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A Review on Vehicle Overtaking Assistance and Their Implementations

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Abstract: ***In an era of autonomous vehicle development, the need of a proper driver assistance systems is still there, which should be use full in various geographical conditions. One such application is on road vehicle overtaking assistance system. Overtaking maneuver is still considered to be the one of the most difficult maneuver throughout the world and making a decision of overtaking is always a difficult task for a driver to perform a safe overtaking maneuver. In this paper various technologies used for overtaking assistance have been discussed in detail, along with their developed system. Also, a detail comparison of all these systems is done for the development an ADAS application.***

Keywords: ADAS, Overtaking, Maneuver, Assistance

1. Introduction

ADAS is a driver assistance system designed to assist the driver while performing manoeuvres on roads. Due to diverse geographical conditions and incapability of a driver to take a proper decision at the time of performing any manoeuvre has raised the demands for driver assistance systems. To develop such a system, vehicles are loaded with lot of sensor on and inside it and with the help of these sensors the driver assistance work is done. Overtaking is still one of the difficult manoeuvres where driver need to be assisted with the help of an ADAS application.

1.1 ADAS

ADAS (Advance Driver Assistance System) is a driver assistance system designed for the safety and better driving experience. These safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to potential problems, or to avoid collisions by implementing safeguards and taking over control of the vehicle. Adaptive features may automate lighting, provide adaptive cruise control, automate braking, incorporate GPS/ traffic warnings, connect to smart phones, alert driver about other cars or dangers, keep the driver in the correct lane, or show where the blind spots is. These features are developed based on inputs from various sensors preset inside or outside the car or with the help of a vision based camera. Additional inputs are also possible from other sources separate from the primary vehicle platform, such as other vehicles *i.e.* vehicle-to-vehicle (V2V), or Vehicle-to-Infrastructure (such as mobile telephony or WIFI data network) systems.

ADAS is a system which will help drivers on various driving conditions and are currently only used for assisting and helping functions, leaving final decision making to the car driver. The driver is still the topmost ranking decision maker. The driver must have ability to override the electronic assistance in all conditions to prevent failures. The driver is legally responsible for his driving (e.g. one still can use the breaks to get to a full stop even if cruise-control wants to accelerate). Overtaking is one such ADAS application were the driver is assisted while performing an overtaking manoeuvre. Overtaking is considered to be the most dangerous manoeuvre among all other. So if a system is developed to assist the driver while overtaking it will reduce many accidents and deaths happening due to performing improper overtaking manoeuvre.

1.2 Types of Overtaking Maneuvers

According to the paper [2], overtaking manoeuvre can be classified as Normal overtaking, Flying overtaking, Piggy backing and 2+ type of overtaking. In normal overtaking manoeuvre the driver follows the in lane vehicle and waits for a sufficient gap to overtake that vehicle. In flying type of overtaking, the driver doesn't wait for a sufficient gap and overtakes the vehicle without reducing its speed. While in piggy backing type of overtaking, the driver fallows another vehicle, which is overtaking a slow speed and vehicle and in 2+ type of overtaking manoeuvre, the driver overtakes multiple in lane vehicles in one manoeuvre. Also, according to another paper [4], four overtaking levels are considered, Normal overtaking manoeuvre, Aborted overtaking manoeuvre, Lane sharing and cutting in type of overtaking manoeuvres.

2. Literature Review

The thought of building an autonomous car has been from 1920's but the actual work for making a driverless car has started in last two decades with the help of developing ADAS applications. Each new ADAS application is one step towards building a driverless car. One such application is an Overtaking assistance system and the work for this system has started in and around year 2008-2009 and is still going around due to its highly complex scenario.

As the scenarios for each country is different, various authors has came up with various models and for various countries and none of them has been able to provide a full proof system because of the highly volatile environment while performing an overtaking manoeuvre. Here work done by various authors has been discussed based upon overtaking assistance work and system proposed by them.

Overtaking is one of the most risky manoeuvres on the road. Various people who have worked on this idea have proposed

various technologies to assist the driver during the overtaking manoeuvre. One such technology proposed in the year 2009 by Rafael Toledo-Moreo, Jose Santa, Miguel Angle Zamora-Izquierdo [1] is based on sharing vehicle kinematics information and road shape to other vehicles present in an around this vehicle. Here when an ever an ego-vehicle (vehicle whose driver need to be assisted for overtaking) changes a lane, its kinematics information along with the road shape is communicated over the 3G cellular network. Lane prediction is done by an interactive multi model filter which consists of global navigation satellite system (GNSS), odometer and inertial measurement along with the digital map of the road. Now when two vehicles are approaching the same location and driving in opposite direction, then their trajectories are predicted based on the above information obtained and the risk estimation is done for performing the manoeuvre. With this system the main purpose is to estimate the risk while performing an overtaking manoeuvre.

Another technology used to perform overtaking manoeuvre was proposed in the year 2013 by author Antonio S. S. Vieira, Joaquim Celestino Jr, Ahmed Patel, Mona Taghavi [2]. Here again the concept of kinematics are used but the medium of communication between two vehicles is through VANET (vehicle Ad Hoc Network). In kinematics information the position and mobility (Speed and the direction) of vehicle is shared through the network. So overtaking becomes easy, once one knows the position and speed of vehicle though it is out of vicinity. In this method a broadcast protocol is used in a vehicle which is in overtaking situation share the information through it. This protocol helps to assist the driver while performing the overtaking manoeuvre.

The above two methods proposed were based on vehicle to vehicle communication and sharing the vehicle kinematics information obtained from the vehicle. But in the year 2015 author A. D. Jarnea, R. Dobrescu, D. Popescu, L. Ichim [3] another approach was proposed which was not based on communication but by obtaining the real scenario operations and assisting that driver with the system in real time environment. In this method two stereo vision cameras along with two radars were used to assist the driver while performing an overtaking manoeuvre. With the help of this cameras and radars, vehicle disparity map of front and back side is acquired for the vehicle surrounding environment. Here Cameras are used to obtained front and back distance of objects with respect to disparity map and to get the lane detection. Also the radars are used to obtain the obstacle distance on front and lateral sides.

Later in the year 2016 authors of Iran Ali Tavakoli, Ehsan Ayazi and mahdi Sokouni Ravasani [4] were identifying the different variables which will be influencing the overtaking manoeuvre on two lane two way roads in Iran. According to them the traffic flow in two directions is not separated, so to perform an overtaking manoeuvre the other lane is used which might be difficult to take decision for the driver as the traffic is coming continuously from the front side on the lane of overtaking. Here they have consider four types of overtaking manoeuvre, which are normal overtaking (accelerative overtaking), aborted overtaking manoeuvre, lane sharing and cutting in (precipitous return to the driving lane) type, on which various effective and significant parameters were examined. This data was obtained by collecting data from the field, which was accompanied, with an automotive expert and some policemen's. Also large numbers of drivers were interviewed and their experiences of overtaking were obtained from them. This data collection was done various types of roads, different weather conditions, with different age group driver, different numbers of passengers present inside the vehicle and many other which are related to overtaking manoeuvre.

3. Existing Systems

In cooperative overtaking assistance system [1] four main subsystems were used. This is vehicle-to-vehicle communicating system based on the available infrastructure of 3G communication. Also it is a based on the vehicle kinematics information and road shape, so the subsystems required are the communication and the navigation systems and then comes the collision avoidance. In Communication System, it connects the vehicles around and in the area of interest of the ego-vehicle and exchanges positions-velocity-time (PVT) with the help of overlay communication approach over cellular network. Navigation System provides the information of vehicle position which is essential in the prediction of lane change and collision. The lane change prediction is obtained by an interactive multi-model filter which employs global navigation satellite system (GNSS), dead –rocking sensors and digital maps, then comes the collision Detection Logic, It compromises of an on-board system intelligence which predicts the lane change manoeuvre and estimates a potential collision. If this finds any possibility of collision it immediately warns the driver. Finally in human-machine Interface (HMI) system is used to interact with the driver and make driver aware about collision.

Another system of VANET-DAS [2] is based on coordinate position message broadcast protocol which interacts with the other vehicles using some wireless sensors. Therefore the communication need air waves and frequency spectrum which can work irrespective of any infrastructure. The advantage in this type of system is that the vehicle position can be obtained will in advance, though the vehicle is relatively long distance away from the ego-vehicle. During overtaking two lane changes are involved, first when a vehicle in lane need to overtake so lane is shifted and second to return back to its original lane after overtaking is performed. So using these kinematics decisions the principle is divided into three steps, overtaking intentions, passing vehicle is really behind the leader at a safe distance and to check if the vehicle travelling is in same direction. Based on these conditions the decision for overtaking is done. Here the distance is calculated between two vehicles by obtaining the position and mobility of the vehicle at a particular time. These experiments were performed using a simulated environment and not in real.

In this system [3] the camera captures the real time images of the front and back side of the vehicle and calculates the disparities. This disparities information of the object is then send to the global map. The radars used obtain the distances

between the object and puts its values on the map. Once the map is prepared the lane detection is done to find were the vehicle is and how to overtake it. Now two lanes are detected left and right along with the distance of the distances of the surrounding objects which are displayed on the maps. Then when any vehicle is detected on the road and is going with slower speed, the driver is informed to take overtaking decision. To perform successful overtaking manoeuvre the lane of overtaking should be free if not then the overtaking is not allowed.

4. Comparison

In this section various systems previously developed are compared with each others. Vehicle to vehicle communication and sensor based techniques are the two technologies used for developing an overtaking assistance system. In vehicle-to-vehicle communication techniques, two methods are used for communication between two vehicles, one is using 3G cellular network and other is based on VANET (vehicular Adhoc network). In the cooperative overtaking maneuver method, that uses 3G cellular network for communication, the main purpose is to estimate the risk in overtaking. It is a kinematics sharing based techniques, which needs physical infrastructure to exchange messages, so that maneuver is authorized and safe. VANET based DAS, also uses kinematics information but the medium of communication is based on vehicular Adhoc network. It can be used with or without any physical infrastructure other that air and frequency spectrum. Here the position coordinates of the vehicles is shared to know the exact location of the vehicles. The other technique is based on the sensors, which is different from vehicle to vehicle communication technique. In this technique various sensors mounted on the car help the driver to take the decision of overtaking. The system developed using sensors consists of two cameras and radars mounted on the car. These sensors detect the vehicles on the roads and using the disparity map measures the distance and speed between of the vehicle on the road. With this information the driver is assisted to perform overtaking. All these systems were designed for different countries and different geographical conditions.

5. Conclusions

After the complete study of the different research works done by different authors in different countries it can be concluded that a system need to be developed which will be assisting the driver in different geographical conditions along with different road conditions. As it is observed that overtaking is a very difficult maneuver to perform on two way two lane roads and when it comes to Indian two ways two lane roads, it becomes most difficult to perform a safe overtaking maneuver. Therefore a system which needs to be developed should assist the driver, when to steer the vehicle and when to apply the brakes while performing an overtaking maneuver. It should suggest the driver when to perform an overtaking maneuver in a real time scenario, using a simple driver assistance system. This system should be independent of external infrastructure so as to be used anywhere. Also, looking towards Indian road and traffic conditions a precise, accurate and cheap system is required to be designed for these conditions.

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