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Education Game Indonesian Old Museum Explorer using Fuzzy State Machine

M Rozikin, R Dijaya* and C Taurusta

Computer Science, Universitas Muhammadiyah Sidoarjo, Sidoarjo, Indonesia

*rohman.dijaya@umsida.ac.id

Abstract. Indonesia has a diverse culture from the form of creation, work, and intention, but over time Indonesian culture is eroded by the sophistication of the times. Using entertainment media such as games will be able to provide knowledge about culture through the game and can develop morale, using 3D interactive design of an object such as historical heritage will look close to real and with the Artificial Intelligence (AI) used in the opponent will make the game that is played becomes fun or not monotonous. This study uses the Fuzzy State Machine (FuSM) method which aims to shape character behaviour like human like behaviour. The results that can be generated from FuSM are behaviour that changes according to the conditions and rules that have been determined. This is where the AI that is formed will not always be the same in the same situation, all will be different depending on the conditions and rules that exist.

1. Introduction

Indonesia is a country rich in cultural diversity. The national culture based on Pancasila is a manifestation of Indonesia's creativity, work and initiative and is the entire effort of the Indonesian people to improve their dignity and status as a nation, and is shown to provide knowledge. But unfortunately, culture in Indonesia is almost gone, by inviting someone to learn culture through games is very effective at this time. Based on the results studied by Hanny Haryanto, entitled Moral Education by Using an Immersive Game Reward System, states that when a person likes and plays a certain game often, it can influence the effect on the player's morale and behavior in accordance with the games that are often played [1]. Games never limit the age and status in the community, every circle is allowed to play games, even if old, young, rich, poor, male, or female. Because games can always entertain the whole community. One expert defines the game is a system in which players are exposed to artificial problems, which are determined by the rules, which will get measurable results, [1]In modern times there are so many media. There are smartphones, computers, portable games, tablets and other game machines. Most current games have used 3D graphics and there is Artificial Intelligent (AI). AI can be concluded as a technique used in character games to form the illusion of intelligence in the behavior of Non Player Character (NPC). The technique used often utilizes existing methods in AI science. However, this AI game is often used as a reference to several broad groups of algorithms as well as using techniques from robotics, control theory, computer science and computer graphics widely. AI-based computer games are an innovation of games made with the approach of human behavior (human like behavior). Computer games can be made realistic if supported by implementing human like behavior in the Player, NPC Followers and NPC Enemy [2]. When we talk that the game has a good AI, it means that in a game character shows consistent and realistic behavior, reacting appropriately to



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the actions of players and other characters [3]. Finite State Machine (FSM) algorithm can be used as a method for modeling intelligence and behavior. This method is flexible and robust with respect to modeling, able to achieve high levels of complexity. However, FSM has certain limitations with regard to brand capabilities, this limitation is directly related to Boolean logic players, making FSM can only act in one state at a time. As an extension of FSM, there is something called Fuzzy State Machine (FuSM). The ability of fuzzy logic to represent ambiguous states, makes them applicable to various fields such as electronic games, intelligent character modeling and so on [4].

By calculating and analyzing the things above, it can be understood that the purpose of this writing is to create a game on a platform with the theme of Indonesian culture, with the intention that the Indonesian people to recognize, pay attention to, protect and preserve the culture that is owned by Indonesia. In this game, players will be in an old museum that has some relics left. After that the player will explore each room in the museum to find objects and collect them, but when collecting them there will be obstacles where there are enemies attacking players, the use of FuSM here is used to create enemy behavior Suitable with the actions of the player. After finishing finding relics and being able to answer all questions, the player will be able to move to the stage.

2. Related Work

NPC is a type of autonomous agent designated for the use of interaction media such as games and VR (virtual reality). NPC is used to play the role of a character in the story and has some expertise to improvise their movements, their actions directed directly by the player's movements. There are several AI studies which are NPCs in the game, until now they are still being developed [5]. FSM is an automata in which there are states that have a limited amount or also foam called finite. This state is used to understand the relevant part of the system's previous conditions. Because the total state that exists has limits, all previous conditions of the system often cannot be remembered, because the system must be formed in such a way as to remember the most important and forget what is not needed. The advantage of this FSM is that the system can implement a need that has a fixed amount, similar to hardware or circuitry [6]. Making AI in games that use FSM is a technique most often used for decision making (problems), and at the same time with scripting, and is widely used to form systems in the game. FSM is widely known as a technique for event-based conditions or phenomenon modeling. This technique is a method for designing behavior or object modeling systems based on a condition that has been interpreted in a set. FMS is a tool that has some number of states that can move based on inputs to make the transition from one state to another or cause an output or an action to occur. An FSM can only be in one state at a time [7].

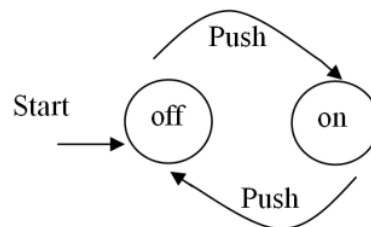


Figure 1. The basic model of finite state automata [8]

Figure 1 shown the easiest picture of an FSM is a switch "on" or "off". The picture will remember a condition that is currently in "on" or "off" and when the user presses / push button, having an effect with different results each time the user presses it Suitable for the existing state. FuSM is an automata in which the transition of each state occurs not from the event, but based on fuzzy variables and Suitable transitions, each state also has fuzzy. Because of that nature, when anything happens the system can be in more than 1 state, but can also be in each state at the same time [9]. Each state has its own membership value. FuSM is used to provide behavior that is more difficult to predict, and differs from ordinary FSM

that is easily predicted. FuSM has properties similar to traditional FSM, where automata are a collection of states yang, which are combined by fuzzy transition. As in FSM, a state shows the conditions for carrying out an action. However, the difference that makes the difference between FSM and FuSM is that the system is not required to be in the state at a certain time. in each state S_j can be combined with a fuzzy state activity ranging from 0 to 1 which shows the number of systems contained in the state [10]

3. Method

FSM is used as a way of describing the behavior of enemy character actions, and fuzzy logic is used to determine behavior in motion based on existing variables. This fuzzy logic is applied to the behavior of the enemy based on the player's behavior for the design of the formation of NPC behavior can be seen in the picture. Three variables are used to regulate NPC behavior, these variables are "Distance", "Time", and "Condition". The process for forming NPC behavior is shown in the figure 2.

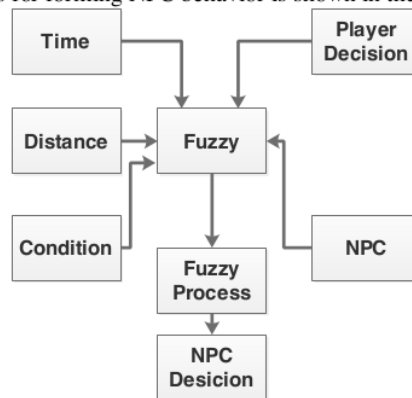


Figure 2. FuSM with Fuzzy Logic

the player's condition facing or not. For the membership function "Distance" there are 3 variables namely "Near", "Medium", and "Far" with intervals of values from 0 to 330. Fuzzyfication calculations are obtained and some functions used on point variables are 3 linear descending, trapezoid curves, linear rise, By manual calculation below:

Decreased Linear Membership Function (Near):

$$\mu[x] = \begin{cases} (200 - x)/(200 - 120); & 120 \leq x \leq 200 \\ 0; & x \geq 200 \end{cases} \quad (1)$$

Trapezoid Curve Membership Function (Medium):

$$\mu[x] = \begin{cases} 0; & x \leq 160 \text{ atau } x > 280 \\ \frac{x-160}{200-160}; & 160 \leq x \leq 200 \\ 120; & 200 \leq x \leq 240 \\ \frac{280-x}{280-240}; & x \geq 280 \end{cases} \quad (2)$$

Linear Function Rise (Far)::

$$\mu[x] = \begin{cases} 0; & x \leq 240 \\ \frac{x-240}{330-240}; & 240 \leq x \leq 330 \\ 120; & x \geq 330 \end{cases} \quad (3)$$

For the membership function "Time" there are 3 variables namely "New", "Medium", and "Old" with intervals of values from 0 to 600. Fuzzyfication calculations are obtained by using a function that is used, namely linear down, triangular curve, linear up by manual calculation below:

Decreased Linear Membership Function (New):

$$\mu[x] = \begin{cases} \frac{160-x}{160-0}; & 0 \leq x \leq 160 \\ 0; & x \geq 160 \end{cases} \quad (4)$$

Triangle Curve Membership Function (Medium):

$$\mu[x] = \begin{cases} 0; x \leq 120 \text{ atau } x > 300 \\ \frac{x-120}{300-120}; 120 \leq x \leq 300 \\ \frac{300-x}{460-300}; 300 \leq x \leq 460 \end{cases} \quad (5)$$

Linear Function Rises (Old):

$$\mu[x] = \begin{cases} 0; x \leq 420 \\ \frac{x-420}{600-420}; 420 \leq x \leq 600 \\ 1; x \geq 600 \end{cases} \quad (6)$$

For the membership function "Condition" there are 2 variables namely "visible" and "invisible" with intervals of values 0 to 5. Fuzzyfication calculation is obtained by using a function that is used, namely linear down, linear up by manual calculation below :

Decreased Linear Membership Function (Invisible) :

$$\mu[x] = \begin{cases} \frac{4-x}{4-1}; 1 \leq x \leq 4 \\ 0; x \geq 4 \end{cases} \quad (7)$$

Linear Function Rises (Visible):

$$\mu[x] = \begin{cases} 0; x \leq 3 \\ \frac{x-3}{5-3}; 3 \leq x \leq 5 \\ 1; x \geq 5 \end{cases} \quad (8)$$

Fuzzy rules are arranged to form the behavior of enemy NPC in the matrix table there are 3 inputs namely time, distance, and conditions. The test scenario is carried out to find out the shortcomings and to find out the application made has met the criteria Suitable for the purpose it was made.

4. Result

The scenario tested will provide several different input values to check the behavior of the movement of the NPC. Table 1 shown a lot has been achieved overall with no obstacles, Can be known the level of success by using the game engine unity of compatibility testing on each device is 90%.

Table 1. Device Running Test

No	Device	Android	Chipset	RAM	Testing Result
1	Redmi 4A	Android 7.1	Snapdragon 425	2	Success
2	Zenofone C	Android 4.4	Dual-Core	1	Success
3	Sony Xperia XZ	Android 8.0	Snapdragon 820	3	Success
4	Polytron Prime T8 R255B	Android 8.1	Mediatek MT6737	2	Fail
5	Redmi Note 7	Android 9	Snapdragon 620	3	Success
6	Xiomi 6X	Android 8.1	Snapdragon 660	4	Success
7	Xiomi Redmi Note 5 Pro	Android 7.1.2	Snapdragon 505	4	Success
8	Xiomi Note 2	Android 5	Mediatek MT6795	2	Success
9	Sony Xperia C3 Dual	Android 4.4.2	Snapdragon 400	1	Success
10	Samsung J7 Prime	Android 6.0.1	Exynos 7870 Octa	3	Success

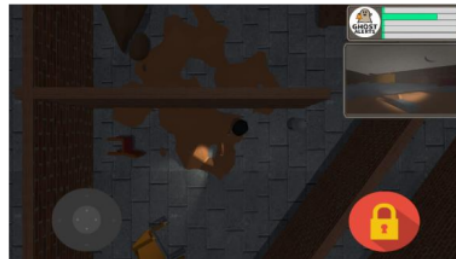


Figure 3. Success Test Running

In Figure 3 is the result of the Success test where most applications can run smoothly without any obstacles on the device that has been tested. The state test will be Quiteati, whether all states are running well Suitable with the existing rules and variables and recheck whether there are 2 states that are active together so that it is suitable with the Fuzzy State Machine, in Unity there is an animator which can be made a state machine and the Quiteati occurs. In Figure 5 is a FuSM where there are 2 active variables at the same time. Testing will be done by matching the value of the variable that has been given and will be tested whether the Player is suitable with the behaviour given to the NPC.

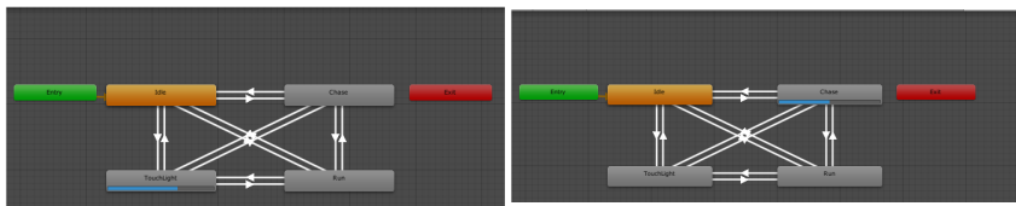


Figure 4. State FuSM 1 and State FuSM 2

In experiments conducted 18 times by testing each rule the results obtained were 100% suitable as shown in table 2.

Table 2. Testing FuSM Result

<i>Distance</i>	<i>Time</i>	<i>Input Condition</i>	<i>Output</i>	<i>Player Testing Result</i>
8	30	4.5	Run	Suitable
21	56	1.2	Attack	Suitable
33	180	4.2	Run	Suitable
41	320	2.3	Attack	Suitable
27	426	3.5	Run	Suitable
55	459	2.6	Attack	Suitable
90	27	4.7	Quite	Suitable
168	96	2.6	Quite	Suitable
157	335	4.5	Run	Suitable
211	423	2.1	Attack	Suitable
187	485	3.9	Run	Suitable
110	572	3	Attack	Suitable
261	124	4.9	Quite	Suitable
278	86	1.8	Quite	Suitable
300	187	4	Quite	Suitable
298	320	2.1	Quite	Suitable
281	550	4.4	Run	Suitable
310	590	2.2	Attack	Suitable

5. Conclusion

FSM is used as a way of describing the behavior of enemy character actions, and fuzzy logic is used to determine behavior in motion based on existing variables. Based on the research that has been done in making and developing this game, a conclusion can be drawn as follows: Educational Media is a game that has become a new field of learning, especially in this game entitled "Exploring the Old Museum Using Fuzzy State Machines" as a means to encourage Indonesian culture so that Indonesian culture can be recognized again.

- Development of NPC behavior using fuzzy state machine methods that produce NPC that cannot be guessed through existing variables Suitable for the rules that have been made. Suitable with the rules that have been made
- The application can run well through several devices with a trial with a suitability value of 90%.

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