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Computer simulation model for traffic enforcement using unity engine

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Abstract. In this paper, we have presented a graphical representation of road traffic. The intersection rules can be manipulated to the configurations set by the user. In the real world, traffic congestion is inevitable. In fact, the Philippines is considered to have the 3rd worst traffic in Southeast Asia. This research aims to provide a system to help lessen the rate at which traffic congestion occurs. With the help of this simulation model, authorities may simulate situations that may aid in their decisions in order to improve traffic flow.

1. Introduction

The study was intended to have direct relevance to the development of a tool for preventative strategies in relation to traffic management. The fundamental reason for this was the major challenge of road traffic becoming a bigger and a more serious problem as time passes by. As the economy grows, so does the complications of road traffic [1].

Philippines is considered to have the 3rd worst traffic problem in Southeast Asia. This is evident as Filipinos waste 28,000 hours in traffic. That sums to wasting up to more than three years of a person's life. Considering that a person's average productive life is 30 years, this means that an individual has lost more than 10% of their working years due to traffic. Aside from that, according to Senator Ralph Recto, the Philippines suffers from a ₱2.6 billion economic loss each day. These issues are thanks to the massive problem of traffic congestion. One often hears suggestions that congestion may be solved with one or more big ideas but none of these can deliver a complete solution aside from provide only temporary relief. With that being said, building more roads will not necessarily be a solution for traffic congestion. Considering aforementioned issues regarding previous solutions, one would question as to what could be a better and a more effective remedy for traffic. The answer is to improve how management is done.

It was decided among the researchers to develop a traffic simulation because it is an effective solution to the current issue. Building more roads, particularly bigger ones, is not necessarily the best solution. A better approach of this would be to improve management. A simulation provides this vital improvement for the management of traffic. A few key factors as to why this is an effective solution are costs, efficiency, and scalability. This solution is cost effective as it is cheaper to develop simulations than to build roads. This is evident as building, repairing, or improving roads not only cost a hefty amount of funds but also costs a lot of time, manpower, as well as having to sacrifice functioning roads by closing them resulting in more traffic congestion during the operation. Using a simulation to diagnose traffic issues is efficient because it is more accessible for data gathering and manipulation compared to the vague real-life evaluation where unintended effects and possible hidden causes to problems are harder to identify [2]. Scalability could possibly the most impressive factor as to why this is a liable solution to traffic congestion. A computer simulated system can scale up to the demand quite quickly [3]. Given enough research and development, a computer simulated system will surely become a powerful tool to help solve, create, or operate something. This is not exclusively applicable to solving traffic issues, it is applicable to anything. In regards with solving traffic problems, the system's scalability will help by being able to keep up with the expanding complexity of the infrastructure that the network of roads is built upon [4].

This study aimed to develop a computer visual simulation model to simulate traffic situations so that better and more efficient actions may be made. The system will greatly improve road management as well as provide a sandbox for authorities to test their plans on road routes and the configuration of traffic regulations without the risk of negatively affecting the lives of the people. This research will also provide a model for future researchers as basis for their studies as well as provide a platform for testing their hypothesis and ideas. The simulation may also be used for testing by evaluating and comparing different configurations of traffic regulations to find which configuration is better and more applicable at certain conditions, to visually inspect and aid the detection of potential traffic congestion situations in which case the system acts as a tool for predicting outcomes of, and to better understand the flow of traffic in order to make better and more educated decisions to help with the problem regarding traffic [5].

Some of the few possible contributions or applications for this study would include research data, traffic prediction systems, and navigation systems (i.e. Google Maps, Waze). The most important contribution would be the data gathered from utilizing the system. The data gathered from using the system would help develop better navigation systems. It could also be possible to use the system to make predictions of upcoming traffic conditions such as simulating what would happen if a major highway were to be closed down. If the system were accurate enough, the data it will provide will prove useful and reliable.

2. Review of Related Literature

These are some of the review of related literature being reviewed in this research.

2.1. Adaptive Road Traffic Management

According to this research, the adaptive vehicle route guidance system integrated in the intelligent vehicle agent was developed based on a hybrid method [6]. This grants or allows for simultaneous and intelligent fine-tuning of the road traffic in the structure given by the real-time adjustments. They also proposed an algorithm where the road structure can uphold more vehicles without cutting down the average speed of traveling vehicles while taking into account the simultaneous road traffic information.

2.2. Traffic: Why It's Getting Worse, What Government Can Do

Traffic congestion was not mainly a problem, but rather the answer or solution to our essential mobility problem, which was that too large of a number of commuters want or need to travel at the same times each day [1]. Why is it like this? This is because adequate operations of both the economy and academic systems require people attend work and go to school during approximately the same hours. This results in the ever so hectic rush-hours commuters must endure to get to their destinations. With each car added into the equation, traffic problems increase exponentially, so much so that even something as simple as running errands prove difficult. People have no choice but to commute at approximately the same time that they end up interacting with each other. That essential requirement is impossible to alter without damaging our society and economy. The same issue persists in every major urban area in the world [7].

2.3. Managing Traffic Congestion
It is challenging to anticipate what instruments or tools to use that will aid or be helpful in clearing up the traffic issue or at least to just temporarily lessen it. Prices of road fees and parking payments may not be an economic problem once people are wealthier. It is unlikely that we will ever know when to say whether issues regarding traffic congestion are solved permanently or just solved for the time being. countless subsidies are required to further improve and enhance public transport facilities. Asking how to integrate or how to incorporate new and distinctive types of transport is another essential question, since there are distinct interest groups among different transit administrations, departments, and agencies. It proves challenging to influence or to persuade people to choose public transport rather than to use their own private cars [8]. So, when prices of road fees and parking payments are affordable for most of the public, a relevant number of them may still perhaps choose private cars.

2.4. Analysis of Human Driver Behaviour in Highway Cut-in Scenarios
The action, behaviour, and attitude of human motorists in response to cut-in vehicles moving at comparable speeds is what this research paper analyses. Regardless if automated or human-driven, both types of vehicles will inevitably encounter this situation in day-to-day highway commute [9]. Data have been collected from a diverse pool of human subjects using a driving simulator with pre-programmed scenarios[10]. To understand each driver's behaviour in response to cut-in vehicles, a novel means of visualization and analysis based on relative positions is proposed in this paper.

2.5. Application of Traffic Simulation Model
According to this paper, traffic simulation is generally adopted approach in terms of traffic arrangement, advancement, and imitation of existing systems. Its ambition is to carefully recreate traffic regulations and flow examined on the road model. It plays a significant part on traffic management and development as it can be practiced to create a strategy on administering the traffic flow [11]. The objective of this simulation model is to display the transport condition on changing design.

3. Methodology

This section discusses the methodology used in the research as well as the framework used in order to achieve the desired objective of the study.

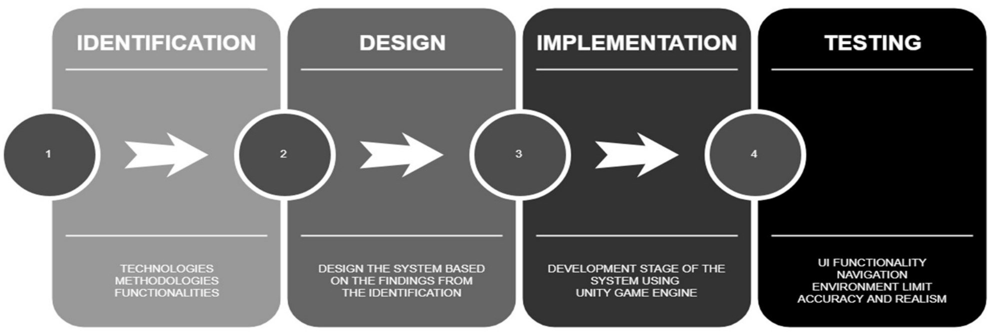

Figure 1. Conceptual Framework

The conceptual framework as seen in Figure 1 was originally designed by the researchers. This illustrates the basic steps necessary to developing the system. The system was conceptualized based on the related literatures. The papers the researchers found influenced the system by being the basis of its design. The related literatures also guided the researchers on deciding which elements to focus on such as which traffic regulations to be made modifiable.

3.1. Identification
Before proceeding with design and implementation, it was necessary to identify all functionalities of the system. Functionalities such as the necessary UI elements needed to allow the user to control the system. It was also important to identify all the algorithms, processes, and tools required to create the system. In order for us to identify all of the components needed for the system, the researchers must first understand how traditional traffic management is done as well as considering how existing adaptive traffic management is used in helping with coming up with solutions for traffic problems. They did this by researching traffic regulations most likely modified to change the flow of traffic. During their research, the researchers found that three regulations are modified to best suit the current situation of a particular traffic issue at hand. These regulations are namely No Left turn, No Right turn, and No Entry. The researchers concluded that the system will provide control of these three regulations making them modifiable. The researcher also concluded to use the built-in navigation functionality provided by Unity Game Engine. The available navigation agent provided by Unity Game Engine is called NavMesh(Navigation Mesh). The NavMesh agent utilizes the A* graph algorithm to enable movement and intelligent navigation of objects within the simulation. Once that was done, designing the system came next.

3.2. Design
Designing the system was much easier since the methods, functionalities, components, and other elements are broken down and identified. Each method was plotted out as to how it functions and how it interacts harmoniously with other functionalities. For this phase, the researchers decided upon which tool to use. As they were doing a 3D model, the researchers found Unity Game Engine to the best tool to use as it had available libraries and assets readily available to ease development of the system. Their design required an interactive but simple UI and the simulation model. Unity Game Engine provides all of these.

3.3. Implementation
As seen in Figure 1, implementation comes next after design. This is the phase of which the system is built with code. For this phase, instead of coding everything, readily available functions from the Unity Game Engine library were used. A Unity Game Engine asset called Playmaker was also heavily utilized as it provided an FSM interface which made the development of the functionalities much easier and more efficient. On top of Playmaker, Modular Traffic, another Unity Game Engine asset complementing Playmaker, provided the necessary models and object behaviour for the simulation. These assets and tools helped in the development of the system adequately. The previously mentioned NavMesh was utilized to implement intelligent navigation into the system. Although not heavily used in the navigation of the AI vehicles, NavMesh plays an important role in the navigation of the pedestrians. Instead of heavily relying on the NavMesh agent for the AI vehicle's movements, those objects use additional raycasting to guide navigation. This is because when left alone to rely on the NavMesh, the AI vehicles will behave undesirably. By using raycasting, the system can direct where the AI vehicles can and should go, giving the system further control of where the objects could go.

3.4. Testing
Testing came last. The system underwent unit testing of all the functionalities multiple times to identify bugs and other issues so that it will be fixed as soon as any were found. Unit testing was done by repetitively running the simulation given the circumstances that showed issues and then fixing those issues to move on to the next.

System testing was predominantly done visually since the system is a visual simulation. Object behaviours were observed and validated. The system would also be tested based from the expected functionalities. The Artificial Intelligence instances of each virtual car must behave as expected considering given parameters. Road regulation modifications must be implemented simultaneously with the AI cars responding by following the set rule. The following were tested to ensure the system's performance.

1. UI Functionality - It was expected that the user is able to control the module using the given user interface. Each button must perform the expected operation.
2. Navigation Functionalities - The roads must be used and followed by the virtual cars. It was expected that there shouldn't be any virtual cars going past their supposed limits within their routes.
3. Environment Limit - The elements of the simulation must behave accordingly. The actions performed by the virtual cars must be feasible in the real world and must be as realistic as possible.
4. Accuracy and realism of traffic rules - Physics elements that are crucial to this project are inertia and gravity. The simulation must be as realistic as possible. Traffic regulations must also be practical and realistic.

Unit testing for the AI cars behavior was done by visually inspecting if they reacted accordingly to inputs. The researchers examined the actions taken by the AI cars if the traffic regulations changed. Interaction between AI cars and AI pedestrians was also tested. In this case, the AI cars must stop if ever pedestrians were crossing the pedestrian lane. The AI cars must also never go out of bounds. This means that the AI cars should only traverse through the road provided to them. The AI cars was also tested on their reaction upon collision with other cars, in this case, they must stop.

To test whether the system was useful in real life applications, the researchers created a model of the road infrastructure of one of the busiest roads in the city of Cebu, Cebu Business Park. The control model was made to be, as much as possible, a copy of the real life road infrastructure with its respective configurations of road regulations. As a test subject, the researchers created an independent model with a road infrastructure based from the control model of which the researchers could then modify the traffic regulations and then perform comparisons between both models.

After numerous modifications, the researchers finally found a configuration of the road regulations that would improve the traffic flow in such a manner that would benefit more commuters compared to the control model. This comparison was done visually, and took several attempts. The unit of which the researchers compared the two models is the average time for all cars of a given road configuration to travel a certain distance as well as visually inspecting the number of cars moving versus the number of cars stopped at a given time.

After the tests, the researchers found that the simulation will display useful visual information such as where congestions start, traffic congestion density, bottlenecks, road infrastructure flaws and many more. Utilized properly by trained professionals, such as engineers and the authorities, the simulation can be used to remodel the existing road infrastructure and design to have the best possible traffic conditions beneficial to the majority of the people.

4. Result and Analysis

As shown on figures 2 and 3, the intersections' rules can be changed according to the configurations set by the user. This will greatly benefit the traffic enforcers; their role of enforcing traffic rules will be much easier and will be done more efficiently as they have basis for their decisions. It will show them the possible outcomes when the configuration is executed. The cars will follow the rules set by the user and will interact with each other as realistically as possible, using signal lights to indicate their current and intended actions. Pedestrians may also be generated to simulate an even more realistic environment but with the cost of graphical performance as it will demand more from the computer to simulate.

As shown on figure 4 and 5, the user is also able to view a 3rd person perspective of a random car or pedestrian. In this view, the user is able to move the view around using the mouse, however the camera will only stay focused on the car or pedestrian. The system also provides a Free Camera view which allows the user to freely move around and observe the simulation using the WASD keys. To edit an intersection's road regulations, it is recommended that the user select the Overhead Camera view to have a better perspective on the environment. To edit road regulations, the user must click a section of the road of which is to be edited. Green arrows will appear indicating that these are the paths the cars may take. If the user wishes to set a "no left turn" rule, then the user can simply click on the arrow pointing to the left. The arrow will turn red and the rule has been set. Given this type of interaction, the system is very straight forward to use.

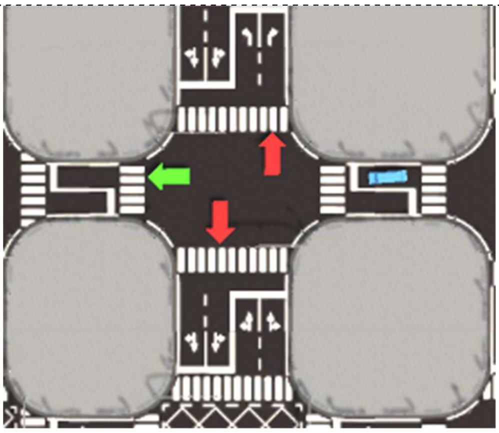

Figure 2. Intersection Configuration

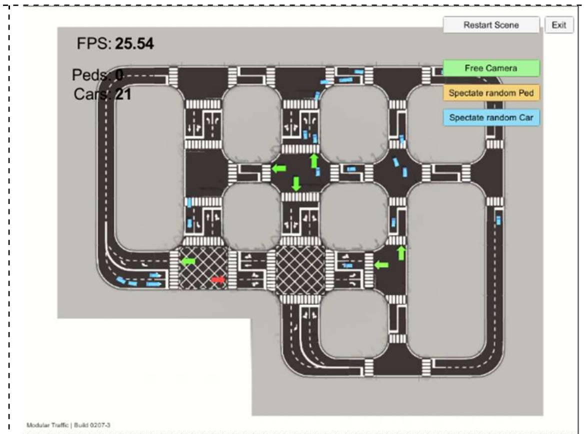

Figure 3. Road model and its configuration

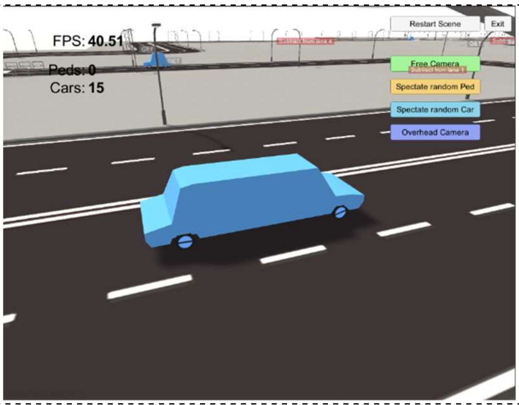

Figure 4. Car Artificial Intelligence

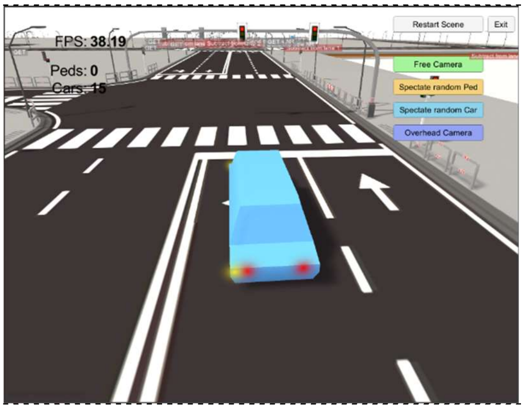

Figure 5. Car Artificial Intelligence

As seen on Figure 6 and 7, important information is displayed such as the current number of pedestrians and cars. Information about the number of cars moving and stopped is also shown. More important information like the wait time of the traffic light is shown and is editable. The wait time for the traffic lights greatly influence the flow of traffic in the simulation. Lastly, the average distance travelled per minute of the cars is also displayed. The higher the average distance travelled per minute, the more desirable.

The system is simple and straight forward to use. Necessary information such as the traffic light wait time and average distance travelled per minute helps the user identify whether the traffic regulation configuration is more efficient or not. With the visual element of the system, the user will also be able to pinpoint problematic areas of the environment and address them accordingly without the risk of having to compromise the activities of real-life people.

5. Conclusion

In this paper, the researchers have presented a graphical representation of road traffic whose intersection rules can be manipulated according to the configurations set by the user. In the real world, traffic problems such as congestions are unavoidable, however, there are numerous manners of ways of decreasing the rate at which it intensifies as well as a better way to decide upon what action to take to relieve or lessen the congestion. With the help of this system, authorities may simulate situations that may aid in their actions to improve traffic flow. Researchers will also benefit from this as this will provide them with a model to aid with their studies. The traffic regulations available for change in this system is limited, however it is very possible to improve this by enabling more regulations to be changed. Potential improvements for the system would be allowing more control over more regulations, making the AI object behaviours of pedestrians and vehicles more realistic, and optimizing the system to run more efficiently to allow a simulation of a bigger scale.

Figure 6. Important Information

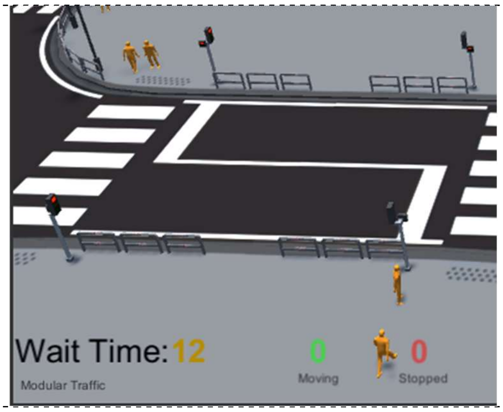

Figure 7. Important Information

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