An Advance Driving Assistant System Simulator using Unity-3D

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ABSTRACT

Simulations are 3D environments that are based on real-world scenarios. As technology is evolving in automobiles, the need for advancement in Artificial Intelligence (AI) of automobiles and to train AI systems of the automobiles are getting expansive. This study investigates the problem of collecting reference data for the testing and evaluation algorithms for autonomous vehicles using unity simulation. Using computer simulations is one way to solve this issue. A genuine system modeled using computer simulations, including all of its static and dynamic properties. There are 4 modules: forward & backward collision, speed warning, traffic light & sign detection, and lane departure system. All the modules are implemented in C# language and the unity-3d platform. The composite collider module is used for the lane departure in which the line render algorithm is applied for forwarding/backward collision. This method reduces the testing period while ensuring accuracy and efficiency in data collection. The construction of a simulation environment based on Unity with the ability to test sensors and algorithms for autonomous cars and display deviations from reference data is the goal of this research work. Roads, sidewalks, buildings, traffic signs, and automobiles are among the common city players, and items in the simulation model are presented in the simulation. The simulation is tested by the methods like black box testing, use case testing, performance testing, stress testing, module testing, Software-In-the-loop, Driver-in-the loop testing.

Keywords: *ADAS, simulations, forward collision detection, backward collision detection, signal detection*

1. INTRODUCTION

Driving safety has always been a top priority in the automobile business. Advance Drive Assistant Systems (ADAS) are structures that aid the motive of power of a vehicle's operating system, enhancing a manufacturer's market competitiveness [1]. In addition to gathering real-world datasets, obtaining reference data, also known as ground truth data, for assessment purposes is a challenge. For instance, measuring vehicle localization accuracy using stereo cameras or 3D laser range finders may be evaluated with a more precise sensor, like a differential GPS, as demonstrated in the widely used KITTI dataset [2]. ADAS is a technology that is designed to increase driver effectiveness and enhance transportation safety. Collision Prevention Systems, Intelligent Speed Adjustment, and Lane Departure Warnings are all examples of adaptive cruise control systems [3]. Advanced driving systems have made great strides over recent years, intending to make roads safer (e.g., reduction in the number of crashes), increasing the driver's sense of well-being. Automotive protection is an important approach for the assembly of global and country-wide visions. As customers place a greater emphasis on safety, accident reduction measures become essential for automobile companies, but the challenge arises when collecting real-world data sets i.e., data for car detection, data for signals detection, and data for the road of lane departure systems. All these dataset costs too much time and equipment. Simulations on computers are the solution to this issue. A genuine system may be modeled using computer simulations, including all of its static and dynamic properties. This method reduces the testing period while ensuring accuracy and efficiency in data collection [4].

This paper presents a simulation of an advanced driving assistant system. Towards ameliorating this, the assessment of the contribution of four different features has been utilized for detecting forward and backward collision detection, lane line detection, Signal detection, and Speed limit warning. Furthermore, we work on other features too, for example, side object detection (like poles), turn indication, give speed warnings by detecting the speed sign board. Finally, the simulation for ADAS is made and evaluated by different users.

The rest of the paper is organized as follows: section II discusses the related work; the proposed methodology is presented in section III; the setup is elaborated in section IV; results with discussions are presented in section V, and the conclusion with future work is written in section VI.

2. RELATED WORK

Similar systems have been introduced lately but the functionalities are dispersed in different sub-systems. There are several broad methods for testing and simulating an autonomous vehicle. To effectively represent the behavior of self-driving automobiles, every simulation must incorporate a hypervisor of the sensors. Although ideal models are necessary to narrow the distance between the simulation and reality, they are not sufficient to achieve this goal [5]. MathWorks produces a graphical modeling tool called Simulink. It provides a graphical modeling editor, a customizable set of block libraries, solvers for simulations, and an integrated development environment (IDE). The techniques based on learned features employ deep learning (DL) algorithms to learn and extract suitable gunshot acoustic features in a fully automated manner [6-17]. VTD (Virtual Test Drive) is an application programming interface developed by MSC Software for the development of physics-based sensors (radars, lidars, and cameras). It has been designed specifically for automotive applications. It covers the full spectrum from generating 3D content to simulating complex traffic scenarios and, ultimately, to simulating either simplified or physically driven sensor systems. It is used in software development and hardware development. It has an open and modular design which allows it to easily interface and integrate with third-party or custom simulation packages [18]. Virtual 3D Game-on simulation, tells us about how simulations are made and why they are so important, and how they can be helpful. The system is tested by the students to test the simulation. Virtual Medical Coaching Ltd.'s 3D virtual simulation tool was introduced by 1st-year radiography students. To use this technique, instructors enabled the students through a complex process of learning anatomy, radiographic placement, and pathology [19].

A traffic recognition system is designed, where core features are traffic cons, distance matching tests, and road tests. Real-time detection [20, 21] is done work through detecting road cons and checking the distance from other cars. The machine vision is utilized to join with some Dc motor controllers, and brake controllers by giving them power with BMS (Battery management system). The autopilot car is made and it gets 50 successful, in which embedded device, is served as the car's brain, not only directing the machine vision system to capture road images but also sending appropriate commands to VCU (virtual control unit) after processing the images and analyzing the car's status. VCU served as a link between the embedded computer and the onboard hardware. VCU collected real-time vehicle status data and sent it to the embedded computer [22]. The goal of ADAS to addresses the primary cause of accidents, and distractions, to address the problem of road mortality. The informational panels on the road are seen according to numerous studies, to influence a decrease in vehicle speed [23].

For the safety of the automobile, Viola jones, HOG, DPM, R-CNN, FAST R-CNN, YOLO, SSD (single shot detection), and Retina Net algorithms are employed. The prototype of the ADAS system is designed for reading variable signal signs. It includes a Retina-Net neural network, which has an average accuracy of 0.703 and distinguishes the VMS in an image and pinpoints its location with a degree of confidence. Retina-Net is based on ResNet50. The VMS-equipped portion of the image is then analyzed to extract the count using the Tesseract OCR model [24]. The RAND Corporation is an independent non-profit research organization that publishes reports on public policy challenges. RAND Corporation presented numerous studies and reports on healthcare education transportation to national security. The driving safety study was one of the first to examine the safety implications of autonomous vehicles. According to ADS would need to drive hundreds of millions, and even hundreds of billions, of kilometers (miles) before demonstrating their reliability in terms of preventing accidents and minimizing injuries. RAND also published a report called "Measuring Automated Vehicle Safety" which outlines some key findings from their research. This report provides a framework for measuring vehicle safety that could be used widely by automakers, policymakers, and the general public. Moreover, the authors also considered options for proxies (factors that may correlate with safety through simulation and closed courses). It provides a structured methodology for measuring the safety of ads at various stages of their development. While recognizing that the close-hold nature of ADS data makes it difficult for companies to share this data with government agencies, the report highlights the types of information that could be made available in a way that would support a better public understanding of ADS safety issues [25]. Transport Systems Catapult (TSC) is an independent company in the UK. It was founded in 2011 by the Department for Business Innovation and Skills (BIS), the Department for Transport (DfT), and Rolls-Royce plc. TSC has been awarded £30 million from BIS to develop the next generation of connected and autonomous vehicle technology [26]. The summary of the existing works is mentioned in Table 1.

Table 1. Summary of Existed Work

Ref#	Year	Work Performed
[27]	2022	Virtual 3D Game-on simulation
[28]	2020	Traffic Recognition
[29]	2021	Detection of signs on the road
[30]	2019	Simulation using SUMO and Unity 3D
[31]	2019	Cars-Electronic and Electrical Systems
[32]	2019	Traffic signs detection
[33]	2018	Advanced driver assistance system algorithms
[34]	2017	Machine learning techniques in ADAS

3. METHODOLOGY

The block diagram of the proposed ADS simulation is shown in Fig. 1, and details of each stage are presented in this section. There are three phases of the simulation. In the first phase of the simulation, the user interacted through the front end, the user saw the car module and the environment module. The second phase of the simulation is the back-end coding of the simulation. Here user can't see the working or scripts behind the simulation. The user only interacts with the actuators to use the simulation and the real-time animation system shows the user to make new scenarios. In the forward collision, we made colliders that detect the other objects who come near to our object. In speed limit warning, we use the limit velocity module of unity to check the speed of the object. In lane detection warning, we use a line render component to detect lane marking on the road and provide information about the line to the user and gave a warning to the user about the current lane. Fig 1 shows how a simulator works in unity-3d. First the vehicle model and environment model combine to form the user interface, then animation, combined with the simulator(unity) with actuators which are controlled by the user itself. In this way, the model works and the user interacts with it.

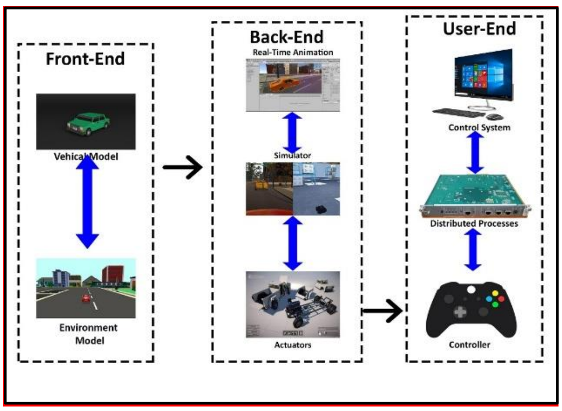

Fig. 1. Proposed system's framework.

3.1. FORWARD COLLISION WARNING

A mesh collider is used in a forward collision, where a collider is a game object and its work is to detect physical collisions. A collider cannot be seen and it has no shape, yet it contains several types known as Box, sphere, capsule, compound and mesh colliders, etc. The mesh collider is utilized in the proposed module because the collider compound is not accurate in many cases. In a 3D environment mesh collider, providing accurate results. In the proposed simulation, a collider is utilized in the front as well as the back side of the car, whenever another car moves near another car, the system starts giving a warning. The simulation results of the forward collision warning system are presented in Fig. 2.

Fig. 2. Forward Collison Warning

3.2. SPEED LIMIT WARNING

The Advanced Driving Assistant System (Simulator) can be detecting speed limit sign boards and give warnings to the driver if the vehicle is exceeding the limit. This module is implemented in this research which makes the proposed system capable of detecting the signboards within the game and provides us a warning to lower the speed whenever the system detects the speed limit signboard as depicted in Fig. 3.

Fig. 3. Speed Limit Warning.

4. LANE DETECTION

The Lane Detection feature of the Advanced Driving Assistant System (Simulator) is designed to detect lane markings on the road and provide information to the driver about the lane they are currently in. This information can be used by the driver to make decisions about their driving, such as changing lanes or turning. Also, whenever the user unconsciously switches a lane, this module would display an error warning as well.

We use the line render component to detect the lines on the road so whenever users cross those lines the system is generating a warning.

The Line Renderer part takes a variety of at least two places in 3D space and defines a straight boundary. We are utilizing a Line Renderer to draw anything from a basic straight line to a complex spiral Fig. 4 is showing a lane detection warning.

Fig. 4. Lane Line Warning.

The line is generally consistent; in which we draw at least two different lines, by utilizing numerous Game Objects, each with its Line Renderer.

5. SIMULATION SETUP

This section discusses the setup which is employed to evaluate the proposed simulation system. There is no hardware used in this project but the hardware in the loop (HIL) is used which is the keyboard or steering wheel. We just need a computer system having the following requirements to run this software system:
RAM: 16 GB
GPU: 4 cores (minimum)
Windows: 10
Disk Space: 5 GB
Graphics Card: 2 GB Recommend (PNY V2 NVidia Quadra 2GB Graphic Card)

6. RESULTS AND DISCUSSION

Over two dozen people tried out the simulation, and they all said it is a lot of fun. Even though the game is enjoyable, it also offered a reasonable level of engagement and difficulty. We can say that the Unity environment aided in the construction of the ADAS simulations effectively. If the car's search for a route on a track is implemented using typical AI research approaches, it would not have gained access to the Unity platform's elements of the pointer system, the physical engine, and vector calculating algorithms.

Unity components made it easier and faster to implement the car's path-finding process on the track, allowing it to properly simulate human driving behavior. To make the simulation more entertaining, new path-finding algorithms should be added to the current system.

Furthermore, the program may be used as a driving simulator for instructional reasons, even though it is created for learning and innovation. Fig. 5 shows the entry page of the simulation. Through our simulations we can make our youngsters aware of traffic rules, instead of giving them knowledge or instructions, we can tell them by our simulation about what these traffic signs indicate. Furthermore, we can add more traffic rules that are followed in foreign countries, from which most of the youngsters are unaware to train them in a better way. Fig. 6 shows the loading page of the simulation.

Fig. 5. Start Page of the Simulation

Based on successful testing with actual video data, it can be determined that the mixture of Unity is an ideal platform used for developing driver assistance systems. Future development of (advanced) adaptive cruise control may be based on the proposed model. Fig 6 shows the loading page of the simulation.

Fig. 6. Loading Page

Fig 7 shows the lane departure system. Expandability of the simulation software and modular implementation of driver aid technologies to accomplish results.

Fig. 7. Lane Departure Warning

Fig 8 shows the traffic light detection.

Fig. 8. Traffic Light Detection.

For future work, we will look forward to developing an ADA system using jetson nano which will be the final product. Based on this, it is possible to add further driver assistance functions, for example, an extension of the cruise controller to realize an Adaptive Cruise Controller (ACC). Fig 9 shows the comparison between our simulation and Simulink simulation on the internet.

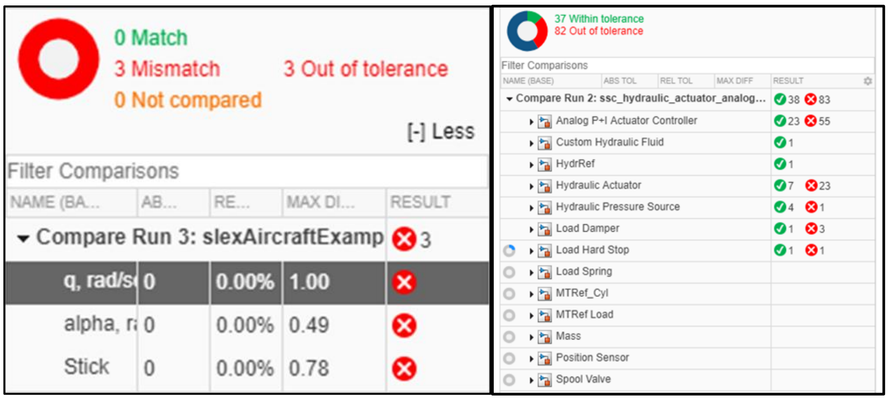

Fig.9. Comparison Between Two Simulations

To develop such systems, it can be necessary to expand the vehicle model in Unity with additional sensors. Another extension can be a comprehensive description of driving dynamics. The current model is sufficient for testing the lane-keeping assistant, but it is not satisfying for situations where dynamic limits are reached. It is important to take into account that such situations can appear when developing and testing further driver assistance systems.

7. CONCLUSION

In this paper, advanced driving assistant system simulator using unity-3D is proposed. The proposed system can efficiently detect and localize cars by giving warnings about the other cars which are in the front as well as in the back of the car. The system is not real-time, but it is a virtual environment and it would take some time to make its module further better this would only be possible if we implement it in hardware form. In future advancing driving assistant systems will be developed using jetson nano.

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