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An Analytical Paper on Adaptive Cruise Control

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Abstract: Adaptive cruise control for assessing the risk of collisions between adjacent vehicles and adjusting the distance between them to improve driving safety. An adaptive cruise control system is developed on an AIT intelligent vehicle is implemented. The vehicle's original throttle system and braking system have to be changed to create the adaptive cruise control system. By using a dc motor with a position control algorithm, the original throttle valve which is operated by a cable from the accelerator pedal is changed to the drive-by-wire System. An autopilot vehicle is considered as a solution to prevent crashes.The methodology to predict dangerous situations and change the speed automatically to avoid a crash,predicting adjacent vehicle positions can be applied on a real vehicle in the near future. The proposed method allows estimating each driver's operating characteristics and applying the estimated results to obtain the prediction of the trajectory and based on such estimation, the probability of the collision is calculated.The method detected lane changes with 99.3%, achieved trajectory prediction error of 0.066 m, speed and distance from adjacent vehicles accordingly to minimize the collision risk.

Keywords: Adaptive Cruise Control, Driver,Macroscopic Model, Microscopic Model, Vehicle.

INTRODUCTION

Cruise control system is developed for highway driving. This system is useful for driving long, straight roads and the destination is further apart. The conventional cruise control becomes less useful when traffic congestion is increasing.To cope up with this situation the adaptive cruise control (ACC) system is being developed. Conventional cruise control provides one control mode i.e., speed control for a car while ACC offers two control modes, speed and distance control.Through acting as longitudinal control operator, ACC eliminates the discomfort of driving in dense traffic[1]. ACC will operate like the traditional cruise control which is used to maintain the pre-set velocity of the vehicle.ACC can adjust the velocity automatically to keep a proper distance between the obstacle and the ACC-equipped vehicle. This is achieved by measuring the relative distance between the host vehicle and a vehicle in front using laser or radar.Low-speed ACC is one of the devices working in congested traffic to maintain the gap behind the obstruction vehicle behind. Sometimes that sort of ACC program is called stop-and-go ACC.High speed ACC is the evolution of the cruise control system. As in traditional cruise control, the system provides speed control when there is no vehicle in front of the host vehicle.If a vehicle is running at a slower speed in front of the host vehicle, the throttle and the braking system will be controlled to maintain the inter-vehicle gap set by the driver.When the path ahead is not obstructed, the host vehicle will travel again at the pre-set pace, resulting either from the slower forward vehicle shifting the lane or the driver of the host vehicle switches to the other lane[2].

There are aggressive drivers performing a dangerous lane change even if they are not guaranteed adequate speed and distance.Car crashes are recorded to occur mainly because of lane changes. In this scenario, if an autonomous vehicle unexpectedly decelerates to maintain the distance from a lane-changing car, and it can result in a collision with the following vehicle as shown in Figure 1.Positive awareness of potential movements of the surrounding vehicles is necessary to prevent rear accidents caused by the cutting situation. In addition, automatic control performed based on the expectation to avoid collisions would dramatically improve driving safety[3].

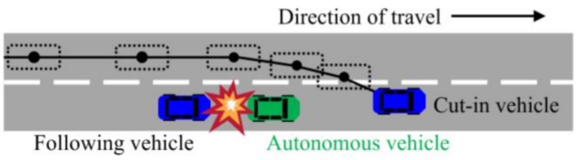

Figure 1: Rear Collision Caused By the Interrupting Vehicle

If the autonomous vehicle suddenly decelerates in order to avoid collisions with interrupting vehicles, the following vehicle may cause a crash.To develop secure autonomous driving, two main techniques can be implemented: First, it includes trajectory analysis of the surrounding vehicles.Different methods for forecasting

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vehicle motions have been suggested, and the models can be divided into macroscopic and microscopic model.Although macroscopic model is useful in analysing traffic flow, such as congestion or traffic volume, the collision avoidance method is not suitable.Macroscopic model treats a multitude of vehicles as flowing through a stream. Although the macroscopic model is effective in analysing traffic flow, such as congestion or volume of traffic, the collision avoidance system is not suitable for this.Microscopic model simulates an individual vehicle's behaviour and can be used to predict neighbouring vehicles future actions. Nevertheless, to achieve the correct output they need the data on specific parameters[4].

OVERVIEW

1. *Problem Definition:*

This paper assumes the driving environment in which autonomous vehicles and human drivers coexist. The driving scene assumed in this paper is illustrated in Figure 2.There are human drivers around the autonomous vehicle, which is fitted with integrated measuring devices such as a GPS tracker and lasers used to collect the movement data for vehicles that surround it.It is believed that the sensing range is within 120 m. It is possible to get the relative speed and distance of nearby vehicles. In the autonomous vehicle the approach proposed is implemented[5].The adjacent vehicles are cut in the autonomous vehicle's front space, thus reproducing one of the main factors of a crash.The cut-in vehicle's future location is forecast for a time horizon, and the probability of collision is extracted from the prediction outcome.It should be considered the collision risks not only to the cut-in vehicle but also to the following vehicle.If the autonomous vehicle decelerates immediately to keep a distance from the cut-in vehicle, then the rear collision may occur. The risk assessment towards the two vehicles is strongly required[6].

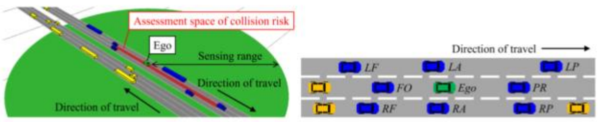

Figure 2: (A) The Autonomous Vehicle has Measurement Devices Used to Acquire the Data on the Distance and Speed of the Adjacent Vehicles. (B) The Autonomous Vehicle is Defined as Ego, and the Maximum Number of Considered Adjacent Vehicles is Eight.

The green vehicle represents an autonomous vehicle, and the blue vehicles are the adjacent vehicles which are the objectives of the method proposed. In the proposed method the yellow vehicles are not considered.When one of the adjacent vehicles is cuts in the autonomous vehicle's front space, thus reproducing one of the main factors of a crash.The ego vehicle is shown in green colour, and the eight corresponding vehicles are shown in blue.The yellow vehicles are non-target vehicles that are outside the scope of the proposed method. The maximum number of adjacent vehicles listed would be eight.In the diagram, LF represents the following vehicle on the left lane, LA is the alongside vehicle on the left lane, and LP on the left lane shows the preceding vehicle. FO is the next vehicle on the same ego vehicle lane; and PR represents the ego vehicle's preceding vehicle.The ego vehicle keeps track of adjacent vehicles while estimating their driving intentions and predicting their trajectories[7].

An advanced ACC (AACC) system is proposed to overcome the limitations mentioned in the process characteristic estimation and trajectory prediction.There are two components of the AACC: a predictor and a planner. The predictor is created by the number of vehicles adjacent to it. If N adjacent vehicles are around the ego vehicle, N units are created, and then each unit predicts one adjacent vehicle's trajectory.The predictor's inputs are data about the ego's location and speed of the neighbouring vehicles. This information using GPS and a controller is a network bus. Laser scanners are installed to measure adjacent vehicles position and speed.The predictor is composed of three subparts: estimation of driving intention, estimation of operation characteristics and prediction of trajectory. The predictor outputs are the trajectories of vehicles adjacent to N[8].

The operating characteristics of the adjacent drivers are calculated at each step. Four characteristic variables of the process are calculated using the measured information: three parameters of the GM model and the reaction time.The approach applies the predicted driving purpose and the characteristic activity variables to carry out the trajectory prediction.When drivers intend to keep the current lane, such as maintaining and adjusting it, they aim to maintain the safe distance from the same lane's preceding vehicle. The vehicles in the adjacent lane must be remembered when drivers plan to change a lane, such as changing and arriving.

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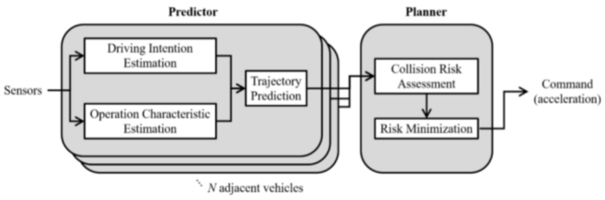

Figure 3: Adaptive Cruise Control

2. *Driving Intention Estimation:*

All drivers can be assumed to have merely two intentions: lane-keeping and lane-changing. When a driver is satisfied with a current driving condition, he or she can maintain a current lane and only focus on keeping as a distance from the previous and subsequent vehicles.If the driver is in a frustrated state with the current driving situation, he or she may attempt to change a lane. For the estimation of the trajectory this paper precisely describes the driving intentions as shown in Figure 3.When a driver intends to keep, the driver controls the speed to keep a safe distance from the vehicles that proceeded. On the other hand, expresses the intention of starting a lane change until the lane marking is crossed.Arrival aim represents a move until the vehicle enters the middle of the target lane, after being over the lane marking. When a driver wants to change, the drivers start changing the speed on the target lane with respect to the vehicles[9].

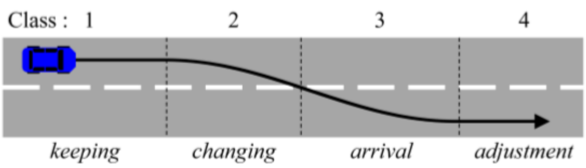

Figure 4: Definition of Driving Intentions

The method proposed defines every intention as a class and uses the SVM to treat the estimation of driving intentions as a multiclass problem. Two characteristics representing the target vehicle's lateral movement are extracted: distance from the centreline, and lateral speed. The Figure 4 Describes the definition of Driving Intentions.

3. *Trajectory Prediction:*

The potential adjacent vehicle movement is predicted according to the vehicle's projected driving purpose. The lateral location is placed at the centre of the current lane when holding is calculated as the current goal.In comparison, when change is determined, the lateral location is set to the middle of the adjacent lane. If the expected goal shifts or arrives, the target vehicle's lateral location is calculated via the sinusoidal model.The popular models are arc model, trapezoidal acceleration model, isokinetic migration model, and sinusoidal model while numbers of lane change models have been proposed.The isokinetic model of migration is simple and easy to measure but the manoeuvre produced would be impractical.The arc and trapezoidal acceleration models are poorly versatile, as they allow design parameters to be defined.The sinusoidal model, on the other hand, calculates the lateral acceleration according to the lane-changing length and the duration can be measured without any specific parameters.The proposed method extracts the length at the moment when the lane-change is observed, using the lateral velocity and the lane width[10].

CONCLUSION

This paper suggested a new adaptive cruise control to enhance driving safety by predicting potential adjacent vehicle manoeuvre and chances of collision with it.It focused on the cut-ins situation in which the surrounding vehicle intrudes into the ego vehicle's front room.The proposed system predicted adjacent vehicle manoeuvres based on their estimate of purpose. For better prediction, the real-time estimate of each driver's operating characteristics is performed, allowing the prediction accuracy to be dramatically improved.The ego-vehicle changed its speed to minimize the risk of collision based on the manoeuvres expected. Compared with human drivers and the state of the art previous ACC systems, the AACC has been demonstrated to improve driving safety.ACC simulation model is used for controlling a vehicle's throttle and brakes which do not adjust the controller's repetitive mode.A two-stage cascaded controller framework is used to tackle the vehicle's non-linear dynamics, especially the drive train. Depending on the desired conditions two separate controllers are used as the upper controller to control velocity and distance.

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