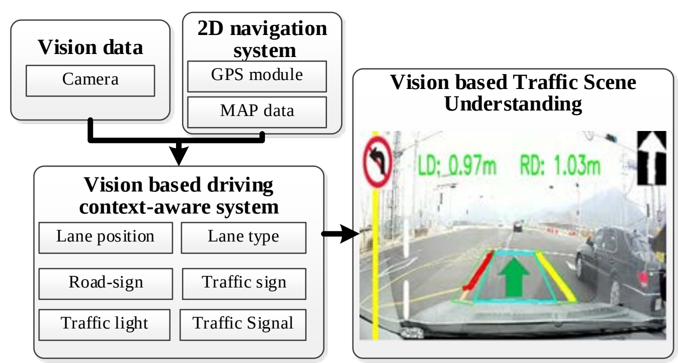


Fig.2. Vision based road-scene understanding for autonomous vehicle

From the IPM image, road marking ROI is extracted and classified as shown in Fig.3 process[5]. From the normalization and image filtering process, HOG-SVM method classifies various road marking types.

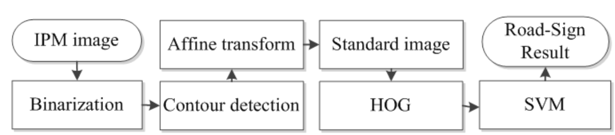


Fig.3. Algorithm block diagram of Road Marking

For the traffic sign recognition(TSR), we added robust ROI refinement technique for compensating color and shape based traffic sign detection(TSD) algorithm's weakness as shown in Fig.4. As a result, proposed TSR-after-TSD algorithm achieved robustness to the scale and translation variation of cropped ROI area[6].

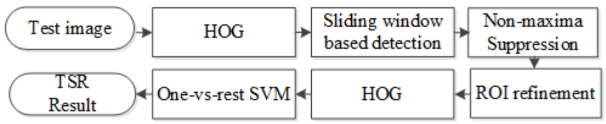


Fig.4. Algorithm block diagram of TSR

Compared to shape based traffic information, Traffic light recognition(TLR) is more difficult to detect and recognize it exactly because radiated light source is hard to distinguish and sensitive to color-space. Therefore, as shown in Fig 5, we used color-space conversion method and enhance target colors. Then, spatio-temporal consistency check scheme is applied to decide final result[7].

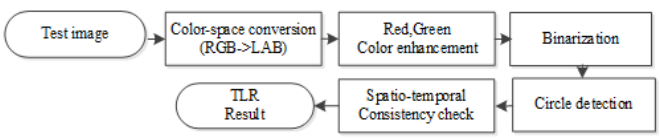


Fig.5. Algorithm block diagram of TLR

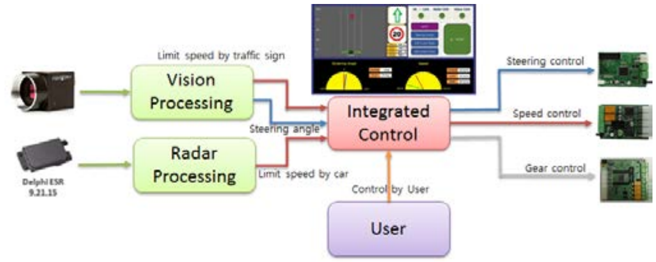
III. Implementation Result and Discussion

In this paper, we proposed a vision based traffic scene understanding system. Verifying implemented sensing system's functionality and performance, we applied it to our autonomous driving platform as shown in Fig.6.

Integrated algorithms are implemented in the vehicle's vision processing computer(VPU) and shows real-time performance at VGA image resolution, 30fps. Each visual perception results are used to control vehicle's steering and speed as shown in Fig. 7.

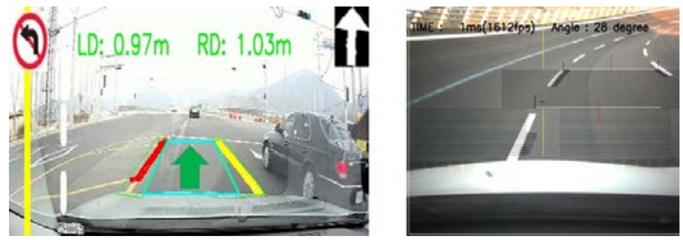
From the driving field test, we successfully finished visual perception based autonomous driving under the environment of 30km~80km speed and daytime brightness condition. As a future work, we need to improve algorithm's robustness under the more complex traffic situation as well as brightness change.

(a)



(b)

Fig.6. Sensing system architecture of DGIST's autonomous vehicle platform: (a)Test vehicle platform (b)Sensing and Control system for autonomous vehicle



(a) (b)

Fig.7. Experimental results: (a) traffic scene understanding and (b) steering angle estimation

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