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UTM
UNIVERSITI TEKNOLOGI MALAYSIA

Virtual Reality Application Real-Time Action Detection To Assist Learner In Car Driving

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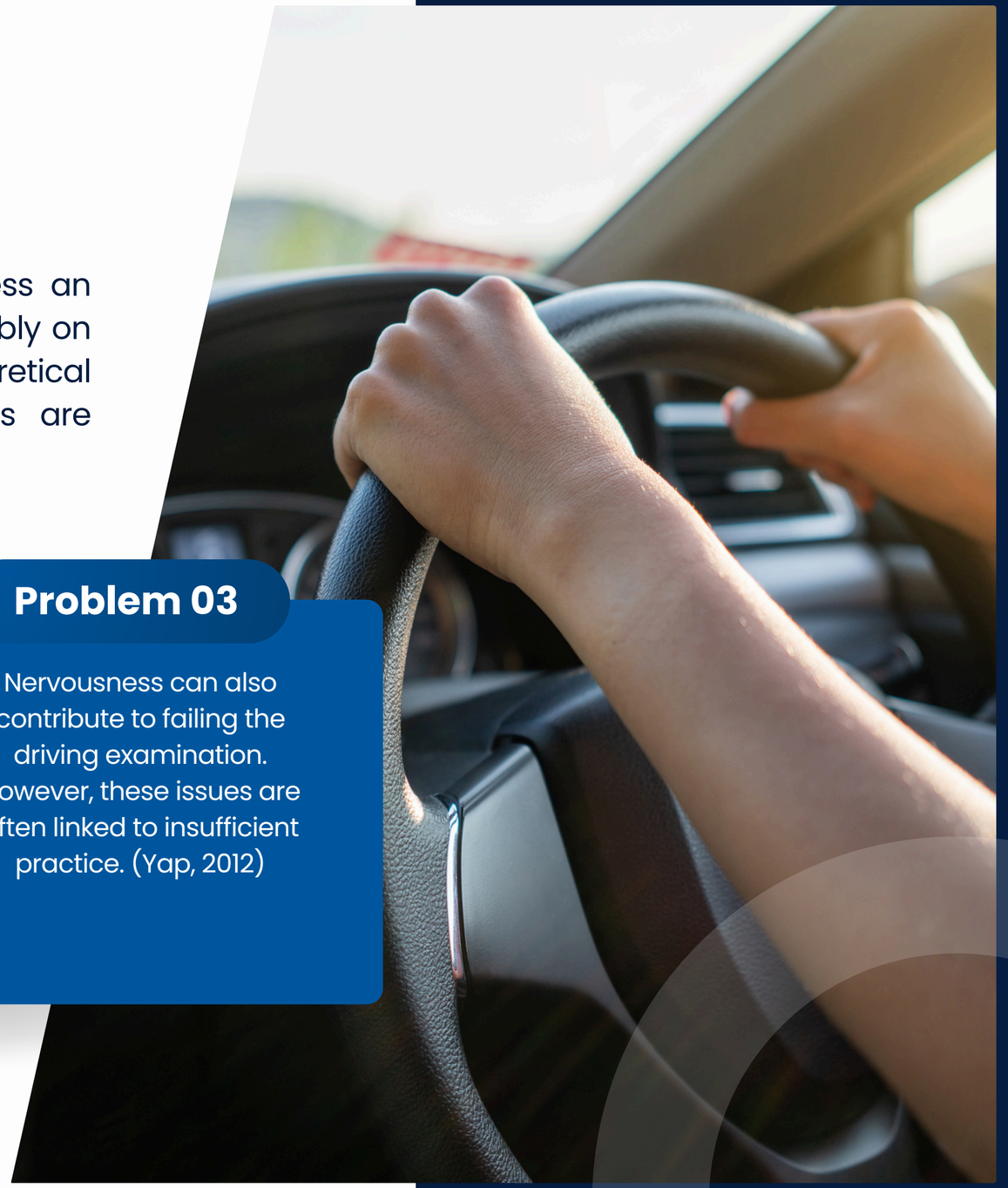
Problem Statement

The driving test is an important assessment designed to assess an individual's ability to operate a motor vehicle safely and responsibly on public roads. These examinations typically assess both theoretical knowledge and practical driving skills to ensure that drivers are competent and aware of road safety regulations.



Problem 01

Many candidates struggle to meet the strict standards set by examiners, resulting in failure in the practical part of the exam (Anwar, n.d.).

Problem 02

Unpredictable weather conditions, like heavy rain, can cause failure due to low visibility or the candidate’s oversight in turning on the headlights (Leon, 2019).

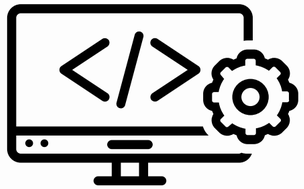
Problem 03

Nervousness can also contribute to failing the driving examination. However, these issues are often linked to insufficient practice. (Yap, 2012)

Objectives

Objective 01

To study the previous works in line with collecting data analysis on driving tests.



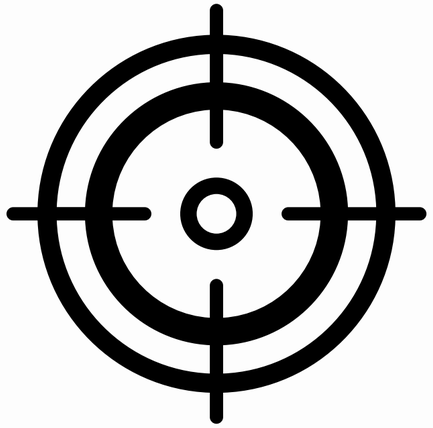
Objective 02

To design and develop a 3D car driving application using virtual reality environment that can assist learners in driving.

Objective 03

To evaluate user experience and the interaction between learner and the virtual reality environment when driving.

Project Scopes



Scope 1

This project is a single-player educational learning application designed exclusively for the virtual reality (VR) platform, presenting users with 3D real world scene.

Scope 2

It targets individuals aged 18 and above without a driver's license in Malaysia, assuming basic VR experience and utilizing English as the language of instruction.

Scope 3

This project needs a simulator pedal as an input for acceleration and braking.

Scope 4

This project provides real-time feedback on the actions of users when driving.

Scope 5

This application provides players with repeated challenges, allowing them to restart from the closest respawn point when they make significant driving errors.

Scope 6

The application records users' play results in a database and requires VR headset and VR controllers for this application.

Scope 7

The project follows driving rules outlined in the Driver Education Co-Curriculum Book (Kurikulum Pendidikan Pemandu Kelas D Automatik), focusing on Rutin Sebelum Memandu (RSM) and Rutin Selamat Memandu. It simulates virtual cars equipped with automatic gearboxes.

Project Importance (Proposed Solution)

01 This project is developed to allow users to practice how to drive a car in a safe environment and improve their driving experience by utilizing the VR headset.

02 The main concept in this application is the users need to drive a car using the simulator pedal and VR controllers to control the throttle, brake, steering, handbrake, and gearbox.

03 When users drive the car, the real-time action detection system will always remind the users when users make some mistakes.

04 Users need to make timely adjustments to ensure smooth driving. After many times of driving using VR, users can easily drive on the road and pass the driving examination.

Comparison Between Existing Systems

Virtual Driving School

This game gives players tips on how to become safer drivers, in a hyper-real, virtual environment. It also engages novice drivers with a virtual experience that improves hazard perception and raises awareness of risk-taking in a digital world

Car Parking Simulator VR

Car Parking Simulator will provide a very lifelike sandbox in VR for players to play with, where players will be solving environment-based puzzles via the vehicles, learn to park if players are new to driving or simply have fun the way players want to.

Proposed Idea

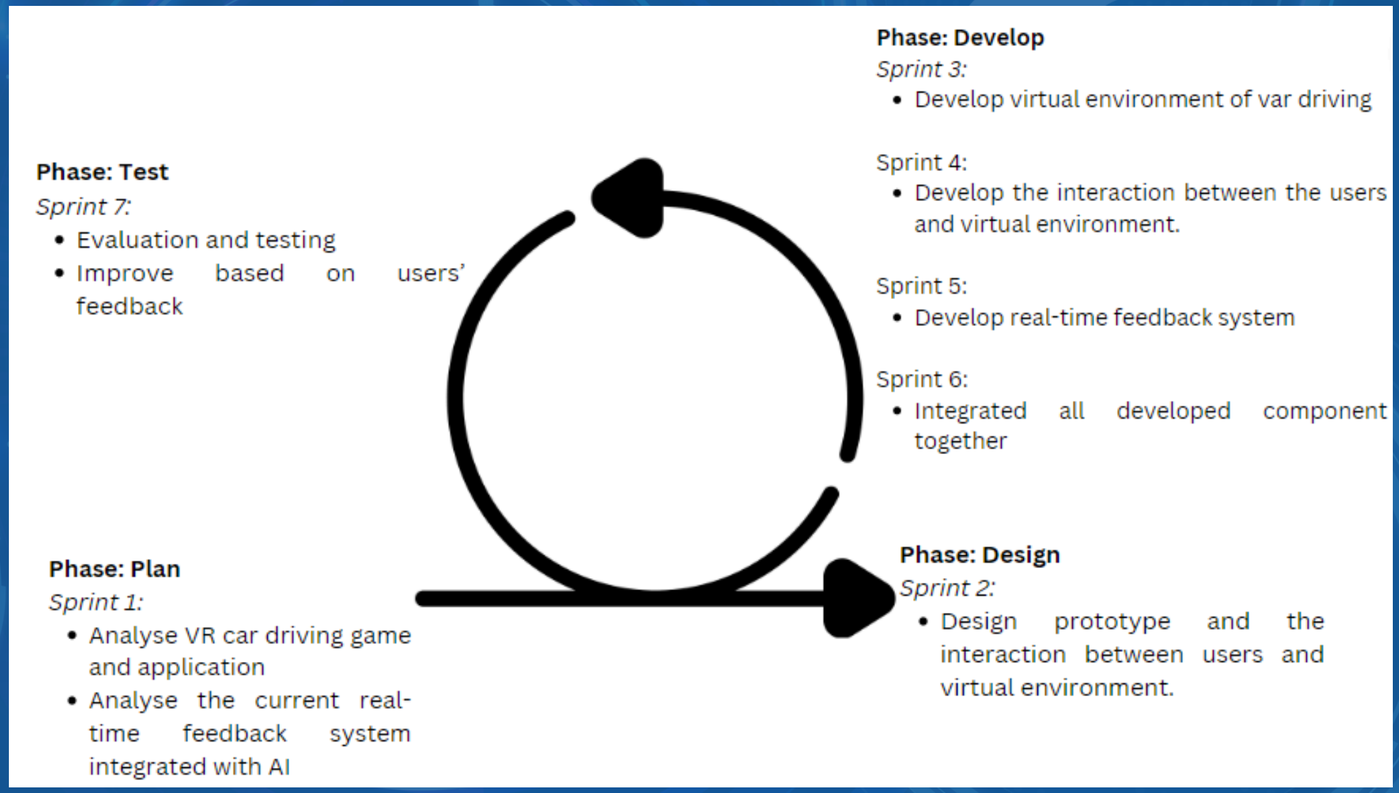
This project is a single-player educational learning application for driving. When users drive the car, the real-time action detection system will always remind the users when users make some mistakes.

Comparison Between Existing Systems

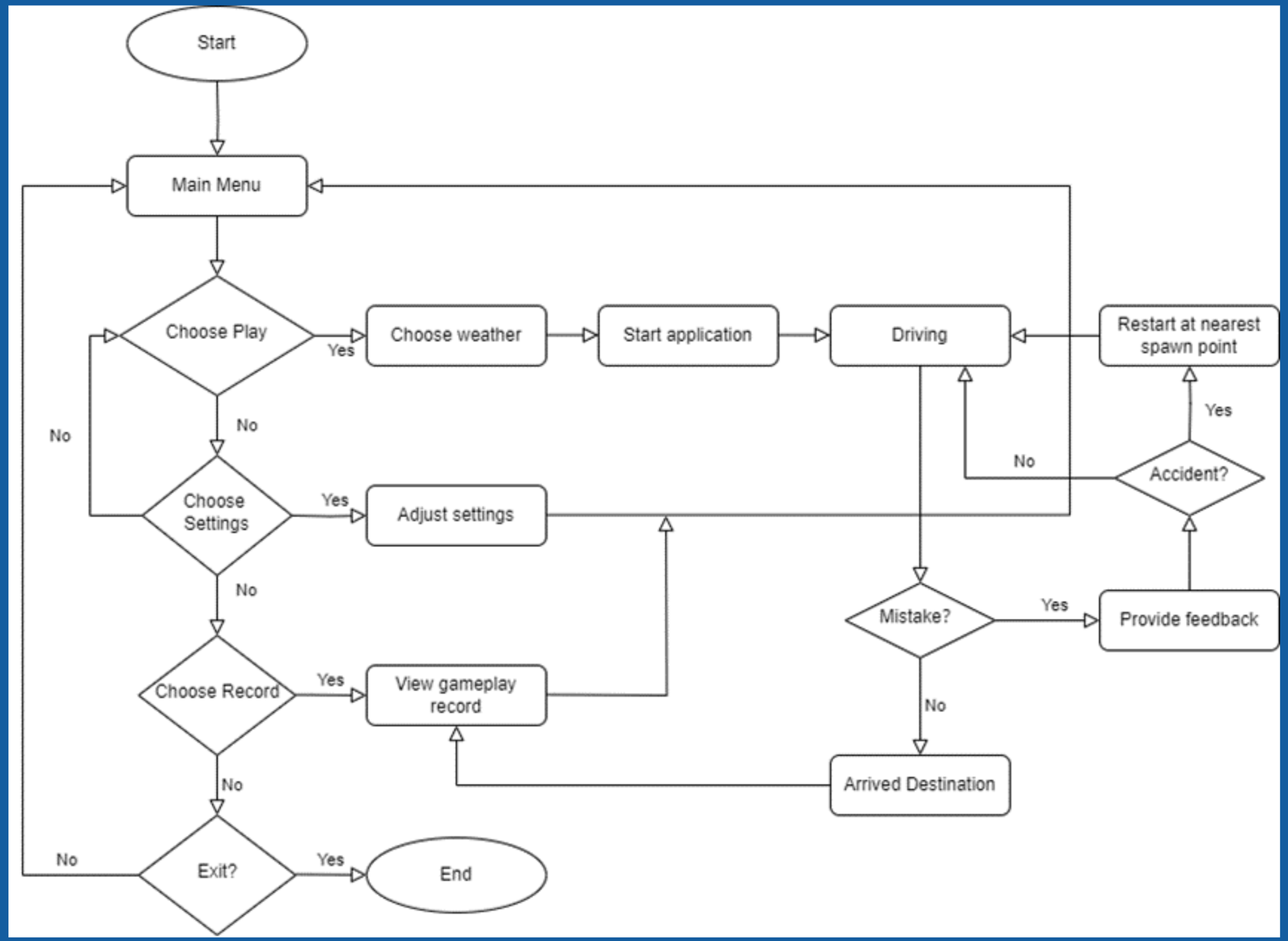
	Proposed Idea	Virtual Driving School	Car Parking Simulator VR
Game Modes	Single User	Single User	Single User
Supported Player Modes	Sitting	Sitting, Standing	Sitting, Standing
Audio	Yes	Yes	Yes
Head Mounted Display (HMD)	Yes	Yes	Yes
Supported Platform	VR	Windows, IOS, VR	VR
Gamification Concept	No	Yes (Skill-Based Game)	Yes
Environment	Real World	Real World	Anime
Navigation	Yes	Yes	No
Steering Wheel Supported	Yes	Yes	No
Real Time Feedback when Doing Mistake	Yes	No	No

METHODOLOGY

Agile is a form of software development methodology that divides projects into many phases, commonly known as sprints. Agile can be divided to six iterative phases, including plan, design, develop, test, deploy and review and it forms a continuous cycle of development. However, the phases of this project will only be completed up until the testing stage.

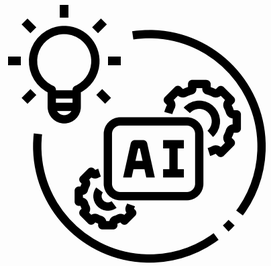


Application Working Flow



Technologies Used

Unity



Unity ML-Agents Toolkits

Real-Time Feedback System

VR HMD

Unity

Unity is a powerful game development engine used to create the VR car driving application. It provides various tools for building immersive environments, realistic physics, and complex interactions.

Moreover, the complex interactions between game objects are supported by Unity. Developers can program the traffic lights to change in response to traffic flow and the pedestrian can interact with the traffic lights.

Unity also has built-in support for various VR platforms, and this allows developers to create VR car driving applications with the head tracking, hand tracking, hand controllers and interactive audio. Unity XR Toolkit is one of the useful packages to simplify the process of adding VR interaction and make the VR development easier.

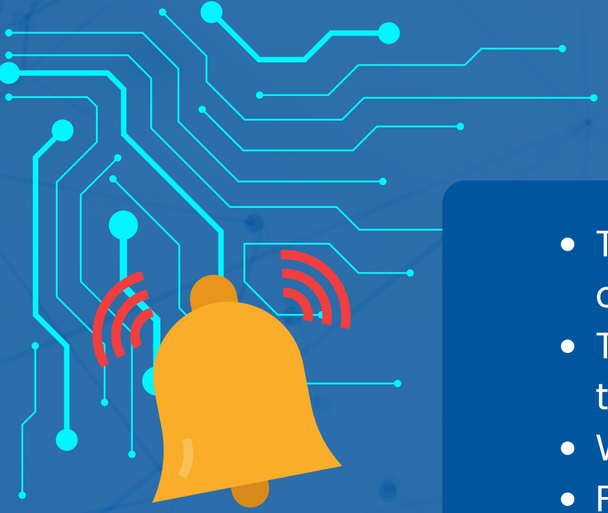
Additionally, Unity features a strong physics engine that can mimic real-world physical interactions. This is essential for driving simulations because it enables precise modeling of vehicle dynamics, collisions, and environmental interactions.

Unity offers tools for optimizing performance by using features such as level of detail (LOD) management and occlusion culling.

Unity ML-Agents Toolkits

ML-Agents allows developers to integrate machine learning into the application. The type of the machine learning used in Unity ML-Agents Toolkits is reinforcement learning. AI agents will learn by trying different actions and receiving rewards or penalties. In this project, ML-Agents are used to train AI-driven cars that can follow the traffic rules and react to the users' actions. AI cars learn to drive by getting positive feedback for good driving and negative feedback for mistakes.

The real-time feedback system will integrate with the ML-Agents toolkits to provide immediate and continuous feedback to users when driving a car. Implementing ML-Agents needs to set up the virtual environment with defined observation and actions spaces to configure the AI agents' behaviors, design a reward system, and train the agents using the reinforcement learning algorithm. Once trained, the AI agents are integrated with the real-time feedback system to enable immediate feedback based on their actions while driving.



Real-Time Feedback System

- The real-time feedback system can monitor the user driving actions and provide immediate feedback for corrections.
- The feedback system continuously observes the user's driving behaviors such as speed, lane position, traffic signal and interaction with other vehicles.
- When the system detects a mistake, it will provide various types of alerts like visual alerts and audio cues.
- For visual alerts, on-screen messages will pop out to highlight specific mistakes such as speeding or illegal lane change.
- For the audio cues, sound effects or spoken warnings can alert users to their mistakes.

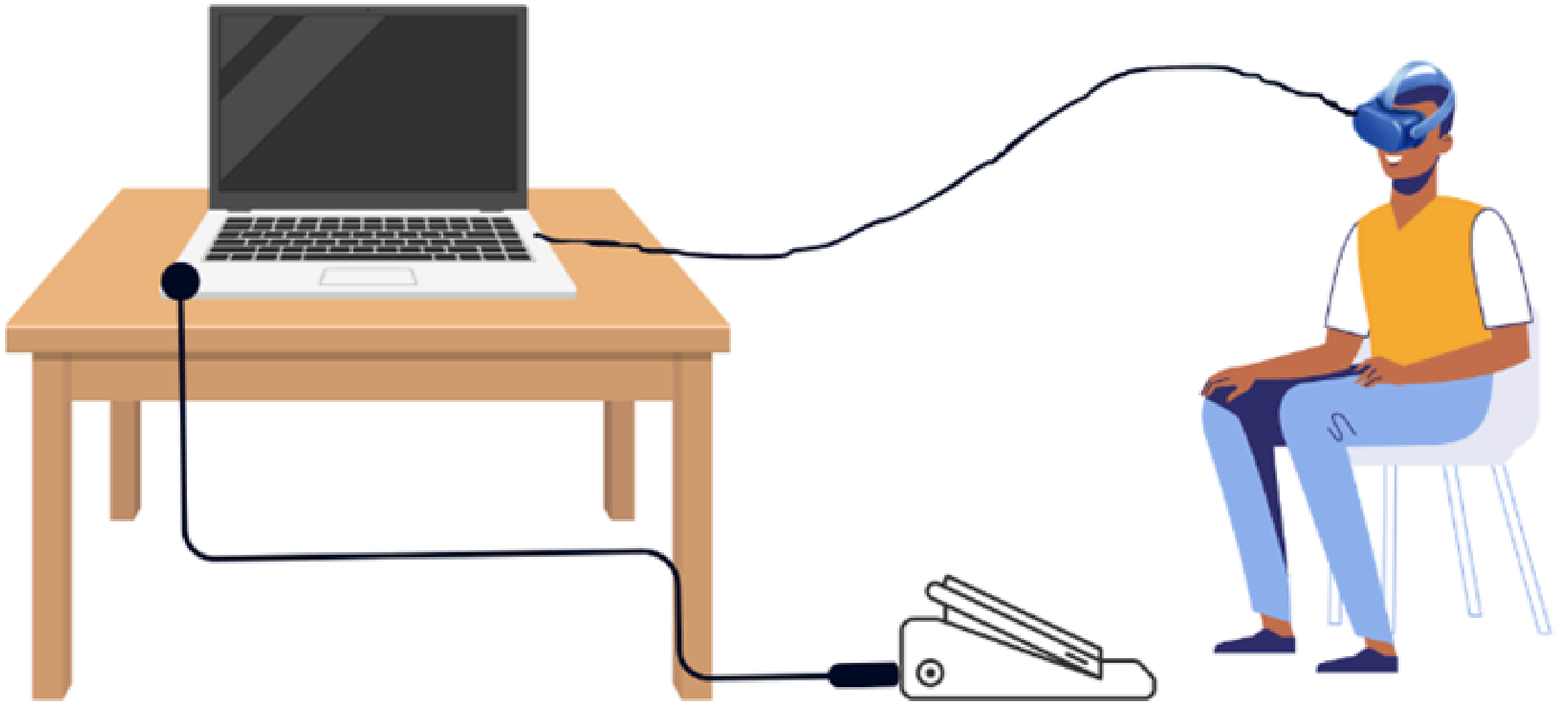
VR HMD

- VR HMD like the Meta Quest 3 are used to immerse users in the virtual driving environment.
- The HMD provides a 3D view of the city and tracks the users' head movements to make the experience feel real.
- Users are allowed to look around the virtual world just like in the real world, and this can enhance realism and interaction of car driving.
- This immersive technology helps users engage with the virtual environment deeply and provides a more effective and engaging learning experience in VR car driving applications.

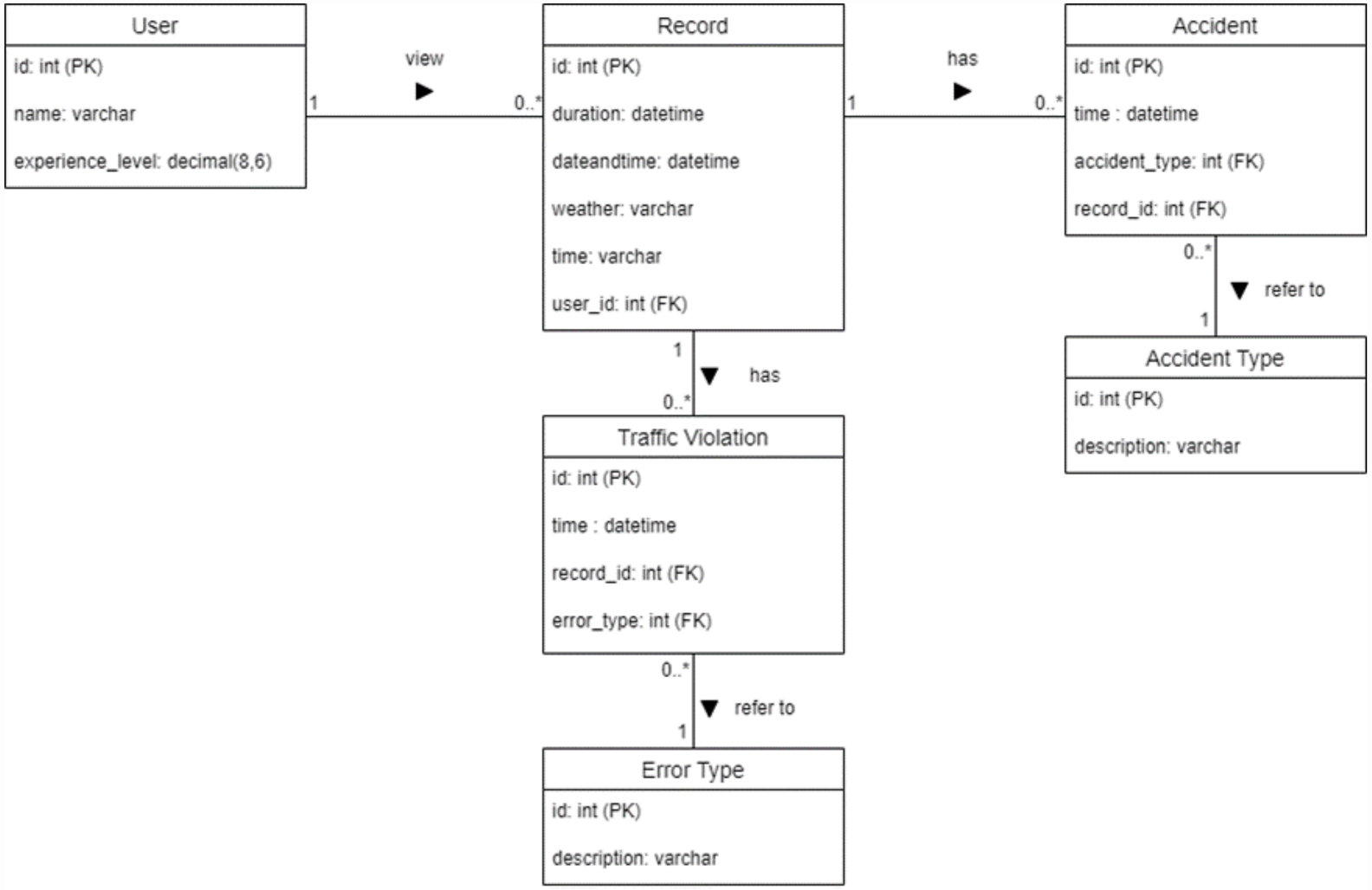
Hardware and Software Specification

Hardware	Software
Laptop • **CPU: Intel(R) Core(TM) i7-9750H @ 260GHz** • **NVIDIA GeForce GTX 1650 & Intel(R) UHD Graphics 630** • **Memory: 16.0 GB** • **Window 11**	Unity 2023.2.20f1
VR HMD • **Meta Quest 3** • **USB-C cable**	Visual Studio Code
Controllers • **Touch Plus Controllers** • **PXN V3 Pro (pedal)**	

Project Design



Database Design



Interface Design

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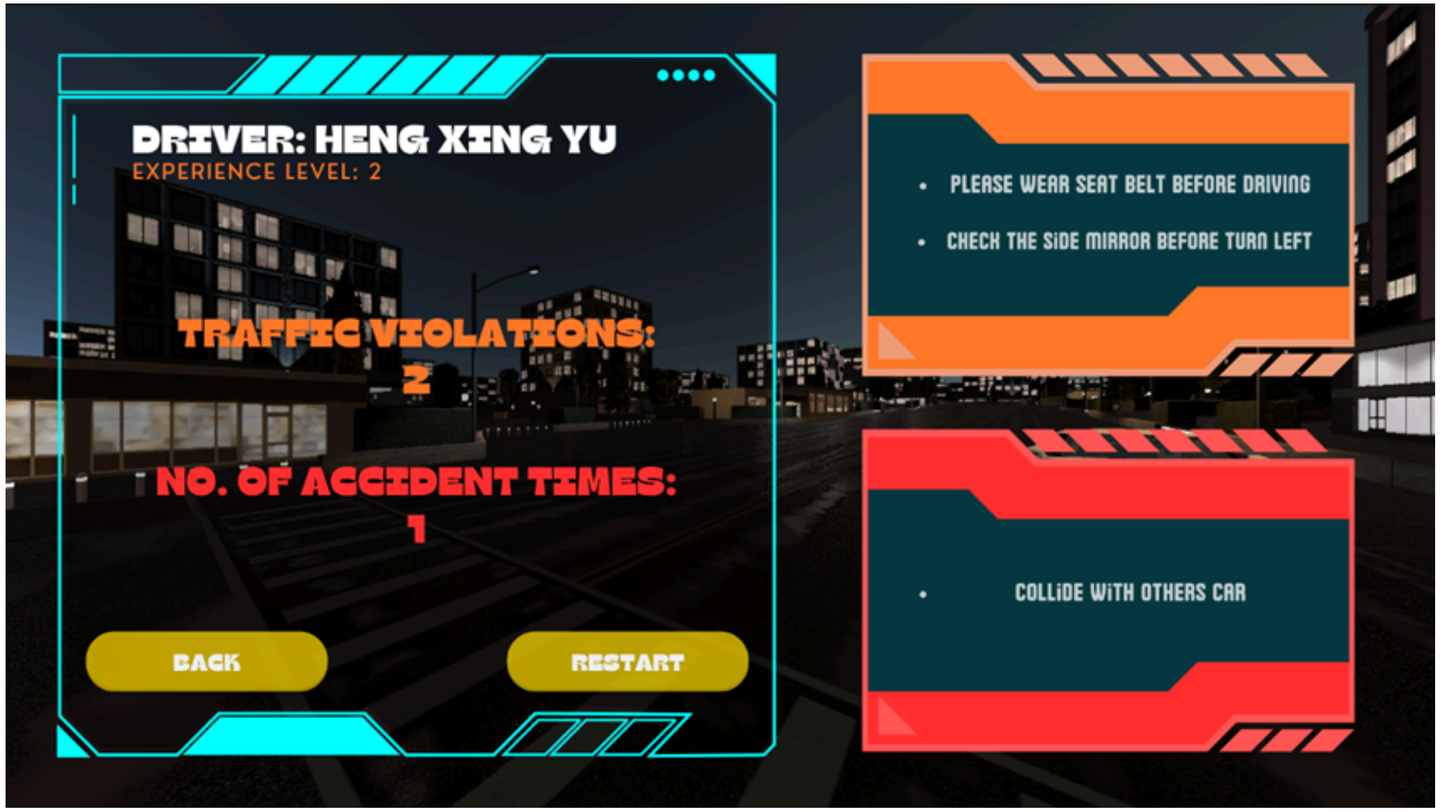

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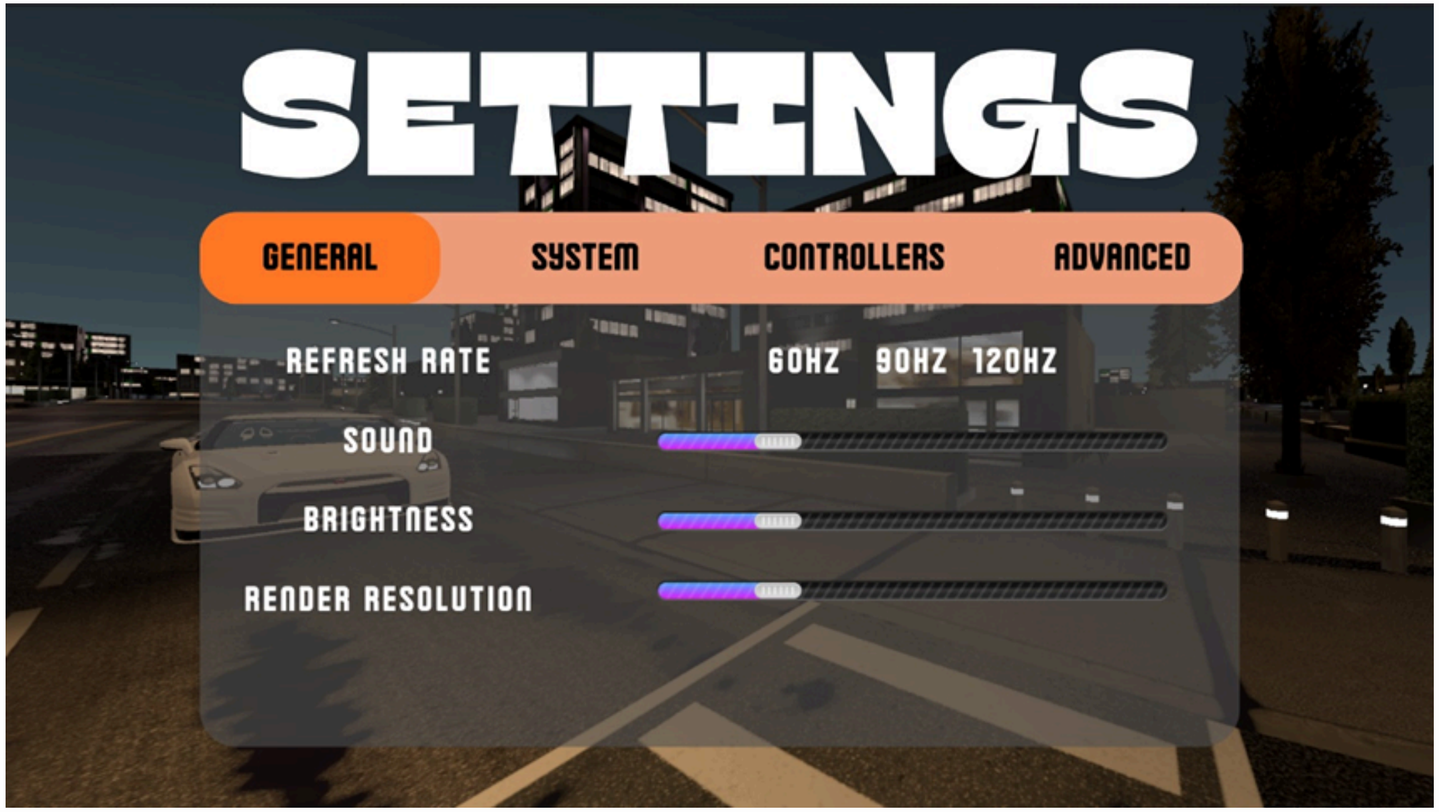

Interface Design

Conclusion

Expected to Achieve

- Study the previous works in line with collecting data analysis on driving tests
- Design and develop a 3D car driving application using virtual reality environment that can assist learners in driving
- Evaluate user experience and the interaction between learner and the virtual reality environment when driving

Constraints

- The decision of buying pedal is difficult because the website only provides a limited number of resources for connecting pedals to VR headsets, and some pedals may not connect at all.
- With little to no experience with VR, there was a lot of reading and research required
- The laptop's specifications are slightly lower for developing VR applications .

THANK YOU!