A Safety Model for Drivers during Lane Deviation using Lane Departure Warning Systems

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Abstract – According to National Highway Traffic Safety Administration, one of the leading causes of deaths on highways is a class of accidents popularly known as Run-off-Road (ROR) accidents. These accidents are due to inattention, intoxication, incapacitation, drowsiness and unintended steering wheel motions. So the automobile industries and consumers alike are continuously embracing the value of crash prevention technologies. As a result the industry has seen the introduction of lane departure warning systems.

Keywords – LDWS, Image processing, ROR, TLC

I. INTRODUCTION

Lane Departure Warning Systems (LDWS) are electronics systems that monitor the position of a vehicle within a roadway lane and warn a driver if the vehicle deviates or is about to deviate outside the lane. It is a driver warning system designed for to reduce the number of unintended lane departures. Currently the most common approach for preventing run off road accidents is the use of rumble strips on the road shoulders. Rumble strips are areas of grooved pavement usually placed about 6-15cm beyond the lane boundary. When the vehicle drifts off the road, its tire hits the rumble strip which vibrates the vehicle and makes a loud noise alerting the driver to take corrective action. This type of system sounds a warning when the driver actually in a situation which has been pre-defined as dangerous i.e. when the vehicle’s tire is a set distance past the lane boundary. An alternative approach which does not require infrastructure modification is to use a system which can detect when the driver is in danger of departing the road and sound an alarm in time for the driver to take corrective action. This system sounds a warning when the driver is in a situation which has been defined as dangerous i.e. when the vehicle’s tire is a set distance past the lane boundary. An alternative approach which does not require infrastructure modification is to use a system which can detect when the driver is in danger of departing the road and sound an alarm in time for the driver to take corrective action.

Determining whether the vehicle is in a lane departure warning system state can then be used in turn to either warn the vehicle is in a particular state (similar to rumble strips) or to actually predict when the driver is in danger of departing the road which rumble strips cannot do.

All the current approach to LDWS make one key assumption, that exploiting individual’s differences between drivers is not helpful. These systems either use physical based models which ignore driver’s behavior. Most systems assume that the driver behaves same in all situations and pay no attention to differences in driver behavior due to changes in road geometry, traffic environment and changes over time. However the real drivers weave and oscillate over the road. This behavior can lead to alarms in situations which are not dangerous and only serve to annoy the driver. The difficulty in developing an adaptive lane departure warning system lies partly in adapting to safe patterns in driver behavior while not adapting to unsafe changes. Ignoring changes and differences in driver behavior can lead to an increase in the number of nuisance alarms which could make adoption of a LDWS difficult. So improving warning algorithms and alarm decision models can decrease the nuisance alarm and increasing acceptance. The number of nuisance alarms can be reduced while maintaining the adequate warning time, using an improved warning algorithm, alarm decision model and individualized training.

II. PREVIOUS WARNING ALGORITHMS

There is a lot of previous work done on driver models. Most of these models take some combination of vehicle state and road geometry as input and provide the drivers expected steering command as output. We focus on two specific warning methodologies: Roadside rumble strips and time to lane crossing (TLC). There are
The first requirement for a lane departure warning system is to measure the lateral position of the vehicle within the lane. Different systems allow to get the vehicle lateral position have been listed:

- Sensors to detect continuous or intermittent magnetic markers placed down the centre of the lane.
- A forward-looking video based sensor to track visible road features
- A downward looking video based sensor to track visible lane markings
- A laser or millimeter wave radar transmitter/receiver pairs to actively illuminate and measure the position of special targets/markers placed in or on the roadway infrastructure
- A high accuracy GPS receiver with an accurate digital map of the road network

The most commonly used lane-sensing device is the forward looking camera video based sensor. The basic principle of this system is to record the road in front of the vehicle and it uses image processing techniques to find the white or yellow lines on the picture. The fig. 1 shows step by step process of the LDWS using camera imaging.

![LDWS camera solution schematic](image)

Fig. 1 : LDWS camera solution schematic

The system scans horizontally the pictures to detect a step increase in intensity within a certain window of time. This means that only lines of a certain width can be detected. The system also uses a Kalman filter to estimate the lane position when the lines are dashed. Then using the position of the lines on the pictures the algorithm can compute the vehicle position on the lane. In this paper we use a commercially available video based lane sensing system called AutoVueTM developed by the company Iteris. The system evaluates the lane markings in the range of 6 to 15 meters in front of the vehicle and gives the vehicle lateral position with an accuracy of ±5 cm. The system works on any marked roadway, both day and night and in any weather conditions where the lanes markings are visible.

### III. LANE DETECTION

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### IV. LANE DEPARTURE WARNING ALGORITHMS

A basic warning algorithm uses the Time to lane crossing (TLC) value. If TLC reaches a threshold value, then a warning is triggered, but how to set the threshold value. The threshold value can be set to zero or to a value bigger than 0 which is recommended as 1. However the best time to deliver an early warning depends strongly on the roadway characteristics (lane and shoulder width, curvature, etc.), driver lane-keeping behavior (degree of meandering, curve cutting behavior, etc.) and vehicle type. If it is set to 0, then the LDWS works as an “electronic rumble strip” and triggers a warning if the vehicle does cross the lane boundary. If it is set to a value bigger than 0, then the LDWS predicts that the vehicle may soon cross the lane boundary. But if the driver turns his steering wheel and the lateral velocity changes, then the prediction may become wrong and the LDWS will trigger a warning even if the vehicle does not actually cross the lane boundary. So setting TLC to 0 means a small number of nuisances warning which result a small available time for the driver to react. On the contrary, setting TLC to a positive value means a bigger available time for the driver to react, but a larger number of nuisance alarms. A linear function is used to fit the near vision field, and a quadratic function fits the far field. The linear part of the vehicle with respect to both lane boundaries, while the parabolic part is flexible enough to fit curved parts of the road. The orientation of both lane boundaries is then computed and used to anticipate lane crossing. A lane departure warning system (LDWS) should give as much warning time as possible, while triggering few, if any, false alarms. In this paper, a virtual lane boundary based LDWS (VLWM) is proposed to approach this goal. VLWM 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. Real world driving data are used to test the LDWSs. Compared with time-to-lane-crossing (TLC) based
method, the VLWM has a much lower false alarm rate, while their warning time is almost similar. Meanwhile, VLWM has a much longer warning time than the roadside rumble strip (RRS), while the false alarm rate is almost as low as that of the RRS. Fig. 2 shows the model of LDWS.

V. RESULTS

The safety margin signals window shows a plot of a safety margin metric. The safety margin metric is determined by the distance between the car and the closet lane marker. When the safety margin metric shown in yellow drops below 0 shown in magenta the car is in lane departure mode otherwise the car is in normal driving mode.

VI. CONCLUSION

From the result it can be concluded that, the major contribution of this paper is the development and evaluation of a warning algorithm with a novel alarm decision model, trained to a particular driver and evaluated on real world driving data, this decision model determines when the driver is in danger of a run-off-road (ROR) crash, based on the use of lane changes as simulated substantial lane departures. This model is then used in the Future Offset Distance (FOD) warning algorithm, along with a linear vehicle state predictor, to
reduce nuisance alarms while maintaining adequate warning time.

VII. REFERENCES


