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*Original Article*

# Simulation of a Vehicular Adhoc Network (VANET) for Mitigating Vehicular Accidents

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***Abstract*** *- Vehicles have increased dramatically in number globally over the past few decades. As a result, rather than concentrating on enhancing road quality, producers, researchers, and the government are now concentrating on enhancing road safety. Vehicular Adhoc Networks (VANETs), which enable communication between vehicles and between vehicles and infrastructure, are one new type of network that has emerged due to the rapid advancement in wireless technologies. In recent years, many novel ideas have been developed, including smart cities and living labs, where Vehicular Adhoc Networks (VANETs) play a significant role. Introducing a new plan that uses an innovative city framework to convey data about traffic conditions to drivers, assisting them in making informed judgments. Our suggested plan includes a warning message module made up of Intelligent Traffic Lights (ITLs), which informs drivers about current traffic conditions by developing a VANET composed of Configure and create a 3D simulation that will capture and represent all vehicle units and roadside units and simulate various safety scenarios as this model will offer a great potential to reduce the incidence of accidents on our roads.*

***Keywords*** *- VANET, Smart city framework, Intelligent Traffic Lights (ITLs), Intelligent Traffic System (ITS), Routing protocol.*

## 1. Introduction

The World Health Organization (WHO) estimates that vehicle accidents cause the deaths of more than 1.3 million people annually worldwide. In Nigeria, there are anticipated to be 3,330 accidents between January and March 2022. 26% of all collisions ended in fatalities, while 62.8% of cases were deemed severe because they put victims in danger of dying [1]. With more vehicles on the road, attention is also being paid to enhancing road safety and in-car entertainment. Therefore, there is an increase in the creation of new services and apps for vehicle contexts. A few typical examples are applications for traffic and safety security monitoring, multimedia streaming, data collection for smart cities in coordination with wireless sensor networks, Vehicle-to-Vehicle (V2V) communication, etc. A more contemporary technology that can enable such developing vehicular applications is VANET.

VANET can be broken down into three streams based on network configuration: Wireless Wide Area Network (WWAN), hybrid wireless architecture, and adhoc V2V communication. Since the cellular gateway's access point is fixed in the WWAN, direct communication between the vehicle and the access point is made possible. The Hybrid Wireless Architecture uses WWAN access points at some locations in the network, whereas adhoc communications are used for communication between those terminal points [2, 3]. Adhoc vehicle-to-vehicle communication falls under the third category; no fixed access point is required for this type of communication. Because each car is built with its wireless network card, it is possible to set up an adhoc network for every single one. A component of MANET, VANET interacts with equipment adjacent to the side of the road and facilitates communication between cars. They have qualities that set them apart from other networks.

The absence of road information can increase the likelihood that the vehicle's location can be accurately stated at that moment. In the VANET, the vehicle is an entity, and while it is moving, its nodes are restricted to the road topology [4]. The nodes can supply the necessary energy for data processing and information transfer to keep the node operational. Vehicles equipped with VANET can communicate alerts to other vehicles regarding roadblocks, traffic conditions, and local news. VANETs' main goal is to make driving safe and comfortable for users by resolving their choices while driving. The ideal handoff and Internet connectivity are more challenging to maintain in moving vehicles due to their high speed [4, 5].

The condition of Nigeria's roads is getting worse as time passes, and the number of accidents on some stretches of road has increased alarmingly. Although fixing these roads would not be particularly expensive, bureaucracy and related corruption have caused prompt rehabilitation of these roads to be postponed indefinitely. Due to these factors, serious accidents, some of which are fatal, regularly threaten the lives of Nigerians. Additionally, some drivers leave a lot to be desired regarding how they operate a vehicle by completely disregarding basic traffic laws like maintaining a constant speed when approaching intersections or curves, keeping the required gap between vehicles, and maintaining reasonable regard for other road users. Consequently, it has become imperative to seek a technology-based solution to address these other problems [6].

## 2. Review of Related Works

In [7], one of the most current and challenging study fields for automakers and ITS designers is Vehicular Adhoc Networks (VANETs). The availability of such networks allows a wide range of applications, including safety applications, mobility, and connectivity, enabling drivers and passengers to utilize transportation systems smoothly, effectively, and safely. It is necessary to choose the optimum routing protocol for safety applications. The three most widely used routing protocols in VANET are DSR, AODV, and DSDV. Indeed, using VANET simulation tools makes it possible to test and assess various routing protocols associated with the VANET system before implementing them live. This essay compares and contrasts three routing protocols for the VANET system in Khartoum.

The authors in [8] presented the efficient clustering V2V routing based on PSO (Particle Swarm Optimization) in VANETs (CRBP) is a method that is suggested in this work to increase the effectiveness of V2V. The vehicle nodes with identical motion directions are determined before choosing the cluster heads. The second step is constructing the route particle with its velocity coding rules, iteration rules, and fitness function for the routing optimization. Third, signal-improving techniques are suggested to increase cluster and inter-cluster routing effectiveness.

In [9], Vehicle-to-Vehicle (V2V) communication models and Vehicle-to-Infrastructure (V2I) communication models both have the potential to be used by Vehicular Adhoc Networks (VANETs) to facilitate communication between cars. End-to-End (E2E) communication delay and message reachability are crucial performance measures for VANET applications and are requirements for messaging services related to safety. Numerous studies have been done on the effects of various car mobility patterns on communication performance in VANETs and over various road networks. A study analyzing mobility speed variations and their effects on E2E delays and message reachability for sender-oriented messaging methods on VANETs has not been adequately studied. This study assesses the effects of vehicle speed variances on the performance of two messaging systems used often in VANETs: the furthest distance and link quality-based techniques.

In [10], the Vehicular Delay Tolerant Network (VDTN) system uses moving nodes-vehicles on the road-to transmit data from one location to another via several intermediary nodes. Because there are now trade-offs between several metric factors, including delivery ratio, delay, and overhead ratio, efficient data distribution in VDTN is challenging [11]. The performance of a routing algorithm may be enhanced by including significant social network parameters in the computation of forwarding probability, such as community, social strength, trust, friendship, and selfishness. The metric variables, however, respond differently depending on how these parameters are tuned. If these factors are appropriately balanced, the trade-off between the metric variables may be resolved with an optimum outcome.

The authors in [12] proposed an Intelligent Transportation System (ITS), which found that Vehicular Adhoc Networks (VANETs) are the best alternative. For smart ITS to be supported, information must be distributed effectively in data packets. Vehicles interact with one another in VANETs to share traffic data either directly or through pre-existing infrastructure. Typically, the broadcast approach is used for data delivery. Data broadcast in VANETs is a complex problem because high mobility vehicles with different densities must exchange and route the time-sensitive safety information to other targeted vehicles. Therefore, it must be addressed using the exact existing and novel solutions.

In [13], the unique mobility, driver behaviour, and networking requirements of VANETs make it challenging to verify their applications and protocols. There is a lack of a realistic test bed that can simulate the VANET environment and allow for user testing and evaluation of both Quality of Service (QoS) and Quality of Experience (QoE) despite network simulators frequently analyzing network performance. The needs for such a test bed are examined in this paper, which also introduces a flexible VANET test bed design. Utilizing typical VANET applications, this architecture is tested to determine whether it can be implemented for use in vehicles.

In [14] proposed the position-based routing suitable for VANETs due to its simplicity and lack of routing tables. However, it is challenging due to vehicle changes and unstable behaviour, causing route redundancy and high end-to-end delay. A position-based reliable emergency message routing scheme is proposed, utilizing mobility metrics to enhance EM delivery in dynamic environments. In [15], due to their distinctive qualities, including frequent link failure, quick topology changes, and high vehicle mobility, Vehicular Adhoc Networks (VANETs) are drawing more attention. Applications, including traffic management, emergency alerts, and collision avoidance, are available on VANETs. This work presents a bio-inspired adaptive routing system for VANETs, emphasizing extreme and complicated situations like underground mines.

In [16], by enhancing transportation systems and enabling them to become intelligent and accident-avoidant, vehicular adhoc networks are essential to their improvement. Greedy protocols that use direction to determine hop selection are effective for one-way traffic because they choose the next hop to deliver warning messages depending on the current position of relay nodes relative to the destination node. Such protocols, however, suffer from performance loss because they ignore the nodes' bi-directional travel direction in traffic and are subject to dynamic topological changes. To address the dynamic nature of bi-directional highway environments for effective and reliable routing of warning signals, this study pioneers the use of movement direction and relative positions of source and destination nodes [17].

The authors in [18] proposed that Mobile Adhoc Networks (MANETs) are divided into the subclass of Vehicular Adhoc Networks (VANETs). Wireless networks (V2V and V2I) between automobiles and infrastructure are constructed using VANETs. In contrast to MANETs, VANETs bring a range of applications to improve driver safety and foster a comfortable driving environment. Through vehicle-to-vehicle connections, these applications transmit messages. A vehicle can build a source-to-destination route via routing, a core VANET process. Due to the topology's frequent changes and the associated vehicles' high movement rates, routing in VANET is a complex operation. In order to overcome this difficulty, this study offers a Predictive Geographic Routing Protocol (PGRP).

In [19], Vehicle Adhoc Networks (VANETs) are highly mobile, autonomous nodes that wirelessly connect and send various data, some of which may be crucial. Routing packets in these networks is a complex problem because of VANETs' continuously changing topology and the participating vehicles' high-speed mobility. To do this, TGRV employs a monitoring system that enables every vehicle to keep track of the accurate packet forwarding rate of its next hop. The monitoring system uses distance prediction in a modified promiscuous mode to accurately forecast the next hop's correct packet forwarding rate. The trust values of interactions are decreased over time by employing a decay factor to improve the accuracy of trust management. TGRV utilizes the quantity and confidence of two-hop neighbours, which aids in choosing the next hop located in a more dependable area.

In [20], traffic issues, particularly in nations with dense populations, are drawing attention to Vehicular Adhoc Networks (VANETs). To decrease accidents and improve traffic flow, safety, and $CO_2$ emissions, Intelligent Transportation Systems (ITS) are required. Although connection stability during packet exchange is not addressed, the existing routing protocols for VANETs strongly emphasize dependable communication. This study develops an Obstacle Prediction Based Routing Protocol (OPBRP) that uses vehicle kinematics and mobility prediction to identify vehicles, transmit packets, and choose the best path. The study makes two key contributions: improving the prediction routing protocol to transmit packets along a trustworthy path and introducing new decision-making rules for selecting intermediate nodes to increase the packet delivery ratio.

## 3. Methodology

This section outlines the process for simulating the system that will employ VANET to reduce accidents and incidents. Using the simulation tool Blender, a 3D model simulation of this system's operation will be produced. An open-source, cost-free 3D modelling program is called Blender. You can make 3D visualizations using Blender, including VFX shots, 3D animations, still photos, and video editing. Small studios and individuals can profit from its unified pipeline and responsive development approach, making it a good choice for them. Blender can be used on systems running Linux, macOS, and Windows because it is a cross-platform program. It also has relatively small memory and drive requirements compared to other 3D creation suites. Compared to other 3D creation programs, it also has comparatively low memory and drive needs. Its interface uses OpenGL to deliver a uniform user experience on all supported systems and hardware.

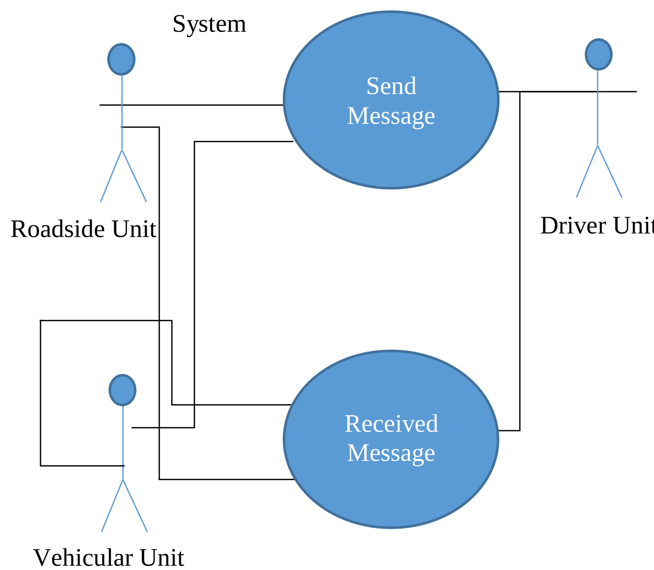


**Fig. 1 Use case diagram**

The use case illustration in Figure 1 succinctly explains how the system works. Although it does not provide a detailed explanation of the system's operation, it does provide a general overview. The main actors in the system are the vehicles and the roadside units. They start the system's functioning. Keep in mind that the system's primary purpose is communication. When one of these devices detects something on the road, like a construction site or a broken-down car, it stores the information and transmits it when it gets close to another roadside or vehicle unit. The driver, who is a secondary actor, will next decide how to proceed based on the knowledge he knows. The order of the actions in the study's system is depicted in Figure 2.

The roadside unit, whose name suggests that it is situated on a road, is spread out over several roadways. Since they are stationed along these highways, they can record any occurrences as they happen and subsequently transmit the information to any nearby vehicles equipped with vehicular units. The information is then displayed to the driver by these vehicle systems, who uses it to decide what to do next. The procedure is repeated as often as new circumstances arise or new accidents happen on the road so that drivers will constantly be aware of what is coming and may behave accordingly.

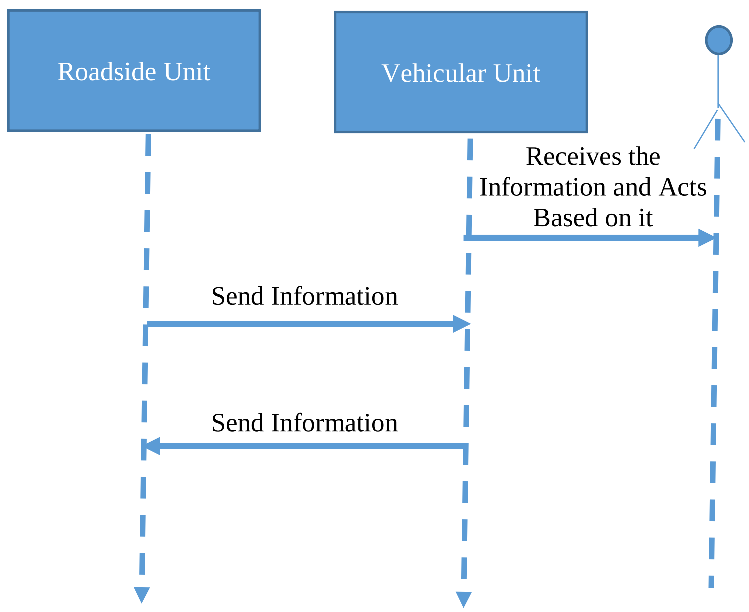


**Fig. 2 Sequence diagram**

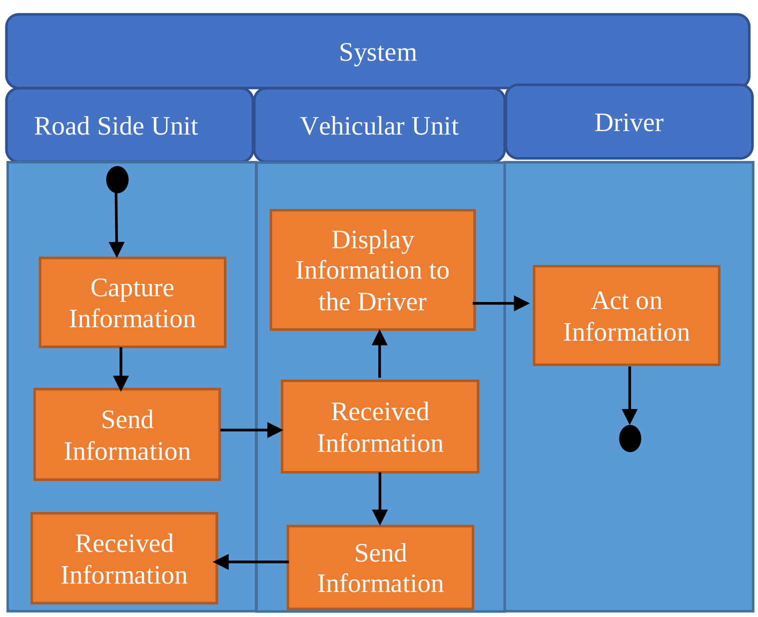


**Fig. 3 Activity diagram**

The activity diagram of the study's system, shown in Figure 3 illustrates what each component will perform or how they will operate and interact. The roadside device gathers data from the road and transmits it to any approaching vehicle using the vehicular unit. When another vehicle or roadside unit is encountered, this one will continue by displaying the information to the driver and passing it to them. The class diagram for the proposed study's system is shown in Figure 4, and each class collaborates with the others. Figure 5 depicts how the various parts work together, beginning with the roadside unit, which gathers data first before sending it to the vehicular units in approaching cars.

If roadside units are at the vehicle's other routes, they can receive the information from these mobile units and transmit it to the driver. A 3D creation tool called Blender was used in this investigation. There are steps involved in making the 3D simulation, and these processes consist of:

- Modelling
- Animating & Rigging
- Rendering

### *3.1. Modelling*

A mesh primitive shape (such as a circle, cube, or cylinder) is often used to start mesh modelling. You may start altering from there to produce a more oversized, intricate shape. The three main modes of the 3D viewport enable the creation, editing, and manipulation of mesh models. Numerous tools are available in each of the three modes. Object Mode: Supports fundamental actions like object creation, object joining, controlling shape keys, and UV/colour layers. Most mesh editing activities are performed in edit mode. Sculpt Mode: Supports sculpting with brushes instead of working with individual mesh pieces.

### *3.2. Rigging and Animation*

An object is animated when it is made to move or change shape over time. There are several techniques for animated objects: Objects moving together include those that change over time in size, orientation, or position. Altering them: causing their vertices or control points to animate; inherited animation: When one object moves due to the motion of another item (such as its parent, a hook, or an armature). Keyframes are frequently used to produce animation.

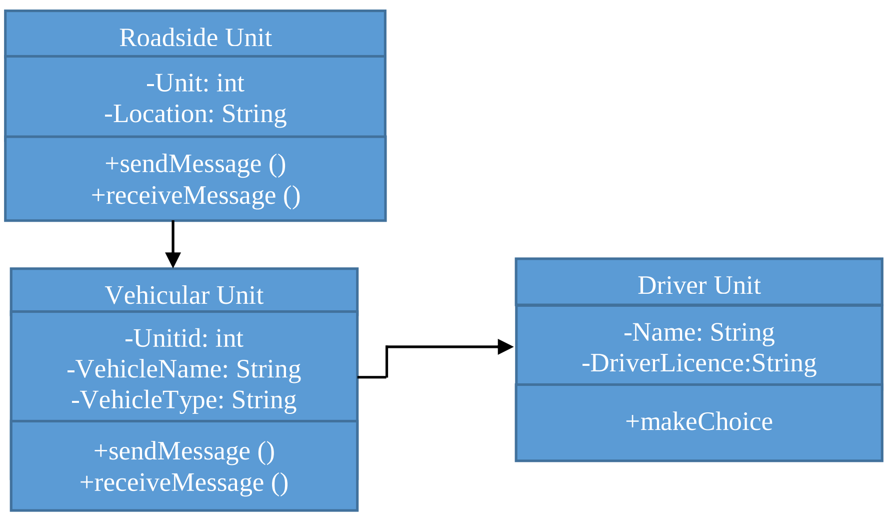


**Fig. 4 Class diagram**

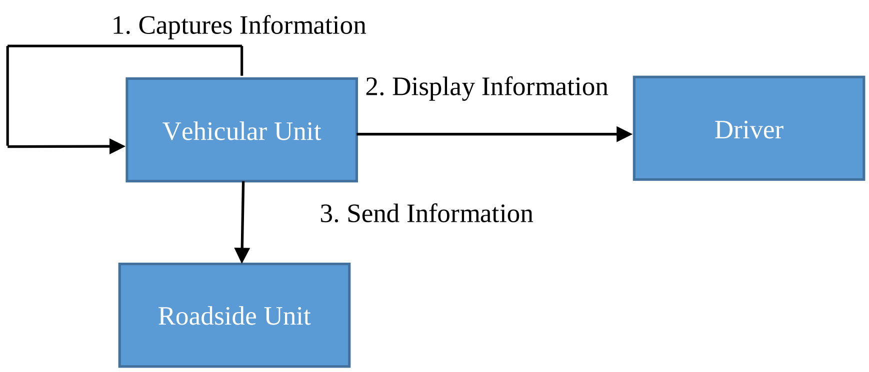


**Fig. 5 Second collaboration diagram**

### *3.3. Rendering*

Converting a 3D scene into a 2D representation is known as rendering. With varying powers, Blender comes with three render engines: Physically based real-time renderers include Eevee, Cycles, and Workbench, which is made for modelling, layout, and previewing.

To exercise creative control or to incorporate actual footage, renders can be divided into layers and passes that can later be composited together. Non-photorealistic line rendering can be added with Freestyle. All render engines supported by Blender's interactive 3D viewport rendering allow for quick iterations on lighting and shading. The finished, high-quality image or animation can then be generated and output.

## 4. Result and Discussion

The systems were all independently modelled for this study's scenarios. Among the materials used to accomplish this are;

### *4.1. Extrude*

This was used to create new subsections from pre-existing mesh faces or vertices. All automobiles in this project were created from a simple mesh (cube) by extrusion.

### *4.2. Loop Cut*

This subdivides meshes into more individual segments. This was a critical factor in detailing all models.

### *4.3. Bevel Tool*

This was used to smoothen all sharp edges. This was particularly important for modelling the curved edges of automobiles and building crevices.

### *4.4. Inset Tool*

This was to create extra geometry in or around an existing mesh. Building windows, as well as car rims, were facilitated by this tool.

### *4.5. Knife Tool*

This was used to create irregular cuts and shapes from existing mesh individually. This was used to create road bumps and dents.

### *4.6. Bisect Tool*

This was used to create irregular cuts and shapes from existing mesh collectively. This was used to create road bumps and dents.

### *4.7. Mirror Tool*

This was used to create active replicas along the selected axis such that any modifications done on one half of the model simultaneously affect the other half. This was used to create the opposite sides of cars, buildings and bridges.

### *4.8. Duplicate*

Used to copy and paste selected models in desired areas.

### *4.9. Transform*

This was used to move, scale and rotate selected meshes with freestyle. All render engines supported by Blender's interactive 3D viewport rendering allow for quick iterations on lighting and shading. The finished, high-quality image or animation can then be generated and output. Figures 6-13 show the screenshot of the vehicular unit. The simulation in Figure 9 shows and explains the functions of the proposed system.

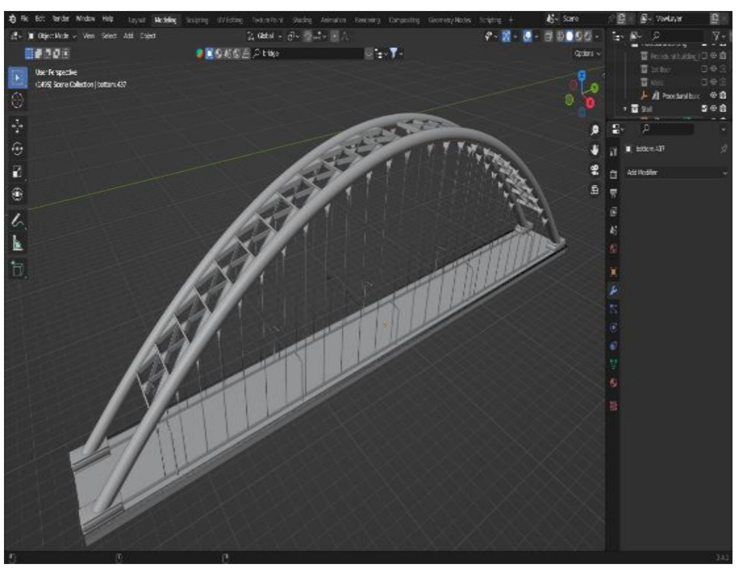

**Fig. 6 Model of a bridge without texture**

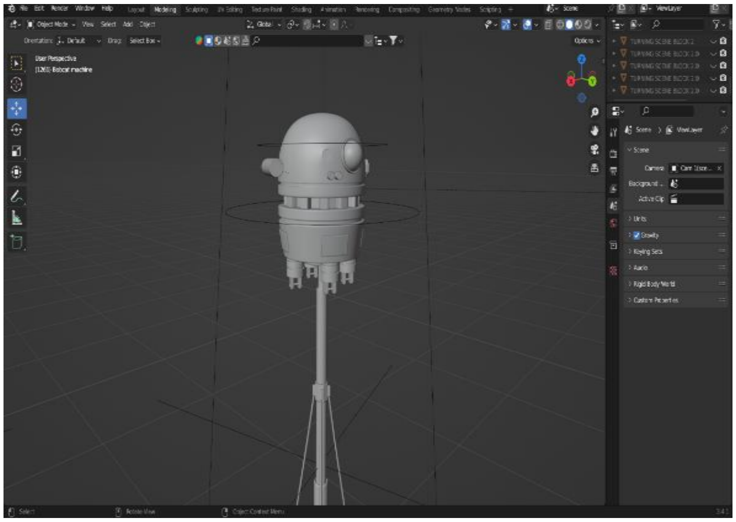

**Fig. 7 Model of roadside unit without texture**

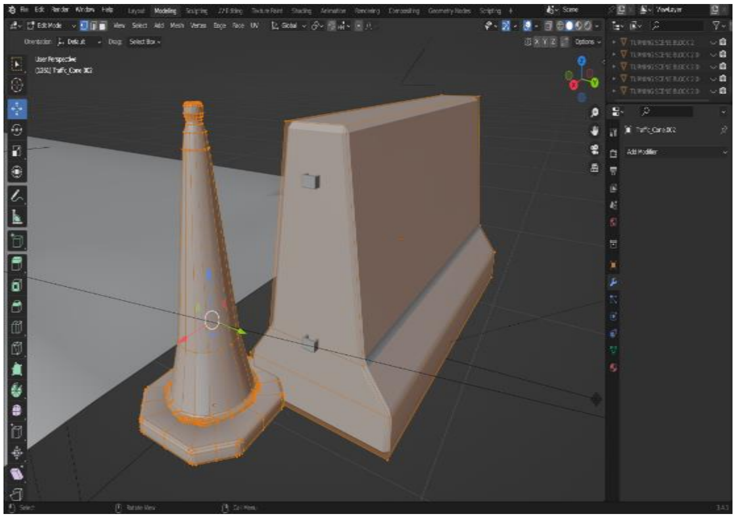

**Fig. 8 Model of construction objects**

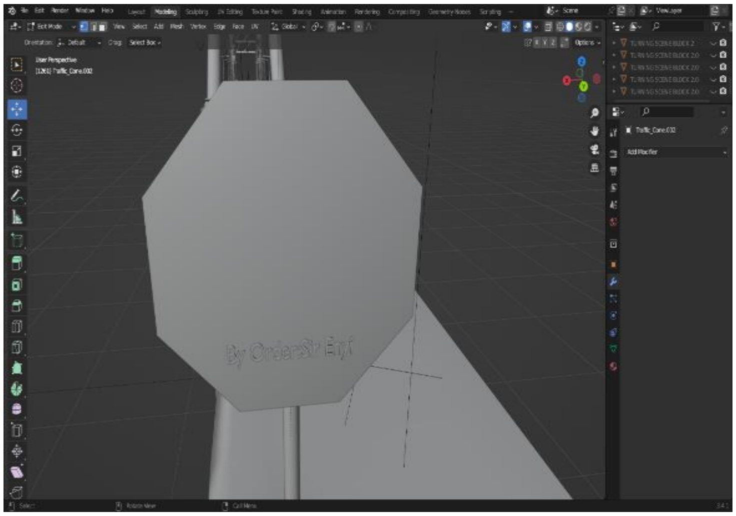

**Fig. 9 Model of a road sign without texture**

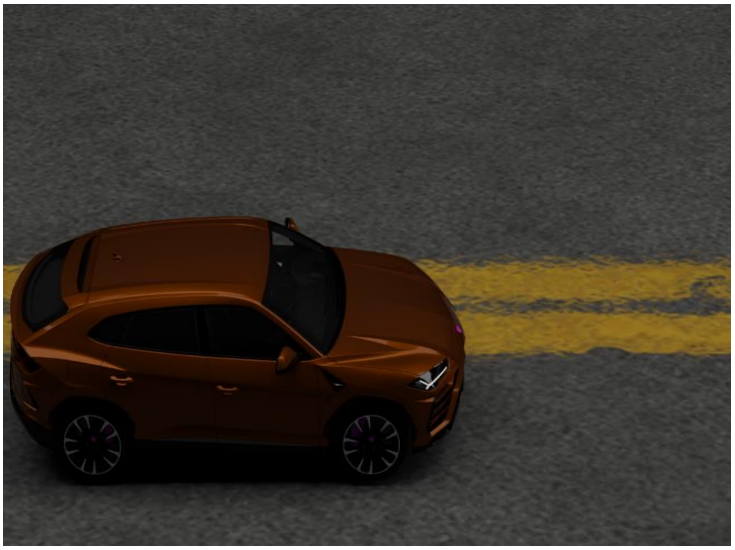

**Fig. 10 Vehicle with vehicular unit**

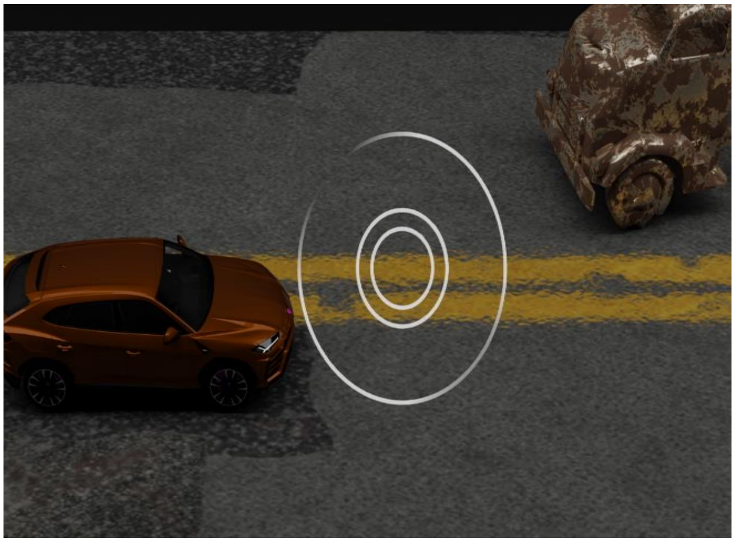

**Fig. 11 Vehicle with the proposed system moving on the road**

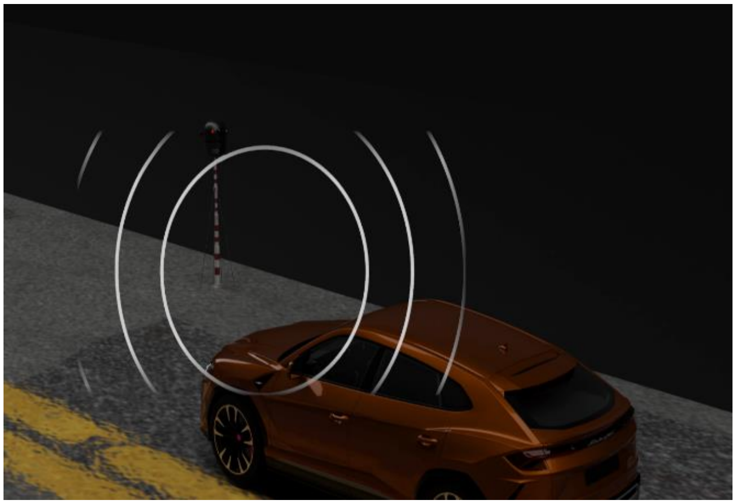

**Fig. 12 Vehicular unit communicating with the roadside unit**

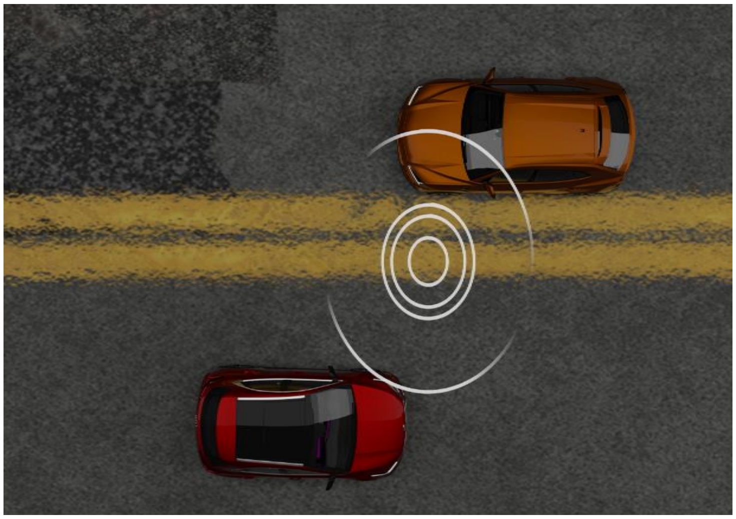

**Fig. 13 Vehicular unit to vehicular unit communication**

Here, all the stages have been completed, objects have been modelled, animations have been worked through, texture has been added, and it has been rendered. The simulation is ready to serve its purpose. Screenshots to show what it entails are displayed in Figures 10 and 11.

Figure 10 shows that there is a broken down vehicle on the road, and it shows the vehicular unit in the vehicle capturing the information of a broken down vehicle on the road. It will display this information to the driver for them to make decisions, and it will also keep this information to share with another vehicle with a vehicular unit or a roadside unit. Figure 11 shows that the vehicle comes across another vehicle with a vehicular unit; the vehicle is headed in the direction it is coming from, so it relays the information. The information is then relayed to the driver in the car so he or she knows what to expect while going on.

## 5. Conclusion

As time passes, the condition of Nigeria's roads deteriorates further, and some sections of the country's highways now see an alarmingly high accident rate. These roads do not need to be fixed often, but the process has been continually postponed due to bureaucracy and the corruption it fosters. Due to these factors, serious accidents, some of which are fatal, regularly threaten the lives of Nigerians. In order to reduce vehicle accidents, this project will imitate VANET. The system design comprises the system architecture, class diagrams, use case diagrams, sequence diagrams, and system activity diagrams. Therefore, the study suggested a technological method to improve communication between moving cars and their travel routes. In order to create a system for seamless information flow, we built the suggested remedy, and the study incorporated the idea of the VANET and its related roadside and vehicular units. The chosen method was then put into practice and virtually tested utilizing Blender for the 3D design and an online-based render farm for the rendering of the 3D design in order to demonstrate how the suggested system operates in real-time clearly. The rendered mp4 film demonstrates the success of the suggested solution and the accomplishment of the intended functionality and features. The entire testing process makes use of all test techniques and test scenarios. It was used to assess how well the system performed compared to expectations. Allow the planned study to be implemented in the actual world for future studies.

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