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Development of the 3D Game "Lavender's Warmth" Using the Collision Detection Method

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Abstract **–**.This study presents the development of a 3D puzzle–adventure game titled "Lavender's Warmth" using the Collision Detection and Finite-State Machine (FSM) methods. The use of Collision Detection is essential because the game relies heavely in physical interaction between puzzle pieces, slots, and environmental object. Without Collision Detection, the game would fail to validate puzzle placement. Meanwhile, the FSM approach is required to regulate enemy behaviour in structured manner. The Finite-State Machine was chosen because it is one of the most widely adopted approaches for modeling NPC behavior, offering deterministic transitions, low memory usage, and ease of debugging. Alternative techniques such as behavior trees or utility AI are more complex and unnecessary for the simple enemy mechanics in this game. Therefore, Finite-State Machine provides the most appropriate balance between functionality, performance, and development simplicity. The game was developed using Unity 3D and tested through functionality, method, and user evaluations. The results showed that all main features worked as expected, with 52.63% of users strongly agreeing and 40.64% agreeing that the game was engaging and enjoyable. The implementation of both methods successfully enhanced interactivity, responsiveness, and gameplay consistency.

Keywords –game; puzzle; collision detection; finite-state machine.

I. INTRODUCTION

Adventure games are a genre of games that invite players to explore the beauty of the environment and world within the game[1].This type of game generally emphasizes exploration, puzzle solving, and player interaction with the environment presented. The combination of adventure and puzzle elements makes players not only enjoy the story, but also play an active role in determining the course of the game through interaction and decision-making.

The game developed, titled "Lavender's Warmth," was inspired by the game "Mekorama" from google playstore, has a puzzle theme with a calm and soothing atmosphere. In addition, the concept of physical interaction in this game was also inspired by "Garry's Mod (Gmod)" from Steam, allows players to lift and move objects within the game.

The selection of the topic "Lavender's Warmth" is important because it integrates two basic methods, namely collision detection and finite-state machine, which are fundamental components in 3D game development, but have not been widely discussed together in the context of puzzle-adventure games. This research contributes by directly implementing both methods in an interactive 3D game, thereby serving as a reference for academic and practical game research and development.

In its development, the game "Lavender's Warmth" applies the Collision Detection method as the basis for interaction between players and puzzle objects. This technique enables the system to detect collisions between two or more objects in the game world. The Bounding Box type is used because of its simple shape, which is a square or block, making the computation process more efficient and easier to implement.

Various studies show that Collision Detection is an important component in 3D game development because it ensures that the system can recognize collisions between objects, validate interactions, and maintain gameplay mechanical consistency[2][3]. This method has also been proven to improve the accuracy of the system's response to player interactions, whether in action, educational, or puzzle games[4] . In addition, the integration of Collision Detection with other methods such as Finite-State Machine further improves game quality and user experience[5].

On the artificial intelligence side, the use of Finite-State Machines (FSM) is widely applied to regulate NPC behavior due to its structured, deterministic, and efficient nature. Various studies on educational games, RPGs, and action games prove that FSM is capable of producing stable, easily controlled enemy behavior transitions that are appropriate for the game conditions[6]. The combination of FSM and Collision Detection has also been proven effective in creating adaptive AI responses and accurate object interactions, thereby improving the overall quality of gameplay [7][8].

Game can be effectively used as educational tools through a fun and interactive gaming approach. This proves that games not only serve as entertainment, but also have great potential in supporting a more engaging and efficient learning process.[9]

This study is expected to demonstrate that the integration of Collision Detection and Finite-State Machine methods can be applied effectively in 3D puzzle–adventure games to produce consistent, responsive, and reliable gameplay mechanics. The development of "Lavender's Warmth" is also intended to provide a game environment that not only offers entertainment but also challenges players' literacy abilities through puzzle interpretation, narrative comprehension, and interaction with in-game information. Thus, the game is expected to serve as both a technical implementation model and a medium that supports cognitive engagement, particularly in strengthening players' critical thinking and literacy skills.

II. RESEARCH METHODOLOGY

2.1 Puzzle-Adventure Game

Each game has different rules or objectives. Some games focus on shooting action, while others are simply about fishing to collect aquatic animals. Because there are

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so many different types of games, genres or categories have been created to make it easier to identify games[10]. These categories can also be combined to create new game ideas.

Puzzle-Adventure is a combination of the Puzzle and Adventure genres. This game genre offers exciting adventures and challenging puzzles to progress through the game's story. The combination of these two genres allows players to feel directly involved in the game's story.

2.2 Collision Detection

Collision Detection method is used as the main mechanism for detecting interactions between objects in the game environment. Collision Detection is a computational process that aims to determine whether two or more objects in virtual space intersect or enter the same space. This method is an important component in game development because it determines how characters, objects, and environmental elements can interact responsively according to the rules of the game[11].

2.3 Bounding Box

Bounding Box is one type of AABB Collision Detection method. This method provides imaginary boundaries in the shape of a block or cube for each object in the game. These boundaries serve to simplify the collision detection process without the need to calculate the actual shape of the object, which may be complex. When these boundaries come into contact with the boundaries of another object, a reaction may occur, the outcome of which can be adjusted to achieve the desired result [12]. An example of a bounding box can be seen in Figure 1.

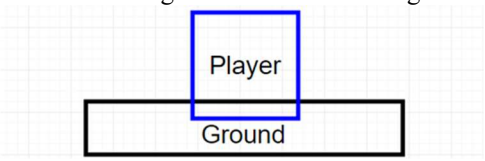

Figure 1. Bounding Box Illustration

2.4 Finite-State Machine

This study applies Finite State Machine (FSM) as the basis for controlling the behavior of non-player characters (NPCs). FSM is a computational model that describes how an entity moves from one state to another in response to an event. Each state represents a specific condition of the character, while transitions between states are triggered by inputs or conditions that occur in the game environment[13]. The FSM approach was chosen because of its low complexity, high efficiency, and ease of debugging and maintenance. Thus, the FSM method is capable of supporting the implementation of NPC behavior that is stable, responsive, and in line with the mechanical requirements of the game in this study. The form of state transition can be seen in Figure 2.

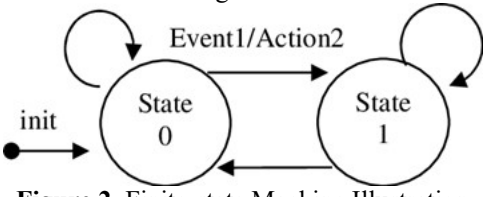

Figure 2. Finite-state Machine Illustration

In the context of game development, FSMs are often used to control the behavior of non-player characters (NPCs). For example, enemy characters can be in a “patrol” state, then transition to a ‘chase’ state when they detect a player, and return to a “standby” state when they lose track of the player. Thus, the implementation of FSM plays an important role in supporting a more dynamic gaming experience and ensuring stable interactions between players and NPCs within the game environment.

2.5 Non-playable Character (NPC)

NPCs are characters in games that are not controlled by players, but rather by artificial intelligence. NPCs play an important role in games because they can make the game more immersive. NPCs are commonly used as a tool to provide context or background to a game's[14].

2.6 Low-poly 3D Model

Low-poly is a type of 3D model that contains as few polygons as possible. Low-poly is commonly used for game optimization because computers render fewer polygons[15]. Low-poly is also commonly used as an art style because its simple shapes can create a unique style. Figure 3 shows characters with few polygons but still able to provide a clear form.

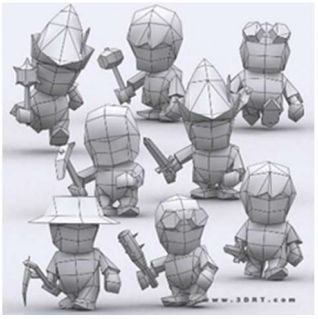

Figure 3. Low-poly Model Example

III. Results And Discussion

3.1 Analysis

Analysis is used to identify functional and non-functional requirements and the application of methods so that the game development results can meet the expected results.

3.1.1 Functional requirment

Functional requirements contain features that will be designed in the game “Lavender's Warmth”. The following are the functional requirements:

1. Players can be attacked by enemies.
2. Players can interact with NPCs by pressing the E key.
3. Players can pick up objects with the F key and put down objects by pressing the F key (if an object is currently being held).
4. Players can control the character with the (W, A, S, D) keys to walk, the space bar to jump, and the shift key to run.
5. Players can view missions or puzzles that need to be completed.

3.1.2 Non-functional requirement

1. The game can be played on a desktop.
2. The game has 4 puzzles that must be solved.
3. The game is played offline.
4. The game is played solo.
5. The game uses low-poly 3D graphics.
6. The Finite-State Machine method is implemented on enemies.
7. The Collision Detection method is implemented on puzzle-related objects.
8. Character control uses the mouse and keyboard.

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3.2 Bounding Box Application

The reason why bounding boxes were chosen is because this game uses collision detection to detect whether puzzle pieces are inside puzzle slots or not. Therefore, this game does not require complex collision shapes to check puzzle pieces. An illustration of collider interaction can be seen in Figure 4, where colliders are depicted with dotted lines. When a puzzle-piece collider touches a puzzle-slot collider, the puzzle-slot collider will check whether the slot should be filled with that piece or not. If so, the slot will return a true value. If not, the slot will return a false value.

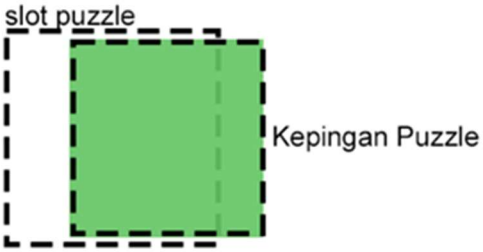


Figure 4. Bounding Box Application

3.3 Enemy Finite-state Machine

Figure 5 illustrate finite state machine flowchart that will control the controlled ghost character. The initial state of the ghost is patrol. When the ghost sees the player within a certain distance, it will start chasing the player, but if the player manages to get out of the ghost's field of vision, the ghost will return to patrolling. If the ghost manages to touch the player, the player will be captured, and when the player is captured, the player will be returned to the checkpoint.

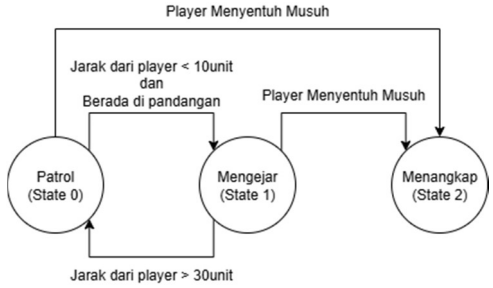
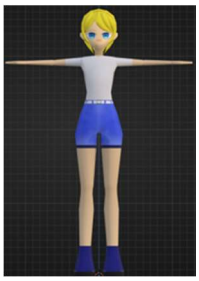
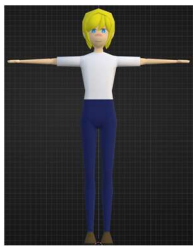
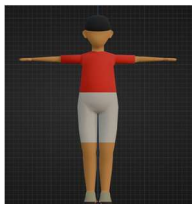
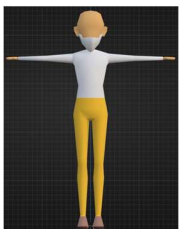


Figure 5. Finite-state Machine Application

3.4 Quest Giver NPC

The following are important NPCs for obtaining missions to progress in the game.

Table 1. Non-playable Character List

NPC	Name
	Ren
	Lin
	Kepala Desa
	Sepuh

3.5 Puzzle Object

The following are puzzle object that player will encounter in the game.

1. Puzzle Stage 1

Figure 5. Puzzle stage 1

Figures 5 show puzzle object that players will encounter. There are three holes in the wall object that will be filled with the puzzle pieces.

2. Puzzle Stage 2

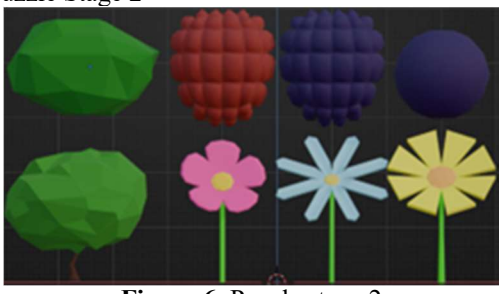


Figure 6. Puzzle stage 2

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Figure 6 shows the model results for puzzle 2. This object was created so that the game world would not only be filled with lavender flowers, but also other types of plants. The player will give these object to quest giver.

3. Puzzle Stage 3

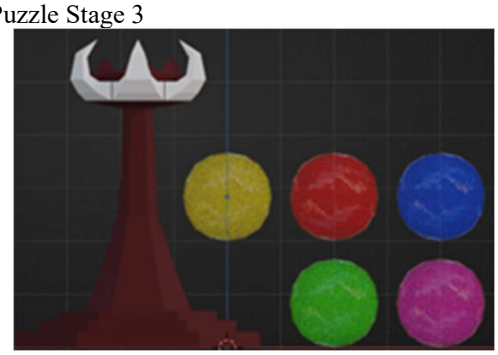

Figure 7. Puzzle Stage 3

Figure 7 Shows the modeling results for the final puzzle. There are 5 crystal objects that will later be placed on top of the pillar object.

3.6 Enemy

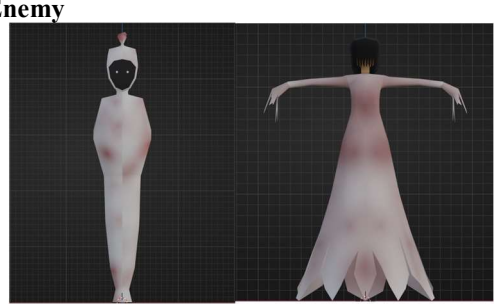

Figure 8. Player's Threat

Figure 8 shows the appearance of Kuntilanak and pocong. In the game "Lavender Warmth's," they becomes an enemy because they're being controlled by Shaman.

3.7 Game UI

The following are UI games that player will see and interact in the game.

1. Main Menu

Figure 8 Displays the main menu containing the game title, the start button to start the game, the settings button to open the settings menu, and the exit button to close the game.

Figure 9. Main Menu

2. Option Menu

Figure 10Shows the settings menu containing the fullscreen button, volume slider, close button, and credits button.

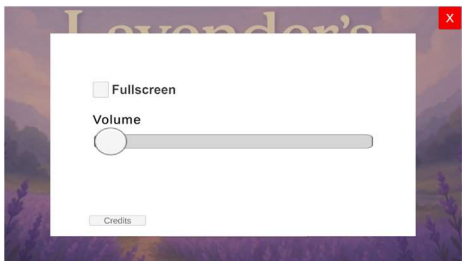

Figure 10. Option Menu

3. Pause Menu

Figure 11 Shows the UI that appears when the player presses the Escape key.

Figure 11. Pause Menu

4. Heads-Up Display

Figure 12 displays the UI that players will see during gameplay. There are three elements displayed: a white crosshair, game control instructions, the current mission, and a notes page icon.

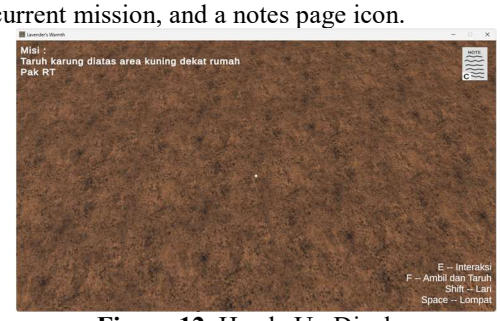

Figure 12. Heads-Up Display

5. Dialog

Figure 13 Displays the UI that appears when the player dialogues with an NPC. There are two elements: the dialogue text and instructions for continuing the conversation.

Figure 13. Dialog UI

3.8 Collision Detection Testing

This were conducted to ensure that interactions between collisions could provide responses in line with the design. This table shows that collision detection has functioned as expected.

Table 2. Collision Detection Testing

Testing Scenario	Scenario Result	Result
Player fill the puzzle slot with the correct piece	Puzzle slot return true as value to the game manager.	Success

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Player fill the puzzle slot with the wrong piece	Puzzle slot return false as value to the game manager.	Success
Player took out the correct piece from the puzzle slot.	Puzzle slot return false as value to the game manager.	Success
Character touched enemy NPC	The character's vision darkens, then brightens again when the player is moved to the respawn point.	Success
Character touched enemy NPC while carrying puzzle piece	The puzzle piece that being carried will be dropped and then the character will return to respawn point.	Success

3.9 Finite-state Machine Testing

This tests is were conducted to ensure that the enemy AI could run according to the Finite-state Machine flow that had been created. This table shows that the enemy AI worked as expected.

Table 3. Enemy Finite-state Machine Testing

State	Condition	Expected result	Testing	Result
Patrol	Did not detect a player	Enemy moving accordance to patrol point	Observing Enemy from far distance	Success
Patrol to Chase	Enemy see players from a distance of less than 10 meters.	Enemy Chasing player	approaching the enemy from the front	Success
Chase	The player is in the ghost's view	Enemy Chasing player	The player moves while avoiding contact	Success
Chase to Capture	The player touches the ghost	Player moves to check point	The player let themselves to be touched by the enemy	Success
Chase to Patrol	The player moves 30 meters away from the ghost.	The enemy returned to patrol the patrol point.	The player moves away from the enemy's radius	Success
Patrol	Did not detect a player	Player are not chased by ghosts when they are not within the ghost's field of vision.	The character is next to or behind the ghost.	Success

3.10 Functionality Testing

Testing in table 4 was conducted to ensure that the planned features could be used successfully. This testing also ensured that there were no bugs that could cause a poor experience during gameplay.

Table 4. Functionality Testing

Function	Testing Scenario	Scenario Result	Result
Character Navigation	Player press the WASD button to move	The character moves according to button input	Success
Character Jump	Player press the space bar button to jump	The character jumps after pressing the space bar	Success
Character Run	Player press the shift button to run	The character runs when the shift key is held down	Success
Interacting with NPC	Player press the E button to start conversation with NPC	The character cannot move during conversation and a dialogue box containing the NPC's conversation appears	Success
Continue the dialog with NPC	Player press the enter button to continue the conversation	There is a transition between the initial dialogue and the next dialogue. When the dialogue ends, the dialogue box closes and the character can move again	Success
Interacting with heirloom and scroll	Player press the E button to interact with heirloom and scroll	An image containing content appears on the scroll	Success
Closing the scroll	Player press the enter button to close the scroll	The image displayed in front of the camera disappears	Success
Pick-up item	Player press the F button to pick-up a puzzle piece	The character can lift puzzle pieces, and the pieces move in the direction of the camera's view	Success
Drop item	Player press F button while lifting an object	Puzzle pieces that are being lifted fall from the character's grasp	Success

3.11 User Testing

Table 5. User Testing

Statement	Assesment				
	1	2	3	4	5
The game menu is easy to understand.	0	0	0	7	11
The game controls are easy to understand.	0	0	1	7	10
The game objectives are easy to grasp.	0	0	0	8	10
The interaction system (pick-up and interact) is easy to operate.	0	0	1	8	9
The game mechanics (puzzle and exploration) are engaging.	0	0	2	7	9
The game flow is consistent and not confusing.	0	0	4	9	5
The game provides a fun and relaxing gaming experience.	0	0	2	6	10
The game's visuals match the “calm” theme.	0	0	1	10	7
The environment and object designs create a comfortable atmosphere.	0	0	3	6	9
The sound effects (SFX) support the game's atmosphere.	0	1	1	9	7
The background music provides the right mood for this game.	0	0	0	8	10
The overall audio-visual quality is satisfactory.	0	0	2	11	5

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The character controls are responsive and easy to use.	0	1	0	5	12
There is no delay or input issues while playing.	0	0	0	8	10
The game runs smoothly without any lag.	0	0	2	4	12
Text, UI, and objects are easy to see clearly.	0	0	1	6	11
The overall game performance is adequate.	0	0	1	6	11
I feel satisfied after playing "Lavender's Warmth".	0	0	0	10	8
This game has the potential for further development.	0	0	0	4	14
Total	0	2	21	139	180

Description
1 = Strongly Disagree
2= Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree
Number of Question = 19
Number of User = 18
Divisor = 19*18 = 342

Table 6. User Testing Evaluation

Percentage	Value
Percentage of users who strongly agree	(180/342)*100% = 52,63%
Percentage of users who agree	(139/342)*100% = 40,64%
Percentage of users who neutral	(21/342)*100% = 6,14%
Percentage of users who disagree	(2/342)*100% = 0,58%
Percentage of users who strongly disagree	(0/342)*100% = 0%

Table 5 shows that out of 18 players who have tried playing the game "Lavender's Warmth," 52.63% of players strongly agree with the statement, 40.64% of players agree with the statement, 6.14% of players are neutral about the statement, 0.58% of players disagree with the statement, and 0% of players strongly disagree with the statement. It can be concluded that the game that has been created has received many positive impressions from players.

Table 7. Puzzle Difficulty Testing

Difficulty				
Very Easy	**Easy**	**Medium**	**Hard**	**Very Hard**
1	1	6	5	5

Based on Table 7, 18 respondents rated the puzzles in the game "Lavender's Warmth" as having a medium to high level of difficulty. Meanwhile, the other 2 respondents rated this game as having an easy level of difficulty.

IV. CONCLUSION

This research resulted in the 3D puzzle-adventure game "Lavender's Warmth" for desktop computers, which applies the Collision Detection (Bounding Box) method to puzzle and Finite State Machine (FSM) methods to enemy NPCs. The test results showed that all the main features functioned as designed and received positive responses from users, with 52.63% strongly agreeing and 40.64% agreeing with the game aspects. A total of 88.9% of respondents rated the puzzle difficulty level as medium to hard. Thus, "Lavender's Warmth" is considered successful in providing a relaxing, interactive gaming experience that challenges players' thinking skills.

For further development, Lavender's Warmth still has several potential improvements that can be implemented. First, a save system feature is needed so that players can save their game progress and continue without having to start over from the beginning, making the gaming experience more comfortable and flexible. Additionally, the game could be developed by adding numeracy-based puzzles to provide challenges that are not only entertaining but also contribute to improving players' basic math skills. In terms of world design, the game environment could be enriched by adding more rural objects, such as traditional architectural elements, local household objects, and vegetation commonly found in villages, making the game world more immersive. Finally, visual quality can be improved through the application of high-poly modeling, which allows asset details to appear smoother and more realistic compared to the low-poly approach currently used. These developments are expected to enhance the quality of the game.

REFERENCES

[1] D. A. Zaelany, M. N. Azizah, N. G. Angkasadaiana, R. M. Nuriansyah, A. C. Padmasari, and R. F. Salsabila, "Perancangan Board Game The Journey of Knowledge sebagai Media Bantu Pembelajaran Sejarah," *Journal of Innovation and Teacher Professionalism*, vol. 2, no. 1, pp. 26–35, Apr. 2024, doi: 10.17977/um084v2i12024p26-35.

[2] S. R. Laili and D. Arwin Dermawan, "Implementasi Algoritma Collision Detection dan Markov Chain untuk Menentukan Behaviour NPC dan Karakter Player pada Game Higeia," *Journal of Informatics and Computer Science*, vol. 03, 2021.

[3] M. Rizal Yusuf, A. Panji Sasmito, and H. Zulfia Zahro, "PERANCANGAN GAME MITOLOGI 3D 'GESANG' DENGAN METODE ALGORITMA COLLISION DETECTION," 2024.

[4] T. K. Pamungkas, A. Surahman, and Z. Abidin, "Desain Interaksi Game Belajar Aksara Lampung Bersama Muli Dengan Metode Collision Detection," *Jurnal Informatika dan Rekayasa Perangkat Lunak*, vol. 4, no. 1, pp. 96–102, Mar. 2023, doi: 10.33365/jatika.v4i1.2458.

[5] H. S. Rosyad, F. Santi Wahyuni, and R. Primaswara Prasetya, "PEMBUATAN GAME 3D 'BUDI THE DELIVERY BOY' MENGGUNAKAN METODE COLLISION DETECTION," 2024.

[6] A. Andi, J. Charles, O. Pribadi, C. Juliandy, and R. Robet, "Game Development 'Kill Corona Virus' For Education About Vaccination Using Finite State Machine and Collision Detection," *Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control*, Nov. 2022, doi: 10.22219/kinetik.v7i4.1470.

[7] I. Arfyanti, S. Suryani, and S. Widya Cipta Dharma, "DEVELOPMENT ZOMBIE HUNTER BATTLEGROUND WITH FINITE STATE MACHINE DAN COLLISION DETECTION," *JTIS*, vol. 3, no. 3, 2020.

e-ISSN: 2614-8404
p-ISSN: 2776-3234

[8] R. Irawan, Y. S. Siregar, and M. Khairani, "Rancang Bangun Game 3D Edukasi Basic Web Development Menggunakan Unity 3D," *Jurnal Komputer Teknologi Informasi Sistem Komputer*, vol. 2, no. 3, pp. 2024–525, 2024.

[9] P. W. Mega Aliesa, F. Santi Wahyuni, and A. Fahrudi Setiawan, "GAME EDUKASI 'PENGENALAN TRANSPORTASI' 2D BERBASIS ANDROID," 2023.

[10] M. R. Hisham, J. Pratama, L. Andito, A. Kho, and H. Wijaya, "Analisa Klasifikasi Genre Game PC Terpopuler," *Journal of Information System,Graphics, Hospitality and Technology*, vol. 4, no. 01, pp. 27–31, Mar. 2022, doi: 10.37823/insight.v4i01.145.

[11] A. Kartadinata and M. Akbar, "IMPLEMENTASI SISTEM CHARACTER PLAYER PADA GAME RPG 2D MENGGUNAKAN GAME ENGINE GODOT," *Jurnal Informatika dan Teknik Elektro Terapan*, vol. 13, no. 3, Jul. 2025, doi: 10.23960/jitet.v13i3.7163.

[12] J. T. K. Perangin-Angin, Pieter Octaviandy, and Robby Wijaya., "Permainan Monster Defence Dengan Metode Collision Detection Dan Boids Sebagai Media Edukasi Pengenalan Warna Bagi Anak-Anak," *Jurnal Armada Informatika*, 2024, [Online]. Available: https://doi.org/

[13] Asrianda and Zulfadli, "Konsep Finite State Machine dan implementasinya pada Game," *Jurnal Sistem Informasi*, 2022.

[14] Business Insider, "What does 'NPC' mean? Understanding non-player characters, an important aspect of any video game," Business Insider, May 28, 2021. Accessed: Aug. 23, 2025. Available: https://www.businessinsider.com/guides/tech/npc-meaning

[15] 3D Studio, "High Poly Modeling vs Low Poly." 3D Studio. Accessed: Aug. 21, 2025. Available: https://3dstudio.co/id/low-and-high-poly-modeling/