USING SUMO TRAFFIC SIMULATOR: A REALISTIC TRAFFIC SIMULATION FROM THE CITY OF ROME

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ABSTRACT: *Rome is one of the busiest cities in the world and the largest in Italy. Many people use public transportation and due to the heavy rush of people during office hours, Rome may face severe traffic clogs and jams. Hence, a study of the traffic condition of Rome is a subject of great interest to many researchers. Moreover, the Roman authorities have urged the researchers to find suitable solutions in order to address the long-running problems in the city. This paper is based on traffic simulations using simulation tools and software that focuses on the study of the traffic condition in Rome. Previously, the researchers needed to manually study and survey the traffic trends in different streets but now, the research activities are aided by the software simulation tools. Hence, this paper focuses on the different traffic simulation tools that are popular among researchers in order to determine their working and benefits during the study of the traffic of a particular area or city. Precisely, traffic simulation requirements, methods, traffic simulators, and a case-specific to Rome have been analyzed and discussed.*

Keywords: traffic simulators; realistic simulation,

1. INTRODUCTION

Traffic Simulation is a software-controlled simulation that is used to analyze the existing traffic condition in a particular area. This is essential in order to introduce new plans and services in order to reduce excessive traffic pressure in cases of extreme congestion. In this type of simulation, real-world traffic scenarios are captured and simulated using some specific software and the traffic condition is then analyzed [1]. Based on the analysis, suitable conclusions are reached regarding how the congestion can be reduced and suitable developments are implemented accordingly [2]. Simulation modeling is an undeniably mainstream and viable device for breaking down a wide assortment of dynamical issues, which are not amiable to examine by different means. Simulation models are intended to "copy" the conduct of such frameworks. Legitimately composed models coordinate these different element practices and cooperation to deliver a definite, quantitative depiction of framework execution [3]. In order to solve the problem of Roman traffic, simulation modeling is necessary. In the simulation model, the map of Rome will be generated in the software including all the roads and alleyways. Different colored markings will be added on roads depending on its nature – cobblestone, asphalt or others [4]. After that, the estimated daily traffic will be recreated and placed in the map and the simulation will be started. With the simulation, readings will be taken continuously [5]. New ideas will be recreated in the same simulation in order to generate the possible outcomes of the changes in the simulation [6]. In this paper, the vehicular traffic simulation process is analyzed based on real-world traffic scenarios from Rome, Italy. Hence, the focus of this paper is on the traffic simulation software as well as a real-life traffic scenario from the city of Rome, Italy.

2. TRAFFIC SIMULATION

Traffic simulation is a software generated and virtually recreated real-life traffic scenario in order to gain sufficient insight into the existing traffic condition in a particular city or area. The number of vehicles is increasing at an exponential rate all over the world. As a result, traffic clogs are frequently occurring and in large cities, they take very severe turns [7]. It has even been reported that on a particular road in a certain city in China, a traffic jam lasted for almost 12 days [8]. This shows why traffic clogs are becoming serious concerns in today's world. There are a number of consequences of these traffic clogs some are listed below.

2.1 LATE COMING

Due to intense traffic jams, students and workers reach schools and offices respectively very late. This is seriously hampering their work and studies. Moreover, being stuck in traffic for a long time results in a serious loss of energy of the commuters. Hence, traffic jams are affecting the work energies of the officials as well as the school students.

2.2 MENTAL AND PHYSICAL HEALTH

Traffic jams also hamper the physical and mental health of the commuters on the road. Due to stagnant cars in a traffic jam, the exhaust gas increases in quantity over a small area. This gas is poisonous and seriously influences the health of drivers and commuters causing asthma, lung inflammation, blurring of eyesight. Very high amounts of this gas can also cause deaths [9]. However, this is not the only problem. During traffic jams, many drivers inside the cars continuously ring the horns which are usually very high that continuous exposure to these sounding horns can cause hearing disability temporary or permanent and can even affect the mental health of some people, especially in the elderly people.

2.3 GLOBAL WARMING

According to some studies, traffic jams would be one of the serious problems that cause global warming. Many drivers, while stuck on a traffic jam, keep their engines in standby mode instead of shutting them down completely. This is very dangerous as toxic and poisonous gases are continuously produced from the exhaust chamber and these gases contribute to the global warming effect at a constant rate.

Researchers are continuously studying these harmful effects of traffic jams and are trying to find suitable solutions for the associated problems. However, they have faced constant difficulty in studying the traffic pattern of a particular city as a manual survey is not possible in the large cities and the pattern is different every day. Moreover, the number of cars and other vehicles is increasing at an exponential rate and hence, studying them in the real environment is impossible. After several years of unsuccessful attempts, researchers

finally have the help of software technology. It is now possible to design software where the real-life scenario can be recreated in the virtual environment and simulation can be done to analyze the results. Currently, there are a number of a traffic simulation software like PTV VISSIM, TransModeler, TRANSYT-7F, SUMO and others where an entire real-life scenario can be recreated with the virtual interface of the software. These simulators can then be used to simulate many scenarios for different purposes. This simulation software have significantly helped the researchers to simulate certain scenarios and find the answers they looking for in their research work. Moreover, from the simulation results, the researchers are now able to predict the traffic trend for the next certain period of time so that the traffic police can then efficiently manage the traffic on the road. Hence, traffic simulation software is very useful and effective tools to find answers to the growing traffic problems in the world.

3. RELATED WORK

Rome is the capital city of Italy as well as the Lazio region and encloses the Vatican City inside its boundaries. As a result, Rome is easily one of the busiest cities in the world and the most traffic-congested city in Europe. In their works, Barrachina *et al.* [10] expressed their concern that the Roman authorities need to take immediate action to reduce the traffic congestion in Rome. They made their own experimental simulations in order to analyze the traffic problems in different cities including Rome. Benner *et al.* [11] conducted research on the role of computer-based tools in simulated scenarios. Fontaras *et al.* [12] presented a model for the evaluation of CO2 emissions from roads. Fedorko *et al.* [13] conducted research on simulation models for light-controlled road junction creation by the program Tecnomatix Plant Simulation.

Several researchers have worked on solving traffic-related problems around the world using traffic simulation software. However, before the development of the simulation software, researchers utilized manual survey techniques and estimated data for an average number of vehicles over a particular road for finding solutions for the traffic problems. In order to make efficient analyzation, Ma, Huang and Koutsopoulos [14], integrated traffic, emission, and dispersion processes into the computational framework and proposed a model calibration approach when measurements are not directly available. Bieker et al. [15] worked on traffic simulation using the SUMO simulation tool. They conducted their research in the city of Bologna, Italy. They first extracted the map of the city and recreated the SUMO road network by extracting on the roads of the city and excluding every other object. The researchers considered two main regions of Bologna, namely, Andrea Costa and Pasubio. Andrea Costa area covers the most crowded area of Bologna that also includes the football stadium. On the other hand, Pasubio covers the health district and several key routes pass through it. After recreating the two areas, the researchers created two different scenarios on the same map – one during morning traffic and one during a football match. After simulation of the traffic for 3 days, they obtained a graph that reflected the amount of traffic throughout different hours of a day. Moreover, the researcher Vent [16] also used the SUMO simulation package and he mainly based his work on the city of Dublin, Republic of Ireland. He took the network data from OpenStreetMaps and placed the map for simulation in SUMO. He also gathered the traffic count data from the period of 2008 to 2012.

Using SUMO simulation tool, in order to create the actual traffic demand, researchers used the *DFROUTER* tool of SUMO. The main reason behind this choice was that *DFROUTER* could be used to analyze the traffic flow on a highway by having all the on- and off-ramps covered with detectors. Using this tool and SUMO representation, the researchers easily extracted the data they needed for the project. Huang *et al.* [17] based their studies mainly on the simulation of vehicle accessing highways and they proposed an access density approach reflecting the impact of traffic speed variation of different access types. They compared their approach with existing access density approaches and demonstrated highly correlated crash rates comparing with previous studies.

4. TRAFFIC SIMULATION SOFTWARE

There are a number of traffic simulation software that are being used by researchers to simulate traffic scenarios. Some of the useful and popular simulation tools are listed below:

4.1 PTV Vissim

PTV Vissim [18] is a commercial microscopic traffic simulation and it offers the user simulation of scenarios in 2D and 3D. Complex junctions and corners can be simulated where the main traffic clogs occur due to a lack of sufficient support on the directional traffic signals. PTV Vissim allows the user to simulate all kinds of vehicles and public transportation like buses and trains for recreating a more realistic scenario. Moreover, a large number of interfaces provide seamless integration with other systems for signal controllers, traffic management or emissions models is supported.

Figure 1: Simulation in PTV Vissim

4.2 TransModeler

TransModeler [19] is another commercial simulation software that is widely used by researchers owing to its low size and ease of use. Moreover, this software also allows traffic simulation in 2D as well as 3D. However, one issue with this software is the low quality of graphics whereas other software like Vissim provide a very high quality of graphics. However, understanding the working of TransModeler is much easier than the others, and it is most suitable for beginners who have not used simulation software before.

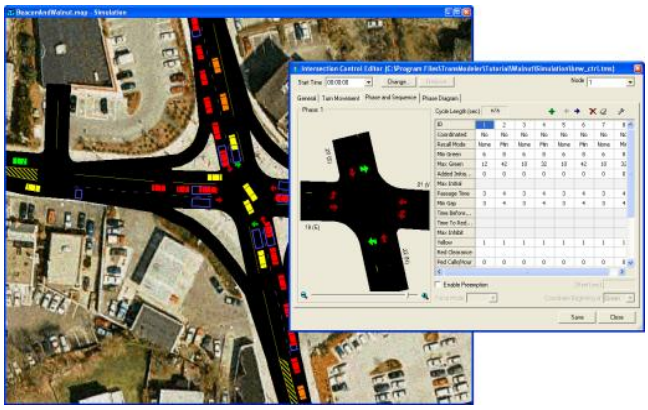

Figure 2: Simulation Using TransModeler

4.3 TRANSYT-7F

TRANSYT-7F [20] is a macroscopic simulator that combines a state-of-the-art optimization process with a cutting-edge macroscopic simulation model. However, it requires Microsoft Windows and Microsoft Internet Explorer.

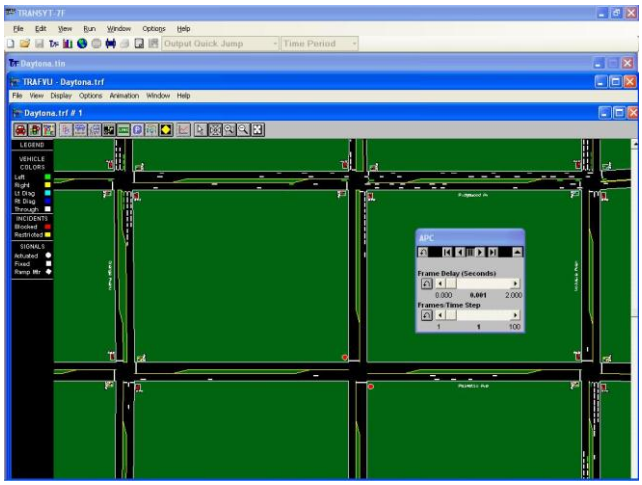

Figure 3: Simulation Using TRANSYT-7F

4.4 SUMO

SUMO [21] is an open-source, microscopic, multi-modal traffic simulation. A single-vehicle movement through given road networks can be simulated. It has many features included needed applications to prepare and run the simulation.

Figure 4: Simulation Using SUMO

4.5 CityEngine

CityEngine [22] is a 3D Modeling software that is used to generate road networks, as indicated in Figure 5. In order to convert the traffic simulation into a scalable 3D environment, CityEngine is coupled with Unity game engine together with the Heisenberg crowd simulation.

Figure 5: CityEngine modeling

Once the simulator receives a road network, internal data is generated and stored but would be used by simulated vehicles mapped in exact locations. When the simulation is triggered, a pre-designed algorithm dictates the behavior of each vehicle and road networks be followed. Lastly, the positions and behaviors of each car are animated in a display, including making turns, stopping, accelerating and decelerating, paving way for new vehicles just as happens in a typical city – observing all traffic lights and road signs.

The most significant aspect of this system is the code used to guide the simulation behaviors. The code is based on data from a road network structure obtained from CityEngine data, including the current positions of all vehicles, as indicated in Figure 6. All vehicles involved in the simulation are contained in a global list where each one of them stores its current velocity, direction, and position.

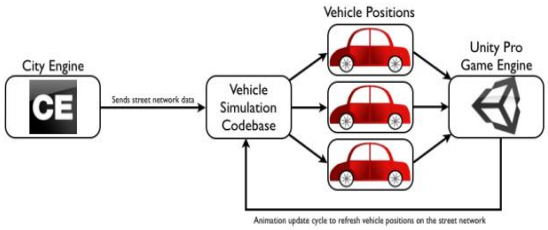

Figure 6: 3D Environment

5. CASE STUDY: REALISTIC TRAFFIC SCENARIO FROM THE CITY OF ROME

In the case study of Rome City, the Simulation of Urban Mobility or SUMO was used for traffic simulation because it helps in preparing and performing traffic scenarios together with simulation. SUMO uses the Krauss car model, which is based on safety aspects of the braking distances of each vehicle.

In order to run the simulation using the SUMO simulation tool, we need to have at least two input files. The first is the road network file which should be an XML file (i.e. .net.xml) containing the definitions and attributes of edges, nodes, traffic lights, and connections between them. The second file is the routing file (i.e. .rou.xml) that contains vehicle definitions, depart time, and route edges. The road network file can be imported from OpenStreetMap and converted by the command line application

NETCONVERT that comes with the SUMO package, to convert the OSM file to XML file readable by SUMO. The traffic demand can be generated using several tools of SUMO including DUAROUTER, JTRROUTER, and DFROUTER. Every tool has its own work nature and requires specific inputs according to its nature.

It is recommended to use DFROUTER to analyze the traffic flow when the targeted area that has on- and off-ramps covered by detectors. For DFROUTER configuration, input files have to be specified such as A. road network file where the edges, nodes, traffic lights, and connections are specified; B. Detector file where detectors and locations are specified; and C. Measure file where the traffic flows is specified.

Figure 7: SUMO Network of the City of Rome

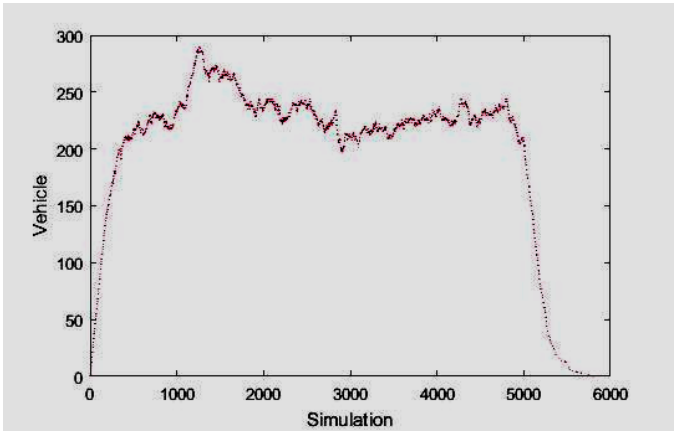

Figure 8: Running Vehicles over Time

Figures 7 and 8 present the SUMO road network of the city of Rome and the simulated vehicles over time. The quality of the actual data would significantly affect the simulation quality. Based on the results, the current simulation is quite limited due to the small amount of actual data.

6. DISCUSSION

This paper deals with the analysis of the subject of traffic simulation with special emphasis on a case study of traffic conditions in the city of Rome. Before moving to the case study, the subject of traffic simulation has been put under study. According to the study, traffic simulation tools have made it easier for researchers to study the traffic pattern of a particular street without having to undertake a manual survey of the traffic count. As per the analysis, there are a number of traffic simulation tools that are being used by researchers such as PTV Vissim, Transit-7F, TransModeler, SUMO, and CityEngine. Although all of this software have one common objective, each one of them has its own unique features and benefits and hence, researchers are able to select one of the tools based on their exact requirements. However, before the invention of the simulation tools, researchers used a manual survey process that resulted in a lot of errors and wrong information. At that time, the road authorities used to record the number of vehicles playing through a particular road junction throughout the day. The researchers used this data to find a particular pattern of the traffic pattern. However, the main issue with this data was that the number of cars was recorded for the entire day instead of particular periods like 1 hour, 2 hours, etc. Hence, the exact pattern could not be found and hence, an average count was always considered.

The focus of the study in this research is the traffic condition in the city of Rome. It has been found in the research that Rome is one of the busiest cities in the world and the extreme traffic movement result in traffic congestion and jams. Moreover, due to these traffic jams as well as the nature of roads in the city, the number of road accidents in Rome is increasing day by day. In addition to these accidents, sometimes the traffic jams last for more than 2 or 3 hours that delay the passengers that are on the way to their workplaces, transit terminals like airports, railway station, and others. In addition, due to the continuous stagnant mode of the cars on the street, the toxic gases from the exhaust are piling up and harming the environment. For finding suitable solutions to address these issues, traffic simulation tools like SUMO can be used to reproduce a virtual model of the Rome road map and then the traffic movement can be simulated under different conditions.

7. CONCLUSION

In this paper, traffic simulation requirements, methods, traffic simulators, related works, and case-specific to Rome have been analyzed and discussed. From the analysis of the topic, it has been found that there are a number of traffic simulation software that are popular among the researchers to simulate traffic scenarios from the real world. The popular simulation tools include PTV Vissim, which offers the user to simulation a scenario especially in complex junctions and corners where the main traffic clogs occur due to lack of sufficient support on the directional traffic signals. PTV Vissim also allows the user to simulate all kinds of vehicles and public transportation for recreating a more realistic scenario as well as the feature of microscopic traffic simulation. TransModeler is another popular simulation software that is widely used by researchers owing to its low size and ease of use. However, one issue with this software is the low quality of graphics as it was mainly prepared for low-end computers with much lower specifications than the current updated systems. In addition to the traffic simulation, it also provides the feature of changing and tuning signal timing in the simulation environment. Another traffic simulation software that has been discussed in this paper are Transyt-7F and SUMO. Finally, in order to study the traffic of a particular region, the city of Rome has been considered and analyzed. It has been observed that traffic simulation tools will be useful and beneficial for studying and addressing traffic problems in the city.

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