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The Behavior Change of Intelligent Agent Using Finite State Machine in "Save Karang Mumus" Game

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Abstract: Save Karang Mumus is a learning game about caring for the environment. This game is an educational game that can provide knowledge to players so that players are expected to learn while playing. Save Karang Mumus Game uses a role-playing game genre where players must play a role to complete the mission of the game. Multimedia Development Life Cycle development method is used for the development of this game starting from concept, design to distribution. This research focuses on the behavior of NPCs that change based on certain conditions using the Finite State Machine (FSM) method. NPCs will chase players based on the variable amount of trash collected and Health Points. The game is tested using alpha test and beta test. Based on the results, the game can be played well and get a percentage value of 65.66% of the respondents' test results. An application can be said to be good if it is more than 61% and less than 80%. It can be concluded that Save Karang Mumus Game is successful and worthy to be played.

Index Terms: Educational games, Artificial Intelligence, Finite State Machine, Role Playing Game, Non-Player Character.

1. Introduction

Playing is a reflection of physical, intellectual, emotional, and social abilities and playing is also a good medium for learning because by playing, children can communicate, learn to adapt to the environment, do what they can, and recognize time, distance. and sound [1]. In the times, playing game can use computers and smartphones. Game is a game using electronic media that can provide entertainment in the multimedia form that is designed as attractive as possible so that players can get satisfaction in playing. Playing games can be used as a learning media in learning. An interesting and easy-to-use learning media is to utilize information technology. Entering the industrial revolution 4.0, technology has become a demand in human life [2]. All things are required to always take advantage of technological developments, especially in terms of using technology such as smartphones. The development of technology in the current era needs to be used to provide education that builds the development of children's character [3]. One of the learning media that can be used is educational games. Educational games are learning media which are designed to provide an educational experience or learning experience to the players which are presented in a fun way [4].

Games will be interesting if given an artificial intelligence. In this study, researchers made a game that was not just an ordinary game, this game was given artificial intelligence to determine the behavior of Non-Player Character (NPC) using the Finite State Machine (FSM) method. In this game, NPCs can be given artificial intelligence to determine their behavior. There are three layers of NPC behavior [5], namely action selection, steering, and locomotion as shown in Fig.1.

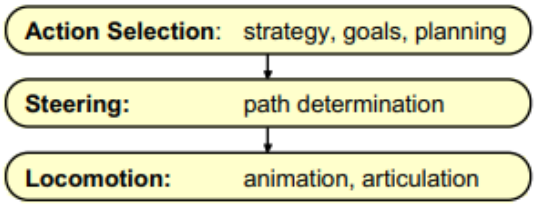

Fig. 1. Behavioral Movement Hierarchy [5]

The artificial intelligence in this game is concentrated on NPC behavior. NPC behavior moves using the Finite State Machine (FSM) method. FSM is a system design method that can describe a system's behavior with three things: state, event, and action [6]. This method is widely used as a reference in making special games in giving behavior to NPCs. There are several researchers who use FSM methods such as [6, 7, 8, 9] which are used to provide NPC behavior on games that have been made.

Research [10] with the title of an educational game for collecting organic and inorganic waste using Finite State Machine (FSM). This game provides education about the importance of maintaining cleanliness in the surrounding environment, because with a dirty environment it causes disease and the environment becomes uncomfortable to live in. This game also applies the FSM method to enemy characters which is used to determine the enemy's movements and actions. In another study, [11] researched environmental hygiene games using the Finite State Machine method. This method is used to give artificial intelligence and difficulty level to the game.

In a study conducted by [12], researchers used the FSM method to determine the response of the non-Player Character based on the interaction made by the player. In another study conducted by [13] entitled Kinect-based educational game for children with special needs (Autism) with Finite State Machine. This method is used to determine the user's flow in answering a question that appears in the game.

In this study, it provides changes in the behavior of intelligent agents as NPCs using the Finite State Machine method. This game is a Role-Playing Game type where players play the role of characters in a story [14]. In this game, players have the role of cleaning volunteers to clean up trash around the Karang Mumus River. Players have quests or missions to complete in completing the game. In completing quests or missions, players must be careful in looking for trash because there are NPCs that can chase players under certain conditions. These conditions are the amount of garbage that has been collected and the player's health points (HP).

2. Methodology

2.1. Game

Game is a game that uses electronic media that can provide entertainment in the form of multimedia which is designed as attractive as possible so that players can get satisfaction in playing. The game can also be said to be a game consisting of a set of rules that create a competitive situation from two to several people or groups using choosing strategies that are built to maximize their own victory and minimize the victory of the opponent.

Basically, the game has four elements, namely mechanics, story, aesthetics, and technology [15]. Mechanics is the procedures and rules in the game, story is a series of events that occur in the game, aesthetics talks about what is seen in the game such as graphic design and user experience, and for technology is technology in terms of game making. In addition to playing, games can also be used as learning media. Educational game is game that have learning content and are intended to improve the player's ability to learn something [14].

2.2. Role-Playing Games (RPG)

RPG is a game where player take on role of characters in a fictional story created by the creator. Player has the task of carrying out the roles that have been determined by the creator and are required to go through the decision-making process. In general, player will be faced with certain problems and carry out quests to solve these problems [14].

Basically, RPG has many forms of role playing such as Tabletop RPG (TRPG), Live Action RPG (LARP), Massive Multiplayer Online RPG (MMO RPG), Multiplayer Online RPG (MORPG), Computer RPG (CRPG), and Single player RPG (RPG) as illustrated in Fig.2.

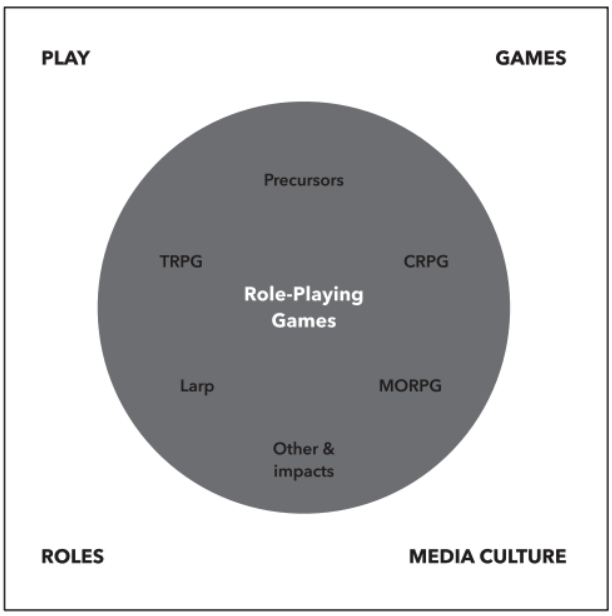

Fig. 2. Form RPG [16]

2.3. Finite State Machine (FSM)

FSM is a system design method that describes a system's behavior with three aspects: state, event, and action [6, 7, 9]. FSM divides the response of the game object in state as a result of which the object has a share for the response of each game object. The implementation produces a certain sequence in the game which results in the game following the game flow that must be passed later which can interpret a set of events that chooses when an action must change to another action. Fig.3 explains that there are two states with two events and four actions shown in the figure. When the system starts, the system will transition to State0, in this state the system will generate Action1 if it gets Event0. From State0 will transition to State1 if Event1 occurs, resulting in Action2. On State1 will return Action3 if it gets Event0. From State1 will transition to State0 if it gets Event1 which results in Action4.

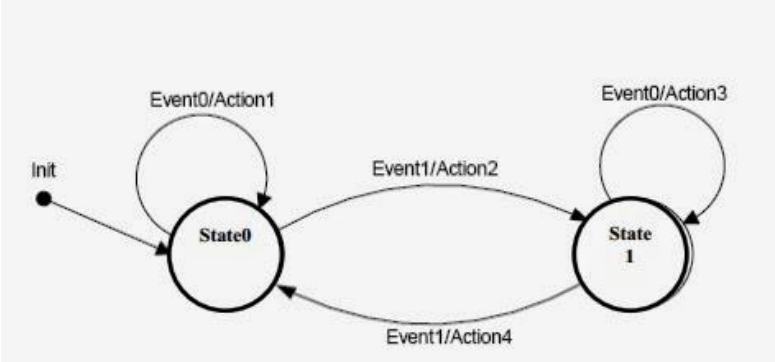

Fig. 3. a Simple FSM [12]

2.4. Multimedia Development Cycle

The Multimedia Development Life Cycle development method is used in this study. The game development method starts from concept, design, material collection to distribution stage. The development stage is shown in Fig.4.

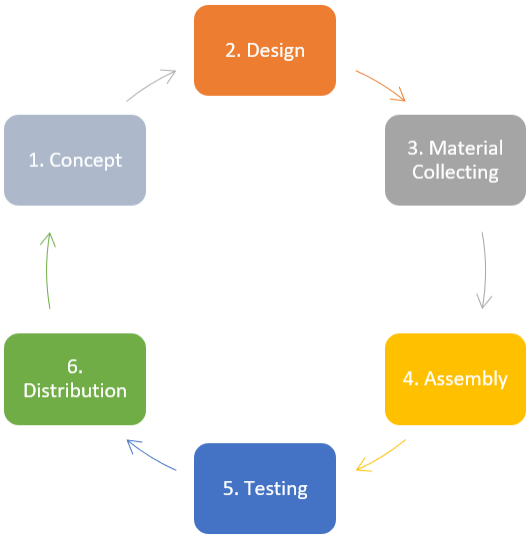

Fig. 4. Multimedia Development Life Cycle

1. Concept

Concept is the step to determine the purpose and who uses this game. The purpose of this game is to provide education about environmental care from an early age.

2. Design

Design is the stage where detailed game specifications are made in a game design consisting of game architecture, display, game scenarios, and the application of the Finite State Machine method.

3. Material Collecting

Material collecting is the stage where the collection of materials according to the needs to be done. These materials are in the form of images, backgrounds, sound effects, music and others which are obtained free of charge.

4. Assembly

Assembly is the stage where all multimedia objects or materials are created. Making games based on game scenarios that have been done. All objects or materials are created and combined into one application.

5. Testing

This stage is also known as the alpha and beta testing stage where testing is only carried out by the maker or the environment of the maker itself. This test aims to check that the games that have been made are running well in terms of functions and algorithms that are applied and in accordance with the objectives of making the game.

2.5. Concept and Design of Finite State Machine

Artificial intelligence in this game is concentrated on the behavior of NPCs. There are two NPCs in this game, namely the Rat NPC and the Worm NPC. NPC Rat as Agent 1 and NPC Worm as Agent 2. NPC behavior moves using the Finite State Machine (FSM) method.

To give behavior to the agent, several variables are used in this game. The variables used are the amount of trash and health point (HP). In this game there are three stages: 1) The first stage, players must collect 7 pieces of trash; 2) The second stage, the player must collect 10 trash; 3) In the third stage, players must collect 15 pieces of trash.

From the variables that have been determined, rules can be made for input in the application of the Finite State Machine. From each stage agents 1 and 2 chase players based on the range of agents. Here are the rules in the game:

Stage 1:
Agent 1 chases with a range of 3 squares
Stage 2:
if trash > 5 && health points > 350 then Agent 1 chases with a range of 5 squares
Stage 3:
if trash > 5 && health points > 350 then Agent 1 chases with a range of 5 squares
else if trash > 10 && health points > 350 then Agent 1 chases, Agent 2 chases with a range of 11 squares

More details about the behavior of agents can be seen in Fig. 5. The figure describes the behavior of agents in games that are based on game rules that have been designed.

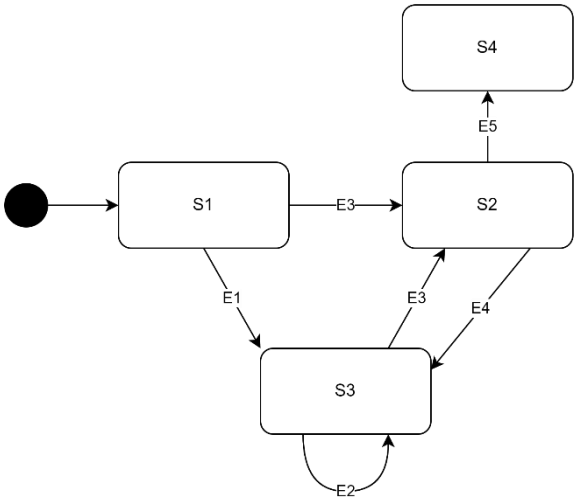

Fig. 5. FSM Agent 1 and Agent 2

Description:
state
S1 : Starting position
S2 : NPC chasing
S3: NPC is waiting
S4: NPC catch player
Events
E1, E2 : No player approaching
E3 : Player enters agent zone
E4 : Player away from agent zone
E5 : Silent player

3. Result and Discussion

Assembly results based on game analysis and design are as follows:

3.1. Game Display

Fig.5 is the initial view when playing the game "Save Karang Mumus". There is a New Game, Continue, and Options menu. “New Game” menu to play a new game, “Continue” menu to continue previously saved games, and “Options” menu to adjust game sound.

Fig. 6. First View in Game

Fig.7 (a) is the first quest that must be completed by the player. The quest is to meet “Pak Sukandar”. The player meets “Pak Sunandar” to register himself as a cleaning volunteer as shown in Fig.6 (b).

(a) (b)

Fig. 7. (a) First Quest, (b) Meet “Pak Sunandar”

Fig.8 shows the player must clean up the leaf litter around the Karang Mumus River. While collecting garbage, there are NPC Rats walking around the riverside location.

Fig. 8. Player Collects Leaves Trash

After the player completes the first quest, it will continue to the next quest, namely going to “Taman Samarendah” as shown in Fig.9. This quest is the last mission that the player must complete as shown in Fig.10. Players must collect 15 pieces of trash to complete the mission. When collecting trash, players must be careful in collecting it because there are two NPCs that will chase player based on the amount of trash they get.

Fig. 9. Second Quest

Fig. 10. Complete the Final Mission

3.2. Device Specifications

In testing this game, it will be tested on two different smartphone devices, especially device specifications. Table 1 shows the specifications of each device.

Table 1. Device Specifications

No.	Device Name	Specifications
1.	Sony Xperia 5	• OS: Android 11 • Chipset: Qualcomm SM8150 Snapdragon 855 (7 nm) • CPU: Octa-core (1x2.84 GHz Kryo 485 & 3x2.42 GHz Kryo 485 & 4x1.78 GHz Kryo 485) • GPU: Adreno 640 • Memory: 128GB 6GB RAM
2.	Sony Xperia 10 II	• OS: Android 12 • Chipset: Qualcomm SDM665 Snapdragon 665 (11 nm) • CPU: Octa-core (4x2.0 GHz Kryo 260 Gold & 4x1.8 GHz Kryo 260 Silver) • GPU: Adreno 610 • Memory: 128GB 4GB RAM

3.3. Game Testing

a. FSM Testing

FSM testing in the initial state starts from Agent 1 and Agent 2 is in S1 which is in the initial position of the agent. In this S1, the agent is affected by 2 events, namely E1 and E3. When the agent receives E1 then the agent will do S3. If the agent receives E3 then the agent does S2. S2 is affected by the HP and trash variables that have been set in game creation as shown in Fig.11. From S2 the agent can do S3 and S4 based on the event received by the agent. The agent will do S3 if the agent is affected by E4 and will do S4 if it receives E5. The results of this test are in accordance with the FSM model used in Fig.4. For more details, it is shown in Table 2.

(a) (b)

(c)

Fig. 11. NPC Detecting Player (a) with 3 squares, (b) with 5 squares, and (c) with 11 squares

b. Alpha Testing

At this stage, testing is carried out using the black box method. This test focuses on the functionality of the game application that has been created. In this test, it is tested using 2 devices shown in Table 1. The game will be tested with different device specifications so that it can produce a comparison of game trials with the appropriate specifications.

Table 3 shows the results of tests that have been carried out using the black box method. From these results, it shows that all the tests carried out were successful on device 1 and device 2.

Table 2. Alpha Testing

Testing	**Detail Testing**	**Result**	
		Device 1	**Device 2**
Navigation Button	Moving each scene	Successful	Successful
New Game Menu	Showing recently started games	Successful	Successful
Continue Menu	Showing previously saved games	Successful	Successful
Options Menu	Showing setting view	Successful	Successful

c. Beta Testing

Beta testing is a test that is carried out by collecting data using a questionnaire to end users. This is different from alpha testing which is only tested by developers. The purpose of this test is to get feedback from users so that developers can re-evaluate. This test was carried out by 10 general people by providing a questionnaire with 10 questions related to the game application [17]. Beta testing results are shown in Table 4.

Table 3. Beta Testing Result

Questions	**Rating**				
	-1	**0**	**1**	**2**	**3**
How did you rate the first time you opened this game?	0	0	3	6	1
What do you think about the audio and visual appearance of this game?	0	0	3	3	4
What do you think about the use of information content in this game?	0	0	3	5	2
In your opinion, how is the interaction and response between this edugame and the users of this game?	0	0	3	4	3
In your opinion, how do all the menus and buttons in this game function?	0	1	2	3	4
After your open and enter this game, what do you think about the accessibility / ease of accessing all the functions and features of this game?	0	0	1	5	4
What do you think of the challenges in this game?	0	0	3	3	4
In your opinion, does this game give you knowledge?	0	1	4	3	2
What do you think about the quality of this game has a standard like the game in general?	0	0	3	5	2
What rating do you deserve for this game?	0	0	1	8	1
Total	0	2	26	45	27
Percentage	0%	2%	26%	45%	27%

Based on the results from table 4, the results of the questionnaire obtained from the respondents' answers are then calculated [9, 17] as follows:

Very Poor (-1) : 0 x -1 = 0
Poor (0) : 2 x 0 = 0
Average (1) : 26 x 1 = 26
Good (2) : 45 x 2 = 90

Very Good (3) : 27 x 3 = 81

$$Y = \frac{x}{number\ of\ respondents * highest\ rating\ score * number\ of\ questions} * 100 \quad (1)$$

$$Y = \frac{(0+0+26+90+81)}{10*3*10} * 100 = 65.66 \quad (2)$$

Equation (1) is a calculation to get the calculated value of the questionnaire results. Based on the calculations generated in equation (2), the percentage is 65.66%. Based on these results, it indicates that this game is acceptable for use according to the good value as shown in Table 5.

Table 4. Score Criteria

Percentage	Information
0%-20%	Very Poor
21%-40%	Poor
41%-60%	Average
61%-80%	Good
81%-100%	Very Good

4. Conclusion

Game Save Karang Mumus was developed using the Multimedia Development Life Cycle method which consists of concept, design, material collecting, assembly, testing, and distribution. With this development method, game development becomes more structured so the game has been made to function properly according to the alpha test that has been carried out using the black box method. The FSM method has also been applied successfully to change the behavior of NPCs. FSM functions to provide NPC responses when conditions are set. This game also provides learning about caring to keep the environment clean.

Based on the results of beta testing, 2% of respondents chose Poor, 26% chose Average, 45% chose Good, and 27% of respondents chose Very Good. After calculating the percentage to get a value of 65.66%. From the results of this test, it can be concluded that the Save Karang Mumus game is successful and feasible to be played by users.

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