SERIOUS GAMING FOR AMATEUR BIKE-RIDERS OF SRI LANKA: A CONCEPTUAL STUDY

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Abstract

The fatalities and injuries caused by accidents are relatively high due to rapid urbanization and exponential motorization. In particular, the accidents from motorcycles are significant as this class of vehicles is considered less safe and exists in large numbers across Low and Middle-Income Countries. The researchers have identified that the primary cause of motorbike-related accidents is lack of knowledge of traffic rules by the amateur bike riders. Further studies have proved that fatal crashes occur mostly among the young age group ranging from 21 – 25. Hence, this paper aims to present a framework on applying the serious gaming concepts in conjunction with the state of the art Artificial Intelligence techniques to educate and train the bike riders with the traffic rules of Sri Lanka as this young group tends to get fascinated and immersed by simulator games often. The proposed design of the game is based on the Design, Play, and Experience Framework

Keywords: vRide, Simulator Game, Serious Games, Waypoint Systems, Vector Calculation

1. Introduction

Annual death tolls around 1.2 million from road traffic crashes [1]. The World Health Organization reports (2013) that the traffic-related injuries and fatalities are highly prevalent in Low- and Middle-Income Countries and it amounts to nearly 90% when compared with Developed Nations. Further WHO emphasizes that the exponential motorization, lack of road safety culture, poor conditions of the road, and lack of knowledge on road safety are the root causes for high rates in Low- and Middle-Income Countries. Also, the contribution of road accidents from Motorcycles is relatively high due to the reason that it is typically considered less safe than other motor vehicles. In Sri Lanka, around 55% of the vehicles registered comprised of motorcycles alone which is much similar to the mode of transportation in other Low- and Middle-Income countries. Rather, scholars have evaluated that 40% of the annual total accidents in Sri Lanka are Motor Cycle related accidents [2]. Further, road traffic accidents have been enlisted as 10th as the leading causes of deaths in Sri Lanka [3].

The Sustainable Development Goal launched by the World Health Organization in the year 2015 targets to halve the number of global deaths and injuries from road traffic accidents by the year 2020. However, the rate is steadily increasing, and it is

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forecasted that deaths and injuries resulting from road traffic crashes will rise to 65% from the year 2000 to 2020 globally, particularly in Low- and Middle-Income Countries like Sri Lanka. Therefore, the implementation of countermeasures to overcome this huge loss is an urgent need for the country. Since the root cause of this peak rate could be attributed to the lack of knowledge in traffic rules and the negligence to learn it accordingly especially by the bike riders, this particular research has aimed at using the domain of "Serious Games" as a timely solution which can significantly contribute to providing training to amateur bike riders of the country.

Serious games are generally characterized as games whose primary objective is not entertainment in contrary to the traditional video games designed to provide pure entertainment as depicted in Figure 1. It is further believed to improve the user experience through providing multimodal interaction [4] [5]. In addition, the word 'serious' in serious games is meant for its crucial role in conveying a message or knowledge or input or any content to its intended users [6].
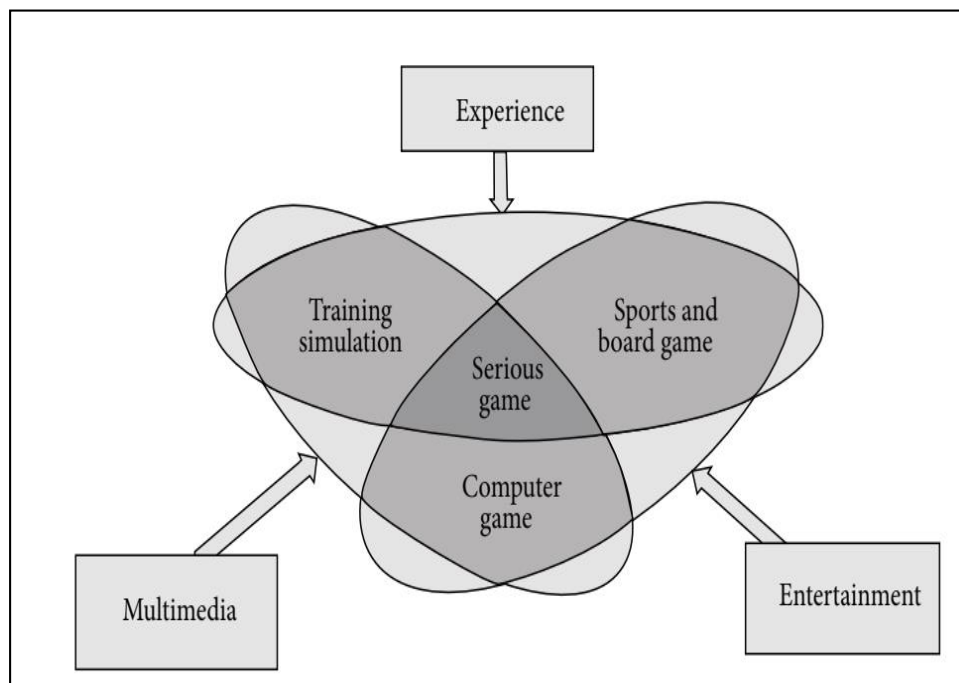

Figure 1. Definition of Serious Games [6]

Serious games have been applied in many spaces, yet the application of serious games for Education and Training is highly successful. Further, it has brought significant changes and has been much successful in providing mental as well as activity-based training. Hence, this research identifies the domain of serious games as a countermeasure to reduce the rate of motor traffic accidents, particularly the accidents caused by motorcycles, through the development of a simulator game to provide training and knowledge to amateur bike riders in compliance with Sri Lankan Traffic Rules.

2. Background Literature

2.1 Potential Applications of Serious Games

2.1.1   **Education & Training:** The Educational domain is considered to be the one that has been benefited from Serious Games immensely. The Serious Games application is very much coined with Education and Training. The tendency to get addicted to games and the obsession that players have with digital video games have been utilized to improve the learning process of the players. The game "Skills Arena" [7] has been developed for the teaching of arithmetic skills with varying levels of difficulty through the use of Nintendo Gameboy. The game was also reviewed, and it has obtained proven success in improving the mathematical skills of the students involved. "Making History" [8] is yet another example of Serious Games which has been used for the teaching of History lessons. The case study on this game has also identified increased benefits in understanding history over traditional methods. "Lost in the Middle Kingdom" [9] is another typical serious game that allows and trains the players to learn second languages. In addition to the above games, the serious games in the domain of Education and Training have come up with several objectives as follows but not limited to social awareness; teaching about poverty; to make players realize the hardship in farming; to educate on transportation difficulties, effective management of water & energy management in highly populated cities; to educate on challenges related to sustainability; to train the surgery residents on surgeries.

2.1.2   **Health & Wellbeing:** The application of serious games for health and well-being is also highly notable. "Heartlands" [10] is a mobile-based exercise game where the players are supposed to walk around an area of their choice during which the heartbeat will be monitored through a pocket PC enabled with Global Positioning System (GPS). "Monster and Gold" [11] is another such game that encourages the players to jog in order to maintain an optimal level of heart rate. An Exercise-based game titled 'Fish'n'Steps [12] keeps a track of record of footsteps using a pedometer. This game is a multi-player version where the players encourage each other to improve walking. The study on this game proved that it helped for the improvement in health practices. Moreover, another instance of a serious game applied in the field of health and well-being is Sensor Network for Active Play, SNAP in short [13], which involves the active movement of the whole body through various dance steps instructed in the game. The game evaluates the performance of the player through the use of diverse sensors designed in a network. This game has also proven that this application is much success in terms of energy expenditure as well as the adjustment of the rate of the heart.

2.1.3   **Advertisement:** The games that are used for advertisement are often coined with the term 'Advergames'. This type of game is mainly designed for the promotion of either a brand or a product or a service to its players. Many brands have been successful in advertising their brands through the use of Advergames such as NFL, Formula One, Pepsi, 7-Up, Burger King. These

products are commonly advertised within certain other games where the brand is generally retained within the memory of the players as they get into the games intensely. A controlled study [14] conducted to evaluate the impact of such a mode of advertisement revealed that around 35% of the respondents were able to recall the advertisements displayed in the video game they played.

2.1.4   Cultural Heritage: This particular domain typically aligns with that of Education where the application of serious games provides cultural education. However, they do bring out certain additive advantages of conveying an awareness of cultural heritages and let the players appreciate artifacts since the games generally reproduce the cultural heritages and sites through real-time interactive visualization or a simulation of realistic heritage scenarios. The application also up brings a thought of preserving places of cultural value. The developers use techniques such as storytelling or providing inbound training in order to educate the players on the culture and the tradition, the beliefs, norms, and social values of different historic periods.

ThIATRO [15] is an online serious game that enables multiple players to play online where the learning of art history is made easy for its players. The game uses the Web3D technique to provide bidirectional interaction between the museums and the people who visit. The game has been successful in providing a virtual 3D social experience. Solis Curse [16] aims at improving the cultural awareness among its players through a series of questions asked during the play. The player is allowed to progress and score high with the right choice of answer. The game also possesses a global ranking ladder based on the scores obtained.

2.1.5   Interpersonal Communication: Another serious use of a serious game is its application in developing interpersonal communication. Communication is essential to living a better life in this world. Several games have been built to develop linguistic skills as well. Tactical Language and Culture Training Systems [17] utilize the Artificial intelligence approach that enables the players to interact in Arabic to identify a virtual town. The players need to get to a particular town by interacting with the locals through the use of appropriate languages and gestures. Another such training system is VECTOR [18] that helps its users to practice the American culture and the language. The game StoreWorld [19] allows its players to learn the etiquette of the business world by providing training on social interaction.

Another such game is SimParc [20] that supports intercultural management of participation through which the players need to perform proper communication to promote biodiversity as well as social inclusion. These games provide a great platform to provide a good practice where the players do not hesitate to get trained as they can learn from their own mistakes without hesitation. Rather, these games have cost-effective when compared to the real coaching classes on interpersonal communication.

2.1.6   Medicine: Applications of serious games in biomedical health care fall mainly under 04 categories namely monitoring of health; detection & treatment; therapeutic education & prevention and rehabilitation. Home

Automated Telemanagement (HAT) system [21] teaches the symptoms related to congestive heart failure and how this disease behaves. This system also allows its users to monitor their symptoms, track their changes in body weight, and enhance their quality of life. Another similar framework has been proposed by [22] for the diagnosis of patients. This game collects information about its players in a very relaxing manner and helps immensely for the monitoring of their health. Match-3 [23] is another game that is used to control obesity during childhood by the use of Wii-mote. Brain chi, Dancing Robot [24], 21 Tally [25] are a few other examples where the serious game is used for the detection and treatment of various diseases and disabilities.

The use of serious games for therapeutic education has also been highly successful. These games either teach the patients or the people around them to cope up with an illness. One such game is Elude [26] that helps patients suffering from depression by educating the people surrounding him/her. The players get the knowledge at first and it also allows them to get involved in the therapy. Rehabilitation has gained wide popularity especially among the potential applications of serious games in biomedicine when compared with others. This has mainly benefited the patients who have lost control of motor skills and certain other disorders. Rehabilitation Gaming System [27] has been developed focusing on people who are suffering from Brain Lesions. This game utilizes the technologies to monitor the movement of fingers and limbs.

Thus the application of serious games can be graphically illustrated as in Figure 2.

Education & Training	Health & Well-being	Advertisement
Domains of Serious Games		
Interpersonal Communication	Cultural Heritage	Medicine

Figure 2. Potential Application Areas of Serious Games

2.2 AI controlled Racing Games

Game systems that emulate the styles of human playing games have been developed using components controlled by Artificial Intelligence, which are often known as 'bots' by research workers. Bots provide the human users the higher experience of gaming enjoyment by which the player is made to believe that his/her opponent is also a human. The popular first-person shooter game Counter-Strike [28] is one such game.

Video game PacMan [29], in the early period also consisted of bots which used pathfinding algorithms. Finite state machines, fuzzy state machines, and decision trees are some of the algorithms used for designing AI-controlled video games. Checker or Chess game uses the decision tree technique for decision-making process [30]. Decision trees and other A* techniques are applied for developing bots

which would imitate the behaviour of human. The effectiveness of the bot is measured not by its efficiency but by its capability of the extent to which it can imitate human behaviour, and hence the time taken by the bot to react is one of the criteria in measuring the performance of the bot.

Though the researchers and racing game developers use AI techniques, they have been unable to find a solution for the collision of game objects with random dynamic obstacle objects. Human players tend to make small adjustments while driving cars in driving and racing games, as in their real life, which requires AI techniques to ensure the imitation of the human behaviour of bots. The bot in the Racer game developed by Chan et al., is developed using a few AI techniques. The game used three games contemporary AI concepts and techniques as described below [31].

1. *Waypoint System with Vector Calculation*

Waypoint system is the very first AI technique applied for controlling the cars, which consists of a set of waypoints where each waypoint is a 3D coordinate denoting a key position on the track. The main reason for the application of this technique is its simplicity and effectiveness.

A vector calculation is carried out to turn the car to its present waypoint, through which the number of times the game requires to steer is determined. The calculation is carried out depending on the present waypoint and the present car position, from which the steering and braking level bases of the car is derived. But the input and output vector showed a non-linear relationship, which resulted in less effectiveness of the system and hence the researchers embraced the method of a conditional monitoring system to enhance both the waypoints and the vector calculations.

2. *Conditional Monitoring System*

The input and the output vectors created a nonlinearity between them and hence the accurate steering and braking levels of the car were unable to be obtained. This problem was refined by the application of a condition monitoring system into the racing game. The satisfactory output was obtained by the enhancement of the foundational waypoint system with the conditional monitoring system. Other than this technique, an alternative technique that incorporates a non-linear mathematical functional model using artificial neural networks were applied to the racing game.

3. *Artificial Environment Perception*

Trigger detection and artificial environment perception is another method to control the car in a gaming system. Trigger detection is a technique used to detect the specific object in the game within the vicinity of another game object or obstacle, through which it can be ensured that one object does not collide with one another. This is done by adjusting the output level of the car to steer the car away from the obstacle.

Another alternative technique for artificial environment perception is the ray-casting technique, commonly used in contemporary video games, which draws a line from a game object in a specific direction of the car heading. The line drawn is used in determining whether the car will collide with an obstacle on its way. The major drawback of this technique is that it can detect obstacles only in one direction while the trigger detection technique is able to detect an obstacle in all directions.

2.3 Tools and Technologies

2.3.1   Tools

2.3.1.1 Unity 3D Development Engine: Unity Game Development engine is a platform which facilitates the users the designing of graphics and physics calculation. It also adds the feature of positioning, scaling, and adding realistic objects into the game system. Unity Game Development engine is integrated with an integrated Development Environment (IDE), that is platform-independent. Also, the engine does not require many lines of code and can be used to develop games for multiple platforms [32].

2.3.1.2 Microsoft Visual Studio: An integrated development environment (IDE) provided by Microsoft is a software tool that is used to develop computer and mobile software programs [33].

2.3.1.3 MonoDevelop: MonoDevelop alias Xamarin Studio is an open-source IDE that is used to develop Mono and .NET projects. MonoDevelop is also one of the IDEs supporting the development of games using the Unity Game Development engine with the features of automatic code completion, a GUI, source control, and a web designer. Also, MonoDevelop is one of the primary compilers of C# in its early versions [34].

2.3.2   Technologies

C# is the programming language that is to be selected for the development of the game due to its compatible nature with the classes in the Utility Game Development Engine. C# is one of the object-oriented programming languages which has been designed for the Common Language Infrastructure with its simple, modern, and general-purpose characteristics. The language is very suitable for the development of distributed software [35].

3. Methodology

The methodology of the research has been developed based on a systematic review of underpinning concepts and literature along with a pilot study. This pilot study was conducted to analyze the views and perceptions of the potential game players through a questionnaire survey. The proposed methodology is depicted in Figure 3 below.
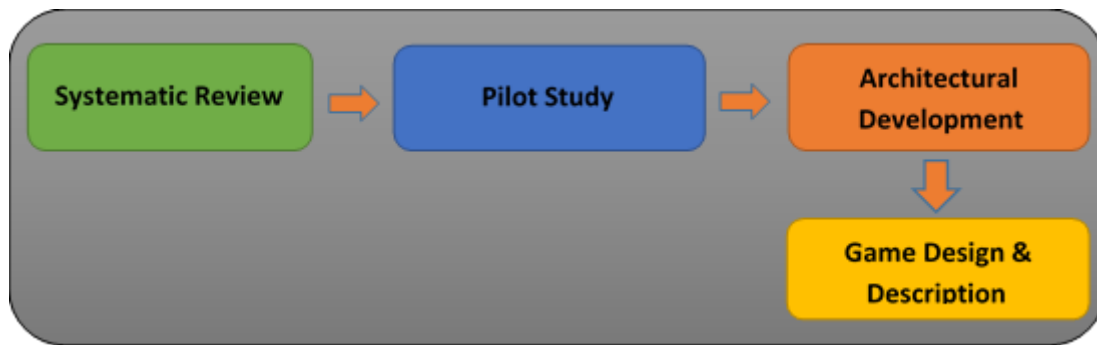
Figure 1. *Proposed pipeline*

3.1 System Review

"Sri Lanka is experiencing an increasing number of traffic accidents, posing a danger to citizens throughout the country. Accidents take place unexpectedly and unintentionally, cause damage, injury, and death, as well as trauma and heartache for victims." says the popular newspaper, Daily Mirror [36]. Also, another study reveals that in Sri Lanka an accident occurs every ten minutes and the loss of lives is around six or seven [37]. The Sri Lankan Police list several reasons for the occurrence of road accidents and the lack of knowledge in road rules and regulations are listed as the fourth major factor for causing road accidents [38]. Therefore, the game vRide is proposed in this research to educate children, school students, youths, and adults, the road safety rules to reduce the fatality caused by road accidents.

3.2 Pilot Study

The main aim of the study was to identify the user perspectives and user expectations of the proposed game. The study was able to unravel several new ideas to be adopted in designing games. The study consisted of 250 respondents who are aged 21 – 25 years. The selection of this age group is mainly because it has been statistically proved that this age group is more prone to motorcycle accidents in Sri Lanka. In addition to this, video games are much prevalently played among this particular age group.

The survey showed a positive response and the suggestions on choosing a game genre, improving the interface, improving the training experience were also queried. Further, the study also investigated the essential game elements. The game design has been proposed adhering to the obtained comments.

The decision on choosing a racing game was also based on the user comments as well as the trending topics of Google. The choice of racing games as a genre of vRide over other potential genres such as Trivia, Puzzle, and Roleplay games was mainly decided based on the Google database [39]. The trending percentage of each of the above genres in Sri Lanka was obtained for a period of 05 years ranging from August 2015 to August 2020 from Google Trends. The graph shows that racing games are highly preferred and popular among other genres throughout 05 years as presented in Figure 4.
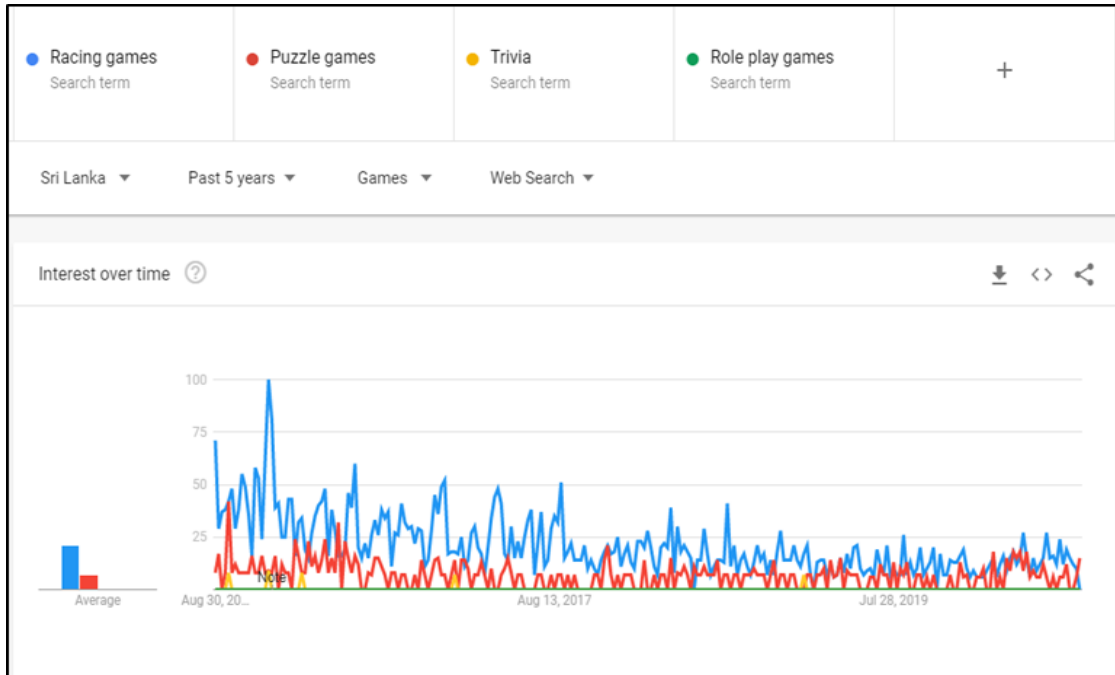
Figure 2. Google Trends of Video Game Genre as of 2020 [39]

The investigation on game elements such as points, badges, leader boards, and incentives as per the industry blueprints of essential game elements revealed that the players are very much interested as much as these elements are incorporated in a game. The responses related to the game elements are provided below in Figure 5. Further, respondents also suggested to include punishments as another essential game element for those who violate traffic rules.
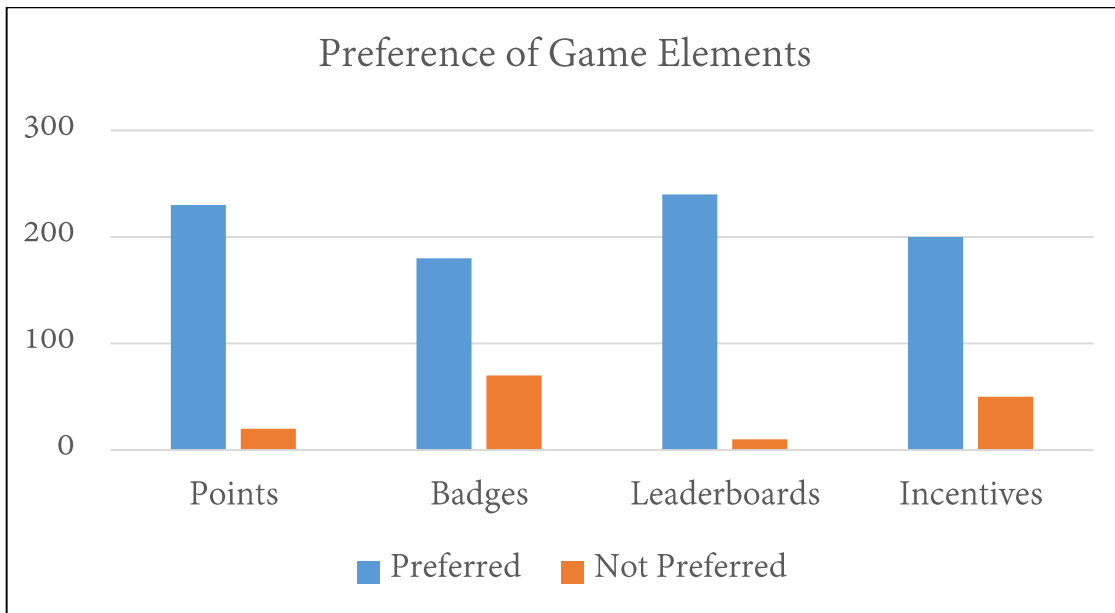

Figure 3. *Preference of Game Elements*

Further responses obtained from the above study have been incorporated in the designing of the game. The detailed description of the design is presented in 3.4

3.3 Proposed Architecture

The architecture of the game has been developed based on DPE (Design, Play, and Experience) Framework forwarded by Brian Winn [40]. The framework comprises 04 key game elements. According to the above conceptual framework, the architecture of the game vRide is as follows:

3.3.1 Learning

It is the expected content to be learned or trained by the player by playing games, in this case, getting knowledge and practice on the traffic rules and regulations of Sri Lanka.

3.3.2 Story Telling

The background story of the game and includes a description of the character(s), the setting, and the ultimate goal of the game. The goal of vRide is to reduce the accident rates through motorcycles in Sri Lanka by providing a handheld experience to amateur bike riders. Further description is presented in 3.4.

3.3.3 Game Play

It is how the player interacts with the game. This particular game is a Bike racing game where the player interacts through a keyboard.

3.3.4 User Experience

The emotions and attitudes of the player while playing the game. The rewards and punishments of the game are expected to bring out positive changes in the behaviour of the players.

3.4 Game Description

Based on a typical serious game framework and proposed architecture, the gaming platform can be described as follows: The name vRide stands for Virtual Ride. The main player in this game is the motorcyclist. A pilot study was also conducted to analyze the views and perceptions of the potential game players through a questionnaire survey. The survey showed a positive response and the suggestions on improving the interface, improving the training experience were also taken under the consideration in developing this simulator game.

The control of this game is mainly done through arrow keys of the keyboard where the Up-arrow key is intended to accelerate, Down-arrow key to decelerate and Left and Right arrow keys to perform the diversion in left and right direction respectively. The game can have three levels of difficulty (Difficulty Level 1: Amateur Mode; Difficulty Level 2: Intermediate Mode; and Difficulty Level 3: Expert Mode) and provides a choice of geographical locations either in a local crossroad having low traffic or busy main streets with high traffic congestion.

The rules and regulations of the game underlie and comply with the Motor Traffic Act (Chapter 203) published by the Democratic Socialist Republic of Sri Lanka [41]. The simulation will be made in such a way to provide a true experience of riding a motorbike on Sri Lankan roads. The performance of the rider is evaluated by means of providing a scorecard at the end. The scorecard also includes the mistakes left by the rider as a violation of Traffic Rules in order to educate the rider. This is done by traffic inspectors who provide punishments in case of the violation of traffic rules. The imposed punishment would deduct the score gained as well. Further, increasing the number of punishments would reduce the overall achievement level of the player.

The design is also focused on introducing different classes of vehicles as well as certain other non-human characters in the streets traveled to provide good training through simulating the real-world scenarios. Further, certain non-spontaneous situations would be faced by the riders in order to provide intensive training and knowledge to handle such spontaneous situations in the real world. The speed of the motorbike would be displayed using a digital speedometer located at the top center of the game screen. The increase of speed beyond the accepted limit would be alerted to the rider and counted as a violation of traffic rules.

4. Discussion and Conclusion

The game-based approach to study the road rules by the Sri Lankan drivers help them to experience the ability to play a game that replicates the modern motorcycle racing games along with the simulator for a vehicle. The game provides the players with a virtual environment to self-evaluate their skills and knowledge in driving by the points rewarded to the player according to the pre-defined rules and regulations of the racing game.

A real-world experience is given to the user through the games developed by the application of AI techniques, which comprises of real-world objects, real-world roads, and paths with obstacles. The traditional AI techniques for this type of game development are not suitable as they do not support the waypoint system, physics engine, and vector calculations for the game components. Further, this game successfully emulates the behaviour of a human driving a motorcycle. Therefore, it could be concluded that the domain of serious games which has gained resurgence in recent days can be well engineered to train the amateur bike readers on road traffic rules as a countermeasure to lower the fatality rate caused by accidents in Sri Lanka.

5. Conflict of Interest

The authors declare that there is no conflict of interest to declare.

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