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Application of the Finite State Machine Algorithm on 2D Platformer Rabbit Games vs Zombies

Ade Solihin[1], Eka Wahyu Hidayat[2], Aldy Putra Aldya[3]
[12,3]Informatics Engineering, Faculty of Engineering, Universitas Siliwangi, Tasiikmalaya, Indonesia
[1]ade.solihin14@student.unsil.ac.id, [2]ekawahyu@unsil.ac.id, [3]aldy@unsil.ac.id

Abstract- This research develops Android games by applying the FSM Algorithm (Finite State Machine) for the movement of NPC (Non-Player Character) to produce dynamic movements. The popular and legendary game with the appearance of side scroller is Super Mario Bross and Shovel Knight, the game is the most preferred game of its time to the present, but the game does not apply AI (Artificial Intelligence) so the game seems less challenging. The game is a concept game that is currently rarely used. Based on this, a side scroller-based survival game was created by implementing AI on NPCs on the Android platform. The AI used is the FSM Algorithm which functions to regulate enemy movements. The method used in developing multimedia products of this game uses MDLC (Multimedia Development Life Cycle). Based on the tests that have been carried out, the alpha test results are functionally appropriate and the results of beta testing using UserAcceptence Test (UAT) obtained a value of 86.40% which is declared feasible to use and can be developed. The advantages of this game are the presence of shock elements in the form of landslides, bursts of water, rock rain, and attacks by eagles.

Keywords- **Android, Artificial Intelligence, FSM, Game, Side Scrolling**

I. INTRODUCTION

The game console continues to evolve with the development of technology, starting from the quality of graphics, controllers that start from cables have now developed into wireless such as Playstation 4, XBOX-one, PSP, Nintendo Wii-U and many others. Even the current console includes broadband which is useful for accessing the internet such as a smartphone. Today's technology is widely used, namely smartphones with several reasons including because it is lightweight, fast, easier to use, and carried when traveling, besides that there are game features that are in demand by many people[1], [2].

The game continues to grow rapidly every year, many games are developed from the previous game by observing, imitating and modifying it so that the game that exists today only has similarities with existing games. Game is one of the media of technology that is popular among the people to become a necessity as a medium of entertainment for both small children and adults[3], The game itself is a lot of genres or types, as we know there are types of Suvival, Simulation, Role-Playing Games (RPG), Real-Time Strategy (RTS), First Person Shooter (FPS), Fighting, Action, and many genres others[4]–[8].

Examples of classic games that are popular among the public are one such as Shovel Knight, and Super Mario Bross. The game is the most preferred side scrolling based survival game of its time until now it can still be played. Side Scrolling Game is a game where players will be able to move from left to right to continue the purpose of the game and can sometimes move horizontally [9].

But the two games above can only be played on the Playstation or Nintendo console. Both of these consoles can only be owned by certain groups because the price is quite expensive and cannot be played freely anywhere and the two games above do not apply the element of Artificial Intelligence (AI) so the game is less challenging. One element that plays an important role in games is AI or artificial intelligence where computer programs act and think like humans rationally at the same time. The computer will react and answer the actions given by the opponent [10].

This game is included in multimedia-based applications where a multimedia is a tool that can create dynamic and interactive presentations that convert text, graphics, animation, audio and video [11]–[13].

Based on the above review, the research solution that will be taken is to build games with consoles that are easily available, by applying AI Finite State Machine in Non-Player Character (NPC). The application of FSM to the game is useful for determining various types of NPC responses based on the interactions performed by players [14]. And the application of Collision Detection to check collisions between two objects, either NPCs with players or other objects so as to produce reduced blood on the opponent and vice versa [15], with challenging gameplay where in the game there will be many elements of shock and unusual characters namely rabbits vs zombies.

The main problem in this research is how to design and build Games for the Android platform using Artificial Intelligence on NPCs, how to apply the Finite State Machine Algorithm to NPCs in the Rabbit vs. Zombie survival game, and how to test the side scroller 2D platformer Rabbit vs Zombie with alpha test for game functionality and beta test to take feedback from users.

The aim of this research is to design and build Games for the Android platform using Artificial Intelligence on NPCs, implement the FSM Algorithm on the survival game Rabbit vs. Zombie, and test the 2D platform game Rabbit

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vs Zombie side scroller with alpha test for game functionality and beta test to take feedback from users.

II. RESEARCH METHODS

The flow of research methods used in this study uses the research framework as follows:

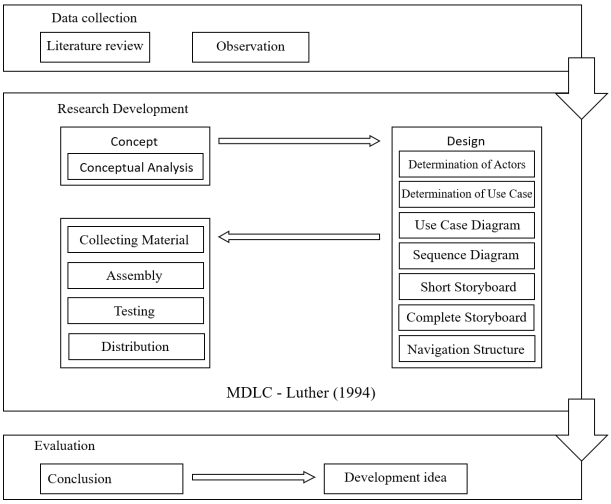

Figure 1. Research Methodology

This data collection is intended to collect all data and materials needed in making this application. The techniques used in carrying out this data collection include literature study and observation. The literature study is done by reading written data by studying and reading books and other media to support the research process, in the form of looking for a variety of theoretical references and conducting studies on previous research related to this research..

The development method used in making this product is Multimedia Development Life Cycle (MDLC) - Luther (1994), this method consists of Concept, Design, Material Collecting, Assembly, Testing, Distribution [16].

The evaluation phase is carried out after all the process of making the application has been successfully carried out including the drawing of conclusions and the idea of development.

III. RESULTS AND DISCUSSION

A. Concept

This stage is to determine product goals, identify users, determine the type of product, size, and target. Determining the objectives and characteristics of the user can determine the product as well as the multimedia design developed or worked on.

Table 1.Concept Description

Title	Rabbit vs. Zombie
Audiens	General
Duration	Unlimited
Animation	2D character animation (* .PNG)
Audio	Instrument (* .MP3)
Image	Image, Icon, Button (* .PNG and * .JPG)
Text	Button and game instructions
Interaktivity	Button and link
Theme	Side scrolling based survival game
Character	More than 1 character
Application Description	This game provides experience in playing with various challenging obstacles and using unfamiliar main characters, in order to reach the finish, the player must survive while going through various challenging obstacles and collecting carrots in each trip.

B. Design

This stage is carried out in detail starting with the initial description of the product such as application architecture, application interface, style, and other supporting elements. This stage will affect the next stage, collecting and assembly materials.

Table 2. Short Storyboard

Scene 1: Display the main menu consisting of the Play, Help, and Exit menus
Scene 2: Play menu displays Gameplay
Scene 3: The Help menu displays a guide to how to play the game

Story Board in this research is presented using SDW (Screen Design Worksheet) as a tool to bolster sketches that become a reference for the actual display of programs. The following is a sketch of the game application "Rabbit vs. Zombie" in the picture below:

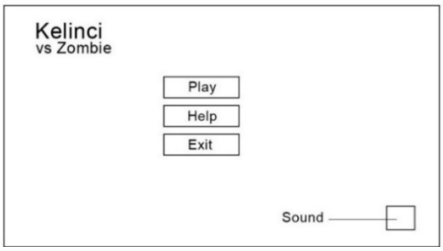

Figure 2. Main Menu Display (SDW No. 1)

The Main Menu consists of several menus such as Play, Help, and Exit.

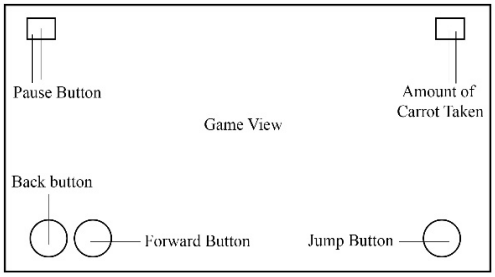

Figure 3. Display Gameplay (SDW No. 2)

The gameplay view is the result of the play menu display.

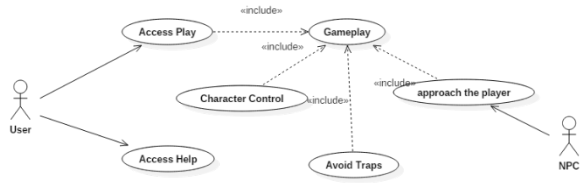

Figure 4. Use Case Diagram

Use case diagrams describe typical interactions between system users and the system itself, by giving a narrative of how the system is used.

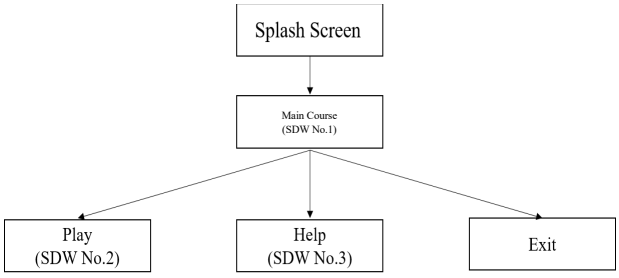

Figure 5. Application Navigation Structure

The navigation structure of this application describes the flow of a program so that users can understand every feature in the application.

C. Collecting Material

The collecting material stage includes collecting assets and materials according to the needs of multimedia application products to be built.

1. Making 2D Objects

2D objects in this game are made using Adobe Photoshop, and other objects take from sites that provide objects for free so that they can be used for game-making needs in research. Following is the process of making 2D objects in the picture below:

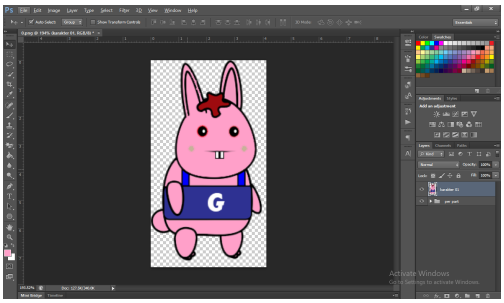

Figure 6. Making Character Objects

2. Sound

This game uses audio as a complement when playing so it doesn't seem lonely. Audio used in this game is obtained from a special site that provides free audio for games, with audio titles used by Cocoa Pocker from Youtube. Making Sound effects

3. Making User Interface

The user interface is very important in an application to run and connect users with the system. The UI in this application is obtained from the site of the UI provider for free without a license so that it can be used in making applications for research.

4. Making Program Codes

Making the program code is made using the C # programming language, the process of writing program code using the application provided by Unity, namely MonoDevelop-Unity.

D. Assembly

This stage is a combination of all multimedia materials that were previously collected at the stage of collecting materials and then processed into a multimedia product. These materials include images, animations, and music that have been created and combined in the Unity application to produce an interactive multimedia product. The following is a picture of the merging process in the Unity application and the results of the manufacturing process:

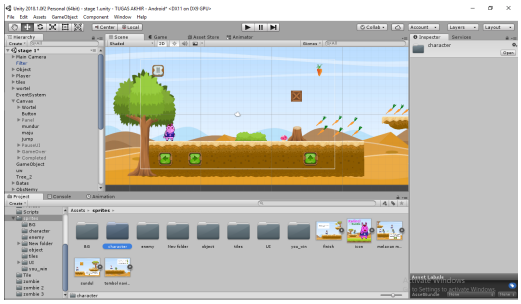

Figure 7. Assembly process at Unity

Figure 8. Main Menu

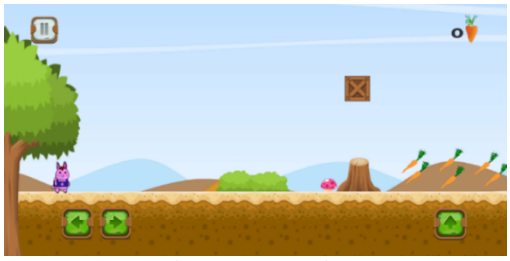

Figure 9. Gameplay

1. Implementation of the FSM Algorithm on NPCs

Table 3. Target Limit

```
transform.position = new
Vector3(target.position.x,
transform.position.y,
transform.position.z);
```

This program is intended as the starting point or target limit of the enemy for action to be taken where the enemy will approach the player.

Table 4. FSM algorithm on NPC

```
if(transform.position.x - Player.position.x <
Jarak)
 {
m_Follow.enabled = true;
m_anim.SetBool ("Serang", true);
 }
```

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```
else
 {
m_Follow.enabled = false;
 m_anim.SetBool ("Serang", false);
```

This program shows the situation where if the position of the enemy and the player with the specified distance, there will be a process that is the enemy attacking or approaching where the player's position is.

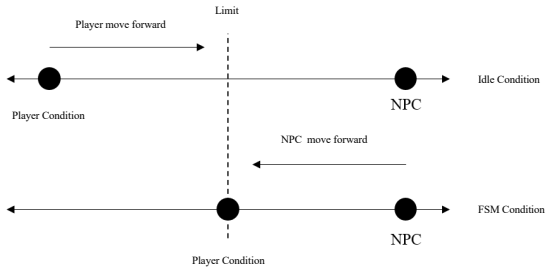

Figure 10. How the FSM Algorithm Works

The picture above shows the situation that occurs is the position of the distance between the enemy and the player is in an idle position (silent), if the player's position is at the target position it will be executed ie the NPC will move and attack the player with the specified distance at the target position.

2. Shock Elements

This game has several elements of shock or traps in the form of landslides, rock rain, bursts of water, and attacks by eagles. This shock element makes the game more challenging to play.

Figure 11. Shock Element in the form of Landslide

The figure 11 is a landslide shock element where as in the red box if the player is right above the object there is no chance for lonca to go to the next road but it will fall so that the player dies and will return to the beginning.

Figure 12. Shock Elements in the form of Stone Rain

The picture above is a shock element from the hailstones, where as in the red box if the player passes right at that position then the rock rain will drop suddenly which causes the player to die and return to the beginning of the game.

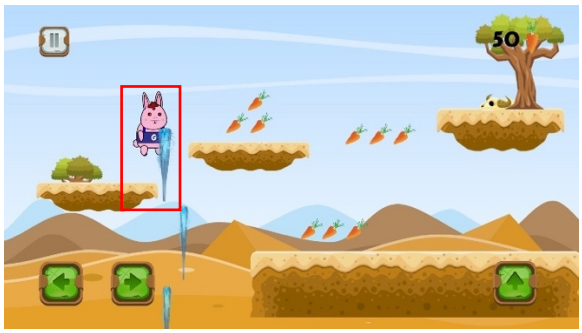

Figure 13. Shock Elements in the Form of Water Spurts

The picture above is a shock element in the form of a burst of water, where as in the red box if the player passes right at that position then the burst of water will come out and if the player is hit by a burst of objects the player will play again from the start.

Figure 14. Shock Elements in the Form of an Eagle Attack

The picture above is a shock element in the form of an eagle attack, where as in the box if the player passes right at that position then the player will return to the beginning of the game.

E. Testing

This stage includes testing products that have gone through assembly stages to see the possibility of errors. This stage can be done using the alpha test and beta test methods to test the application.

1. Alpha Test

The Alpha Test testing stage uses the black-box testing method. The black-box method is used to find out if the game is functioning correctly. Following is the planning table for black-box testing:

Table 5. Alpha Testing

No.	Testing Scenario	Expected results	Application Response	Results
Main Menu Testing				
1.	Main Game navigation button	Showing the main game from the game "Rabbit vs. Zombie"	Moving the scene from the main menu to the gameplay menu successfully runs smoothly	Be accepted

2.	Help navigation button	Displays a guide on how to play the game "Rabbit vs. Zombie"	Moving the scene from the main menu to the Help menu works smoothly	Be accepted
3.	Audio Button	Audio can be set by turning it off or on according to user input	Can turn off or turn on audio	Be accepted
NPC Testing				
1.	NPC	The NPC will move when approached by the player with the specified distance	The NPC responds according to the player's movements approaching the specified distance	Be accepted
2.	NPC	When the player moves away from the position of the NPC with a certain distance, it will shut up	The NPC responds according to the player's movements when playing away the NPC will be silent with the distance specified	Be accepted
3.	NPC	When a player steps on an NPC, the NPC dies	As per the player's response when stepping on the NPC, the NPC died	Be accepted

1. Beta Test

Beta tests are carried out on the application of real-life software that cannot be controlled by the developer and involves end users, in beta testing feedback will be taken from users by filling out questionnaires and considering learning aspects of information, namely VISUALS. This aspect is explained in detail and the material collected is presented in simple and communicative languages complemented by other multimedia components by taking into account the following VISUALS concepts [17]:

1. *Visible*, the material presented is visually clearly visible, the level of readability is high, high level of graphic sharpness contains one meaning.
2. Interesting, that is, the content of the message is in accordance with the needs of the audience, the appearance is good and attractive so that it arouses curiosity, and tries to maintain the continuity of the process of communication or interaction and learning.
3. The simple, focused message, selection of words, letters, images do not change the meaning of the message, language, and straightforward display.
4. Useful, according to audience needs and learning objectives and learning outcomes desired.
5. Accurate, the content of the message has the right meaning, in accordance with needs, the delivery is accurate, based on sources that can be accounted for.
6. Legitimate, the contents of the message are correct, arranged logically following scientific rules and make sense.
7. Structure, a series of messages delivered dramatically, in logical and easily understood sequences.

A beta testing process with questionnaires distributed to respondents, the population taken is people who have or are active in playing games, the samples taken are 30 people, then the percentage of each answer to the questionnaire is identified using the formula:

Interval Formula

$$Results = T\ x\ Px \ldots\ldots$$
$$Index = \frac{Jumlah}{Y} x100 \ldots\ldots \quad (1)$$

I = 100 / total score (*likert*)

Information:
Y = Percentage Value
P = The number of respondents answers to each question
Q = Number of respondents

The total respondents who filled out questionnaires were 30 people. The following is the percentage of the results of the questionnaire processing:

Table 6. Results of the "Good" Questionnaire

#	Aspect	Question	B	C	K	Score	(%)	Info
1.	*Visible*	1	57	20	1	78	86,66%	Good
		2	81	6	0	87	96,66%	Good
		3	42	32	0	74	82,22%	Good
		4	69	14	0	83	92,22%	Good
2.	*Interesting*	5	27	42	0	69	76,66%	Good
		6	36	34	1	71	78,88%	Good
		7	60	20	0	80	88,88%	Good
3.	*Simple*	8	33	38	0	71	78,88%	Good
		9	57	22	0	79	87,77%	Good
		10	87	2	0	89	98,88%	Good
4.	*Useful*	11	72	12	0	84	93,33%	Good
		12	66	16	0	82	91,11%	Good
5.	*Accurate*	13	66	16	0	82	91,11%	Good
		14	46	21	0	67	74,44%	Good
		15	33	38	0	71	78,88%	Good
		16	48	28	0	76	84,44%	Good
6	*Legitimate*	17	51	24	1	76	84,44%	Good
		18	54	28	0	82	91,11%	Good
		19	36	34	1	71	78,88%	Good
		20	48	28	0	76	84,44%	Good
7	*Structure*	21	60	20	0	80	88,88%	Good
		22	69	12	1	82	91,11%	Good
		Total				**70,87**	**86,40**	**Good**

Table 7. Validation Level Category

Percentage (%)	Percentage (%)
0% - 33,32%	Less
33,33% - 66,65%	Enough
66,66% - 100%	Good

The conclusion that can be drawn is that this game has an interpretation of 'Good', so it can be said that this game is feasible to use and the experimental results of respondents who have tried running this game on a smartphone, this game can be run on the android operating system.

F. Distribution

This Tahapan Distribution produces a Survival vs. Rabbit Zombie Game product and this product is distributed on the Playstore and can be downloaded for free. Advantages of the Survival Game application Rabbit vs. Zombie is this game applying artificial intelligence to the character of the NPC, the graphics used by the times, and this game has a shock element that makes this game more challenging to play.

The disadvantage of this game is that the game cannot be played Multiplayer, the application cannot run under the Android OS Jelly Bean, the game does not have the level of the game, and there are still shortcomings in the object that sometimes the player cannot.

IV. CONCLUSION

Based on the results of the research that has been done, conclusions can be drawn, namely:

Has successfully built a game with a 2D platformer based scroller survival genre, Rabbit vs. Zombie that can run on Android smartphones. This game also provides new and different experiences for users with unfamiliar characters used, as well as applying elements of AI to NPC characters, AI used is Finite State Machine which functions to regulate movements on NPCs. In addition, it applies several shock measures in the form of landslides or landslides, rock rains, eagle attacks, and water bursts that make this game more challenging to play.

Having succeeded in applying the FSM Algorithm (Finite State Machine) to NPCs that can move and respond to the movements of player characters, NPCs can move closer if the player advances towards the enemy and when the player moves away the NPC will return to a certain distance.

It has been successful in accordance with beta test testing conducted by involving users outside the developer environment that the Rabbit vs. Zombie Game application product is included as a feasible category to be used with conditions to be refined again.

Based on the research that has been done, some suggestions can be given, namely that the application is more interesting if more NPC characters can be involved in the application, and adding more animated movements to each 2D character, the application is more interesting when adding audio effects to each movement , the app is even more challenging if you add more traps and extend the game flow, and add a leaderboard feature that can compete with other players using Google Play account.

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