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STEERING INTERVENTION STRATEGY FOR SIDE LANE COLLISION AVOIDANCE

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ABSTRACT

Advance Driver Assistance Systems (ADAS) have successfully been integrated in many vehicles; however, the research on its improvement is still on-going. Some of the features of ADAS include Lane Departure warning System, Blind Spot detection, Lane Change Assistance and etc. However, with such systems available, accidents still occurred due to the driver's lack of awareness and negligence towards the given indication and warning, especially situation related to side lane collision. Thus, this paper aims to propose a simple steering intervention control. If the driver still proceed for the lane change when there are other object appearing in the blind spot area, the proposed solution will automatically trigger vehicle evasion mode to avoid side lane collision. The system does not take into account comfort in order to warn the driver. The system was tested and validated using a test vehicle. The results show that the steering intervention provides good vehicle evasion results and hypothetically it may act as the final warning towards the person behind the wheel.

Keywords: lane change, steering intervention, evasion, blind.

INTRODUCTION

Recently, Research regarding Advance Driver Assistance Systems (ADAS) is nowhere near completion. Although it have long been introduced and integrated in many modern vehicle, the advancement of sensor, controller modules and many other technology allow researchers to find methods to further improve its features. ADAS purpose is to increase safety, improve driving experience and reduce driver's work load by automating some of the control elements for example collision detection and information collection.

Therefore Driving can be considered as multitasking due to drivers are required to gather and process information at the same time while maneuvering the vehicle.[1] suggested that lane change process require the driver to process more than 5 information at once including information gathering from environment, opportunity judgement, path planning and etc. Some of ADAS function could replace driver's decision, opening up the possibility of reducing their change to make mistakes during driving.

The second According to [2], majority of driver are positive about having an intervention system. [3] have conducted study on topic by manipulating steering control parameters on their driving simulator. Their result suggests that the intervening system reduces collision rates with at least 6.2% improvement. Earlier research from [4] shows the result which indicates steering intervention that activates automatically lowers the number of crashes by 30% to 50%.

Some of the functionality of ADAS includes; cruise control assistants, Collision Warning and Avoidance and etc. [5]. Various method have been proposed to further improve current commercial ADAS. [6] method whereby the system able to capture the lane change maneuver characteristic of each individual driver and adjust the ADAS accordingly. Some of the system may depend on turn signal to show lane change intention, [7] proposed a method that able to detect driver intention based on human speech pattern using machine learning method.

However, even with such advance technology, without proper decision from person behind the wheel, accidents still happen. Chances for a driver to lack of awareness may occur for example when taking a call or fiddling with smart phone during driving or etc. Under this situation, intervention system is suitable to warn them as well as to increase their awareness after being warn.

This paper focuses on simple steering intervention strategy using predefined trajectory based on lane change sinusoidal model to avoid collision from the side lane. When the driver is unaware of the potential threat at the blind spot, the system will perform evasive maneuver based on human steering handling behaviour. Ride comfort will not be considered as parameter in the strategy. The proposed solution aims to educate the driver to increase concentration during driving.

The rest of this paper will be organized as follows. In the next section, the system structure of steering intervention control are introduced. The follow up chapter will elaborate on predefined evasive trajectory and the parameters used in the study. Fourth chapter will discuss the data and result of the proposed method which was obtained from field test. The last section draw conclusion of the study..

SYSTEM STRUCTURE

Figure-1 shows the overall system architecture block diagram.

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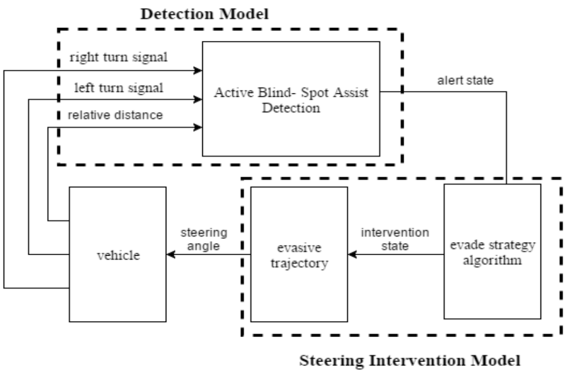

Figure-1. The proposed system.

The supervisor model core is the active blind spot assist system. It monitors host vehicle turn signal and position with lateral distance between the host vehicle and the target vehicle. It is assumed that driver's intention to perform lane change is detected when vehicle turn signal was triggered. Figure-2 illustrates the region where supervisor model determines the target location. Region of interest is classified as warning and alert.

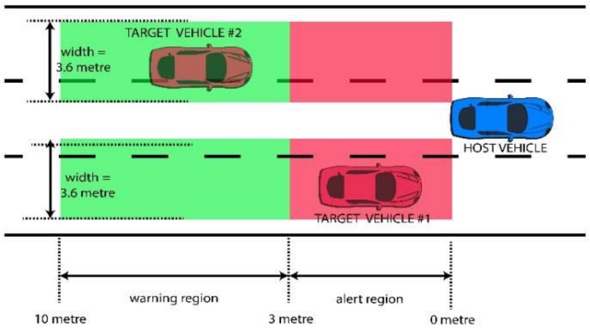

Figure-2. Active blind spot monitoring region.

The system is preconfigured to detect up to 10 meter distance, starting from reference point at host vehicle rear bumper. The first 3 meter are called alert region. In this region, active blind spot assist system will evaluate the potential collision and activate steering intervention when necessary. Steering intervention will activate when all the following condition is met:

- Target is in the similar lane with the lane host desire to change into.
- Target is in the alert region.
- Host activate vehicle turn signal.
- Target relative distance is 1.0m to 1.5 meter from host.

The second regions are the warning region. Any vehicle presence in this region will be tracked in case it enters alert region.

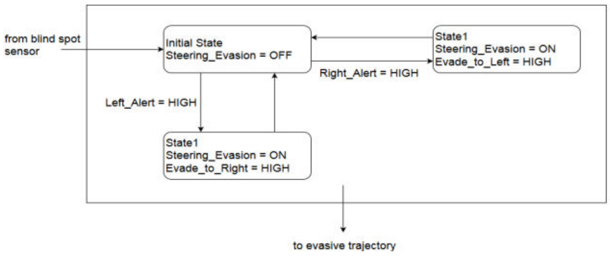

Figure-3. State flow diagram: Evade direction strategy.

Figure-4 shows the Stateflow chart that was implemented to the steering intervention model in Simulink. The chart specifies a system that monitors status from active blind spot assist system and determines the direction of the evasion.

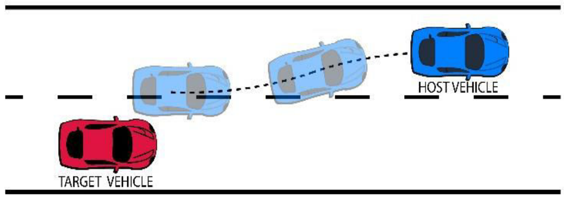

Figure-4. Example of steering evasion behaviour scenario.

The example of evasive scenario was depicted in Figure-4. When the host vehicle attempt to change into the right lane that has target vehicle present in the right alert region, active blind spot assist system will send signal to trigger the steering intervention system. Finally, host vehicle steering will steer away from target vehicle to avoid collision.

EVASIVE TRAJECTORY

Before steering intervention can be achieve, evasive trajectory algorithm must first be define. Its purpose is to obtain a predefined lateral offset that almost mimic average human behaviour when evading threat object. The lane change maneuver sinusoidal model [8] was used to implement the lateral control. Figure-5 picture the desired evasive trajectory. The lateral acceleration of evasive trajectory are as follows:

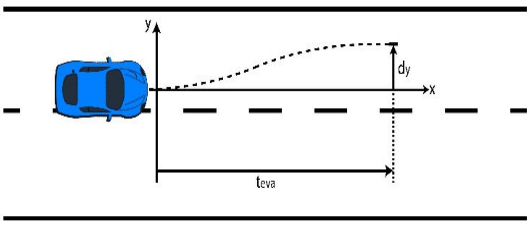

Figure-5. Evasive trajectory.

$$a_{eva} = \frac{2\pi d_y}{t_{eva}^{\ 2}} \sin\left(\frac{2\pi}{t_{eva}} t\right) \tag{1}$$

where

d_y is the in demand lateral displacement modifier

t_{eva} is the total time to execute evasive maneuver
t is the elapsed time $0 < t < t_{eva}$

In the present study, three different intervention setting was chosen by varying the variable based on vehicle speed. Table 1 shows the setting for each group of vehicle speed.

Table-1. Lateral displacement modifier based on vehicle speed.

Velocity (km/h)	d_y
35-65	6
65-85	5
85-120	4

Based on test drive by a few selected experience driver, the time to perform evasive maneuver is between the ranges of 2 to 3 seconds depending on driving style. In this article, which correspond to evasion control is set to 2 seconds. Thus the equation can further be simplified into:

$$a_{eva} = \frac{\pi d_y}{2}\sin(\pi t) \quad (2)$$

RESULT AND DISCUSSIONS

The steering intervention control was integrated and tested using I-DRIVE platform as shown in Figure 6. The test vehicle consists of modified steering mechanism, radar sensor and MicroAutoBox II for control.

Experiment was conducted to test the steering intervention system. The aim is to test the performance of the control strategy and its feasibility by comparing it with the response obtained from manually performed evasive maneuver. According to [3], intervention based on directional steering torque have potential to aid driver in avoiding collision.

Figure-6. Test Vehicle: (a) blind spot detection radar; (b) MicroAutoBox II.

The experiment was carried out on Malaysia highway where the lane stretch long enough to achieve 90km/h velocity. The test was conducted under speed approximately 70km/h and 90km/h

Figure-7 and Figure-8 shown the steering angle and yaw rate which was extracted during automatic steering intervention and manual evasive maneuver process at vehicle speed equal to 70km/h respectively. Whereas Figure-9 and Figure-10 are similar data gathered at speed equal to 90km/h

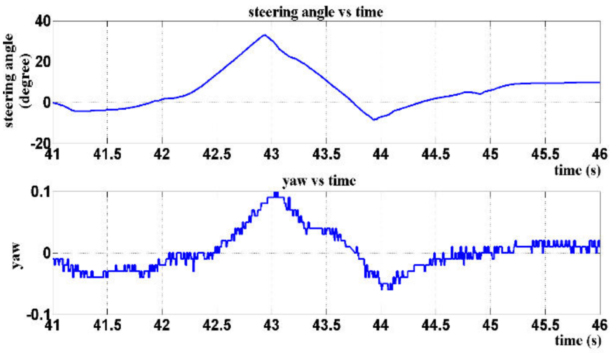

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Figure-7. Steering angle and yaw rate for steering intervention under 70km/h.

The steering intervention and manual evasive maneuver yaw rate obtain at vehicle speed equal to 70km/h are 0.08 rad/s and 0.09 rad/s respectively. Total difference measure in percentage is 13%. For 90km/h, the yaw rate are 0.11 rad/s for the intervening system and 0.08 for the manual evasive maneuver. The percentage difference is at 90km/h is 27%.

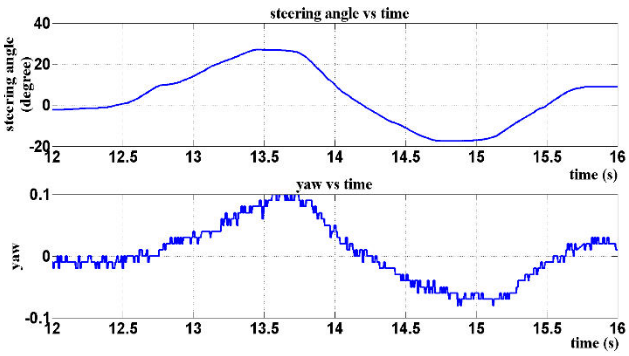

Figure-8. Steering angle and yaw rate for manual evasive maneuver under 70km/h.

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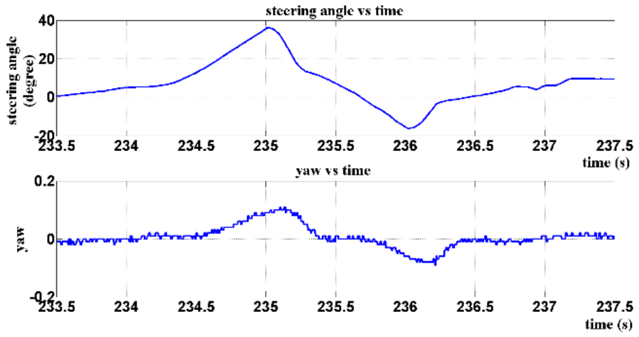

Figure-9. Steering angle and yaw rate for steering intervention under 90km/h.

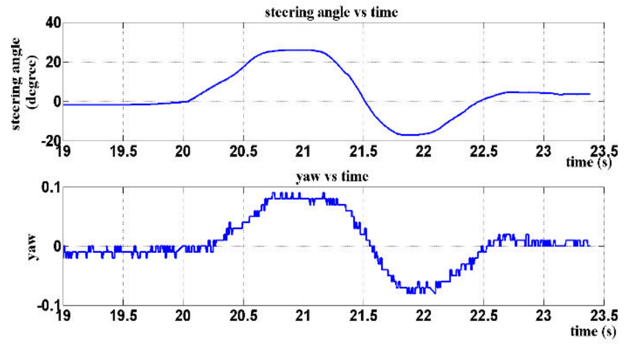

Figure-10. Steering angle and yaw rate for manual evasive maneuver under 90km/h.

The characteristic of steering angle and yaw rate as in Figure-7 and Figure-9 suggest that steering intervention causes the host vehicle to evade from colliding with target and rebalance itself back to follow the straight lane. The result extracted from manual test show similar pattern.

One noticeable difference between intervention and manual evasive maneuver is the steering angle pattern. The earlier figure shows sharp changes in the peak value while the other shows smooth sine wave. The reason is due to the torque at the steering wheel. The randomness of system delay and the friction between tires and the road cause the controller to already sent signal to turn the steering to the opposite direction just before the system reaches the stable value. Human on the other hand, rely on muscle control, thus they are able to compensate based on their driving style. However, as the vehicle speed increased, the intervening maneuver became much smoother.

CONCLUSIONS AND FUTURE WORKS

The core result of this paper has been the steering interventions which focus on avoid side lane collision. At the same time, this function will act as a warning to driver that may have miss out on the caution indication from vehicle ADAS. Steering intervention control takes input from the blind-spot system. At the same time, it monitors the velocity of the host vehicle. Both input affects the predefined trajectory, derived from the sinusoidal lane change algorithm. Result from on the road test shows that the vehicle can perform safe evasive maneuver smoothly and precisely. Further research should take into consideration of the steering evasive maneuver on the curvature. Furthermore, by considering many different emergency scenarios, the steering intervention system will be more flexible and robust.

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