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VEHICLE PLATOON FORMATION AND MANAGEMENT

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Abstract - *Platooning is a driving strategy in which two or more vehicles follow each other in close proximity. Platooning enables the platoon members other than the lead vehicle to draft the vehicle in front of them, increasing fuel efficiency. Platooning reduces the amount of road space taken by the participating vehicles, increasing the effective capacity of the road network. Platooning is done by creating(Linking) multiple vehicles together forming a chain(Platoon) or by incorporating better Intruder Management with the help of a Computer Vision system andRadar and Lidar sensor. It can also be carried out by implementing a GPS routing based Platoon Intersection Behavior system. Platoons use electronic and possibly mechanical coupling to reduce the distance between cars or trucks. This feature will allow multiple cars or trucks to accelerate or brake at the same time. By removing the reacting distance needed for human reaction, this device also allows for a closer headway between vehicles. Automated driving and platooning are projected to increase road capacity and reduce traffic congestion. The authors previously demonstrated that it is necessary to take into account platooning manoeuvres in order to properly understand and quantify the impact of automated driving on the traffic when there are automated and non-automated vehicles coexisting in a mixed traffic scenario. These scenarios are particularly relevant since platooning and automated driving will be gradually introduced, and non-automated vehicles can interfere with the manoeuvres. This study progresses the current state of the art by studying the impact of the configuration of platooning manoeuvres on the traffic flow under mixed traffic scenarios.*

Key Words: Multi-Agent System, Autonomous Vehicles, Platoon, ISO-26262, Functional Architecture, Safety Lifecycle, ACC, V2V Communication, Perception, ADAS, HARA, ASIL, Lane Detection, Maneuvering

1. INTRODUCTION

A platoon is a group of vehicles driving one after the other in a coordinated fashion. A global and tight control enables small spacing between vehicles, therefore significantly increasing highway capacity and traffic flow. Platooning is a method of pushing a large number of vehicles in the same direction. Its aim is to use an automated highway system to increase road capacity. Platooning is a driving technique in which two or more vehicles drive in close proximity to one another.

The platoon control aims to ensure all vehicles in the same group move at the same speed while maintaining a desired distance between adjacent vehicles. Platooning enables the platoon members other than the lead vehicle to draft the vehicle in front of them, increasing fuel efficiency. Highway congestion enforces a huge burden on drivers. Drivers must spend significant time in traffic jams, which has economical and social effects. According to, the key way for improving traffic flow and capacity in highways, is to organize vehicles in platoons. Adaptive Cruise Control (ACC) which automatically adjusts the vehicle longitudinal speed to maintain a desired time headway to the vehicle in front of it, and in the absence of one, aims at achieving a constant cruise speed.

Collaborative vehicle platoon control is a prospective combination of the intelligent and connected vehicles. Truck platooning has been suggested as a concept for reducing semi-truck energy consumption and improving the viability of electric semi-trucks. A platoon's cars are spaced a metre apart to reduce air resistance. Thus greater fuel economy due to reduced air resistance. Congestion can be reduced. There is a chance of substantially shorter commutes during peak periods.On longer highway trips, vehicles could be mostly unattended whilst in following mode. Chances of traffic collisions are reduced.

Some of the existing Platooning projects consist of names like SATRE, PATH, GCDC, Energy-ITS, Scania Platooning. There are several unsolved problems that make Vehicular Platooning just a concept rather than an implemented day-to-day working system. We show that when forming platoons on the fly on the same route and not considering rerouting, the road topography has a negligible effect on the coordination decision. Then, when coordinating two vehicles to form a platoon, we formulate an optimization problem. We propose a platoon formation algorithm that coordinates neighbouring vehicles pairwise to form platoons of several vehicles.

2. SEARCH STRATEGY AND CRITERIA

2.1 A Functionally Safe Dual-bus Platoon Architecture for Future Smart Cities.

Authors: Raghvendra Tripathy, Jyoti Harmalkar, Dr. Arvind Kumar

This paper proposes a system so that platooning can be efficiently and safely implemented on Indian Highways. It mentions poor roads, poor transportation infrastructure and adequate laws as additional roadblocks beside barriers of safety that can be experienced specifically in India that might be experienced while implementing platooning. In order to overcome these roadblocks and to ensure the platooning serves its purpose of safety and reduced carbon emissions. The proposed concept is to drive highly automated buses on highways in public traffic that implements small inter-vehicle distance in order to increase the highway capacity and less air- drag and improved fuel efficiency. There are also additional benefits like green machines, safer streets, reduced time, trailering traffic and space savers. The solution provided by the concept is main system setup, functional architecture of system and proposed safety life-cycle for highly automated vehicles.The main objective of the project is to have trailed buses follow the leading bus. The leading bus which is also called a master bus does the platooning and the trailing buses which are fitted with more advanced automated systems like cooperative and adaptive systems, lane keeping, etc. follow the master bus. The proposed functional architecture of this system is the one proposed by Matthaei and Maurer. It comprises three- strategic level, tactical level and operational level. Nevertheless there are a few challenges that still occur. Driverless operation of a passenger bus on Indian public traffic has different scientific challenges, which are categorized as practical, normative and lawful challenges. Practical challenges such as development and validation of safety concepts. Normative challenges such as no adequate standard to ensure functional safety of the system for an unmanned vehicle. Lawful challenges include absence of laws that grant the permission for operating an unmanned vehicle on the road and unemployment of masses if the vehicles go automated. The practical ways to resolve these challenges will be ensuring to implement a fully tested safety life-cycle. As for unemployment of masses,employment can be provided through the jobs like maintenance of roads, appointing ITI technicians, solutions experts, etc. in order to deal with technical issues that users may face.

2.2 Ad Hoc Vehicle Platoon Formation

Authors: Robert W. Thomas, José M. Vidal

This paper states that Platooning is a technique where two or more vehicles drive in close proximity, one behind the other and this helps in reducing the amount of road space taken by the participating vehicles, increasing the effective capacity of the road network. As the abstract of this paper mentions, Road Traffic is a common problem faced by everyone, so in order to alleviate this problem, Platooning can be used. Typically platoon formation is often centarrly orchestrated mechanism. This paper describes an Ad Hoc Platoon formation game the satisfies that need and assesses possible player strategies. Moving vehicles in platoon, increases the density of traffic which results in increased throughput. Modelling and Simulations have shown that in some scenarios the throughput has been doubled. The majority of platoon composition methods, on the other hand, depend on central orchestration to determine how platoons should be organised. This creates a barrier to entry by forcing the end-user to register with such a system or systems for the areas in which they fly. Users may also have to alter their travel schedule to accommodate platoon formation. Determining what platoons should form and when is computationally expensive and would not scale well to meet the demands of a modern urban environment. This is why we need ad hoc platoon formation. The users don't have to register for a platoon ahead of time, instead they simply need to follow an accepted protocol. This helps in attenuating the computational cost as computation takes place across various platoon enabled vehicles. Following this solution helps us with the benefits of platooning without infrastructure constraints of centrally orchestrated platoon.The platoon negotiation approach may be a regular game with predefined rules that are known to all participants. Ad Hoc Platoon formation can be viewed as an iterative game. The overview of this formation can be specified as the following scenario: Considering that the road conditions and weather conditions are ideal, vehicles who commute through the same route and at the same time on a daily basis are bound to encounter each other. Now these vehicles can independently or travel together by linking with each other and form a platoon in which the trailing vehicles may experience fuel benefits due to reduced air drag. This journey is repeated iteratively. Vehicles can choose to either lead or follow. The formation of the link and the positions and role of each vehicle is decided by the choices of each vehicle. In case of two vehicles choosing the same option, the third factor namely 'chance' helps in deciding the roles of vehicles as head and tail where head leads and tail follows. This game is similar to that of Iterated Prisoner's Dilemma also known as IPD. Different strategies such as Axelrod Tournament, Basic Player Strategies and Moran Process are developed in order to evaluate them to see how they perform against each other while playing Ad Hoc Platoon games. The Methodology used for this was playing these strategies against each other in a round robin style tournament. Two different Tournament styles are used. First, strategies competed in a traditional tournament with every player facing every other player, maintaining their original strategy from one round to the next. Second, strategies played against each other using the Moran process to emulate natural selection. This allowed players to switch strategies between iterations based on how their strategy faired relative to the other strategies. The second tournament type used applied the Moran process. The results show that while defector achieved the highest individual score for a single run, more cooperative strategies, including random, outperformed it. The results of the second tournament again show Grudger as the best strategy. The results support that cooperative strategies are more beneficial in the long run. This is true for both individuals and the system as a whole. Of the five strategies, the three cooperative strategies performed the best as individuals. Defector, the always selfish strategy, performed the worst overall, far behind even Random. Future work will focus on developing simulations to quantify potential fuel and time efficiencies of Ad Hoc Platooning compared to centrally orchestrated methods. How much the penetration rate of platoon enabled vehicles affects potential benefits will also be studied. Additional topics such as preventing the intrusion of non-participating drivers into platoons and application of the methodology presented in this paper to other problems in this domain could also be considered.

2.3 Vehicle Velocity Control in Case of Vehicle Platoon Merging

Authors: Eisuke Kita , Miichiro Yamada

This paper states that the vehicles travel in a row having a short distance in between with the help of the mechanical/electric systems is called vehicle platooning. Platoon formation is a very important technique for increasing road traffic efficiency. The previous studies focused on the safe and stable control of the vehicle platoon. The next should aim in the vehicle platoon. Integrating vehicle platoons at the meeting point is regarded as one of the traffic cases in this study. Here the aim of this study is to discuss the velocity control of the vehicles in the platoon. The head distance and velocity difference are used to describe the velocity control model. The model parameters are determined by stability analysis of the velocity control model. Platooning is a technique where two or more vehicles drive in close proximity, one behind the other. It allows the dynamic formation of platoons which seems to be a natural means to increase participation. The use of the traffic platoon attracts great interest as the key issue to solve the traffic congestion. A recent study of the vehicle platoon is on the stable platoon of actual vehicles. The main focus is to study the velocity control model of the vehicles in case of integrating the vehicle platoons at the interjection.

The VEHICLE FOLLOWING MODEL AND PARAMETER DETERMINATION -

1] Vehicle Following Model which consists of Single-Leader Vehicle Following Helly Model and Multi-Leader Vehicles Following Helly Model.

2] Stability Analysis which has Single-Leader Vehicle Following Helly Model and Multi-Leader Vehicles Following Helly Model.

3]COMPUTER SIMULATION has Road Network and Layout of Vehicle, Merging Process of Vehicles and Sensitivity.
Hence, to conclude the previous studies focused on the safe and stable control of the vehicle platoon. The next should aim in the vehicle platoon. Integrating vehicle platoons at the meeting point is regarded as one of the traffic cases in this study. Here the aim of this study is to discuss the velocity control of the vehicles in the platoon.
The velocity control model is defined by means of a Helly model and its extension to two-leader vehicles following the Helly model. The model is applied for the computer simulation and the experiment using LEGO MINDSTORMS NXT. The difference between the simulation and the experiment is estimated by the mean square error in two cases that the summation of sensitivities is 0.5 or Finally, it is concluded that 0.5 is better than 1.0 for the summation of the sensitivities

2.4 Heavy-Duty Vehicle Platoon Formation for Fuel Efficiency

Authors: Kuo-Yun Liang, Jonas Mårtensson and Karl H. Johansson.

Platooning occurs when heavy-duty vehicles follow closely behind each other, reducing aerodynamic drag and lowering total fuel consumption by up to 20% for the trailing vehicle. However each vehicle has a different mission and thus it should be able to form, merge, split and leave the platoons on the highway on its own accord. The main objective of this paper is to study how to or more scattered vehicles can cooperate to form platoons in a fuel-efficient manner. This paper helps in formulating an optimization problem when coordinating two vehicles to form a platoon. A coordination algorithm is put forward to form platoons of several vehicles that coordinate along with the neighbouring vehicles. With the help of a detailed vehicle model and real road topography, a simulation study is carried out to prove that the approach yields significant fuel saving. Through our research, most of the literature that we came across consisted of techniques to keep the vehicles in the platoon throughout the journey. In this paper, we investigate how many HDVs can change their speeds to form a platoon that is more fuel-efficient than if no platoon formation is performed. The main contribution of this paper is the proposal and study of a novel algorithm to coordinate scattered vehicles to form platoons for fuel savings. The method relies on vehicles being coordinated in pairs. The model used for coordination decision is presented in this paper for the optimization problem for coordinating two scattered vehicles to form a platoon is formulated and then compared to a pure catch-up. The coordination concept is for the extended and a coordination algorithm to form platoons with several scattered vehicles is put forth. Simulations are used to evaluate this approach and the paper is finally concluded with an outlook for future work.

In conclusion to this paper, the author has scrutinized how to form platoons of two or for HDV' S in order to ensure fuel efficiency by incorporating coordination on the fly instead of rerouting the HDV'S which would delay the transport. Also, for a two-vehicle case, the authors have mapped out an optimization problem based on speed as well as air drag reduction the HDV's experience once the platoon is formed. The coordination approach was compared with an advanced model used in Scania, which resulted in the research being directed towards the right direction. Nonetheless, the result assumed no traffic. In a real-time scenario, traffic is an important factor that affects the coordination decisions that will in turn affect the formation of platoons and potential fuel saving. A thorough study of sensitivity analysis will be helpful to coordinate despite deviating from the optimal speed due to road or traffic conditions. The future work for this paper includes improvement and extension of the algorithm to a network of vehicles and for saving fuel more efficiently.

3. Results

To concatenate our research work we would say for efficient platooning techniques it is important for improved traffic and revised traffic laws, a proper standard for ensuring functional safety of the system and development and validation of safety concepts. There is a need to focus on coming up with simulation to quantify potential skills and time efficiency of Ad hoc platooning compared to centrally orchestrated methods. The penetration rate of platoon enabled vehicles and how they affect potential benefits will be studied. Various techniques to prevent an intrusion in the platoon and application of the methodologies in this domain are to be considered. It is important to study the velocity controls of the vehicles in the platoons. Incorporating optimization problem coordination algorithms is important for an efficient platooning. A thorough study of sensitivity analysis is needed and it is required to focus on improvement and extension of the algorithms that we studied in this research.

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