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# INTELLIGENT LANE CHANGE METHOD FOR THE EMERGENCY SCENARIOS IN VANETS

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## ABSTRACT

VANET research papers report that, the findings of a study aimed at testing and evaluating the lane changing and merging abilities, especially under congested flow conditions are very essential now a days. Driver assistance systemshave become a major safety feature of modern passenger vehicles. The advanced driver assistance system (ADAS) isone of the active safety systems to improve the vehicle control performance and, thus, the safety of the driver and thepassengers. To use the ADAS for lane change control, rapid and correct detection of the driver's intention is essential.This study proposes a novel pre-processing algorithm for the ADAS to improve the accuracy in classifying the driver'sintention for lane change by augmenting basic measurements from conventional on-board sensors. The feasibility of the developed algorithm was tested through drivingsimulator experiments. As interest in simulating individual people and crowds has grown, simulating traffic andvehicles to accompany those human interactions has become crucial. Traffic simulation has become an importantdevelopment, helping city planners design roads that do not congest traffic or cause accidents.

**Keywords:** advanced driver assistance system (ADAS), lane change, driver's intention.

## I. INTRODUCTION

As roads become busier and automotive technology improves, intelligent vehicles and driver support systems have the potential to greatly enhance the safety of drivers and passengers by alerting the driver to dangerous situations i.e., Electronic Stability Control (ESC), Adaptive Cruise Control (ACC),Etc. It is becoming increasingly common for luxury cars to be fitted with longitudinal collision avoidance systems. [1]

This paper focuses not only on lane change driving motion, but also complex driving situation, such as lane following after lane change motion or lane following with preceding vehicle.

## II. BACKGROUND

The main idea of this paper is to build a system able to drive an autonomous vehicle on high- way scenarios capable to manage even safety-critical situation, the only estimation of other vehicles behavior is not sufficient. An effective estimation of the safety evaluation and of the risk of collision during the phase of planning of the future trajectory of the host vehicle is necessary. This section contains the risk of collision estimation techniques, together with the introduction of new risk assessment strategies, with advantages and disadvantages of each solution.

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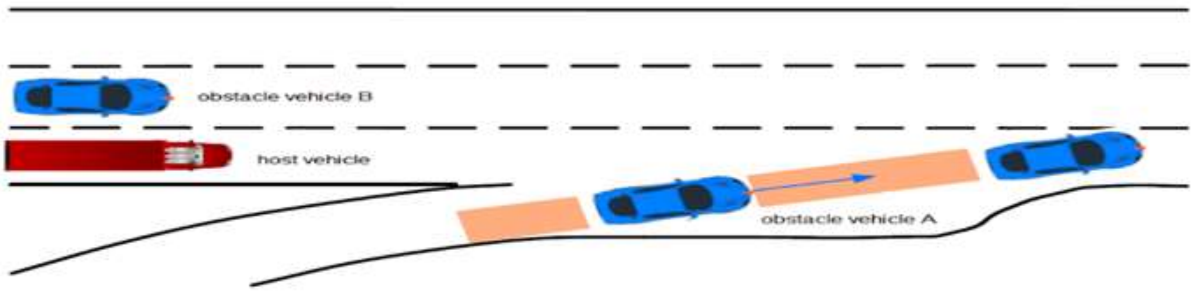


*Figure 1-1: Merging scenario of the obstacle vehicle*

Even if the host vehicle keep the safety distance with the front vehicle, in some cases, vehicle cut in from other lane will reduce the braking distance significantly, which endangers the host vehicle. As shown in Figure 1-1, the host vehicle is in automated driving mode and no other vehicle is on the same lane in sensors' range. Suddenly the obstacle vehicle a cut in front of the host vehicle and the safety distance between two vehicles will soon decrease from the sensor range to the real distance between host vehicle and obstacle vehicle A.Since another obstacle vehicle B on the middle lane, it is impossible for the host vehicle tochange the lane. They are two simple ways to solve this question:

* From the safety aspect, the host vehicle should take an emergency braking in order tohave a shorter time exposed to danger. However, it is less comfortable for the driver and even worse for driver doing sport inside the cabin. What's more, if there is another vehicle behind the host vehicle in the same lane, the risk of rearend collision will increase. Even if no vehicle behind the host vehicle, emergency braking is not that common on the high way.
* From the comfort aspect, the host vehicle should brake pedal slowly in order to reduce the impact from deceleration. The value of deceleration can be set as the maximum deceleration driver can tolerant for sport or sitting comfort, whereas the vehicle will stay in risky for longer time. This way is less aggressive and

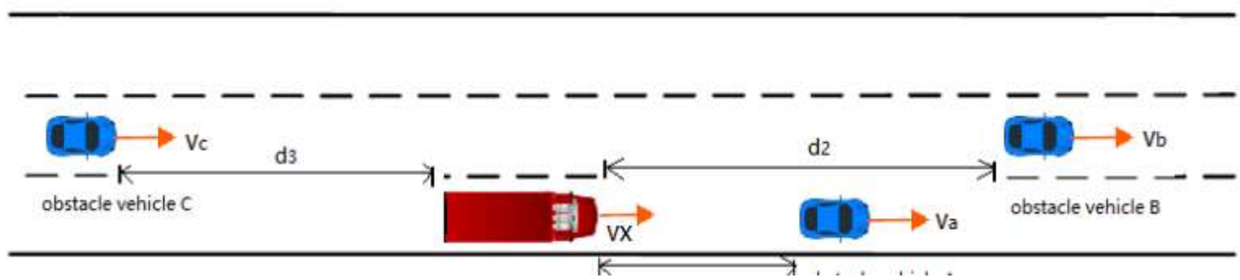


*Figure 1-2: Scenario for host vehicle doing lane change*

the way to solve this problem is quite complex. On one hand, emergency braking is very aggressive on the high way and make the driver fell uncomfortable even horrible. On the other hand, emergency braking could improve safety. In order to solve this problem, the probability of cut in and emergency of front vehicle should be taken into consideration. Since the data is still missing, emergency braking when no vehicle behind the sensors' range might be more conservative way to apply. When there is a vehicle detect behind the host vehicle, the deceleration should be taken in to account the distance between all obstacle vehicle, the speed of obstacle vehicle, TTC and the possibility to change lane.

## III. RISK PREDICTION FOR LANE CHANGE

A driver takes $0-3$ s to realize other vehicle's lane change [7]. Before the lane change, the TTC must be long enough to give drivers in obstacle vehicles plenty of time. In this thesis, a lane change will be taken only when the speed of the front vehicle is lower than 80 km/h. Recalling, braking distance for the truck with the speed 90 km/h is around 40m. An emergency lane change will at least take 3 s, which means 75 m during this period because of the long shape of, it can hardly avoid cash unless it finishes the lane change. An emergency lane change to avoid obstacle will not be taken due the truck dynamics reason. To improve the efficiency, host vehicle can change the lane automatically when $v_A$ is below the lower bound. Before that, the risk of collision needs to estimate. To make the lane change safe enough, the risk will be estimated by the safety distance before

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steering.During the lane change, the longitudinal acceleration of the host vehicle was calculated by the CACC controller to maintain the longitudinal safety distance with obstacle vehicle. The velocity of obstacle vehicle B, C and A is assume with a constant speed. The sampling time for the speed is 0.01 s.

## IV. LANE CHANGE CHARACTERISTIC ANALYSIS

Through the experimentation, the driver's lane change characteristics are obtained. Emergency lane change test data were collected under the severe situation of collision avoidance and general experimental lane change data were collected under the normal safety situation.[6] And both experiments are conducted in several driving speeds; 40, 60, 80, 100kph. From the experimental test data, we confirm that the lane change behaviour has different patterns according to driving velocity regions and driving situations. In the same situation, human drivers perform a lane change manoeuvring with uniform level of lateral acceleration peak and total time of lane change. As the driving situation changes, these two parameters have different values. Detailed results are available below.[13][11][14]

### 1. Fast lane change for High Speed Scenarios

In this section, Low-Level Controller will be tested during a fast lane change. Fast lane change can be used to avoid the crash and improve safety in some scenarios. With the differential braking system and robust controller, the controller can minimise the Load Transfer Ratio (LTR) to prevent rollover. Although this thesis does not take emergency lane change into consideration, it is a very essential aspect of the truck's dynamics performance. In the robust controller already show its ability toreduce LTR, which can be influenced by the longitudinal speed and acceleration. The Figure 3-1 shows that in high speed scenario, the host vehicle in Cruise Control (CC) mode with the speed 90 km/h, the truck can change the lane in 2 s. The peak value of LTR is 0.8727. When the lane change time is 1.5 s, the peak value of LTR will increase to 1.1258, and it is very high probability to cause a rollover. The result shows that the program is very reliable to change the lane in a short time in highvelocity of the host vehicle (right)speed scenario. This property can be used to avoid the obstacle in an emergency situation in the future. Still in the high speed scenario, with the speed 85 km/h and random longitudinal acceleration of zero mean unit variance. The longitudinal acceleration will influence the LTR. When the vehicle accelerates, LTR will be reduced. The peak value of LTR is 0.8256 in this case.

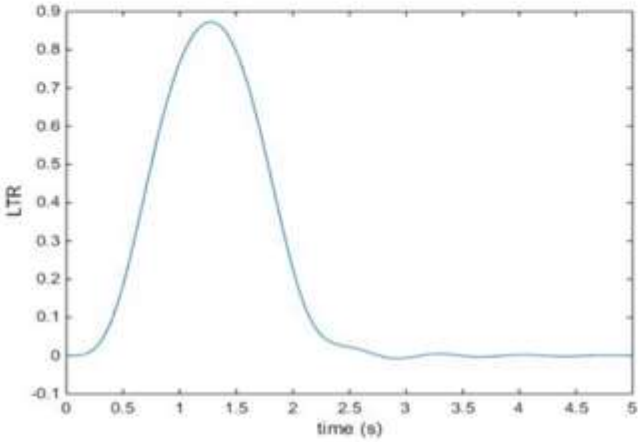


*Figure 3-1: LTR for a lane change in 2 s with robust controller*

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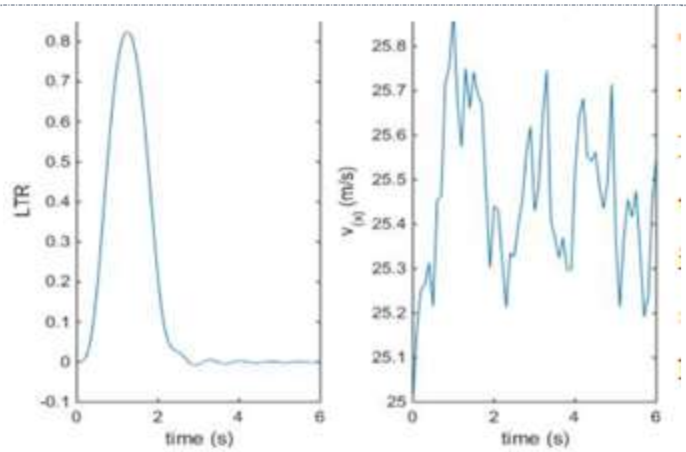


***Figure 3-2: LTR for a lane change in 2 s with random acceleration (left). The longitudinalvelocity of the host vehicle (right)***

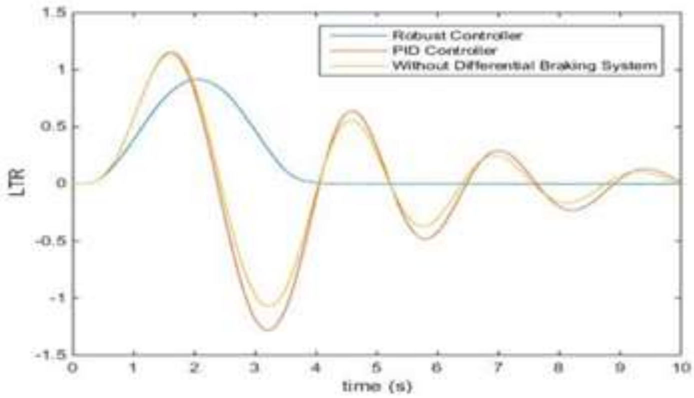


***Figure 3-3: LTR for a lane change in 3.5 s with constant speed***

2. **Fast Lane change for Low Speed Scenario**

The Robust controller with differential braking system improves safety significantly in high-speed scenario for the lane change. However, as mentioned before in Chapter 5, the advantage of the robust controller is not that distinct in low-speed scenario. Figure 3-4 shows the LTR value when the host vehicle doing a CC with the constant speed 60 km/h and the host vehicle change the lane in 3.5 s.

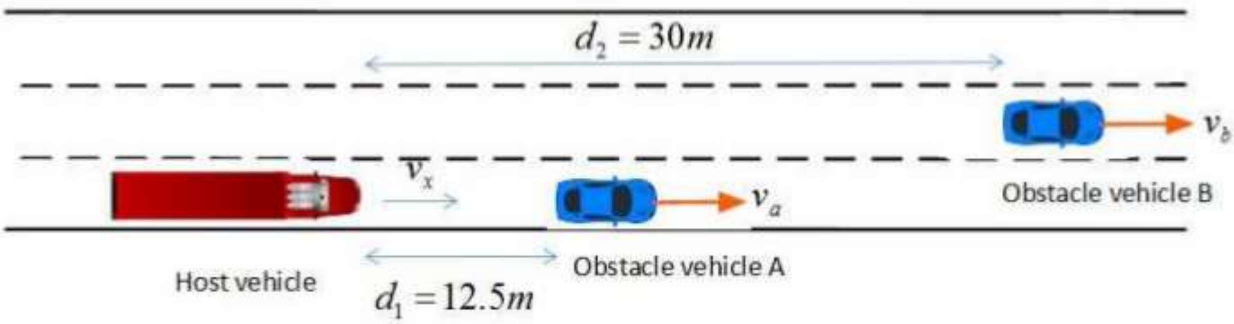


***Figure 3-4: LTR for lane change in 3.5 s with random acceleration***

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The maximum absolute value for Robust Controller, PID Controller, and no controller is 0.9173, 1.2817 and 1.1588.[3][5] The value of proportional and derivative are 0, with the integral −6643.0069. The robust control gain is 1.0e + 06 ∗ [−2.76430.28950.50580.4792] in Figure 3-3. [2][4] Figure 3-4 shows the host vehicle with zero mean unit variance random longitudinal acceleration and change the lane in 3.5 s. The system without differential braking system has the maximum absolute value 1.0434. [6] .Figure 3-4 shows the LTR for the lane change with the maximum absolute value 1.2074 (red line). Meanwhile, the peak value in the same scenario of the robust controller is 0.9747 shown in Figure 3-4 (red line). Both Figure 3-4 and Figure 3-5 shows that the

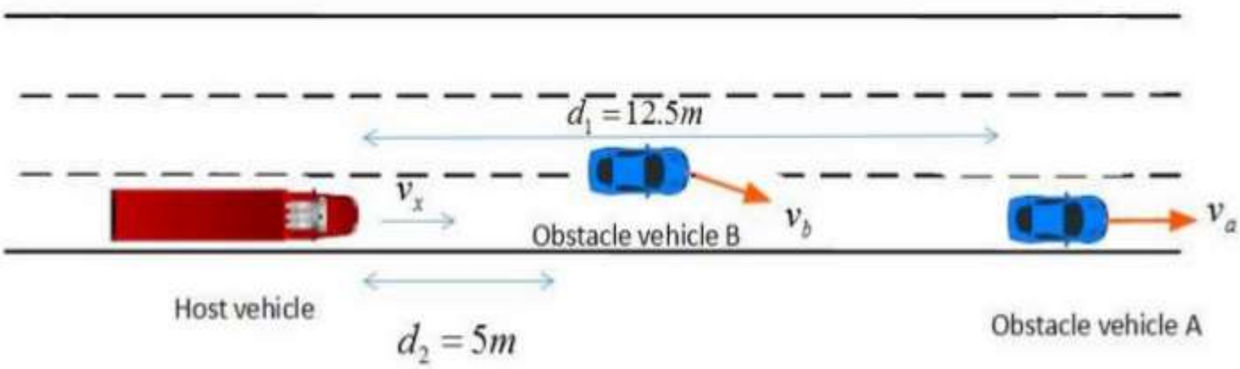


***Figure 3-5: t=5 s of the scenario***

robust controller has the lowest overshoot and converge faster than other two. The parameters in PID controller and the robust controller is the same value as previous.Because the robust can't improve the performance significantly, change the lane less than 3.5 s is not a safe choice in this system. One solution is to use another shape of the trajectory instead of minimum jerk trajectory. For example, the host vehicle can use a step signal as steering angle to avoid a crash.

## V. CONCLUSION

This thesis focuses on the safety and comfort for the driver while doing sports inside thecabin when the truck is in automated driving mode. In the presented work, the problemof trajectory planning and path following applied to the autonomous driving field wasstudied, for application in highway scenarios. Based on the TRUCKletics project, algorithm for improving the performance of the evaluation of collisions, trajectory finder,robust control to prevent rollover was introduced in this thesis.

In High-way road, the trajectory of obstacle vehicle will be estimated. Theestimation based on the linear model with the assumption of the constant velocity.Based on driver's requirement of the speed, the algorithm can decide in which scenariothe vehicle will change the lane. The risk of collision will be checked before the lanechange. The Time to Collision (TTC) and safety distant will be predicted in 7 s lanechange time. The estimation will be updated each 0.01 s with very low computationalcost.

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