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Project Submission Sheet – 2020/2021

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Modelling Simulation and Optimization

TABA – 40%

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***Abstract*—In this study, we will be reviewing few studies which simulate the accident on road or build model and simulation to avoid accidents on the road. In the first study, researchers presented a simulation for the detection of incidents on freeways. Their method was based on the use of a macroscopic dynamic model that describes the evolution of spatial-average traffic variables (velocities, flows, and densities) over highway sections. In the second study, researchers developed a simulation for car collision avoidance. They used Taylor series expansions of the value function's gradient, the representation of an optimal collision avoidance strategy along many optimal paths is employed to synthesize a collision avoidance strategy globally. In the third study, researchers developed a simulation for two-vehicle collisions (central and eccentric). They constructed a vehicle speed model with momentum equation and momentum matrix and constructed a two-vehicle collision accident reconstruction model using a reverse-reasoning approach, realized two calculate modes. In the fourth study, researchers developed a model for predicting traffic conflicts on single-lane and two-lane ramps. The single ramp model was developed based on the negative binomial distribution model, and a two-lane collision model is developed from the Poisson distribution model.**

Keywords—Accident, Simulation, Modeling, traffic, collision, macroscopic, Taylor series, reverse-reasoning, Poisson, negative binomial

I. INTRODUCTION

An accident occurs when vehicles collide with each other, animals, pedestrian, debris on the road, and other factors. Injury, disability, death, and property damage are all common outcomes of traffic incidents, as well as societal and individual financial expenses. Road travel is the most dangerous circumstance that individuals face daily, although the number of individuals killed or injured in such accidents receives less public attention than other, less common sorts of tragedies. Vehicle design, speed of operation, road design, weather, road environment, driving abilities, impairment due to alcohol or drugs, and conduct, particularly aggressive driving, distracted driving, speeding, and street racing, all contribute to the probability of accidents. Road accidents are caused in winter and rain where conditions for driving are but more challenging than normal conditions. Especially in the winter road accident are more due to the snow there is more chance of slipping on the road. The greater number of accidents in the winter is mostly influenced by the factor that holiday season which is in winter. Also, when winter starts, people forget how to give a distance, how to drive slower. Due to the holiday season, people from out of station comes and drive in the city and this condition is different from their home conditions and since they are not familiar with the road conditions, an accident can happen.

Figure 1. Vehicles Collision on the highway

There are ways which can be followed by the driver to avoid accidents on the road. Drivers on the vehicle can increase their following distance because increasing the following distance can increase the reaction time. Drivers need to adapt the road conditions quickly to avoid the accident. During the rainy and winter season due to slippery roads, drivers need to slow down a little bit and adjust their turn much smoother. Obeying speed limits is a must to avoid the accident as increasing the speed will decrease your reaction time and it will take only a fraction of a second to have an accident. In recent times, artificial intelligence made an entry into self-driving cars. But these cars alone cannot avoid the accidents because there are cases where an accident happens when the car was driving on self-driving mode particularly on the highway where reaction time is less. There is a need to construct and built the architecture of the road such that the road does not get jammed by vehicles quite often. So before constructing the actual road we can model and simulate the road design and vehicles on the road. We can get the real values from the survey data like the average number of vehicles on the road, speed limit and with help of this, we can simulate the model on can change these values to a point where we are not able to see the accidents. These optimized values can be considered while constructing the road. Road accidents can be avoided if we follow the limits given on the road and driver driving carefully which is subjective and all these parameters are in our control. In this study, we will be studying about few research studies about the detection of an accident using simulation, avoidance of accident by creating a simulation, and performing analysis of why accident is happened by creating a simulation. In the last study, researchers developed an accident prevention model, and variables in the model were simulated. This study will help us to understand how simulation got developed over the years in the field of road accidents.

II. REVIEW

A. Detection of Accident (1980's)

A. Willsky et. al presented a paper for a dynamic model-based technique for the detection of the accident on freeways [1]. They formulated an equation for detection algorithm based on the Payne equation. Their model takes into consideration of no traffic and traffic conditions for detecting incidents on freeways. They considered three variables in their model like spatial mean velocities, densities, and flows over the freeway for detecting accidents. They have added few variables in the equation to denote the link number, length of the link, acceleration noise, drivers balanced speed as a function of the density of traffic. They reviewed many articles which suggested the many shapes for the curve which exhibit the properties of high and low densities of the traffic. They presented their shape of the traffic curve in the paper in which under free-flowing traffic conditions there was a flat line of velocity and as traffic got to increase the velocity line got decreased exponentially till the maximum density point. This curve was logarithmic, and they represented the whole graph into an equation. In this simulation, the researcher followed Poisson flow with the specified mean value which helped them to simulate the traffic conditions as light traffic and heavy traffic. Further, they represented the traffic diagram as the normal curve in which the free-flowing point was slightly shifted to the center of the curve. They modeled three cases for each link of the freeway. In the first case, capacity reducing on the link due to a decrease in densities. In the second case, they calculated the duration of traffic and with the help of this, they were estimating accidents on the freeways. In the last case, they considered the case of sensor failures. They implemented the simulation by initializing the links on freeways, number of cars, and capacity. By observing the simulations result they were able to detect the accidents when the capacity of one link was increased and reached maximum capacity. Further, researchers implemented the multiple model method and generalized likelihood ratio method and compared both the models in their research. In this comparison, they recorded the mean flow, sensor noise variances, and initial estimation error. These models were built to estimate the accident rate base on the density of traffic. Researchers in their experiment found that both models performed well in estimating the accident at a flow level of 900 cars/hour.

B. Accident Avoidance (1997)

R Lachner implemented collision avoidance by real-time approximation of optimal strategies using higher derivate of value function [2]. The researcher investigated the scenario for pursuit-evasion. The basic idea of this research was to develop a strategy by the correct driver to avoid collision against all possible scenarios created by the wrong driver. They modeled the collision avoidance equation using kinematics equations in which time was the independent variable, and distance of correct driver car and wrong driver car, speeds of the cars, direct of the cars were the state variables. Along with state and independent variables, there was control variable such as turn rate of wrong driver car and turn rate of correct driver car, velocity change rate of both cars. There were also constraints in the model for both cars in terms of the radius of curvature. They also added the constraints for maximum acceleration and braking conditions. Further, the researcher formulated an equation with help of independent, state and control variables. He used the Euclidean distance to calculate the distance between the wrong driver's car and the correct driver's car. This model was triggered at a time when the wrong car is detected by the correct car and will end when the minimum distance between the car is reached. The researcher further discussed optimal path computation by integrating the Isaac equation. The researcher computed an equation by considering both cars and integrating Isaac's equation. He then used this equation to differentiate it and which helped it for simulating the car driving behavior. The researcher carried out multiple simulations to test the generated model. He initialized state, independent, control variables, and boundary conditions for the model and plotted the optimal strategy choose by the correct driver car to avoid the collision.

C. Accident Reconstruction (2009)

L. Zheng et. al did a simulation analysis of traffic accident reconstruction using the reverse reasoning method [3]. Their research discussed the two-vehicle center and eccentric collision. Before discussing the reverse reasoning method, researchers discussed the positive reasoning method. In the positive reasoning method, the speed of the car after crashing and turn and slip simulations are carried out based on the speed of the vehicle before crashing. The researcher discussed the drawback of the positive reasoning method. They found that this method avoids solving the universal face-to-face crash's moment recovery factor. Along with this drawback, there was a downside of this method was that vehicle speed is unknown, few parameters are needed to assume, and the stopping position of the vehicle is determined by the model again and again. Further researchers discussed the two-vehicle non-central collision which can be transformed to point collision. In fact, the collision component of a traffic accident is an entire field and not just a single spot. They considered a problem where they took two vehicles and a collision area. They initialized the force couple M require for the collision. As the impact line of normal momentum force is translated for distance, the collision force couple is absorbed, and the area of the crash is converted to point crash. Further, he discussed the accident reconstruction model of two-vehicle using a non-central collision. The key feature of non-central collision is when vehicles slide after the impact, both translational and rotational momentum occurs. They represented the vehicle dynamic equation based on three sets of rectangular coordinates. After developing the model based on the vehicle's speed, mass, inertia, and rotating angular velocities, researchers discussed the parameter optimization of the reverse reasoning method. They categorized the optimization into two parts, in the first method they discussed position optimization in which compares the corresponding path error of each equation to find the minimum direction by using the minimum angle between the initial velocity direction and the known vehicle longitudinal direction before the collision. Because of the adjustment, the result can be used to obtain a collision position that is the main collision point. In the second method, they discussed the direction optimization of the side collision. By using the rule of the minimum angle between the initial velocity and the known angle of the vehicle longitudinal axis

before the collision, compare the corresponding path error of each equation to find the minimum direction. As a result, it can be used to generate a normal that is the best path normal. Researchers simulated a real-life example on the software in which they considered all parameter such as road type, vehicles speed before the collision, length of braking drag, and using the proposed model, Integral superimposition can be used to obtain the location, direction, and velocity of vehicles at any point during the collision phase since the speed can be reversibly inferred in the reconstruction and the speed is a vector that contains the value and direction of the vehicles' velocity.

D. Accident Prediction Model

Y.W. Cai et. al presented a collision prediction model for interchange merging area based on traffic conflict technique [4]. Researchers initially discussed the data collection in which aerial video was used to collect the data, which was then used to track the vehicles using the tracker. The origin of the coordinate system is the starting point of the acceleration lane, and the horizontal axis is the extension direction of the confluence zone. The speed of any position in the merging area can be obtained by tracking the running process of the entire area of the target vehicle. They divided the traffic conflicts into two parts which were subjective traffic conflict determination and objective TTC value determination. Researchers used the survey for data generation for their model. The further researcher discussed the simulation design. They stated road geometry and traffic flow factor are the important factors in their simulation. They also discussed the other factors such as a number of lane change, traffic density, saturation rate which does not impact the traffic conflict, but they keep these factors in the simulation for qualitative impact. Researchers conducted a few simulations experiment by initializing different traffic flow factors and changing the merging area. These experiments helped them to study the change of traffic conflict depending on given input parameters. After obtaining different traffic conflicts using simulation researcher proceeded their research by modeling a single ramp and two-lane ramp and then by using simulation results, they produced a predictive model of traffic conflict. According to their research, several accidents at the highway are Poisson distribution and negative binomial distribution based on this result researchers decided to use the respective model for regression. In the single ramp model, researchers identified the relation between several heavy vehicles and the number of traffic conflicts, and it was significant. They used the Pearson correlation test to check this relation. Researchers found that the occurrence of traffic conflicts is unpredictable due to the large differences in traffic flow between different traffic flow circumstances and road geometry conditions in merging zones. In the two-lane ramp model, researchers selected the following influence factors for the model, length of acceleration lanes, the traffic volume of main lines, the traffic volume of ramps, the mixed rate of large vehicles, and the speed difference between main lines and ramps. After performing the statistical test, they found that only mainline traffic volume and ramp traffic volume, and large vehicle mix rate were highly correlated with the traffic conflict. Using these variables researchers produced the model for two-lane ramps. The researcher concluded their research by comparing the single lane and tow lane model using MAPE.

III. Conclusion

By reviewing all papers, we can say that simulation is evolved a lot. Initially, simulations were carried out only by using formulating equations, and by using these equations various cases were generated and results of these cases were plotted on the graph to see how the simulation is performing. Further software like MATLAB was used to perform the operation of the simulation and in recent times separate simulation software has been produced to carry out simulations experiment. In the first study, researchers developed a simple system for predicting traffic variables from presence detector data for incident detection. There were few areas in their research where work was needed like sensor failure, use of flow scheduled thresholds, and the researcher mentioned the computational limitation they faced during executing their research. In the second study, the researcher successfully implemented the optimal collision avoidance, and due to the use of fewer state and control variables their model was not complex, but there are too many calculations in this study that cannot be avoided. In the third study, researchers successfully implemented their simulation and found the two hypotheses for a traffic accident, but these hypotheses needed to be research or optimized. In the fourth study, researchers found different factors influencing traffic conflict on single and two lanes. In this research, many variables are not considered during the modeling such as the number of mainlines and gradation rate, traffic density, and several lane changes were not considered during the production of the models.

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