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# Development of Realistic Hazard Scenarios in a Malaysian Driving Simulator for Education

Cheng Yun Quan [1], Sarina Mansor [1]*, Chin Ji Jian [3], Hezerul Abdul Karim [1], Ban Kar Weng[2]

[1] Faculty of Engineering, Multimedia University, Cyberjaya, Selangor, Malaysia

[2] Faculty of Computing Informatics, Multimedia University, Cyberjaya, Selangor, Malaysia

[3] Faculty of Science Engineering, University of Plymouth, United Kingdom

*sarina.mansor@mmu.edu.my*

**Abstract**. In this paper, we present the development of a driving education prototype simulator, aiming to address dangerous traffic situations frequently encountered in daily life, particularly in urban areas like Klang Valley, Malaysia. Our initial driving simulator version focused on track-based training tailored to Malaysian driving exams, but we recognized its limitations in preparing learner drivers for real-world challenges due to the lack of risk. To add the value of study to our project, we designed three scenarios based on common dangerous situations observed in dashboard camera (dashcam) footage from Malaysian drivers. Due to the lack of reliable openly discussed methods on designing such scenarios and implementing it into a virtual environment, we devised a rudimentary method in the scenario designs. Our goal here is to open up the discussion to study reliable methods of designing scenarios not just for driving education but all forms of scenarios that are used for training environments. These scenarios have the potential to benefit education and training by creating realistic scenarios and environments.

**Keywords:** Driving Simulator, Driving Education, Immersive Learning, Traffic Scenarios

# 1. Introduction

Urban areas are notorious for heavy traffic, which inevitably leads to an increase in dangerous incidents and the risk of accidents. Despite reading news articles or watching video footage of such occurrences, learner drivers often struggle to mentally prepare for these challenging situations.

Fortunately, interactive learning tools, like simulators, have been in use for driving training (Hirsch P. et al., 2017), (Blanco et al., 2011) to offer a unique perspective and an invaluable opportunity for drivers to understand and practice their reactions in the face of dangerous traffic scenarios. By placing the learner in the virtual driver's seat, these simulators enable them to experience real-life reactions to hazardous situations within a safe environment. This hands-on approach allows learner drivers to recognize, learn from, and effectively respond to these challenges after being transferred to a real car (Hirsch P. et al., 2017) (Valkveld et al., 2005), (Fisher et al., 2006), potentially saving lives and minimizing the likelihood of accidents. Simulators allow learners to gain practical experience similarly to real world driving (Hirsch P. et al., 2017), (Morgan et al., 2011) which is essential for building confidence and improving reaction times in real-life driving conditions. Extensive research reviews on driving education simulators, driving simulator designs and AI-based vehicles can be found in our previous papers (Cheng et al., 2022), (Cheng et al., 2023a).

In Klang Valley, Malaysia, an urban area renowned for its distinct and perilous traffic situations, these scenarios present unique challenges that may not be immediately recognizable to learners. As the number of road accidents grew in 2022 to 545,588 with 6,080 fatalities, that is one road accident per minute and an average of one death every 86 minutes, comparing it to 2021, it is a significant increase of 47% (Wong. A. 2023). The growth of road accidents is certainly worrying. Hence, we have taken advantage of the accessibility of simulator technology to develop three different dangerous traffic scenarios commonly encountered on Malaysian roads.

There are several works focus on driving simulator design scenarios, such as fast scenario creation (Dols et al., 2016), integration of driving simulators with traffic systems (Jeihani et. al., 2017) and validation of driving behavior in controlled environments (Zhang et. al., 2020). However, there is no published works on driving simulators that catered to Malaysia's traffic. The primary aim of this article is to delve into the methodology we employed to design and create these scenarios virtually. Through our efforts, we hope to replicate the typical hazardous traffic situations prevalent in our region and foster a safer driving experience for all.

The contributions of this paper can be summarized as follows: i) Devising the methodology to design and develop the traffic scenarios in a virtual environment ii) Discuss about the result of development and prediction of real world results and ii) Open up the discussion for a reliable method to design and develop such scenarios in a virtual environment for education and research purposes.

# 2. Background of Implementation

The background of the implementation of the three traffic scenarios is to complement our previous work to provide a more interactive and engaging learning experience (Cheng et al., 2023a). With an engaging experience of hazard recognition and mitigation, it will have a more positive impact on the learner drivers (Cheng et al., 2022), (Cheng et al., 2023a), (Erhel et al., 2013), (Guillen et al., 2012). When we are researching methods to design and develop our scenarios, we realise there are no extensive studies done in this sector that can determine the parameters of designing a traffic scenario to be used effectively for driving education.

# 3. Methodology

The driving simulator is developed on Unity Engine (Unity Technologies, 2023), which is a real time game engine that is easy to use and accessible. The base driving simulator only has a track-based training on Malaysian driving curriculum, this section will be discussing our methods of designing and developing three different traffic scenarios that are commonplace on Malaysian roads. The scenarios are developed based on the modular scenes that were shown in our previous work (Cheng et al., 2023b). The AI algorithm used is a basic point tracking AI from Unity, where we point a mark and the AI car should follow the point. The method we used to lead the AI towards the next point is removing the previous mark and connecting it to the next mark.

## 3.1. Design of Traffic Scenarios

Since the traffic scenarios are based on scenarios that are commonplace on Malaysian roads, there were no reliable methods that were devised or found to design these traffic scenarios. Hence we devised our own method. The method consisted of searching and watching recent (2021 - 2022) dashcam footage videos that were posted online, mostly from YouTube. Then we based on our personal driving experience and dashcam footage to decide on 3 traffic scenarios that are common. We determine that the definition of common to be chosen is based on our driving experience. The traffic scenario has to be experienced at least once a week on Malaysian roads while driving for the past month. With this method, we can choose a few of the most common scenarios to replicate virtually. Three different scenarios were chosen to be replicated: 2 of the scenarios consisted of an Artificial Intelligence (AI) car running a red light and 1 scenario consisted of an AI car cutting into the driver's lane.

## 3.2. Scenario 1

The first scenario that was chosen is a car running a red light on the opposite side of the driver's lane in a T-junction. It is designed to replicate a car dangerously invading the driver's lane and almost causing a collision. Figures 1 and 2 shows the top and the cockpit views of Scenario 1 respectively.

Fig. 1: Top view of Scenario 1.


Fig. 2: Cockpit view of Scenario 1.

Figure 1 shows scenario 1 from the top, the yellow car will be the driver's car, the red cars will be the AI cars. In this scenario, the last red car at the back will be the AI car that will be the "dangerous" car that will follow a designated path and the rest of the red cars will be a static AI car that will not move. The driver will have to avoid collision in order to pass the level.

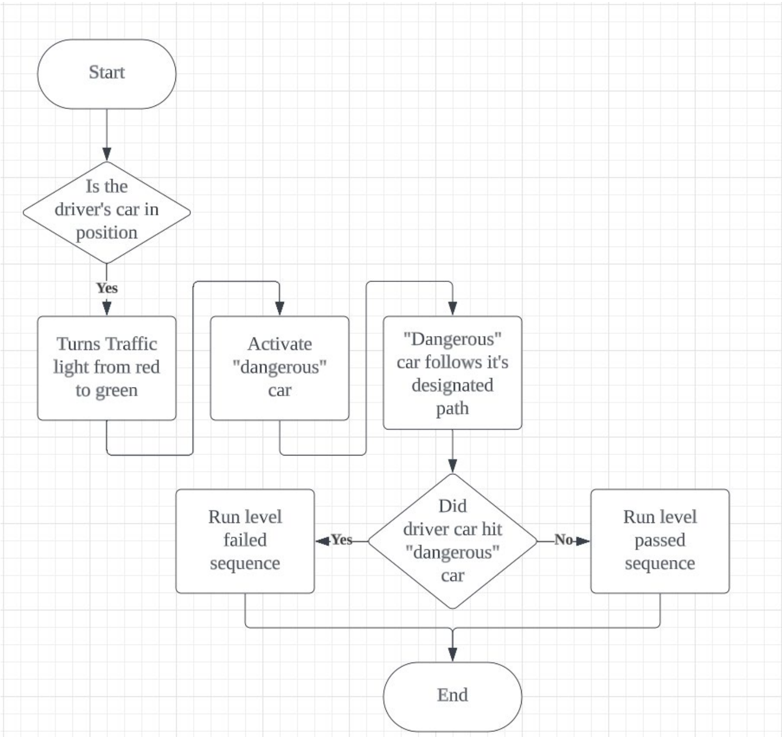


Fig. 3: Flowchart of Scenario 1

Figures 3 shows the flowchart of Scenario 1. The driver will have to drive the car to its starting position behind the traffic light and stop as it is a red light. After the driver stops at the position, the traffic light will turn to green, signifying to the driver that they are allowed to proceed. The "dangerous" car will be activated together with the traffic light change and will follow a designated path that will cross into the driver's lane at the traffic light, creating a close call situation. If the driver successfully avoids the "dangerous" car, they will pass the level. Vice versa, if they are unable to avoid and hit the "dangerous" car, they will fail the level. Figure 4 shows the designated path of dangerous car. The designated path of the car is programmed with a hierarchical finite state machine method that was published in our previous paper (Cheng et al., 2023c).

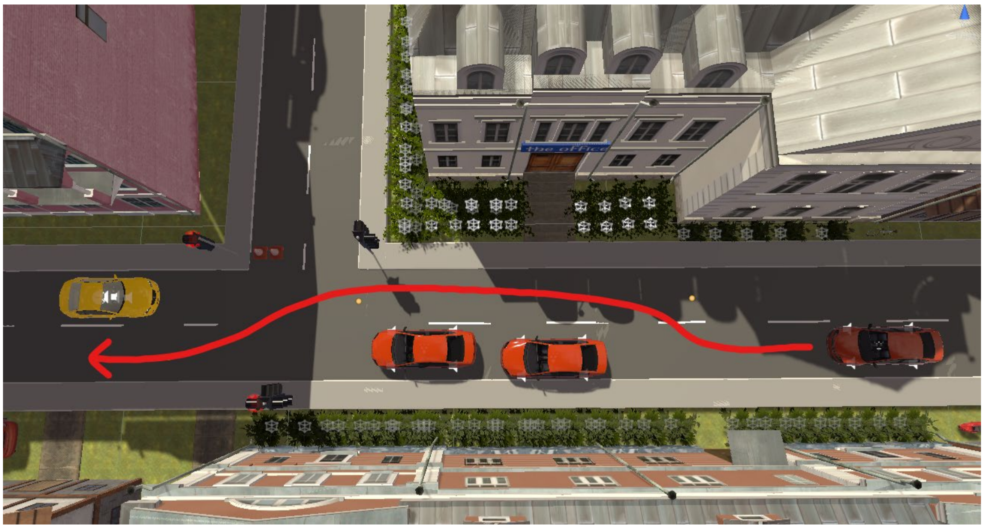

Fig. 4: Designated path of "dangerous" car (red line)


Fig. 5: "Dangerous" car cutting into the traffic junction in Scenario 1

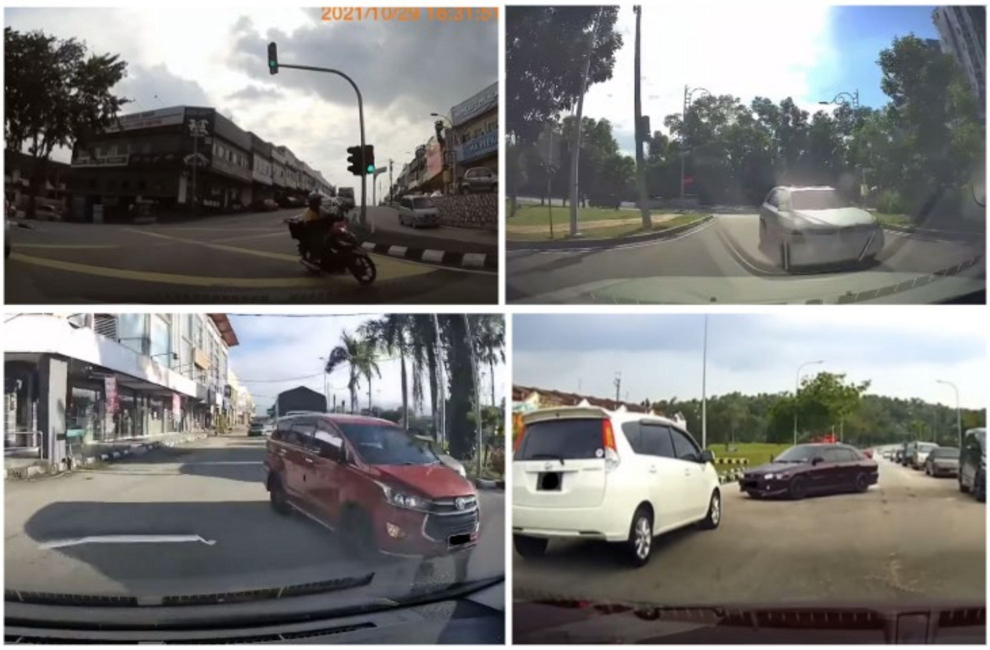

Fig 6. Compilation of similar real life scenarios based on dashcam footage.

### 3.3. Scenario 2

Scenario 2 is designed to replicate a car dangerously running a red light in the driver's left front blind spot. The chosen design is a cross traffic junction that has cars passing through and a "dangerous" car running the red light on the driver's side green. Figures 7 and 8 shows the top and the cockpit views of Scenario 2 respectively.

Fig 7. Top view of Scenario 2

Fig 8. Cockpit view of Scenario 2

Similar to Scenario 1, the driver will be the yellow car and the red cars will be AI cars. Figure 7 shows the layout for Scenario 2, the 2 AI cars on the left side are static cars; the ones at the middle are moving cars that simulate traffic in the scenario; the “dangerous” car will be the one on the right that will run the red light. The driver will have to stop to avoid a collision to pass the level.

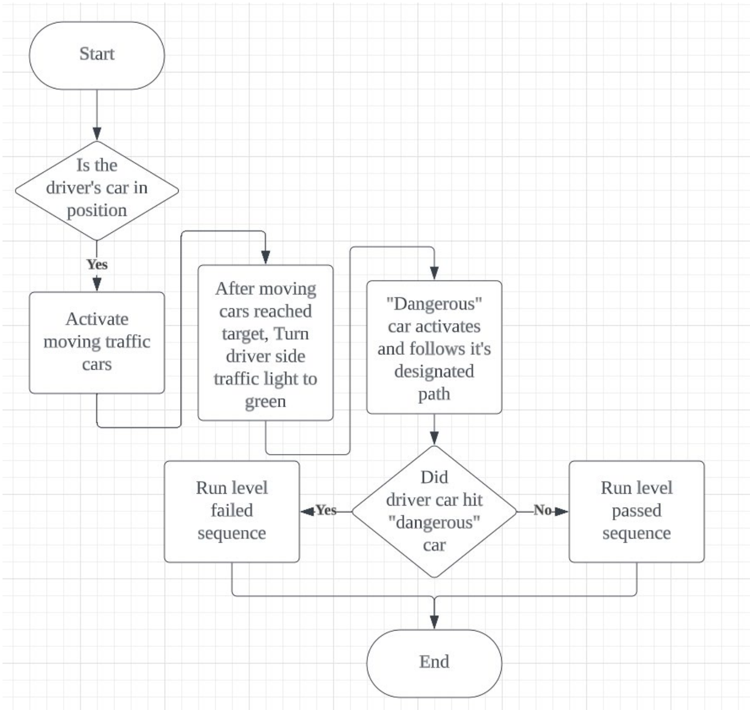

Fig 9. Flowchart of Scenario 2

Scenario 2 flowchart is similar to Scenario 1, as shown in Figure 9. After the driver car is in position, traffic cars will activate and move as programmed. When the traffic cars reach their targets, the traffic lights on the driver's side will change to green and the “dangerous” car will activate simultaneously. If the driver collides with the “dangerous” car, it will be deemed as level failed otherwise, it's considered a passed level.

Fig 10. Designated path “dangerous” car (red line) and moving traffic (green line)


Fig 11. “Dangerous” car in action from cockpit view.

Fig 12. Screenshot of a similar incident with Scenario 2 on dashcam footage.

### 3.4. Scenario 3

Scenario 3 is designed to replicate a car cutting into the driver’s lane dangerously on a highway.

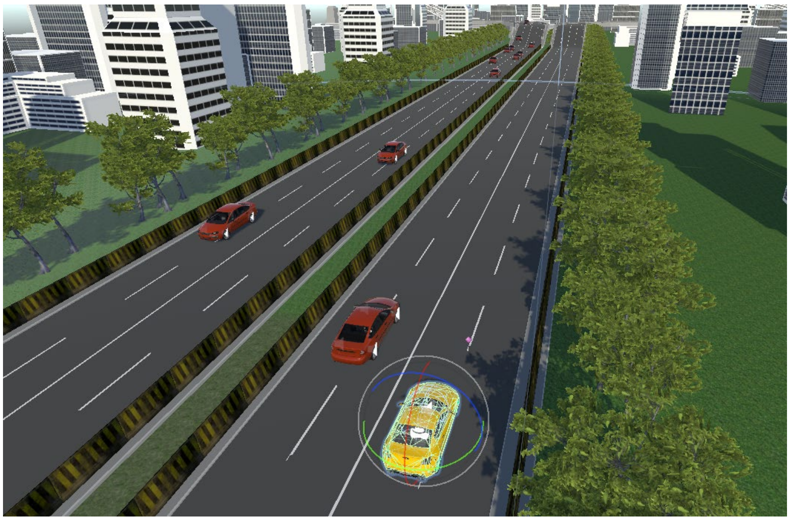
Fig 13. Top view of Scenario 3.

Fig 14. Cockpit view of Scenario 3.

There will be idle traffic on the other side of the traffic to act as background traffic as shown in figure 13. Once the driver car is in position, the “dangerous” car will slowly cut into the driver’s lane fully and exits back into its lane, simulating a careless driver. It will require the driver to take evasive maneuvers to avoid a collision with the “dangerous” car which can be seen on the left of the driver’s car in figure 14.

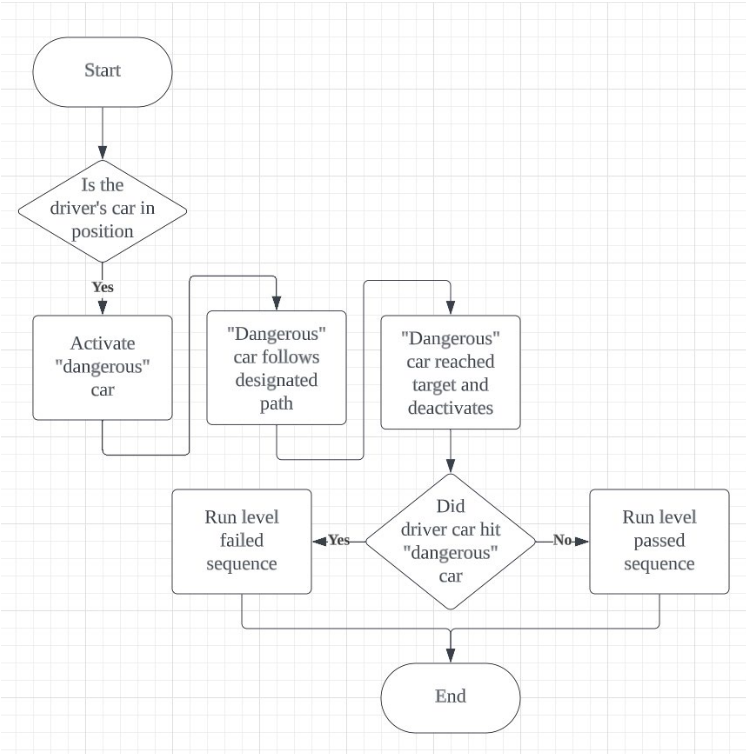

Fig 15. Flowchart of Scenario 3

Figure 15 shows the flowchart of Scenario 3. When the driver's car is in position, it will trigger the "dangerous" car to activate and it will follow its designated path. After reaching its target of moving into the other lane, it will then switch back to its own lane and follow that path till it reaches its target and deactivates itself. If the driver's car did not collide with the "dangerous" car, it will be deemed as level passed.


Fig 16. Designated path of "dangerous" car (red line)

Fig 17. Cockpit view of Scenario 3


Fig 18. Screenshot of a similar incident with Scenario 3 on dashcam footage.

## 4. Results and Discussion

In our driving education simulator project, we have implemented a significant update centered around the design and development of scenarios based on real-life situations. Extensive testing and comparison have demonstrated that these scenarios exhibit a high level of realism, enhancing the training experience for learner drivers. However, we acknowledge the ongoing challenge of virtually creating such scenarios due to the limited exploration in this area of research. There is currently no established, reliable method for determining their designs, as this area of research has not been extensively explored. To address this challenge, we have taken the initiative to develop our own methodology for identifying real-world scenarios that are easily replicable and commonly encountered. By doing so, we aim to pave the way for future projects to experiment with advanced approaches like machine learning and video processing, enabling the creation of virtual scenarios that faithfully mimic real-life situations for educational purposes.

Compared to our prior work (Cheng et al., 2023a), this development provided more realistic scenarios and a more interactive/engaging test compared to our prior work which only had a track test that is based on our real Malaysian driving test track. These scenarios can enable a different scope of awareness testing and threat recognition and mitigation training. It could prove useful in improving the awareness of drivers.

The limitation of these scenarios is repeatability and predictiveness. As the path of the AI cars are determined by points, they have limited repeatability due to the points remaining constant with each new run. We think it is also easily predicted once a driver tries a few runs. Future enhancement could provide new AI cars that use mesh mapping to follow a specific point that is randomised but similar to its original path to make the scenario less repetitive and predictable.

While our designed scenarios have not undergone testing yet, we firmly believe that they will significantly contribute to boosting the confidence of learner drivers on the road. Through hands-on experience, learners will gain invaluable insights into identifying potential threats and adeptly handling hazardous situations. Our project holds the potential for a positive and meaningful impact on driving education, empowering aspiring drivers to navigate the roads safely and responsibly.

## 5. Conclusion

Incorporating driving simulators into driving education provides learner drivers with a secure and controlled environment to learn without the inherent risks of real accidents. The introduction of three real-life scenarios in our simulator allows learners to gain hands-on experience in dealing with various situations they may encounter while driving on the road, offering a unique and invaluable perspective on how to handle such occurrences. We have great confidence that once these scenarios are thoroughly tested, they will make a meaningful and positive impact on driving education. In the meantime, we hope that this article can open up the discussion on using interactive tools and methods for driving education or other fields of education.

## Acknowledgement

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## Ethical Approval

This study adheres to the ethical guidelines. The ethical approval number for this project is EA2732021.

## References

Blanco, M., J.S. Hickman, R.J. Hanowski, and J.F. Morgan (2011). The Commercial Driver. In Handbook of Driving Simulation for Engineering, Medicine and Psychology (D.L. Fischer, M. Rizzo, J.K. Caird, and J.D.Lee, eds.), *Taylor and Francis, Boca Raton, Fla.,* pp. 241–256.

Cheng, YQ., Mansor, S., Chin, JJ., Karim, H.A. (2022). Driving Simulator for Drivers Education with Artificial Intelligence Traffic and Virtual Reality: A Review. In: Alfred, R., Lim, Y. (eds) Proceedings of the 8th International Conference on Computational Science and Technology. *Lecture Notes in Electrical Engineering*, vol 835. Springer, Singapore. https://doi.org/10.1007/978-981-16-8515-6_38

Cheng, YQ., Mansor, S., Chin, JJ., Rahman, M Mushfiqur, Karim, H.A., Kar-Weng, B. (2023a). Modelling and Evaluation of Driving Simulator for Driving Education in Malaysia. *Journal of Logistics, Informatics and Service Science*, Vol. 10, No. 3, pp. 211-220 https://doi.org/10.33168/JLISS.2023.0316

Cheng, YQ., Mansor, S., Chin, JJ., Karim, H.A., Kar-Weng, B. (2023b). Enhancement of Prototype Driving Simulator Using Available AI-Based Game Technology. *In: Yang, XS., Sherratt, R.S., Dey, N., Joshi, A. (eds) Proceedings of Eighth International Congress on Information and Communication Technology. ICICT 2023. Lecture Notes in Networks and Systems, vol 694. Springer, Singapore., pp. 569-579.* https://doi.org/10.1007/978-981-99-3091-3_47

Cheng, YQ., Mansor, S., Chin, JJ., Karim, H.A., Ban. KW. (2023c). Exploration and Showcase of FSMs and HFSMs Traffic in Low-Cost Educational Driving Simulator. In: Kang, DK., Alfred, R., Ismail, Z.I.B.A., Baharum, A., Thiruchelvam, V. (eds) *Proceedings of the 9th International Conference on Computational Science and Technology. ICCST 2022. Lecture Notes in Electrical Engineering, Springer, Singapore.* 983, 465-475. https://doi.org/10.1007/978-981-19-8406-8_37

Dols, J.F, Molina, J., Camacho, F.J., Marín-Morales, J., Pérez-Zuriaga, A.M, Garcia, A. (2016). Design and Development of Driving Simulator Scenarios for Road Validation Studies. Transportation Research Procedia, Vol. 18, 289-296. https://doi.org/10.1016/j.trpro.2016.12.038

Erhel, S., Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers and Education* 2013, 67, 156–167.

Fisher DL, Pollatsek AP, Pradhan A. (2006). Can novice drivers be trained to scan for information that will reduce their likelihood of a crash? *Injury Prevention,* 12, 25-29.

Guillén Nieto, V., Alesón-Carbonell, M. (2012). Serious games and learning effectiveness: The case of It's a Deal*!* *Computers and Education*, 58, 435–448.

Hirsch, P., Choukou, M.-A., & Bellavance, F. (2017). Transfer of training in basic control skills from truck simulator to real truck. *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2637, No. 1, pp. 67–73.

Jeihani, M., NarooieNezhad, S., Kelarestaghi, K.B. (2017). Integration of a driving simulator and a traffic simulator case study: Exploring drivers' behavior in response to variable message signs. *IATSS Research*, Vol. 41, No. 4, pp.164-171. https://doi.org/10.1016/j.iatssr.2017.03.001

Morgan, J.F., S. Tidwell, A. Medina, and M. Blanco. (2011) On the Training and Testing of Entry-Level Commercial Motor Vehicle Drivers. *Accident Analysis and Prevention*, Vol. 43, No. 4, pp. 1400–1407.

Unity (2023) 'Unity real-time development platform'. Available at: https://unity.com

Vlakveld, W.P. (2005) The Use of Simulators in Basic Driver Training. *Institute for Road Safety Research*, Netherlands.

Wong, A. (2023). Malaysia recorded one road accident per minute in 2022. Retrieved from https://soyacincau.com/2023/06/15/malaysia-records-one-road-accident-per-minute-in-2022/

Zhang, Y., Guo, Z., Sun, Z. (2020). Driving Simulator Validity of Driving Behavior in Work Zones. *Journal of Advanced Transportation*, Vol. 2020, ID 4629132. https://doi.org/10.1155/2020/4629132