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To Analyze Calibration of Car-Following Behavior of Vehicles

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Abstract - *The Research calibration process is a basic condition of traffic model which uses car following behaviors for road traffic studies. The transmission channel between moving vehicles in real time traffic environment is modeled in road traffic and neighboring environment of connected vehicles adjacent to the road. The choice of input parameters used in the calibration process reflects the success of the car calibration process itself; therefore, the main goal is to choose parameters which give a large influence on the modeling process. Connectivity to the road will provide information to drivers and vehicles to enhance decision making reliability at the operational level. This e-Road project is an attempt to achieve the aforementioned goals to enhance safety and efficiency in transportation systems. The decision to rebroadcast the message is also affected by the situation of the receiver, such as the distance to the original sender, speed, traffic density, and the interest table of neighboring vehicles i.e. history table. To ensure connectivity in a real-time traffic environment, the relation between communication range and vehicles should be considered. This paper describes a detailed analysis of car-following input parameters and its influence on the modeled traveling time. All these findings provide a novel study of traffic flow theory and traffic simulation and used to detect intelligent traffic system. It detects the malicious behavior of various vehicles. The algorithm was implemented in C# dot net and tested under Windows system.*

Keywords*: Car-following input parameters, input parameters for the process of calibration.*

I. INTRODUCTION

Car following models are essential components of microscopic simulation that are useful for applications in traffic highway scenario and safety which include accident analysis and communication network analysis. The car following behavior has been given importance recently for its opportunity in the field of intelligent transportation systems [1].

In a connected traffic environment Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication network, a vehicle receives information from other vehicles in traffic management center (TMC).This information helps drivers and autonomous vehicles to ensure safe, reliable and efficient maneuvers. On the other hand, result in different traffic patterns influence communication and information availability [2]. In order to increase the probability of verifying potential malicious vehicles position, we keep track of vehicle movements. By exchanging packets in a cell, each vehicle knows the exact position of all other remaining vehicles in a cell. Vehicles in a cell can query the position of a specified vehicle among the neighbors in the cell. When receiving responses from neighbors and computing these positions, the requester comes to an agreement about all neighbors' position [3].

At the operational decision making level and car following behavior, traffic flow theory is a key factor. It takes velocity, velocity difference and position difference observed in last few time intervals as input and car-following model are built in a data-driven way in which trying to reduce human interference to the minimum degree. With local tower detected data, oncoming traffic's radar detected data, and trusted neighbor's data in hand; apply cosine similarity to these data. If the cosine similarity score is above a threshold value, we will accept the data, otherwise, it is dropped. With the accepted data, built a history of vehicle movements, or a History table [4,5].

The basic idea is that a vehicle without position history is not trustable, just like a person without credit history can't obtain a loan. When the position of receiving vehicle is announced, the observer checks the History table to verify the position based on movement consistency [6].

If there is any inconsistency, the particular record is more than likely to be picked up for verification. Vehicle density and communication range are important factors in communication networks. In a real-world traffic environment, 1-hop communications i.e., direct communication between vehicles is not always possible and does not guarantee propagation of all essential messages whereas multi-hop communication ensure that all the vehicles are used for the information will receive it. To ensures this multi-hop communication, enough vehicles should be within the communication range of each vehicle. Without vehicle-to-vehicle communications and additional information, drivers are uncertain about their leaders' behavior and their car-following behavior is expected to be very similar to that of regular vehicles. Therefore, considering the communication range along with the vehicular density is essential to determine the effect of connectivity and automation on the stability of traffic flow. Rest of the paper is organized as follows, Section 1 contains the introduction of car following behaviors, Section 2 contains the related work and necessary background of existing methods, Section 3 contains proposed work and research methods with flow chart, Section 4 presents the model results and discussion followed by concluding remarks with future directions in section 5.

1.1 Related Materials

The car following behaviour describes how a following vehicle reacts to the leading vehicle in the same lane. The transmission of information within vehicular networks is very similar to the behaviour of a fluid spreading through a small porous medium, a disease spreading among people, or information propagation in social networks. Percolation theory is the most efficient and accurate approaches to model. Identifying the similarity between information transmission in wireless communication networks and these phenomena, a few studies showed that the propagation of information in these networks can be captured by the Percolation theory. This theory determines the effects of the vehicular density and communication range on the stability of traffic flow [7]. The percolation theory extends the discrete percolation model. Here it assumes a d-dimensional lattice in Z^d where each pair of vertices in this lattice is connected if the two vertices are represented by Euclidean distance from each other. These nodes are called neighbours, and there is an edge between any two neighbours. Each edge can be used for communication range with probability 0>*p*>*1* [8,9]. Critical density can be estimated by Monte-Carlo simulation. They used the grid structure of street intersections to create an obstructed wireless ad-hoc network and calculated the critical density based on the Percolation theory and geometric properties. Percolation theory investigates combined connectivity and coverage in wireless ad-hoc networks [10].After that it extended the research findings to fixed directional sensors and estimated the critical density for the system. In general, the studies of percolation in wireless networks focus on systems like vehicular ad-hoc networks, which have very limited mobility. The structure of vehicular ad-hoc networks (VANET) is constantly changing and changes the connectivity level, which influences the available information to drivers. Therefore, understanding the effects of highly mobile VANET on connectivity is essential to study the effects of connectivity on traffic flow dynamics [11]. Many questions remain to be addressed, including the effects of communication on human drivers of regular, connected, and autonomous vehicles. This study adopts the Percolation theory to model the availability of information and evaluate the effects of communication range and connected and autonomous vehicles. In the string stability of traffic flow condition, any car following model can be represented by differential equations [12-14].

$$x_n = v_n$$

$$v_n = f(s_n, \Delta v_n, v_n)$$

where x_n is the longitudinal location of vehicle n, v_n is the velocity of vehicle n, s_n is the spacing between vehicle n and the leading vehicle n-1 and Δv_n is the velocity between vehicle n and the leading vehicle n-1. x_n is the differential of longitudinal location of vehicle n with respect to time and v_n is the differential of velocity with respect to time. The studies of car following models on string stability of traffic flow condition in the presence of connected and autonomous vehicles are limited. These studies do not consider the effect of information availability on driver and vehicle behaviour. This is critical because without connectivity, drivers of connected vehicles will not have access to the information and their behaviour should be modelled to the drivers in regular vehicles.

Car following behavior was modeled by different methods such as stimulus-response concept, safety distance models and optimal velocity models. Some models are also developed based on fuzzy inference rules [15-16]. The basic idea is each driver plans his speed for distance after delay such that he can safely stop even in the event of the leading vehicle sudden breaking. A driver adapts his speed in order to smoothly reach the desired speed or to safely proceed behind his leader. The safe distance is important to adopt the driver’s behavior in order to keep the distance. This insured the safe behavior of model and not prevents intrusion among vehicle. It allows more realistic distance to be kept among vehicle. Gipp’s model follows the AIMSUN which is modified version of Gipp’s model. It provides more efficient transportation system and considered in calibration and validation phase. It is continuous integration scheme. It allows for a more accurate solution of system of differential different equations that the model produces than the approach adopted by Gipp’s. This model tries to resemble the behavior of a driver when the headway with the vehicle ahead is sufficiently large [17-18].

Another study on different combinations of leading and following vehicles such as car-truck, truck-car, truck-truck, and car-car are identified in the vehicle-type specific headway. The driver-following behavior is affected by the type of the leading vehicle. A heterogeneous mix traffic condition consists of vehicles such as cars, two-wheelers, three-wheeled auto rickshaws, light commercial vehicles, buses, and trucks. These vehicles significantly vary in the static characteristics such as length, width, and size and dynamic characteristics such as acceleration/deceleration and maximum speed [19-20]. The General Motors model to explain the motorcycle's following behaviors in two situations: First, only one leading vehicle in front and second is two or more leading vehicles in front and neighboring front including either left-front, right-front, or both. A longitudinal movement model was developed for motorcycles [21-22]. In most of the mixed traffic environment, the following behavior of a driver depends on the types of leader and follower vehicles. Understanding the following behavior in mixed traffic is necessary for accurate modeling of such traffic and has useful applications in traffic simulation and safety studies. Hence, in this study an attempt has been made to analyze and model the vehicle following behavior under mixed traffic conditions using trajectory data.

1.2 Research Methodology

A vehicle can collaborate with the real position of neighbor's vehicle and detect behavior of malicious vehicles, thus it achieved local security. Due to this inherent limitation of radar spatial penetration range, it cannot directly use this process to achieve global security but can used local security as a basis for achieving global security. Although we are using preset position-based cells through which can achieve local security to create a local communication network among all the neighboring vehicles. Global security is achieved by exchanging packets among cell members and verifying neighboring vehicles' positions using oncoming traffic. Each vehicle generates information about the state of the traffic based on both what is seen and what is received from other vehicles in the system. In this project, we are using a highway-based scenario, and the cells are having 100 meters in radius, therefore we select 20-30 meter overlaps as interval captured by monitoring devices. When vehicles are close to the interval of two cells in the same route, then that may be chosen as following vehicles. The need of routers depends on the transmission range between all neighboring vehicles. Each record about another vehicle consists of fields such as identification (ID) which uniquely identifies the records belonging to different vehicles, position (POS) that estimated the current position of the vehicle and speed (SPD) which is used to predict the vehicle's position. If no messages containing information about that vehicle are received that time is considered as the broadcast time (BT) which is the global time at which the vehicle broadcast that information about itself. If the transmission range can reach the next cell leader without needing an intermediate hop, then there is no need to have cell routers. The steps to form a network cell are:

- By consulting loaded digit map, each vehicle can decide the width of the overlap regions between two cells.
- Partition the digital map into cells, for example, 100 meter-radius cells, making sure the overlaps; vehicles decide its cells based on its position coordinates and preset digital maps.

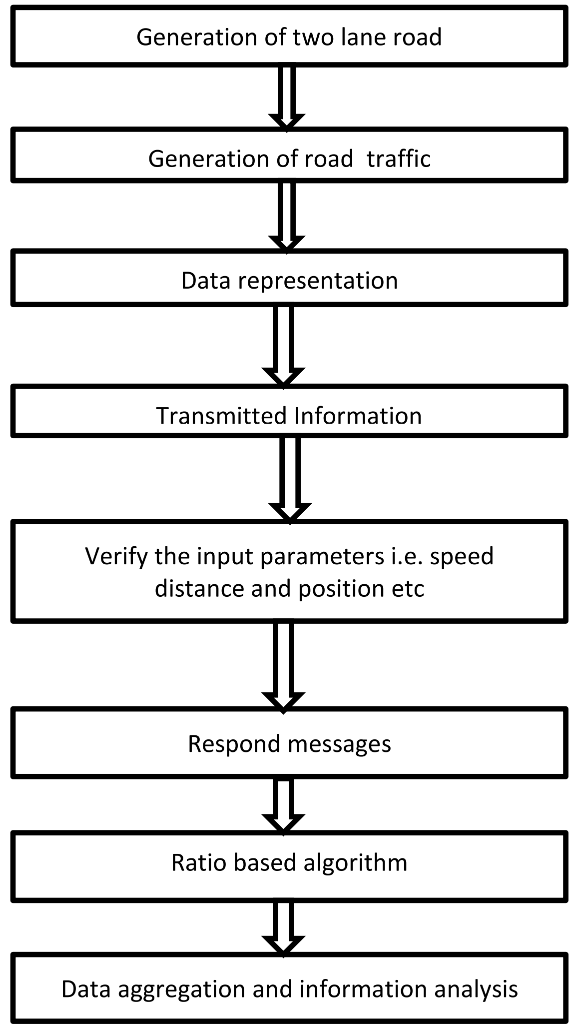

Fig. 1: Systematic flow diagram to analyze car calibration behavior

When a new vehicle enters the system, it waits for 200ms during which it hears the information transmitted by other members of the cell and learns the cell leader's ID. The new vehicle also activates its tower to detect its neighbors. At the end of the time slice, it sends its position information as well as position information of its neighbors. If it was not able to detect the cell leader, it sends a query asking the address (ID) of the cell leader. If no response comes, then new vehicle takes over as a cell leader and announces its new role.

In order to increase the probability of verifying potential malicious vehicles position, we keep track of vehicle movements. By exchanging packets in a cell, each vehicle knows the exact position of all other remaining vehicles in a cell. Vehicles in a cell can query the position of a specified vehicle among the neighbors in the cell.

2. Vehicular ad-hoc network (VANET)

With the advance of communication technology and the proliferation of high performance cellular devices; new data dissemination, traffic control and monitoring applications can be developed for the next generation Intelligent Transportation Systems (ITS). An emerging standard set known as Dedicated Short Range Communications (DSRC)/Wireless Access in Vehicular Environments (WAVE) has also been developed. In particular, VANETs can be used to provide the following networking, computing, and sensing platforms:

1. VGrid: A vehicular ad hoc networking and computing grid for intelligent traffic monitoring and control. The goal is to evolve intelligent transportation system (ITS) from a centralized to a distributed approach, in which vehicles can cooperatively solve traffic-flow control problems autonomously.

2. VMesh: Vehicular Wireless Mesh network is a new networking paradigm. DSRC enabled vehicles dynamically form a mobile transit network to gather and disseminate information.

There has been significant interest in designing new applications, including driver-vehicle safety applications, infotainment, mobile internet services for passengers, and environmental protection applications. In addition to low cost and robust wireless communication devices, vehicles and drivers can also be equipped with storage, processing, and sensing capability devices, currently in the form of powerful smart software. For accident prevention, roadside sensor nodes measure the road condition at several positions on the surface, aggregate the measured values and communicate their aggregated value to an approaching vehicle. The vehicle generates a warning message and distributes it to all vehicles in a certain geographical region, potentially using wireless multi-hop communication. For post status investigation, sensor nodes continuously measure the road condition and store this information within the wireless sensor network (WSN) itself. While VANETs and WSNs have common characteristics, such as network self-organization, they also have important differences. VANET nodes are also highly mobile, resulting in frequent topology changes of the network, whereas sensor nodes are assumed to be static. The different characteristics of VANETs and WSN have led to the development of different technology components for radio, networking, middleware and applications.

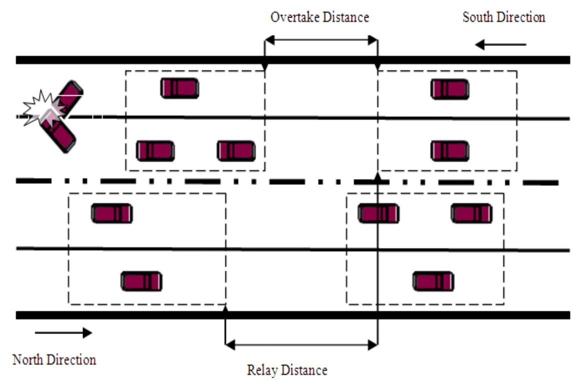

Fig-2: Simulation of vehicular-ad-hoc network

3. Ratio-based Algorithm

The algorithm divides the road in front of the vehicle to a number of regions. For each region, an aggregation ratio is assigned. The aggregation ratio is defined as the inverse of the number of individual records that would be aggregated in a single record. Each region is assigned to a portion where all the remaining free space in the broadcast message. The aggregation ratios and region portion values are assigned according to the importance of the regions and how accurate the broadcast information about the vehicles in that region is needed to be. For example, assigning decreasing values to the aggregation ratios and equal values to portion parameters will result in broadcasting less accurate information about regions that are farther away from the current vehicle, since for those regions, each individual record will represent a large number of aggregated vehicles records.

4. Aggregation Algorithm

This algorithm performs on the records in the validated dataset in order to place more information in the outgoing broadcast messages. This module might as well update the dataset by replacing the original records with the new aggregate version. This sends module the contents of the records in the validated dataset in a broadcast message and broadcasts it on the wireless channel using the wireless card. Display/UI module is responsible for displaying the validated records periodically on the display board. Whenever a node receives record containing information about some vehicles, it first checks the information in that record against the validated records it has. If the record contains information about some vehicles which the node already knows, it performs the following:

1. If the broadcast time of the records is greater than the broadcast time of the stored record, it means the new record is fresher, and therefore the node removes the corresponding vehicle ID from its stored record.

2. Otherwise, the new record contains older information, and hence the node removes the corresponding vehicle ID from the received record.

In Traffic, vehicles apply the aggregation procedure on the records in the validated dataset each broadcast period to prepare the broadcast packet. Our preliminary experiments showed that the effect of each vehicle either replacing its current validated records with the aggregated version, or maintaining the original records in its validated dataset, on the quality of the information gained by other vehicles.

5. Results and Discussion

We extended a microscopic traffic simulator based on the microscopic transport simulator, which features a realistic traffic model. Vehicles in our simulator can accelerate if there is reasonable space ahead, decelerate if the space in front is small or forward vehicles suddenly decelerate, completely stop if there is no way to move or change lane or steadily drive and change lanes. In this project, we use a two-direction highway scenario with two lanes in each direction.

6. Conclusion

By comparing what is heard and seen, a vehicle can determine out the real position of the neighbors' and isolate. Due to the limitation of tower visibility range, we need to combine local security to achieve global security. We present preset position-based cells to create a communication network by securely exchanging packets among cells. Besides, we propose a method to challenge and confirm the position of a vehicle in a remote cell. In this project, we propose a new solution to secure the position information. The goal of our work is to provide a secure topology for a VANET and to build a secure network for applications. The basic idea is the famous saying: "seeing believes". We use radar as a virtual "eye" of a vehicle. Although the "eyesight" is limited due to the limitation of radar transmission range, a vehicle can "see" surrounding vehicles and hear reports. We are using flooding in which each vehicle within transmission range receives the message and broadcasts it to its neighbor's till it reaches the destination vehicle. Our algorithm needs less number of hops compared to flooding. The next experiment was run to calculate the time taken to detect the malicious vehicles in the system. Detection of false position information and reducing the chances of attack is the key to the success of VANETs. This project focuses on this prime area of traffic. Radar acts as the eye of the system and allows a vehicle to trust the information received from the vehicles within its range.

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