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IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN VIDEO GAMES TO SIMULATE CITIZEN BEHAVIOUR TOWARD THE SPREAD, ACCUMULATION AND HANDLING OF WASTE

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Abstract

This research aims to apply artificial intelligence in video games as a medium for educating and providing a simulation of community behaviour related to the spread, accumulation, and management of waste. The research is based on the increasing problem of waste, which requires innovative strategies to build awareness and change community behaviour. The research method used is the game development life cycle (GDLC), which is integrated with machine learning and neural networks to model waste distribution behaviour, adjust player interactions, and provide dynamic consequences for decisions made. Artificial intelligence is trained to produce realistic and responsive game scenarios so that users can feel the direct impact of their waste management actions. The results of this research show that artificial intelligence applied to video games is capable of acting in accordance with given situations with dynamic characteristics that differ from previous occurrences. This video game can increase user understanding and knowledge of the importance of waste management, which can encourage changes in user behaviour through interactive learning experiences.

Keywords: Artificial intelligence, Behaviour, Game development life cycle, Simulation video games, Machine learning.

1. Introduction

The problem of waste accumulation in the world today is still rarely reported by the media, so few people are aware of this issue. Many people do not know that this is a serious problem that really needs to be addressed properly [1]. Large companies engaged in retail are now starting to encourage the use of personal shopping bags, as are businesses in the food and beverage sector, which are now reducing their use of plastic materials. Some people understand this well and are aware of the importance of implementing it, but many are still unaware of how important it is to reduce plastic use in everyday life. Plastic itself is said to be the most accumulated type of waste today due to its rapid increase and difficulty in disposal, without causing other problems [2, 3].

Public awareness and concern about waste are determining factors in the formation of a waste-free ecosystem [4, 5]. This research also shows varying levels of concern among different segments of society. This indicates a lack of education on proper waste management in the community, making it highly advisable to educate the public from an early age. This research was conducted to simulate the current process of waste distribution and accumulation, and it is hoped that it will also raise public awareness of the problem. The application of artificial intelligence (AI) in video games is not new [6]. It has previously been applied in research, using a heuristic method that relies on data in its thinking process. This is very different from the current research, which uses machine learning and neural networks that do not rely on data but rather on neural networks that have been trained using machine learning algorithms. Meanwhile, the development and testing of an AI-based 2d video game in Unity using artificial intelligence algorithms can determine character actions, generate procedural environments, and evaluate player performance through a series of experiments [7].

The purpose of this research is to implement AI into video game simulations so that these simulations can provide visualisations and raise public awareness of waste management. The applied AI has quite complex functions with dynamic situations, requiring the use of neural networks and machine learning. This AI has attributes that influence how it reacts to its surrounding environment. With the surrounding environment (external factors), and personality attributes (internal factors), artificial intelligence can make the best decisions [8]. This development was using the Unity application to create a 3D simulation environment, game logic configuration, and complex AI system integration.

2. Literature Review

Simulation games combine the characteristics of games, namely competition, cooperation, rules, participation, and roles, with simulation [9-11]. Simulations used for real-world decision-making systems differ from those used for learning processes (simulation games). Simulations used for decision-making systems require models that are as realistic as possible, utilizing data from the real world, because these simulations will serve as the basis for informed decision-making [12]. In contrast, the simulation game to be discussed further utilizes data from the real world, allowing it to be integrated into a decision-making and learning system [13, 14]. AI is also a branch of computer science that focuses on designing intelligent computer systems capable of performing tasks that normally depend on human intelligence/abilities [15]. Another definition categorises AI as a system's

ability to interpret external data correctly, learn from that data, and study it to achieve a specific goal and task through a process of adaptation [16]. Both of the above definitions state that AI is a system that has the ability to learn. This ability can be obtained by training it using a certain amount of data [17]. The data will be used as input and then processed through a neural network. The result of this neural network can be considered a decision made by the AI being trained or used. After that, a series of actions can be taken as a result of that decision. During the learning or training process, AI will be given rewards in the form of certain values adjusted to the actions that have been taken.

Machine learning (ML) is a growing branch of computational algorithms designed to simulate human intelligence by learning from its surroundings [18]. Machine learning is considered the core strength of what is commonly referred to as "big data" [19]. Neural networks are also commonly used for forecasting functions, as found in research [20]. Unity is a game engine developed by Unity Technologies that can build video games for many platforms, such as Windows, Android, PlayStation 4, iOS, and others. The video games created can be in 3D, 2D, augmented reality, and even virtual reality formats [21]. The Unity Machine Learning Agents Toolkit (ML-Agents) is an open-source project that allows games and simulations to be presented as environments for training a number of intelligent agents [22]. These agents can be trained using reinforcement learning, imitation learning, neuro-evolution, or other machine learning methods through an API based on the Python programming language [23]. The ML-Agents Toolkit is beneficial for game developers and AI researchers to build complex AI to be tested in a rich Unity environment and then make it easily accessible for larger research and the game developer community.

3. Method

The methods used in this research involved several processes, including data collection and system development, as shown in Fig. 1. The first stage of this research was the initialisation stage, which involved identifying problems by gathering information, analysing requirements, and determining the main target users for video game development. The second stage was pre-production, which involved designing the video game storyline, game genre, character design, and assets required for the video game. After that, the third stage is the production stage. At this stage, the game is created, starting from the storyboard, game environment creation, and programming. After these three stages, the next one is the testing stage. Testing aims to ensure that the system works properly without any errors or bugs.

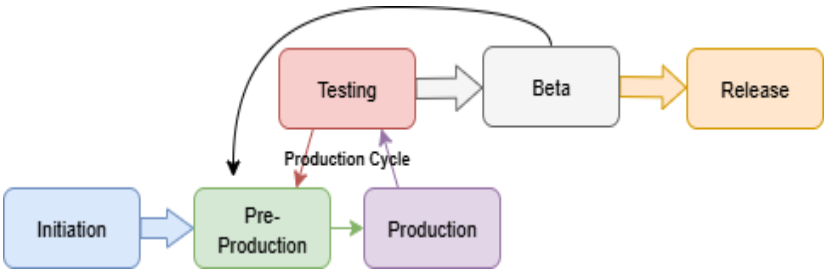


Fig. 1. Research method.

The testing method used in this research is the black box method with the decision table testing technique. After testing, the next stage is the beta stage, where the game is released on a limited basis to obtain feedback from users or testers. This is necessary to fix bugs, improve features, and tailor the game to user needs. After the beta stage is complete, the final one is the release stage. At this stage, the game simulation will be officially released to the public and ready for use by the target market.

4. Results and Discussion

4.1. Initiation

An analysis was conducted on the current cases of waste distribution and accumulation. This was done using data and information that had been collected [24]. The distribution and accumulation of waste certainly involve many components, such as waste, trash bins, the community, stores, and so on [25]. In this research, some of the actions include picking up trash within reach or going to the nearest trash can, disposing of trash randomly or in its proper place if there is a trash can within range, walking to a specific point, and staying in place.

After taking action, AI must be given a value or reward that will help guide it toward the desired goal. When AI with a 'good personality' litter, it will be given a negative reward, while if AI with a 'bad personality' litter, it will be given a positive reward. The AI is also allowed to change the values of its internal factors based on the results of its observations. In this case, these value changes can occur each time the AI makes a decision, with changes ranging from 0.01% to 0.1%. The greatest influence is on mood/comfort at 0.1%, and the smallest is on personality at 0.01%. These values are made very small so that it takes a long time for the AI to change its behaviour (see Fig. 2).

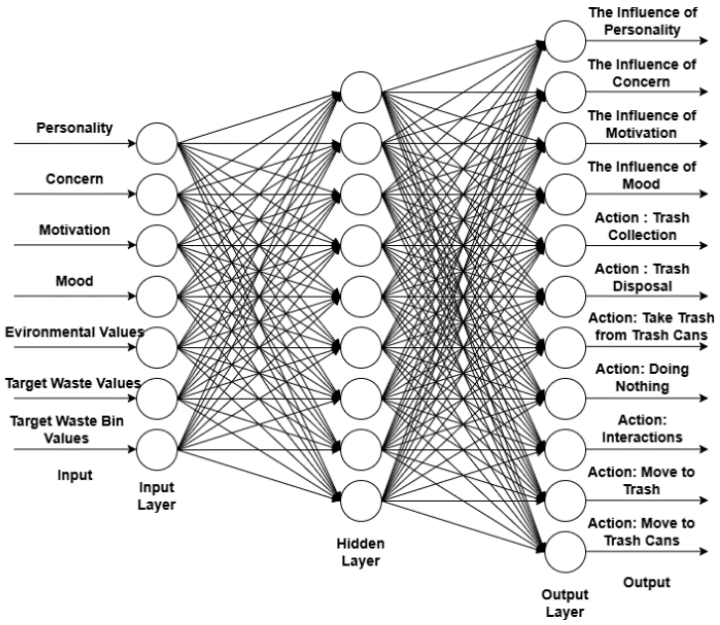


Fig. 2. Visualisation of an applied neural network.

Figure 2 is a visualisation of the data entering and exiting the existing neural network. It can be seen that the output consists of eleven outputs, four of which influence behavioural attributes, and the rest are actions. Simply put, the outputs from these seven actions will be compared, and the largest data will be used as the decision generated by the AI's thinking. When starting the AI training process, all actions will occur randomly and will continue to improve as long as the AI is properly configured in terms of input, output, and reward. To train AI effectively, a special environment or setting is required as a training ground. This training ground must be dynamic and tailored to the final environment of the video game in question. Otherwise, the AI produced will only be accustomed to a specific situation. To provide the AI with a dynamic environment, the video game must be equipped with a spawner that generates trash in specific locations at specific quantities and intervals. This spawner will also be used to automatically add trash to the trash bin.

4.2. Pre-production

Figure 3 is a game layout chart created to ensure that the game is in line with the initial design and to assist game developers in evaluating each step of the video game. It begins with the splash screen, then moves on to the main menu, which provides access to the explore mode, simulate mode, and exit game. From Simulate mode, you can also move to the simulation screen, which contains simulation configurations and allows you to exit the game.

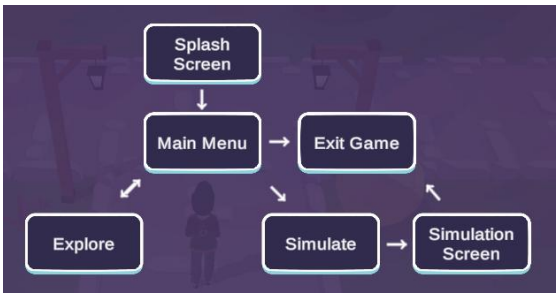
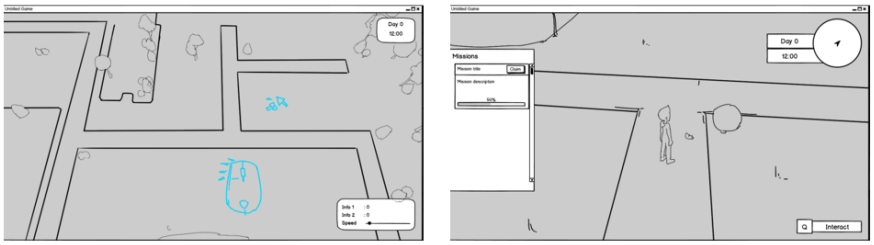


Fig. 3. Game layout chart.

This storyboard serves as a blueprint for the UI/UX design to be created in the production stage. It contains a sequence of images showing how an application will be operated. Figure 4 is a storyboard application of simulate and explore menus.



(a) Simulate menu. **(b) Explore menu.**

Fig. 4. Storyboard application.

4.3. Production

In this section, the programme is created by referring to the previous stages as a reference. In this stage, the video game is created using Unity 3D with the Unity ML Agent Toolkit to train agent behaviour. Figure 5 shows the user interface for the simulate and explore menus. In the simulate menu, players can control the game using the mouse and keyboard, such as pressing the left click to add rubbish. Meanwhile, in the explore menu, players can control the character using the mouse and keyboard to interact and move around the simulation area.

(a) Simulate Menu. **(b) Explore Menu.**

Fig. 5. User interface simulate and explore.

4.4. Testing

Testing was conducted using the black box method with decision table testing techniques based on the inputs and conditions possessed by the player in the video game created. The player opened the video game and selected Explore mode on the Main Menu, then the testing process began. Testing was divided into three parts: testing character movement inputs, camera movement inputs, and character interactions. Table 1 shows the results of character interaction testing.

Table 1. Character interaction test result.

Condition	Set										
	1	2	3	4	5	6	7	8	9	10	11
Press the Q key	Y	N	N	N	Y	Y	Y	Y	Y	N	Y
Press the I key	N	Y	N	N	N	N	N	N	N	N	N
Press the Esc key	N	N	Y	N	N	N	N	N	N	N	N
Click on an item in the inventory panel	N	N	N	Y	N	N	N	N	N	Y	N
Inventory is still empty	N	NA	NA	NA	Y	NA	Y	NA	NA	NA	N
Near the rubbish bin	N	NA	NA	N	N	Y	N	N	N	Y	N
Near the rubbish	N	NA	NA	NA	N	N	Y	N	N	NA	Y
Near the NPC	N	NA	NA	NA	N	N	N	Y	N	NA	N

From the tests conducted, it was found that video games created in Explore mode in particular produced results that matched the inputs provided. This was true in terms of inputs for character interaction.

5. Conclusion

From the research that has been conducted, the results show that video games can simulate the spread, accumulation, and handling of waste quite well. This is done using artificial intelligence (AI) that is able to act according to the situations given, with dynamic and different characteristics from what happened before. When making decisions, AI takes into account its surrounding environment (external factors) and personality attributes (internal factors). By considering these factors, AI can make the best decision, whether it is to collect or dispose of waste.

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