IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

Path Planning and Tracking for Vehicle Collision Avoidance based on Model Predictive Control with Multi Constraints

Nandhini.G[1], Ranjitha Kumari.S[2]

Assistant Professor, School of Computer Studies, Rathnavel Subramaniam College of Arts and Science, Coimbatore, India[1]

Associate Professor, School of Computer Studies, Rathnavel Subramaniam College of Arts and Science, Coimbatore, India[2]

Abstract: A collision warning scheme is one which makes use of data, including communication between vehicles, to enhance vehicle safety and warn drivers of potentially dangerous situations. The propose systems have mostly been cast-off to provide warning information for the driver and do not suggest possible actions. These systems notify the following vehicle about the potential collision condition, but do not provide rerouting selections for the driver which can help avoid traffic congestion. The propose system ant colony based decision making algorithm provides an alternative route for vehicles approaching the accident location in order to decrease waiting and travel time and avoid traffic path. The ant colony algorithm is one of the best decision-making methods for a select the best path rerouting system in VANET. The decision-making system to avoid the congestion path to select the best routing path. This algorithm vehicle send request messages to other vehicles in order to find out about traffic congestion based on the responses message. The propose ant colony algorithm there is no need to continue sending redundant messages and this reduces channel bandwidth by not sending unnecessary messages. The specific "resending" accident messages alongside the propagating messages for one hop by receivers in order to make sure that all needed vehicles are aware of the accident and can take action to reroute to avoid the traffic jam caused by the accident.

Keywords: VANET – Vehicle Ad-hoc Networks, OBU - On-Board Units, RSU- Road Side Units.

I. INTRODUCTION

While passive safety systems, in combination with ever-increasing active safety systems in motor vehicles have been developed to avoid vehicle crashes and minimize the impact of accidents, the need for further reduction in traffic accident incidences using modern control and sensing technologies remains of great interest. In recent years, autonomous vehicles have attracted strong attention from the automotive industry due to their potential applications in collision avoidance. However, fully autonomous driving for the objective of having 'zero accidents on the road' remains a complex task. Further work, such as planning the path upon detecting obstacles, and controlling the actuators so that the vehicle follows the planned path, is often required before the collision avoidance system is road-ready. Thousands of people around the world die every year in road accidents and many more are severely injured. Implementations of safety information such as speed limits and road conditions are used in many parts of the world but still more work are required. Vehicular Ad Hoc Networks (VANET) is used to collect and distribute safety information to massively reduce the number of accidents by warning drivers about the danger before they actually face it. VANET comprise of entities such as sensors and On-Board Units (OBU) installed in the car as well as Road Side Units (RSU).
The data collected from the sensors on the vehicles can be displayed to the driver, sent to the RSU or even broadcasted to other vehicles depending on its nature and importance. The RSU distributes this data, along with data from road sensors, weather centres, traffic control canters, etc. to the vehicles and also provides commercial services such as parking space booking, Internet access and gas payment. The net work makes extensive use of wireless communications to achieve its goals but although wireless communications reached a level of maturity, a lot more is required to implement such a complex system. When the cars go out of its network, other vehicles can join in, connecting vehicles to one another so that a mobile Internet is created. It is believed that the first systems that will integrate this technology are police and fire vehicles to communicate with each other for safety purposes. Ad hoc networks have been studied for some time but VANET will form the biggest ad hoc network ever implemented, therefore issues of stability, reliability and scalability are of concern. The general architecture of VANET communication along with Road Side Unit (RSU).

II. OVERVIEW OF VEHICULAR ARCHITECTURE

VEHICULAR ARCHITECTURE

In vehicular networks, it is expected that there will be limited access to an infrastructure network that will be supported by roadside base stations. Such access is limited in its nature for two reasons. First, the deployment of the infrastructure

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

is expected to be slow and incremental leading to wide areas where there is no access to the infrastructure. Second, a complete deployment is expected to be sparse because of cost. The coverage provide by a roadside base station may be on the order of 200-300m while roadside base stations may be placed every km or so. Consequently, not all vehicles will be connected to the infrastructure at all times. To obtain access to safety or other types of information, it becomes necessary to rely on vehicle-to-vehicle communications.

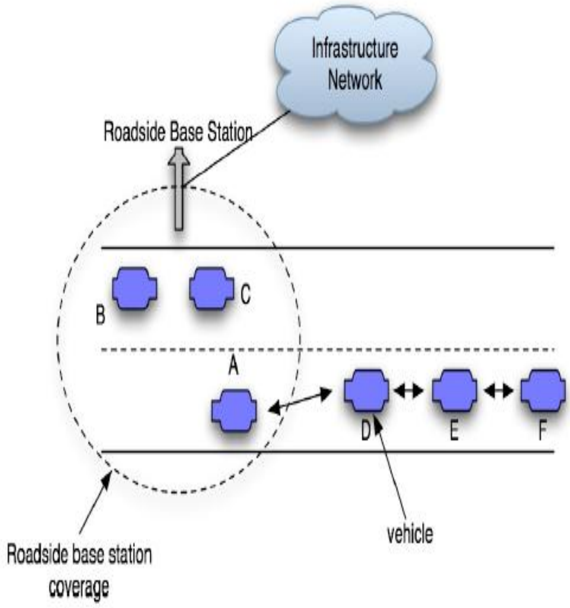

Figure 1.1: Vehicular network architecture

As shown in Figure 1.1, vehicles A, B, and C have access to a roadside infrastructure, which has limited coverage. These vehicles can obtain information from the roadside base station. However, vehicles D, E, and F have no communications with the fixed infrastructure. For instance, Vehicle F will have to rely upon information from vehicle E, which in turn has obtained information that has passed through vehicles A and D. Note that this scenario immediately creates issues that are not necessarily important in other kinds of networks in terms of how to disseminate information and how to assure the security of information. Note also, that vehicles that are in the range of a roadside infrastructure may be connected to the infrastructure for extremely small durations of time because of small coverage and high vehicular speeds. So, the amount of information that can be pulled from the infrastructure is necessarily limited. It is also possible that vehicles move into the range of the roadside infrastructure with some information obtained from cooperating vehicles they have encountered. The issue then becomes one of updating the information, enhancing the reliability or relevance of information or obtaining information that complements that already available to the vehicle.

INFORMATION DISSEMINATION

Information dissemination using DSRC is quite attractive due to the large bandwidth and the possibility of using multiple channels. The IEEE standards propose employing multiple 10 MHz channels, each capable of carrying 27 Mbps of data for vehicular communications. Up to seven channels are available in the 5.9 GHz bands and one channel is supposed to be dedicated for safety applications. The remaining channels could potentially be used for content distribution and delivery. In this section, describe the different types of information that need to be disseminated in a vehicular network and the methodologies that have been considered in the research literature.

TYPES OF INFORMATION

It is expected that the large bandwidth of DSRC will enable a variety of yet to be anticipated applications for vehicular networks such as Internet extension, office on wheels, P2P file sharing etc. The different types of information that need to be communicated and shared in a vehicular network can be classified into four categories: (a) safety information (b) traffic information (c) infotainment and other service information and (d) content. As discussed previously, information may be obtained partly from the roadside infrastructure and partly from other vehicles that are encountered by a given vehicle. In the case of many of the above types of information, the importance and relevance of the information changes with space and time. For example, congestion information that is very far away may become increasingly important and need a more recent update as a vehicle gets closer to a congested area along with updates on alternative paths that may themselves have increased congestion by that point of time.

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

SAFETY INFORMATION

Safety information is the most important of the information types that are communicated in a vehicular network. In 2006 alone, more than 42,000 people were killed in motor vehicle crashes in the United States. In fact, the primary purpose of DSRC is to greatly improve the safety of vehicular traffic. For example, DSRC can be used to prevent collisions between vehicles by providing information to the driver about whether the vehicle ahead is braking, if the speed is too high or the distance to other vehicles or objects is getting too close. Eight safety applications based on deliberations between government agencies and private industry have been identified, which are traffic signal violation warnings, curve speed warnings, emergency electronic brake lights, pre-crash warnings, cooperative forward collision warnings, left-turn assistance, lane change warning and stop-sign movement assistance. Each of these applications makes use of high level data elements such as acceleration (in various quantization levels), obstacle direction, wheel angle, vehicle width etc. Latency associated with many of these safety messages is crucial. The time taken by the driver of a motor vehicle to react to warnings has to be considered while delivering information to him/her, introducing the human component into the picture. The density and environment in which a vehicle is operating also influence the delivery of safety messages.

TRAFFIC INFORMATION

This class of information primarily accounts for congestion on current roads, suggestions for alternative paths to the destination, road construction information etc. that are useful for safety and efficiency, but less time-critical than the "life safety" messages discussed earlier. However, traffic information may still have a higher priority than infotainment or content.

INFOTAINMENT AND SERVICES

DSRC can also be the mechanism for obtaining infotainment and location based services (e.g., where is the nearest coffee shop, or buying a ticket to a movie en route to the theatre), using digital cash for paying tolls, and so on. This could also include information such as available parking spaces in the vicinity.

III. PERFORMANCES OF VANET METRICS

The following four metrics are used to evaluate the performance of the proposed protocol. While reach ability and received distance metrics determine the protocol reliability and effectiveness, transmission and reception overhead metrics quantify the efficiency of the protocol.

NETWORK REACHES ABILITY

Network reach ability measures the fraction of vehicles in the region of interest that receive the message. A good protocol must ensure that most, if all, vehicles intended to receive the message do receive the message before they arrive at the accident scene. **Received distance**

Received distance is the closest Euclidean distance to the accident scene from the arc on the trajectory of a vehicle which was at a point (say A) when the message was broadcast but later receives the message at point B. Note that if a vehicle immediately receives the message at the time the message was broadcast, then the points A and B are identical. The received distance in this case is d1min which is in the minimum of d on the trajectory of the vehicle from A to B1. Similarly, if the vehicle receives the message at point B2 then them received distance in this case is d2min.While the reach ability metric indicates whether all the vehicles receive the message, this metric indicates whether vehicles receive the broadcast message just-in time so that they can reroute and avoid passing through the scene of accident. Hence, the larger the received distance metric, the better the protocol. In addition, observe that the message latency is implicitly captured by this metric.

TRANSMISSION OVERHEAD

Transmission Overhead measures the total number of messages transmitted into the network by all vehicles. This metric is important as it indicates whether or not the message transmission generated by the proposed protocol over whelms the network; in other words, whether it uses excessive amount of bandwidth.

RECEPTION OVERHEAD

Reception Overhead measures the average number of duplicate messages received at a vehicle. This metric determines whether the protocol can effectively solve or mitigate the broadcast storm problem.

IV. RELATED WORKS

[1] S. Chang, and T. J. Gordon, "**A flexible hierarchical model-based control methodology for vehicle active safety systems**," 2008A hierarchical control scheme is applied to the problem of integrated chassis control of a collision avoidance system (CAS). This includes both lateral and longitudinal control, using Active Front Steer in addition to the

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

brake actuators. The inherent flexibility of the control system is provided by the intermediate layer, which employs a form of model predictive control to determine actuator apportionment. The desired vehicle motions in the upper layer, in the form of reference yaw rate and two-dimensional mass centre accelerations, are determined using a kinematic policy (KP) for collision avoidance. The KP uses simple information about range and azimuth angles for multiple points that bound the available vehicle trajectory, and prioritizes yaw motion response based on the worst-case collision threat. This KP approach for CAS is more practical than trajectory tracking approaches because the KP does not need a pre-defined a reference path and does not need any computationally intensive optimization of the vehicle motion control.
The path following approach to collision avoidance is however complex and requires two stages of optimization (first define the intended path, then apply steering and/or brakes to follow that path) that may need to be repeated at high frequency in the rapidly changing conditions prior to a crash or near crash. In order to provide a driver model without a target trajectory generation, Gordon and Magnuski proposed a simple kinematic policy (KP) which determines reference inputs using simple information about range and azimuth angles for multiple points that bound the available vehicle trajectory. In that paper, it was shown that normal driving – lateral and longitudinal vehicle control using road boundaries to constraint the trajectory – is possible without the need to pre-define a reference path, and without need for computationally intensive optimisation. Indeed, for collision avoidance applications, this reference may be obtained from commercially available radar systems, so the method appears attractive from the practical perspective.

[2] K. J. Yanget., al., "**An Efficient Path Planning and Control Algorithm for RUAV's in Unknown and Cluttered Environments**," 2010.This paper presents an efficient planning and execution algorithm for the navigation of an autonomous rotary wing UAV (RUAV) manoeuvring in un known and cluttered environment. A Rapidly-exploring Random Tree (RRT) variant is used for the generation of a collision free path and linear Model Predictive Control (MPC) is applied to follow this path. The guidance errors are mapped to the states of the linear MPC structure by using the nonlinear kinematic equations. The proposed path planning algorithm considers the run time of the planning stage explicitly and generates a continuous curvature path whenever re-planning occurs. Simulation results show that the RUAV with the proposed methodology successfully achieves autonomous navigation regardless of its lack of prior information about the environment.
If new obstacles are detected and if they are located within the safety zone then the RRT path planner must re-plan the path to generate a collision free path. In this research, the run time of the path planning algorithm is considered explicitly when re-planning occurs. Furthermore, the re-planned path we propose also preserves the continuous curvature property which smoothest the transition of the UAV motion from the old path to the new path.

[3] S. Saravanakumar, and T. Asokan, "**Multipoint potential field method for path planning of autonomous underwater vehicles in 3D space**," 2013A multipoint potential field method (MPPF) for path planning of autonomous underwater vehicles (AUV) in3D space is presented in this paper. The algorithm is developed based on potential field method by incorporating a directed search method for sampling the potential field. In this approach, the analytical gradient of the total potent all function is not computed, as it is not essentially required for moving the vehicle to the next position. Rather, a hemispherical region in the direction of motion around the AUV's bow is discredited into equiangular points with canter as the current position. By determining the point at which the minimum potential exists, the vehicle can be moved towards that point in 3D space. This method is very simple and applicable for real-time implementation. The problem of local minima is also analyzed and found that the local minima in 2D space can be easily overcome with the MPPF. A simple strategy to avoid the local minima in 3D space is also proposed. The proposed method reduces the burden of fine-tuning the positives calling factors of potential functions to avoid local minimum. The algorithm development and the simulation results are presented.
In this paper, we propose a multipoint obstacle avoidance strategy to address this problem. The main objective of this work focuses on developing obstacle strategy, the dynamics of the vehicle is not considered in this work. Instead the shape, size and kinematics of the vehicle are considered. In this improved potential field method, a region on a hemisphere around the bow of an AUV is discredited into fewer points in each of the plane. The attraction potential at each point around the vehicle is calculated. Similarly, the periphery of each obstacle is divided into fewer points. Then there passive potential field at each point around the vehicle due to each point on an obstacle is calculated. A critical zone (CZ) is defined and the existence of local minima is detected by checking the presence of obstacles within the zone.

[4] V. Kunchevet., al., "**Path planning and obstacle avoidance for autonomous mobile robots: A review**," 2006Recent advances in the area of mobile robotics caused growing attention of the armed forces, where the necessity for unmanned vehicles being able to carry out the "dull and dirty" operations, thus avoid endangering the life of the military personnel. UAV offers a great advantage in supplying reconnaissance data to the military personnel on the ground, thus lessening the life risk of the troops. In this paper we analyze various techniques for path planning and obstacle avoidance and cooperation issues for multiple mobile robots. We also present a generic dynamics and control model for steering a UAV along a collision free path from a start to a goal position.

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

[5] A. K. Pamosoaji, and K. S. Hong, "**A Path-Planning Algorithm Using Vector Potential Functions in Triangular Regions**," 2013.A path-planning algorithm for a complex work space split into triangular regions is investigated. The algorithm, which is formulated to achieve a goal configuration subject to the desired goal-point orientation, generates a collision-free region-to-region compliant path. To that end, a set of vector potential functions is used. These functions are calculated using information on the triangular regions' vertices, the obstacles' positions, and the goal configuration. Path-planning procedures based on these constraint-satisfying functions are constructed. The proposed path-planning method, entailing velocity-and-orientation tracking control and configuration control, is applied to a unicycle vehicle, and its performance is compared with that of an existing path planning scheme.
In this paper, we propose a method for achieving region-to-region collision-free path planning. We consider three classes of regions: empty, obstacle-inside, and goal-inside regions. We use parameterized vector potential functions and the resultant of the curls of those functions to plan the paths. The elementary vector potential functions are established with reference to the edges of the region and the obstacles. Our contributions are twofold. First, the proposed algorithm enables the linear velocity profile to attain the maximum value, which is an advantageous means of reducing the travelling time. Second, the generated velocity vector fields direct the vehicle to the goal point in such a way that, in the neighbourhood of the goal point, the vehicle tends to approach it at a specified entrance orientation.

[6] A. Shumet., al., "**Direction-dependent optimal path planning for autonomous vehicles,**" 2015.The optimal path planning problem is considered for rovers. Tip-over risk is accurately modelled using direction dependence. In the previous direction-independent model, the value function was approximated using the Fast Marching Method (FMM). The risk was not accurately modelled. Solar energy is considered here for the first time. Minimizing path length, obstacle avoidance and soil risk are also considered. For a direction-dependent model, the value function in the optimal path planning problem can be approximated accurately using the Ordered Upwind Method (OUM) but not FMM. The value function is used to synthesize the optimal control, which is shown to have no local minima. A novel algorithmic improvement, OUM-BD over the OUM to include a bi-directional search is presented. The OUM-BD is slightly slower than the FMM, but can accurately solve a larger class of problems. The OUM-BD is faster than the existing OUM, an optimal bi-directional RRT path planner (Bi-RRT*), and a genetic algorithm (GA) path planner in terms of time, and outperforms both the GA and Bi-RRT* planner in cost in tested examples.
In this paper, the OUM is used to solve path planning problems for rovers. Contributions include a more accurate model oftip-over risk and the introduction of solar energy used in optimal path planning for rovers. Minimizing path length, obstacle avoidance and soil risk are also considered. A novel algorithmic improvement, OUM-BD, combining a bi-directional search using OUM is introduced. The OUM-BD is compared against OUM, FMM (for applicable problems), a genetic algorithm (GA) path planner for rovers [18], and Bi-RRT* in both performance and timing. The OUM-BD is observed to be slightly slower than the FMM, but much faster than the original OUM. All of FMM, OUM-BD and OUM outperform GA and Bi-RRT* in timing and performance in all examples.

[7] T. Shimet., al., "**Autonomous vehicle collision avoidance system using path planning and model-predictive-control-based active front steering and wheel torque control**," 2012.The optimal path planning problem is considered for rovers. Tip-over risk is accurately modelled using direction dependence. In the previous direction-independent model, the value function was approximated using the Fast Marching Method (FMM). The risk was not accurately modelled. Solar energy is considered here for the first time. Minimizing path length, obstacle avoidance and soil risk are also considered. For a direction-dependent model, the value function in the optimal path planning problem can be approximated accurately using the Ordered Upwind Method (OUM) but not FMM. The value function is used to synthesize the optimal control, which is shown to have no local minima. A novel algorithmic improvement, OUM-BD over the OUM to include a bi-directional search is presented. The OUM-BD is slightly slower than the FMM, but can accurately solve a larger class of problems. The OUM-BD is faster than the existing OUM, an optimal bi-directional RRT path planner (Bi-RRT*), and a genetic algorithm (GA) path planner in terms of time, and outperforms both the GA and Bi-RRT* planner in cost in tested examples.
In this paper, the OUM is used to solve path planning problems for rovers. Contributions include a more accurate model of tip-over risk and the introduction of solar energy used in optimal path planning for rovers. Minimizing path length, obstacle avoidance and soil risk are also considered. A novel algorithmic improvement, OUM-BD, combining a bi-directional search using OUM is introduced. The OUM-BD is compared against OUM, FMM (for applicable problems), a genetic algorithm (GA) path planner for rovers [18], and Bi-RRT* in both performance and timing. The OUM-BD is observed to be slightly slower than the FMM, but much faster than the original OUM. All of FMM, OUM-BD and OUM outperform GA and Bi-RRT* in timing and performance in all examples.

[8] W. Kim et., al.,"**Development of a path-tracking control system based on model predictive control using infrastructure sensors**," 2012.This paper describes the development of an infrastructure-based path-tracking control system. The control system consists of an infrastructure sensor module, a vehicle controller and actuator modules. A reference path is defined from a start point to a destination and a modified reference path is generated to obtain a safe vehicle trajectory for collision avoidance in the case where obstacles and other vehicles exist. Receiving information

about vehicle position, heading angle and obstacles surrounding the vehicle from an infrastructure sensor module, the vehicle controller calculates control inputs such as steering wheel angle, throttle angle and brake torque to track the modified reference path which guarantees minimum clearance to obstacles. The vehicle controller comprises three parts: a path generation algorithm, a path-following controller and a speed controller. The path-generation algorithm generates the modified reference path using the model predictive control method. The path-following controller calculates steering angle in order to track the modified reference path. From the speed controller, throttle and brake control inputs are generated to follow the reference velocity. The path tracking control system was implemented using a test vehicle and an infrastructure sensor module.
In this paper, MPC is used to design a real-time path-generation controller which is based on non-linear vehicle dynamics and generates the modified reference path at each time step. By receiving information about vehicle position, heading angle and obstacles surrounding the vehicle from an infrastructure sensor module using wireless devices, the vehicle controller calculates control inputs such as steering wheel angle in order to avoid vehicles or obstacles. The vehicle controller consists of a path-generation algorithm, a path-tracking controller and a speed controller. An infrastructure system includes laser scanner sensors, a signal-processing un it and an infra-to-vehicle communication device. Computer simulation and vehicle tests are conducted to verify the performance of the vehicle controller.

[9] M. Hassanzadehet., al., "**Path and Speed Control of a Heavy Vehicle for Collision Avoidance Manoeuvres**," 2012.In an emergency situation prior to an imminent accident, first in-vehicle warning systems would intervene and aim to make the driver to take a suitable action. If the risk of accident was not eliminated, then an autonomous collision avoidance manoeuvre can prevent it. In this work, path and speed control are intended to be used to perform such a manoeuvre by using steering and braking actuators respectively. In order to provide actuators with suitable control inputs, first a path is planned for the heavy vehicle to follow during the man oeuvre. Then the path is used to calculate feed forward control inputs whereas a feedback controller assures the path tracking by compensating for errors. As a result, a robust path planning and control algorithm is designed and implemented that can perform autonomous collision avoidance manoeuvres for a heavy vehicle. Promising simulation results support ongoing works on vehicle demonstration and experiments on a real heavy vehicle.
Simulation of the path and speed control for the prioritized use case requires a heavy vehicle system dynamics model. Since a combination of steering and braking for collision avoidance manoeuvre is investigated, the model needs to include both steering and braking to well provide the possibility of a proper handling study.

[10] E. Kimet., al.,, "**Model predictive control strategy for smooth path tracking of autonomous vehicles with steering actuator dynamics**," 2014Path tracking control is one of the most important functions for autonomous driving. In path tracking control, high accuracy and smooth tracking are required for safe and comfort driving. In order to meet these requirements, model predictive control approaches, which can obtain an optimized solution with respect to a predefined path, have been widely studied. Conventional predictive controllers have been studied based on a simple bicycle model. However, the conventional predictive controllers have a performance limitation in practical challenges due to the difference between the simple bicycle model and the actual vehicle. To overcome this limitation, the actuator dynamics of the steering system should be incorporated into the control design. In this paper, we propose a model predictive control based path tracking control algorithm to achieve the accurate and smooth tracking by incorporating the dynamic characteristics of the steering actuation system. In the proposed control algorithm, an optimal trajectory of the steering command is calculated by applying a quadratic programming optimization method. The proposed controller was verified by computer simulation with various driving scenarios. The simulation results show that the proposed controller can improve the tracking performance.
This paper presents an MPC-based path tracking algorithm incorporating steering actuator dynamics and constraints. The proposed algorithm derives an optimal steering trajectory to solve the path tracking problem by using a quadratic programming (QP) optimization method.

[11] L. Guo, et., al., "**Lane Changing Trajectory Planning and Tracking Controller Design for Intelligent Vehicle Running on Curved Road**," 2014.To enhance the active safety and realize the autonomy of intelligent vehicle on highway curved road, a lane changing trajectory is planned and tracked for lane changing manoeuvre on curved road. The kinematics model of the intelligent vehicle with non homonymic constraint feature and the tracking error model are established firstly. The longitudinal and lateral coupling and the difference of curvature radius between the outside and inside lane are taken into account, which is helpful to enhance the authenticity of desired lane changing trajectory on curved road. Then the trajectory tracking controller of closed-loop control structure is derived using integral back stepping method to construct a new virtual variable. The Lyapunov theory is applied to analyze the stability of the proposed tracking controller. Simulation results demonstrate that this controller can guarantee the convergences of both the relative position tracking errors and the position tracking synchronization.
Most of those lanes changing manoeuvres researched above ignore the influence of lane curvature change and the vehicle longitudinal velocity on lane changing trajectory. This paper aims at the study of the automated lane changing on curved road, where the curvatures of the outside and inside lane are not zero, nor equal. The main contributions of

this paper are as follows: (1) a trajectory planning method suitable for curved road is proposed based on trapezoidal acceleration profile; (2) the coupled function of the vehicle's longitudinal and lateral motion on lane changing trajectory is taken into account, namely, the curvature radius of which is a vector in lane changing maneuver; (3) on this basis, the trajectory tracking control algorithm is designed using integral back stepping with Lyapunov theory.

[12] X. L. Songet., al., "**Vehicle path planning in various driving situations based on the elastic band theory for highway collision avoidance**" 2013.This paper presents an emergency path generation method which could be applied in various driving situations, such ason a straight or a curved road, and in the lane-change and lane-departure scenarios which are the most likely from a traffic view point. It is based on the artificial potential approach and the elastic band theory. The assessment of the emergency path is based on the dynamic performances; the yaw rate and the lateral acceleration of the host vehicle are chosen in this paper. In order to make evasion manoeuvres steadier, a guide potential attached at the front of the obstacle vehicle and a guide potential attached at the rear of the obstacle vehicle are built to affect the moving vehicles in such a way that it encourages the host vehicle to change lane appropriately. Meanwhile, a hazard map of the road environment including the borders and the obstacle vehicles is generated. Thus, the forces acting on the corresponding nodes of an elastic band should be zero because of the equilibrium condition; the trajectory with a low hazard is calculated via a numerical method. The simulation results show that the approach is acceptable and leads to a successful collision avoidance manoeuvre in various driving situations.

[13] M. T. Wolf, and J. W. Burdick., "**Artificial potential functions for highway driving with collision avoidance**," 2008.We present a set of potential function components to assist an automated or semi-automated vehicle in navigating a multi-lane, populated highway. The resulting potential field is constructed as a superposition of disparate functions for lane keeping, road-staying, speed preference, and vehicle avoidance and passing. The construction of the vehicle avoidance potential is of primary importance, incorporating the structure and protocol of lined highway driving. Particularly, the shape and dimensions of the potential field behind each obstacle vehicle can appropriately encourage control vehicle slowing and/or passing, depending on the cars' velocities and surrounding traffic. Hard barriers on roadway edges and soft boundaries between navigable lanes keep the vehicle on the highway, with a preference to travel in a lane canter.
Thus, we present a potential function for highway driving that encodes avoiding obstacles (primarily other vehicles)and road edges while preferring travel in a lane canter and ate desired speed. This potential function may be envisioned as part of an overall control system for autonomous vehicle navigation in the traditional formulation; however, other applications, such as active driver assistance devices, may represent more realistic near-term options.

[14]R. Hayashiet., al.,**"Autonomous collision avoidance system by combined control of steering and braking using geometrically optimised vehicular trajectory**," 2012.This study proposes an autonomous obstacle avoidance system not only by braking but also by steering, as one of the active safety technologies to prevent traffic accidents. The proposed system prevents the vehicle from colliding with a moving obstacle like a pedestrian jumping out from the roadside. In the proposed system, to avoid the predicted colliding position based on constant-velocity obstacle motion assumption; the avoidance trajectory is derived as connected two identical arcs. The system then controls the vehicle autonomously by the combined control of the braking and steering systems. In this paper, the proposed system is examined by real car experiments and its effectiveness is shown from the results of the experiments.

[15] C. Pozna et., al., "**On the design of an obstacle avoiding trajectory: Method and simulation**," 2009The paper suggests a new mathematical construction for the potential field used in the design of obstacle avoiding trajectories. The main benefits of the proposed construction are the quickness of minimum computation and the compensation for the main drawbacks specific to the "traditional approaches" belonging to the potential field method in general. The potential field definition and its minimum computation concept are presented. Next the concept is included in a design method for obstacle avoiding trajectories. The method is expressed in the form of an algorithm for obstacle avoidance. In the following step a state-space controller is designed in order to control the car along that trajectory. Digital simulation results obtained for the complete dynamic model of a car well validate the method.
The suggested method has been integrated into an obstacle avoidance algorithm. According to this algorithm, the vehicle observes online the universe and makes decisions in order to reach its goal. The goal is an a priori trajectory that must be transformed because of the (initially unknown) obstacles. The transformations are done in two steps: firstly, the obstacle avoiding trajectory is designed, and secondly the control design to track the trajectory is done. The control design is based on a state-space method.

[16] D. J. Cole et., al., "**Predictive and linear quadratic methods for potential application to modelling driver steering control**," 2006.A brief review of the literature reveals that both predictive control theory and linear quadratic (LQ)control theory have been used to design path-following controllers with preview, but it is not clear how the controllers compare. This article derives optimal linear preview controllers using the two approaches starting from a common state-space description of the vehicle dynamics. The transformation of the controllers from ground-fixed axes

to vehicle-fixed axes is discussed. The influences of preview horizon, control horizon and cost function are investigated. For the case of long preview and long control horizons, it is found that the predictive and LQ approaches give identical controllers. The results in this article provide a basis for identifying human steering behaviour from measured data. It should be noted that much further work is likely to be necessary before a physically based model of driver steering control is obtained. At present, there is little understanding of how the human neuromuscular system operates in closed-loop tracking tasks. The best that is likely to be achieved in the near future is the identification of model structures that closely match measured human responses. Understanding the neural processes by which the human achieves the control is likely to remain a challenge for some time.

[17] X. X. Naet., al., "**Linear quadratic game and non-cooperative predictive methods for potential application to modelling driver-AFS interactive steering control**"2013This paper is concerned with the modelling of strategic interactions between the human driver and the vehicle active front steering (AFS) controller in a path-following task where the two controllers hold different target paths. The work is aimed at extending the use of mathematical models in representing driver steering behaviour in complicated driving situations. Two game theoretic approaches, namely linear quadratic game and non-cooperative model predictive control (non-cooperative MPC), are used for developing the driver–AFS interactive steering control model. For each approach, the open-loop Nash steering control solution is derived; the influences of the path-following weights, preview and control horizons, driver time delay and arm neuromuscular system (NMS) dynamics are investigated, and the CPU time consumed is recorded. It is found that the two approaches give identical time histories as well as control gains, while the non-cooperative MPC method uses much less CPU time. Specifically, it is observed that the introduction of weight on the integral of vehicle lateral displacement error helps to eliminate the steady-state path-following error; the increase in preview horizon and NMS natural frequency and the decline in time delay and NMS damping ratio improve the path-following accuracy.

[18] L. Del Reet., al., "**Automotive model predictive control models, methods and applications**," 2010 Automotive control has developed over the decades from an auxiliary the to a key element without which the actual performances, emission, safety and consumption targets could not be met. Accordingly, automotive control has been increasing its authority and responsibility at the price of complexity and difficult tuning. The progressive evolution has been mainly by specific applications and shutter argents, with the consequence that automotive control is to a very large extent more heuristic than systematic. Product requirements are still increasing and new challenges are coming from potentially huge markets like India and China, and against this ground there is wide consensus both in the industry and academia that the current state is not satisfactory. Model-based control could be an approach to improve performance while reducing development and tuning times and possibly costs. Model predictive control is a kind of model-based control design approach which has experienced a growing success since the middle of the 1980s for "slow" complex plants, in particular of the chemical and process industry. In the last decades, several developments have allowed using these methods also for "fast" systems and this has supported a growing interest in it squeals of or automotive applications, with several promising results reported. Still there is no consensus on whether model predictive control with its high reequipments on model quality and on computational power is a sensible choice for automotive control.

[19] Y. Q. Gao et., al., "**Predictive Control of Autonomous Ground Vehicles with Obstacle Avoidance on Slippery Roads**," 2010Two frameworks based on Model Predictive Control (MPC)for obstacle avoidance with autonomous vehicles are presented. A given trajectory represents the driver intent. An MPC has to safely avoid obstacles on the road while trying to track the desired trajectory by controlling front steering angle and differential braking. We present two different approaches to this problem. The first approach solves a single nonlinear MPC problem. The second approach uses a hierarchical scheme. At the high-level, a trajectory is computed on-line, in a receding horizon fashion, based on a simplified point-mass vehicle model in order to avoid an obstacle. At the low-level an MPC controller computes the vehicle inputs in order to best follow the high-level trajectory based on a nonlinear vehicle model. This article presents the design and comparison of both approaches, the method for implementing them, and successful experimental results on icy roads.

[20] JieJi,et., al., "**Path Planning and Tracking for Vehicle Collision Avoidance based on Model Predictive Control with Multi-constraints**," 2017A path planning and tracking framework is presented in order to maintain a collision free path for autonomous vehicles. For path planning approaches, a 3D virtual dangerous potential field is constructed as a superposition of trigonometric functions of the road and the exponential function of obstacles, which can generate a desired trajectory for collision avoidance when a vehicle collision with obstacles is likely to happen. Next, in order to track the planned trajectory for collision avoidance manoeuvres, the path tracking controller formulates the tracking task as a Multi-Constrained Model Predictive Control (MMPC) problem, and calculated the front steering angle to prevent the vehicle from colliding with a moving obstacle vehicle. Stimulant and Car sim simulations are conducted in the case where moving obstacles exist. The simulation results show that the proposed path planning approach is effective for many driving scenarios and the MMPC-based path-tracking controller provides dynamic tracking performance and maintains good manoeuvrability.

IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 7, Issue 1, January 2018

V. CONCLUSION

The proposed system in this utilizes the environmental data through a vehicle-to-vehicle (V2V) communication environment. The propose algorithm consider two parameters to evaluate: (i) delay time, (ii) path reliability. Ns-2 is used to implement the proposed algorithm and monitor its performance through different amount of modifications in environment. The propose ant colony based decision making algorithm isa simple and effective algorithm that can be implement in eachvehicle to assist the driver in certain situations. Re-routing toavoid traffic congestion caused by the accident is the major partof ant colony decision-making algorithm. The experimental results sow better performance compare with existing algorithm.

REFERENCES

[1] S. Chang, and T. J. Gordon, “A flexible hierarchical model-based control methodology for vehicle active safety systems,” Vehicle SystDyn, vol. 46, pp. 63-75, Sep, 2008.
[2] K. J. Yang, S. K. Gan, and S. Sukkarieh, “An Efficient Path Planning and Control Algorithm for RUAV's in Unknown and Cluttered Environments,” J Intell Robot Syst, vol. 57, no. 1-4, pp. 101-122, Jan, 2010.
[3] S. Saravanakumar, and T. Asokan, “Multipoint potential field method for path planning of autonomous underwater vehicles in 3D space,” Intel Serv Robot, vol. 6, no. 4, pp. 211-224, Oct, 2013.
[4] V. Kunchev, L. Jain, V. Ivancevic, and A. Finn, “Path planning and obstacle avoidance for autonomous mobile robots: A review,” Lect Notes ArtifInt, vol. 4252, pp. 537-544, 2006.
[5] A. K. Pamosoaji, and K. S. Hong, “A Path-Planning Algorithm Using Vector Potential Functions in Triangular Regions,” IEEE T Syst Man Cy-S, vol. 43, no. 4, pp. 832-842, Jul, 2013.
[6] A. Shum, K. Morris, and A. Khajepour, “Direction-dependent optimal path planning for autonomous vehicles,” Robot AutonSyst, vol. 70, pp. 202-214, Aug, 2015.
[7] T. Shim, G. Adireddy, and H. L. Yuan, “Autonomous vehicle collision avoidance system using path planning and model-predictive-control-based active front steering and wheel torque control,” P I Mech Eng D-J Aut, vol. 226, no. D6, pp. 767-778, 2012.
[8] W. Kim, D. Kim, K. Yi, and H. J. Kim, “Development of a path-tracking control system based on model predictive control using infrastructure sensors,” Vehicle SystDyn, vol. 50, no. 6, pp. 1001-1023, Jul, 2012.
[9] M. Hassanzadeh, M. Lidberg, M. Keshavarz, and L. Bjelkeflo, “Path and Speed Control of a Heavy Vehicle for Collision Avoidance Manoeuvres,” 2012 IEEE Intelligent Vehicles Symposium (Iv), pp. 129-134, 2012.
[10] E. Kim, J. Kim, and M. Sunwoo, “Model predictive control strategy for smooth path tracking of autonomous vehicles with steering actuator dynamics,” Int.JAutomot. Technol, vol. 15, no. 7, pp. 1155-1164, Dec, 2014.
[11] L. Guo, P. S. Ge, M. Yue, and Y. B. Zhao, “Lane Changing Trajectory Planning and Tracking Controller Design for Intelligent Vehicle Running on Curved Road,” Math ProblEng, vol.2014, pp. 01-09, Jan, 2014.
[12] X. L. Song, H. T. Cao, and J. Huang, “Vehicle path planning in various driving situations based on the elastic band theory for highway collision avoidance,” P I Mech Eng D-J Aut, vol. 227, no. 12, pp. 1706-1722, Dec, 2013.
[13] M. T. Wolf, and J. W. Burdick, “Artificial potential functions for highway driving with collision avoidance,” 2008 IEEE International Conference on Robotics And Automation, Vols 1-9, pp. 3731-3736, 2008.
[14] R. Hayashi, J. Isogai, P. Raksincharoensak, and M. Nagai, “Autonomous collision avoidance system by combined control of steering and braking using geometrically optimised vehicular trajectory,” Vehicle SystDyn, vol. 50, pp. 151-168, Jan, 2012.
[15] C. Pozna, F. Troester, R. E. Precup, J. K. Tar, and S. Preitl, “On the design of an obstacle avoiding trajectory: Method and simulation,” Math ComputSimulat, vol. 79, no. 7, pp. 2211-2226, Mar, 2009.
[16] D. J. Cole, A. J. Pick, and A. M. C. Odhams, “Predictive and linear quadratic methods for potential application to modelling driver steering control,” Vehicle SystDyn, vol. 44, no. 3, pp. 259-284, Mar, 2006.
[17] X. X. Na, and D. J. Cole, “Linear quadratic game and non-cooperative predictive methods for potential application to modelling driver-AFS interactive steering control,” Vehicle SystDyn, vol. 51, no. 2, pp. 165-198, Feb 1, 2013.
[18] L. Del Re, F. Allgöwer, L. Glielmo, C. Guardiola, and I. Kolmanovsky, Automotive model predictive control models, methods and applications, New York, NY, USA: Springer, 2010.
[19] Y. Q. Gao, T. Lin, F. Borrelli, E. Tseng, and D. Hrovat, “Predictive Control Of Autonomous Ground Vehicles with Obstacle Avoidance on Slippery Roads,” Proceedings Of the Asme Dynamic Systems And Control Conference, Vol 1, pp. 265-272, 2010.