

IMPLEMENTATION OF FINITE STATE MACHINE (FSM) AND PATHFINDING METHOD IN 2D GAMES

Betty Dewi Puspasari ¹, M.Sofian Attasauri ², Agung Panji Sasmito ³, Ahmad Fahrudi Setiawan ⁴

¹ Computer Science and Information Engineering, National Dong Hwa University Taiwan

^{2,3,4} Informatics Engineering, National Institute of Technology Malang

810921002@gms.ndhu.edu.tw

ABSTRACT

History is very important for everyone and society because it plays a vital role in people's lives, especially for high school students. A survey of 20 students found that all students knew about the hero Pattimura, while 40% knew less about Pattimura, and 95% wanted to learn about the values of Pattimura's struggle, and there were 5 students who did not know. Based on this problem, the idea arose to create an Android-based 2D game called "Pattimura's Struggle". The purpose of this game is to tell the story of the Pattimura heroes who fought the invaders and their heroic actions. This game is an educational game by telling a Pattimura Struggle, namely a captain who fought the Dutch army. FSM is used to manage the state and transition of NPC behavior, while A Star is used to find the best path to reach the goal to the player. Based on the results of functional testing, a 100% success rate was obtained. The FSM and Pathfinding A Star method tests showed 100% results, and tests on 20 players showed that 89% of players stated that in this game the Pattimura struggle was clearly conveyed to the player and 11% experienced obstacles. Overall, most players said that the game "Pattimura's Struggle" functioned effectively and the historical education in the game was conveyed..

Keywords : *FSM, Game, Pathfinding, Pattimura*

1. INTRODUCTION

History is an important part of human life. The concept of history refers to the concept of time, especially past time. The concept of history as an event conveys a picture of a past experience that can be studied and understood today, to predict current and future events [1].

A hero is a title given to an Indonesian citizen or someone who fought against colonialism in a region that is now the Unitary State of the Republic of Indonesia, where the citizen died or died defending the nation and state, or someone who during his lifetime acted heroically or achieved extraordinary achievements and work for the development and advancement of the nation and state of the Republic of Indonesia [2]. One national hero who has a good example and can be used as motivation is Captain Pattimura. Thomas Matulessy, also known as Captain Pattimura, was a brave leader who fought against Dutch colonialism that attempted to take over the spice trade in Maluku. He had a strong body and a knightly soul.

The importance of history in the lives of every individual and society because history also plays a vital role in the lives of society, especially students at the high school level. The heroic war of Pattimura against the Dutch colonialists is one of the historical events that is worth studying and preserving. The results of a survey of 20 students showed that all students knew the hero Pattimura, then from 20 students who knew the history of Pattimura 60% while 40% did not know much about the history of Pattimura and 95% wanted to learn the values of struggle in the history of Pattimura and there were 5% who did not want to learn the values of struggle

from the history of Pattimura. Games are a medium that can be applied to convey material on the events of Pattimura's struggle against Dutch colonialism well and enjoyably [3].

Based on these issues, the idea arose to develop a 2D Android-based game titled "Perjuangan Pattimura" (Pattimura's Struggle), commemorating the history of the heroes who fought against colonial rule and the heroic deeds of Pattimura himself. A 2D game was chosen because it is simpler to develop, runs smoothly on devices, and is easy to play for all ages, especially students. The 2D game's visuals are also sufficient to convey the historical story and values of the struggle without the need for 3D graphics, which require more cost, time, and effort. This educational game tells the story of Pattimura's struggle, as a captain fought against the Dutch army.

The use of the FSM method in "Perjuangan Pattimura" is very useful for managing the movement and behavior of characters and enemies. Using the FSM method, each character has a clear status, such as standing still, running, attacking, being hit, or dying, allowing for smooth transitions between states. Furthermore, the FSM method helps enemies behave more systematically, for example, patrolling when the player is not visible, chasing when they are visible, and attacking when they are close. This method also makes the game lighter because it only runs one status at a time, so it doesn't burden the system [4].

The use of pathfinding methods in the game "Perjuangan Pattimura" is crucial for managing enemy movement to make it more intelligent and realistic. With pathfinding methods, enemies can find and follow the best path to approach the player,

avoid obstacles, and reach the goal without getting stuck on objects such as trees or buildings. This makes the game feel more challenging because enemies not only move in a straight line but can adjust their direction according to the surrounding conditions. Furthermore, pathfinding methods also help optimize enemy movement so they don't waste time or energy walking in ineffective directions [5].

2. LITERATURE REVIEW

2.1. Previous Research

In the study titled "Application of Pathfinding and FSM (Finite State Machine) in the Android-Based Game 'Lost Civilization,'" the FSM method is used as a decision-making system; it is a control system that demonstrates the behavior or working principles of a system using states, events, and actions. Currently, the A algorithm is used in the development of this game to support the pathfinding method, which allows enemies to find the fastest route to catch up with the player [6].

According to the study titled "Designing a Jayakatwang Adventure Game Using the Finite State Machine (FSM) Method and Android-Based Pathfinding," pathfinding is a way for players to move along the shortest path without encountering obstacles. In real-time games, the pathfinding method is used, where a player determines a starting point and an end point as a goal [7].

This study is titled "Designing a 2D Alien Warfare Game Using the Finite State Machine (FSM) Method Based on Android." This game was created using the Unity Engine and utilizes artificial intelligence to attack enemy or non-player characters. The FSM method provides artificial intelligence so that enemy characters can move closer to the player and attack [8].

According to a study entitled "Designing a 2D Platformer Game 'Adventure Quest' Using the Finite State Machine Method Based on Android," the use of a Finite State Machine (FSM) is a method that can be used to develop this game genre. The FSM approach utilizes various interrelated conditions, events, and actions [9].

Navigation is one of the main problems with artificial intelligence (AI) in games. Characters in games can appear stupid if they have navigation problems. Games become more enjoyable if you can solve pathfinding problems correctly. One way to utilize the pathfinding method is by using one of the plugins and script calls available for the MV Engine RPG Maker. This plugin allows characters or NPCs to count how many map tiles there are on a map and choose the fewest number of tiles needed to reach the desired destination [10].

2.2. Game

Games are a popular form of entertainment, enjoyed by everyone from children to adults and beyond. Besides relieving fatigue from activities,

games also train a person's thinking patterns in finding solutions to problems within the game. Games are also a powerful learning tool [11].

2.3. Godot Engine

Godot Engine (GE) was chosen as the game development tool for this project. GE is a powerful and flexible open source game development engine. By using GE, we can access various features needed to develop quality 2D games, including support for physics, animation, scripting or godot script (GS), and resource management because the game is based on everyday life. The node hierarchy-based management is placed and placed in other scenes, so GE helps developers work faster, besides the editor and interface are also easy to understand quickly by developers [12].

2.4. Finite State Machine

Finite State Machine (FSM) is a methodology for building control systems that describe the behavior or working principles of a system using three elements: state, event, and action. This model is based on a hypothetical machine made up of one or more states. The machine must move from one state to another in order to perform different actions because only one state can be active at a time [13].

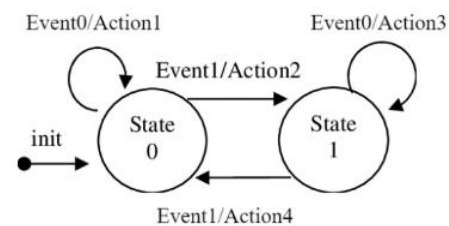


Figure 1. Finite State Machine Diagram

Figure 1, the FSM diagram, has two states. The system starts at State 0, then moves to State 1 or remains in the same state depending on the event, with each transition resulting in a specific action.

2.5. Pathfinding A Star

A star is one of the best pathfinding algorithms, first developed by Peter Hart, Nils Nilsson, and Bertram Raphael in 1968 in Computation on the A Star Algorithm (A*). This algorithm uses the smallest calculation from the initial path to the final path to find the shortest path. This ensures that the total cost of the path is as low as possible [14].

3. METHOD

The system design that will be created in the Pattimura Struggle game, such as storyboard, gameplay, flowchart, Finite State Machine, Pathfinding A Star, menu structure and character design.

3.1. Flowchart

The function of designing a game flowchart is to show the process flow from the beginning of the game to the end of the game, as shown in Figure 3.

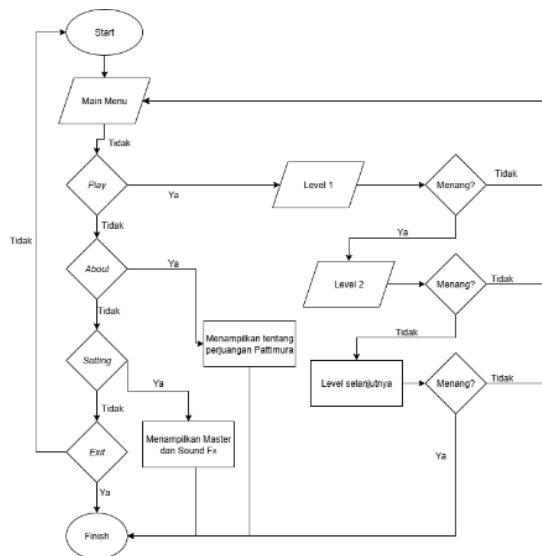


Figure 2. Game Flowchart

Figure 2 shows the game schematic for "Pattimura's Struggle." The game begins with the main menu, which contains four options: Play, About, Settings, and Exit. The start menu allows players to progress through the levels.

3.2. Menu Structure

The Pattimura Struggle game consists of several menus: the main menu, the level menu, the about menu, the settings menu, and the exit menu. A diagram of the menu structure can be seen in Figure 3.

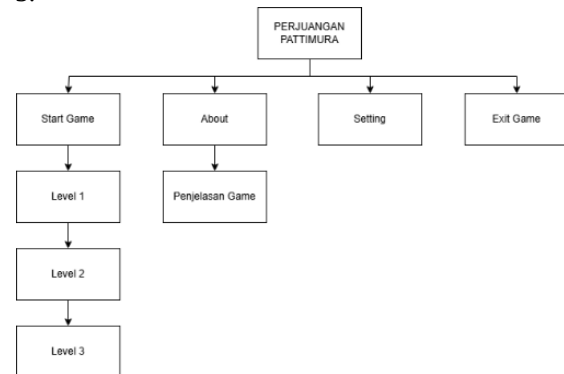


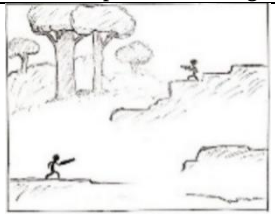
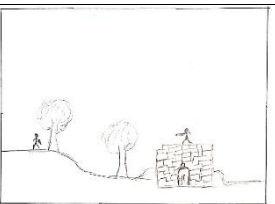
Figure 3. Menu Structure

3.3. Storyline

In 1817, in Haria Village, Saparua Island, the people rose up against increasingly brutal Dutch oppression. Led by Captain Pattimura, the village fighters strategized and attacked Fort Duurstede, a symbol of colonial power in Saparua. With courage and limited weaponry, they successfully captured the fort, shaking Dutch rule in Maluku and igniting a fire of resistance that burned throughout the country.

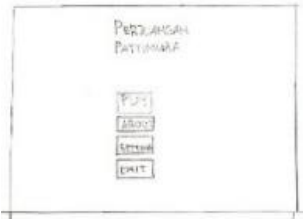
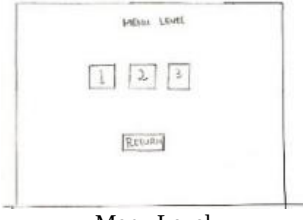
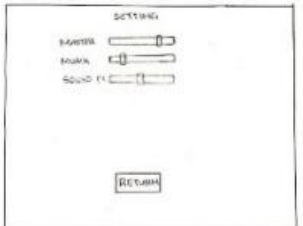
3.4. Storyboard

Table 1. Storyboard

Image	Information
 Scene Map 1 Haria Village	At level 1, players must defeat three ordinary soldiers. Each soldier has 100 HP and 10 Attack, earning a score of 10.
 Scene Map 2 Saparua Island	On level 2, players must perform the same tasks as in the previous level, but the enemies are stronger: three elite soldiers. The elite soldiers have 150 HP and 20 Attack, and the score for defeating them is 15.
 Scene Map 3 Duurstede Fortress	Level 3 is the final map of the game, which is the Dutch commander's fortress. There are three Dutch commanders on this map. The Dutch commander has 250 HP, 35 Attack, and a score of 20. Players can automatically replenish their health until their health is full when their health is below 150..

3.5. Layout Design

Table 2. Layout Design

Image	Information
 Main Menu	This is the initial screen when opening the game. Pattimura's Struggle
 Menu Level	When the user selects the play button on the main menu, they enter the level menu
 About Menu	When the user selects the about button, they enter the about menu
 Menu Setting	If the user selects the settings button, they will enter the settings menu
 Game Layout	This is the layout of the game display on an Android device.

3.6. Application of the Finite State Machine Method

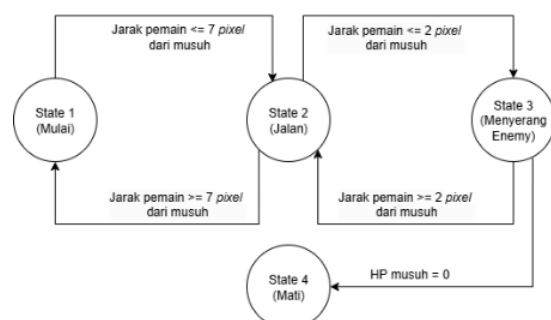


Figure 4. Finite State Machine Diagram for Enemy Level 1

At level 1, the FSM flow is applied to the enemy character. If the player character approaches a distance of ≤ 7 pixels from the enemy, the enemy will chase it, and if the player approaches a distance of ≤ 2 pixels from the enemy, the enemy will attack. If the player moves away from the enemy by a distance of ≥ 7 pixels, the enemy will return to its initial position. As shown in Figure 4.

At levels 2 and 3, the FSM flow is applied to the enemy character. If the player character approaches a distance of ≤ 7 pixels from the enemy, the enemy will chase them. If the player approaches a distance of ≤ 3 pixels from the enemy, the enemy will attack. If the player moves away from the enemy by a distance of ≥ 7 pixels, the enemy will return to its starting position. As shown in Figure 5.

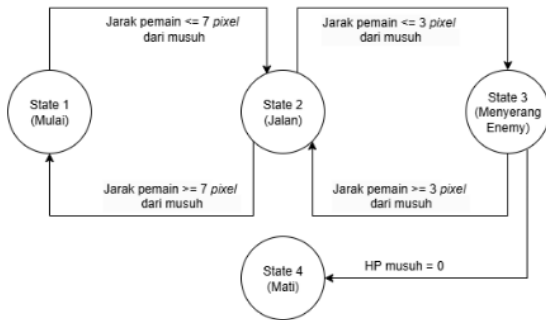


Figure 5. Finite State Machine diagram for level 2 and level 3 enemies

3.7. Implementation of the A Star Pathfinding Method

The most fundamental problem in artificial intelligence (AI) is pathfinding, which is the process of moving a game character's position from the starting point to a specified destination. A Star is a method for finding the shortest path to reach the player's destination. The application of this method is on the player's enemy, the enemy's movement will be able to follow where the player is, the enemy will attack the player if the enemy is close to the player in figure 6.

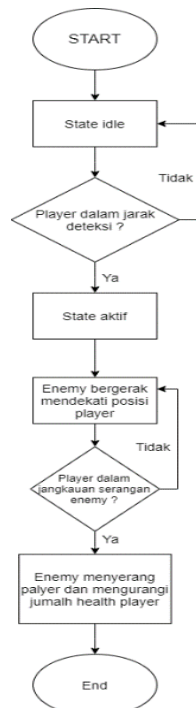


Figure 6. Flowchart Pathfinding A Star on the enemy

4. RESULTS AND DISCUSSION

4.1. Character Design

Table 3. Character Design

Character	Information
 Pattimura	The main character in this game, who continues to be used until the game is finished

Character	Information
 Ordinary Soldier	The main character in this game, who continues to be used until the game is finished
 Elite soldiers	This is an enemy character that can deliver long-range attacks. This enemy is at level 2
 Dutch Commander	This is the strongest enemy character who can deliver long-range attacks. This enemy is at level 3

Tabel 4. Desain environment dan UI

asset	Information
 Platformer Tiles	Platformer tiles for footing
 Tree	Trees for background
 Kouse	Home to be an obstacle
 Gate	Gate to move to each completed level
 Fortress	Fortress to be an obstacle
 Left Arrow Button	Left Arrow Button for player left movement.
 Right Arrow Button	Right Arrow Button for player right movement.
 Jump Button	Jump Button for player upward movement
 Attack Button	Attack Button for player attacks

4.2. Main Menu

Figure 7 shows the main menu of the Pattimura Struggle game, which includes the Play, About, Settings, and Exit buttons. The Play button starts the game, the About button explains the game's purpose, the Settings button allows you to adjust the game's sound settings, and the Exit button exits the game.



Figure 7. Main Menu

4.3. About



Figure 8. About

Figure 8 shows the About menu, which contains text explaining why this game was created, and a Back button to return to the Main Menu.

4.4. Setting

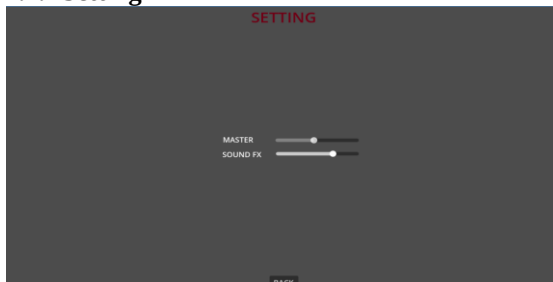


Figure 9. Settings

Figure 9 shows the Settings menu, which contains sliders for adjusting the master sound and sound effects. There's also a Back button to return to the Main Menu.

4.5. Level 1



Figure 10. Level 1 View

Figure 10 shows the map design for level 1, where three ordinary soldiers must be defeated to advance to the next map. If the player dies, the map restarts from the beginning, and enemies respawn.

4.6. Level 2

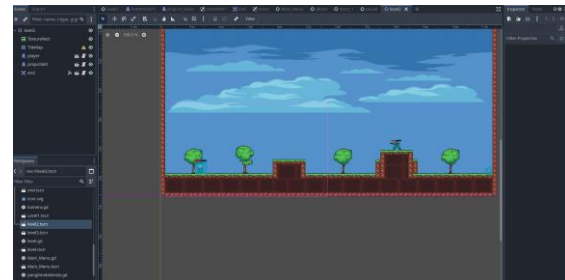


Figure 11. Level 2 View

Figure 11 shows the layout of the Level 2 map, which features three elite soldiers, stronger than those on the previous map, who must be defeated to advance to the next map. If a player dies, the map restarts from the beginning, and enemies respawn.

4.7. Level 3

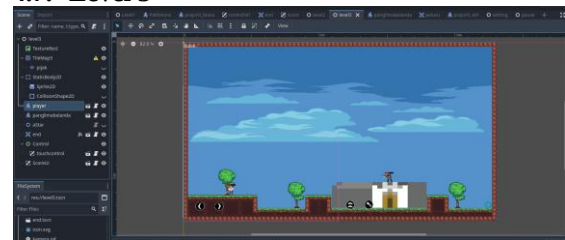


Figure 12. Level 3 View

Figure 12 shows the map design for Level 3, where three Dutch commanders must be defeated to complete the game. If a player dies, the map restarts from the beginning, and enemies respawn.

4.8. Pause menu

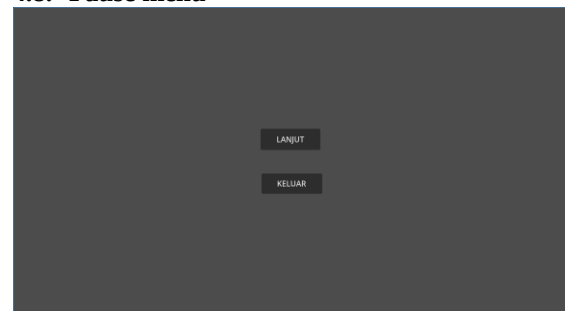


Figure 13. Pause Menu

Figure 13 shows the Pause menu, which includes a Continue button to continue the game and an Exit button to return to the Main Menu.

4.9. Main Menu Testing

Table 5. Main Menu Testing

Number	Tested Features	Expected scenario	Expected results	Results
1.	"PLAY" button on the Main Menu	If you click the "PLAY" button on the Main Menu.	Game displays Story Prologue	In accordance
2.	"ABOUT" button on the Main Menu	If you click the "ABOUT" button on the Main Menu.	Game displays about menu	In accordance
3.	"SETTING" button on the Main Menu	If you click the "SETTING" button on the Main Menu	Game displays settings menu	In accordance
4.	"EXIT" button on the Main Menu	If you click the "EXIT" button on the Main Menu	Exit the game	In accordance

From the test in Table 5, 4 features were tested and the results were 100% as expected where the

play, about, settings, and exit buttons worked as they should.

4.10. About Menu Testing

Table 6. About Menu Testing

Number	Tested Features	Testing Scenario	Expected results	Results
1.	Explanatory text display	In the about menu, the explanatory text is displayed.	explanatory text is displayed	In accordance
2.	"BACK" button on the About Menu	If you click the "BACK" button on the About Menu	Game returns to main menu	In accordance

From the test in Table 6, 2 features were tested and the results obtained were 100% as expected

where information about the game could be obtained and the back button functioned properly.

4.11. Testing the Settings Menu

Table 7. Testing the Settings Menu

Number	Tested Features	Testing Scenario	Expected results	Results
1.	Slider on sound fx.in Settings Menu	Slide the slider left and right	To the left the sound effect gets smaller and vice versa	In accordance
2.	Slider on master in Settings Menu	Slide the slider left and right	To the left the master's voice gets smaller and vice versa	In accordance
3.	"BACK" button on the Settings Menu	If you click the "BACK" button on the Settings Menu	Game displays settings menu	In accordance

From the test in Table 7, 3 features were tested and the results were 100% as expected, where the

player can adjust the sound fx and master volume by sliding the slider..

4.12. Pause Menu Testing

Table 8. Testing the Settings Menu

Number	Tested Features	Testing Scenario	Expected results	Results
1.	"PAUSE" button on the Game Screen	If you click the "PAUSE" button on the Game Screen	The game will stop and the pause menu will appear.	In accordance
2.	"CONTINUE" button on the Pause Menu	If you click the "CONTINUE" button on the Pause Menu	The game will run again.	In accordance
3.	"EXIT" button on the Pause Menu	If you click the "EXIT" button on the Pause Menu	Game displays main menu	In accordance

From the test in Table 8, 3 features were tested and the results obtained were 100% as expected where the pause, continue, and exit buttons worked as they should.

4.13. Player Control Testing

Table 9. Control Player Testing

Number	Tested Features	Function	Expected results	Results
1.		Walk to the right	Character moves to the right	In accordance
2.		Walk to the left	Character moves to the left	In accordance
3.		Player jumps	Jumping Character	In accordance
4.		Player menyerang	Player attacks	In accordance

From the tests in Table 9, 4 features were tested and the results obtained were 100% as expected where all player controls could be run.

4.14. Finite State Machine Testing

Table 10. Finite State Machine Testing

Number	Condition	Testing Scenario	Expected results	Results
1.	Enemy state patrol	Check enemy movements within the specified patrol radius.	Enemy patrols within a specified radius	In accordance
2.	Enemy state chase	Player approaches the enemy according to the state chase radius	When the player approaches the enemy within the chase state radius, the enemy enters the chase state.	In accordance
3.	Enemy state chase	Player moves away from enemy outside chase state radius	When the player moves away from the enemy, the enemy's chase state returns to the idle state	In accordance
4.	Enemy state attack	Player approaches the enemy according to the attack state radius.	When the player continues to approach the enemy within the radius of the enemy's attack state, the enemy enters the attack state	In accordance
5.	Enemy state attack	Player moves away from enemy outside the attack state radius	When the player moves away from the enemy, the enemy's attack state goes out of the radius and returns to the chase state	In accordance
6.	Enemy state death	Player attacks until the enemy's blood becomes 0	Enemy will enter death state and be removed from the map	In accordance

The tests in Table 10 above, which tested six enemy states, yielded 100% results according to the predetermined scenario. This demonstrates that the FSM method effectively manages state transitions, from patrolling, pursuing, attacking, and even

enemy death. Thus, the FSM implementation successfully provided stable and consistent AI for enemy behavior in the game..

4.15. Pathfinding Testing

Table 11. Pathfinding Testing

Number	Character	Condition	Results
1.	Ordinary Soldier	Can find the nearest path from the player's position	In accordance
2.	Elite Soldier	Can find the nearest path from the player's position	In accordance
3.	Dutch Commander	Can find the nearest path from the player's position	In accordance

The test shown in Table 11 above, which covers three conditions, showed 100% results, as expected. This is evident in the results of ordinary soldiers, elite soldiers, and the Dutch commander, who were able to find the shortest path to the player's

position without any problems. These results prove that A-star pathfinding was successfully implemented to support enemy movement in the game.

4.16. Respondent Testing

Table 12. Respondent Testing

Number	Question	Answer	
		Yes	No
1.	Do you think the game's visuals are appropriate?	18	2
2.	Does the character design in the game match the original character of the Pattimura hero?	17	3
3.	Is the history of Pattimura's struggle conveyed in this game?	20	0
4.	Do you feel interested in the history of Pattimura after playing this game?	18	2
6.	Are the music and sound effects supported in this game?	19	1
Total		89	11
Percentage		89%	11%

Berdasarkan Tabel 12 Survei kepada 20 pengguna game "Perjuangan Pattimura" menghasilkan data bahwa 89% pengguna menyatakan game berjalan lancar, dan 11% mengalami kendala. Hal ini mengindikasikan bahwa secara umum performa game sudah baik, namun masih ada sebagian masalah kecil yang perlu diperhatikan agar pengalaman bermain semakin optimal.

5. CONCLUSION

Based on the results of the game design, it can be concluded that the application of the Finite State Machine and Pathfinding A Star methods on enemy characters was successfully applied to the game where the test results obtained a 100% success rate according to the game, so these methods are considered successful in being implemented into the game, from functional testing on the features in the game menu and player control testing also obtained a 100% success rate according to the game so that it is considered to have run well. Based on the results of the questionnaire from 20 students showed that 89% of users stated that the game ran smoothly and 11% experienced problems. So overall, most players stated that the game "Perjuangan Pattimura" ran well, so overall, most players stated that the game "Perjuangan Pattimura" clearly conveyed the history of Pattimura. For further development, it is recommended to improve the appearance of the game, can be played online and the game can be played multiplayer.

REFERENCES

- [1] Martha, Yussi., Sa'diyah, Durratus, Maulana, Habib., Wartho, Warto. (2023) "Konsep Dasar Sejarah: Implementasi Dalam Pembelajaran" (Jurnal Pendidikan Bhineka Tunggal Ika).1(4)165.
- [2] Murthadho, R, A., Suharsono. (2024) "Rancang Bangun Game Tebak Pahlawan Sebagai Media Pengenalan Pahlawan Indonesia Menggunakan Adobe Animate 2023".(Jurnal Teknologi Informasi). 3(1) 2.
- [3] Wicaksono, B, A., Mahmudi, A., & Auliasari, K. (2023). PERANCANGAN GAME ALIEN WARFARE 2D MENGGUNAKAN METODE FINITE STATE MACHINE (FSM) BERBASIS ANDROID. JATI (Jurnal Mahasiswa Teknik Informatika),7(5), 2945-2951.
- [4] Satrio, Imam., Wahyuni, F, S., dan Rudhistiar, D. (2024) Penerapan A* Pathfinding dan FSM (Finite State Machine) pada Game "Lost Civilization" Berbasis Android. JATI (Jurnal Mahasiswa Teknik Informatika), 8(2), 1192.
- [5] Ananda, M, R, G., Sasmito, A, P., and Vendyansyah, N. (2024). "Perancangan Game Adventure Jayakatwang Menggunakan Metode Finite State Machine (FSM) dan Pathfinding Berbasis Android".JATI(Jurnal Mahasiswa Teknik Informatika), 8, (9), 8446-8447.
- [6] Arrazzaq, M.F., Sasmito, A, P., and H.Z. Zahro'. (2023) "Perancangan Game 2D Platformer "Adventure Quest" Dengan Metode Finite State Machine Berbasis Android".JATI (Jurnal Mahasiswa Teknik Informatika).7(3) 2419-2426.
- [7] El Reginald Caesaro San, & Eva Handriyantini. (2022). Penerapan Metode Pathfinding Pada Pengembangan Game "The Book of Aksara" Pada Perangkat Bergerak. Prosiding SISFOTEK, 6(1), 82.
- [8] Saputra, D. (2019). "Penerapan Metode Finitic State Machine Pada Game War Of Astraghoul". JATI (Jurnal Mahasiswa Teknik Informatika),3 (1), 91-97.
- [9] Pahlawan, R.M.R, F.S. Wahyuni and D. Rudhistiar. (2024). "Perancangan Game 2D The Tale Of Hero Berbasis Android Menggunakan Metode Finite State Machine". JATI (Jurnal Mahasiswa Teknik Informatika).
- [10] Ardana, F.Z., A, F.Setiawan.and F.S.Wahyun.i (2024). "Perancangan Game 3D Maggie's odyssey Dengan Metode Pathfinding". JATI (Jurnal Mahasiswa Teknik Informatika Malang). 7(4).2411-2412.
- [11] Pratama, S.D., N. Vendyansyah and R.P. Prasetya. (2024)"Pembuatan Game 2D "ken Arok" Menggunakan Metode Finite State Machine dan Pathfinding.JATI (Jurnal Mahasiswa Teknik Informatika). 8(5) 8389-8396.
- [12] Kurniawan, B. (2010). Ensiklopedia Pahlawan Bangsa yang Wajib Kamu Tahu. Yogyakarta: Pelangi Ilmu