

Development of “Explores the Tenggara City” Using Autonomous Response of Adaptive NPC

Reza Andrea

STMIK Widya Cipta Dharma, Samarinda, 75123, Indonesia
Email: reza@wicida.ac.id

Azahari

STMIK Widya Cipta Dharma, Samarinda, 75123, Indonesia
Email: azahari@wicida.ac.id

Received: 01 May 2020; Accepted: 07 July 2020; Published: 08 February 2021

Abstract: The game is one of the big industries today and can be an alternative entertainment to spend holidays and free time and become a very fun activity for children and adults. The game can also be used as an interactive and attractive promotional media with the theme of traveling. One of the development methods that can support the game platform is Finite State Machine. This method is used to regulate the behavior of Non-Player Character (NPC) in order to guide players to complete the game. The results of the study showed that "Explores The Tenggara City" game is based on Android, has an interesting gameplay and makes the process of knowledge about destination very enjoyable so that players are expected to know information about the destination in Tenggara City. This research contributes to the development of NPC and FSM in promotional games.

Index Terms: Game, traveling, Tenggara, Non-Player Character

1. Introduction

Game is one of the big industries at this time and can be an alternative entertainment to spend holidays and free time and become a very fun activity for children and adults [1,2]. This game explores Tenggara City as one of the media that will be used in promoting destinations in Tenggara Sub-District in a fun way so that it will attract millennial interests to get to know the destinations in Tenggara Sub-District so that it will be better known to the public. Tenggara is a city which has the capital city of region in the East Kalimantan (Borneo). In the past Tenggara was a capital city of Kutai Katenagara Kingdom [3].

For game development, several methods can be used, one of which is by using a game engine that offers a visual development package and other elements, namely Unity software [1,2,4]. Unity supports the development of both 3D and 2D games by reusing elements that have been created so that it will be more efficient in developing "Explores The Tenggara City" game.

One type of game that is popular is adventure games. Adventure games can be developed into one of the promotional media that pleases the community [5,6]. Adventure games with the theme "traveling" can be an interesting medium to introduce various destinations in Tenggara through interactive game media and a finite state machine used in terms of the interaction between players and Non-Player Character. FSM consists of a series of states that determine decisions. Each state can move to another state if it fulfills a predetermined condition [7,8].

The long-term goal to be achieved with the Finite State Machine method is for supporting characters in the game to interact with the player so that it will make this game more interesting. The specific target of this game is that destinations in Tenggara will be easily introduced to the public with interactive and interesting media. This study used multimedia development methods namely, concept, design, material collecting, assembly, testing, distribution, and questionnaire testing.

2. Related Works

Studies on games with the same technique have been carried out, namely:

1. Integration of Hierarchy Finite State Machine and Fuzzy Logic to Design NPC strategy in Game [9]

2. Implementation of the Finite State Machine (FSM) Method in the Agent of "Zambrud Khatulistiwa" Android-Based Tactical RPG Game [10]
3. Modeling of Enemy Behavior Using Finite State Machine (FSM) in the Introduction to Chemical Game [11]

In the study titled "Integration of Hierarchy Finite State Machine and Fuzzy Logic to Design NPC strategy in Game", enemy NPCs will interact directly with players. The game engine used to test the behavior of NPC was Torque Game 1.4, which is a 3D Game Engine. Game Engine is marketed by Garge Games, with the programming characteristics of each game element consisting of many classes [9].

The study titled "Implementation of the Finite State Machine (FSM) Method in the Agent of" Zambrud Khatulistiwa" Android-Based Tactical RPG Game" used 6 stages namely concept, design, material collecting, assembly, testing, and distribution [10]. A finite state machine was implemented in the state, actions, and events for each agent created. The function of state machine is to determine the behavioral response of the agent to the changing conditions that occur in the agent and in the game environment [12].

The study titled "Modeling of Enemy Behavior Using a Finite State Machine (FSM) in the Introduction to Chemistry Game" used the game as a medium in helping the introduction of chemical elements because it is more efficient. Finite State Machine is used as a dynamic variation of response on an agent or NPC [11].

In this study, we used Unity Engine as a game development software with 3D graphics that will explore destinations in Tenggara interactively and the Finite State Machine will be used as an autonomous and adaptive response NPC, so NPC can direct the player to complete the given missions so that the game can run interestingly.

The game refers to the definition of intellectual playability. The game can also be interpreted as an arena of decision and action of the player. In the game, there are targets and missions to be achieved by players. Intellectual playability at a certain level shows the attraction of the game to be played maximally [4,13].

This study used an android device. Android is a Linux-based operating system designed for touch screens mobile devices such as smartphones and tablet computers. Android was originally developed by Android, Inc., with financial support from Google, which was later bought out in 2005. The operating system was officially released in 2007 [14].

In designing AI for games, the state machine is the most widely used technique for decision making and scripting problems which are widely used to design decision-making systems in games [15]. The state machine is widely known as a technique for modeling event-based phenomena or conditions, including explanation and interface design. Finite State Machine (FSM) or also referred to as Finite State Automata, is considered a technique that is widely used in designing AI in games [16].

Transitions control the flow of execution by setting the active state of the state machine through the use of conditions. Transitions can apply one-to-many, in other words, there can be a relationship from one state to the input side and several states connected to the output side, depending on the conditions in the transition. The principle of integrated components in FSM can be seen in Fig.1 [17].

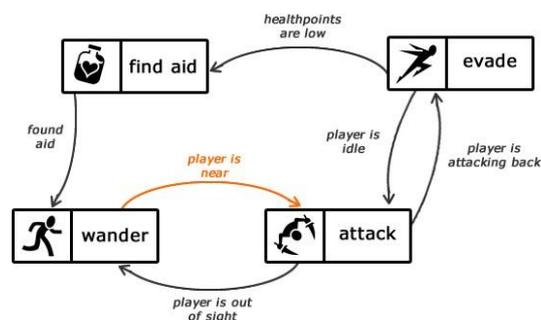


Fig.1. FSM of game agent

FSM is used for ghost behavior in the Pac-Man game with several states that can be used, namely avoiding and chasing, where the states are owned by all ghosts, but if those states are applied to one ghost, then it must be based on the condition of the ghost. For example, to implement the avoiding state, the ghost has the power from the input of the player to make the transition from the chasing state to the avoiding state, while to change from the avoiding state to the chasing state, the ghost has input from the timer. Quake-Style Bots implements FSM that has several states namely FindArmor, FindHealth, SeekCover, and RunAway. Even weapons owned by Quake can have their own mini FSM. For example, the rocket weapon on Quake has several states namely Move, TouchObject, and Die. Players in sports simulations like in FIFA 2002 implement FSM with several states such as Strike, Dribble, ChaseBall and MarkPlayer. Also in the team has several states namely KickOff, Defend, or WalkOutOnField. NPC (Non Player Character) in RTS (Real Time Strategy Games) like Warcraft uses FSM and has states namely MoveTopPosition, Patrol, and FollowPath[18,19].

3. Methodology

This study was conducted in several stages of multimedia development, namely:

1. Conduct a literature study on the educational game development process and the algorithm used, as well as collect the game development materials.
2. The game development process with the multimedia development method, starting from the design to the assembly stage of the FSM into the game system
3. Install the game application into the smartphone of the community and tourism service employees.
4. Conduct beta testing in the form of a questionnaire to several people and review of these documents.
5. Analyze the results of the questionnaire and review of the application of the Finite State Machine in the game.
6. Re-distribute and re-analyze until the test results produce a satisfying percentage.

Each stage is carried out sequentially from the first stage to the last stage, each stage that has been completed must be reviewed. The NPC will express a condition, where the NPC directs and provides an explanation of the destination object, namely Jam Bentong, Kumala Island, Mulawarman Museum, Planetarium. There is a process flow condition that occurs in NPC (Non Player Character). The FSM logic model in Jenny as an agent can be seen in Fig.2

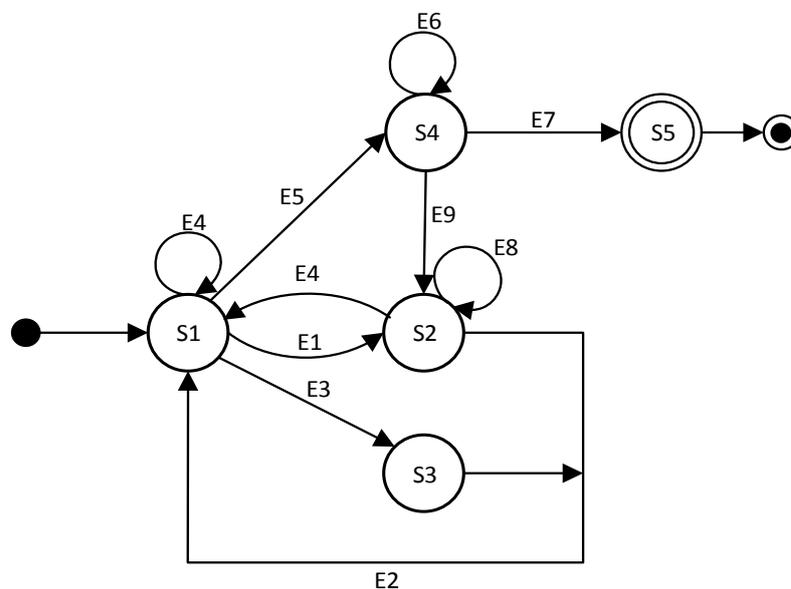


Fig.2. Design of FSM model

Description of Fig.2 and Table 1.

State:

- S1. Idle
- S2. Run
- S3. Give a warning
- S4. Give information about destination
- S5. Give a Trophy

Event:

- E1. The player heads to the NPC
- E2. The player is far from the NPC
- E3. The player is very far from the NPC
- E4. NPC is at the destination point
- E5. The player invites the NPC to talk at the destination
- E6. The player has not completed all destination missions
- E7. The player has completed all destination missions
- E8. The player is in the range of the NPC
- E9. NPC goes to the next destination.

In Fig.2, the NPC is in an idle state or S1 state, if the player heads to NPC, then the NPC will run towards the destination that is entering S2 state and if the player is far from the NPC then the NPC will return to the S1 or idle state, if the player is too far away, then the NPC will give a warning or S3 state, then when the player is only in a distant state, then the warning will disappear and return to S1 state, if the NPC has been at the destination then the NPC will enter the S1 state or S2 state when running, the player and NPC talk when at the destination then the NPC will explain and give a mission to the player if the player has not completed the mission then the NPC will go to the next destination, if the player has completed the mission then the NPC will give a trophy. Each state and event model is described in the state transition in Table 1.

Table 1. State Transition of Game Agent

S	Input								
	E1	E2	E3	E4	E5	E6	E7	E8	E9
S1	S2		S3	S4					
S2		S1						S2	
S3		S1							
S4						S5	S6		S2
S5									

4. Result and Discussion

"Explores The Tenggara City" game is an Android-based game to introduce destinations in Tenggara City in a fun and interesting way for millennials. Tenggara has the interesting place to visit, those are like Museum Mulawarman, Kumala Island, etc. [3]. This game has rules that display content designed for everyone rating.

This game uses the FSM method on NPC (Non Player Character) as an autonomous and adaptive process so that characters can move autonomously. Fig. 3 shows, NPC in form a woman character. In FSM, the NPC is in an idle state when the player approaches, so the NPC will run to the destination and if the player is far from the NPC then the NPC will be idle if the player is too far then the NPC will give a warning and if the player is only in a distant state the warning will disappear and the NPC idle again, if the NPC is already at the destination then the NPC will enter the destination. When the player and NPC talk at the destination then the NPC will explain and give a mission to the player if the player has not completed the mission then the NPC will go to the next destination, if the player has completed the mission then the NPC will give a trophy.



Fig.3. Woman character as NPC

The game has several destination choices, each of which has a different mission, the player can choose to go to one of the 4 destinations, namely Jam Bentong, Kumala Island, Mulawarman Museum, and Planetarium. When the player arrives at the destination, the player will get an explanation of the destination and the player is directed to complete the mission given by the NPC. At Jam Bentong, the player will match the picture, after completing the game in Bentong the player cannot return to playing the game in Jam Bentong and the player must choose one more destination to complete all missions in each destination. On Kumala Island the player will get an explanation from the NPC about Kumala Island and the player is directed by the NPC to arrange the pieces of the picture. At the Mulawarman Museum, the player will get an explanation from the NPC on the Mulawarman Museum and is directed to arrange the pieces of the picture. In Planetarium, the player will get an explanation on Planetarium by NPC and is directed to complete the

picture slide puzzle. After the player completes four missions in each destination, the player gets a trophy and a credit scene will be displayed.

The interface of "Explores The Tenggara City" game can be seen in Fig.4. On the start of game, home scene will be displayed at the beginning of playing the game. There are 3 buttons menu namely, start, credit, and exit menus. The "start" button is used for the player to start the game and enter the destination.



Fig.4. Scene menu

Fig. 5 shows, gameplay of this game. There are 3 buttons on this interface to control character, i.e. joystick button, jump button, and interact button to get information about destination and interact to NPC.



Fig.5. Gameplay

On the destination page, the player will be directed by the NPC to go to tourist destinations in Tenggara City. At the beginning of the game, the NPC will direct the player to Jam Bentong and the NPC will explain the Jam Bentong then the player will complete the puzzle mission which can be seen in Fig.6.



Fig.6. Puzzle Mission Scene

After the player completes the mission at Jam Bentong, the NPC will direct the player to Kumala Island and carry out the mission that can be seen in Fig.7.



Fig.7. Mission on Kumala Island

After the player completes the mission on Kumala Island, the NPC will direct the player to the Mulawarman Museum and carry out the mission as can be seen in Fig.8.



Fig.8. Puzzle Mission at Mulawarman Museum

After the player completes the mission at the Mulawarman Museum, the NPC will direct the player to the Planetarium and carry out the mission as can be seen in Fig.9



Fig.9. Mission in Planetarium

The implementation of Finite State Machine has a function to see changes in the behavior of the NPC to the game. Development of states with each state change that occurs can be seen as follows:

- 1) Idle State = If the player is outside the range of the NPC that can be seen in the red circle in Fig.10



Fig.10. Idle State

- 2) Run to Destination State = When a player approaches the NPC, the NPC will run towards the tourist attractions that can be seen in the red circle in Fig.11



Fig.11. Run State

- 3) Destination State = At the Destination State, the player enters the red dot and invites the NPC to talk then the NPC will explain the destination information and then give a mission to the player that can be seen in the red circle in Fig.12



Fig.12. NPC gives information about destination

- 4) Warning State = If the player is too far from the reach of the NPC then the NPC will give a warning that can be seen in the red circle in Fig.13



Fig.13. NPC gives a warning

- 5) Trophy State = In the last state, the player has completed all game missions so the NPC will give the trophy that can be seen in the red circle in Fig.14



Fig.14. NPC gives the trophy at end of game

Beta testing is live application testing in an environment that cannot be controlled by the developer [20]. After the game development was complete and can be played then beta testing was performed by giving the game to 10 people and giving questionnaires to them and asking for opinions and suggestions for future game development. The results of testing can be seen in Table 2.

Table 2. Result of Beta Testing

Aspect	Rating				
	-1	0	1	2	3
Game title	0	0	1	5	4
Destination Information	0	0	4	3	3
Mobile Device Responsibilities	0	0	3	4	3
Sound Fx	0	0	3	4	3
Character model design	0	0	1	0	9
Button function	0	0	4	4	2
Joystick control	0	0	4	6	0
Destination model design	0	0	0	2	8
Quest and mission	0	0	5	3	2
Game music	1	0	4	0	5
Total	1	0	29	31	39
Percentage	1%	0%	29%	31%	39%

Table 2 shows, of the 10 respondents, the results of the questionnaire obtained from the respondents' answers (1)

- 1. Very Poor (-1) : 1x-1 = -1
- 2. Poor (0) : 0 x 0= 0
- 3. Average (1) : 29 x 1 = 29
- 4. Good (2) : 31 x 2 = 62
- 5. Very Good (3) : 39 x 3 = 117

$$Y = \frac{x}{n} 100\% \tag{1}$$

$$Y = (-1+0+29+62+117) / 300 = 0,69$$

Overall percentage score of beta test (1) was 69%, rating very good had 39%, good had 31%, average was 29%, poor was 0%, and very poor was 1 %.

5. Conclusion

Based on the discussion, it can be concluded that "Explores The Tenggara City" game was developed through the concept, design, material collecting, assembly, testing, and distribution. The function of the Finite State Machine is as an NPC response when there are certain conditions. In this game, the players can find out information about destinations in Tenggara through the responses given by the NPC.

Beta testing showed the level of satisfaction, namely, 1% was very poor, 0% were poor, 29% were average, 31% were good, 39% were very good and of the total counted so as to get 69% points from 10 questions by 10 respondents.

Presenting NPC as a tourist guide and it can give all information about destination in Tenggarong City. FSM is applied to the NPC, make an autonomous character can interact reason of actions and reactions of the players. This makes the game more interactive.

For further application development, it is expected that destinations can be added to Kutai Kartanegara Regency, and in each destination, the player can enter the destination directly to see the objects in it. We suggest for future work, this game can use another method is like moore machine, neural network, or combination probability with finite state machine to make the NPC more interactive

Acknowledgment

This research is funded by Directorate General of Strengthening for Research and Development and Ministry of Research, Technology and Higher Education of the Republic of Indonesia according the Research Contract in Fiscal Year of 2020

References

- [1] Khowaja, K., & Salim, S. S. (2019). Serious game for children with autism to learn vocabulary: an experimental evaluation. *International Journal of Human-Computer Interaction*, 35(1), 1-26.
- [2] Thorn, A., Doran, J. P., Zucconi, A., & Palacios, J. (2019). *Complete Unity 2018 Game Development: Explore techniques to build 2D/3D applications using real-world examples*. Packt Publishing Ltd.
- [3] Sutan, S., Cahyani, R. W., Alam, F., & Syuhada, E. M. (2017, February). Exotism of Batu Putih area in Samarinda, East Kalimantan as conservation area for ecotourism destination. In *AIP Conference Proceedings* (Vol. 1813, No. 1, p. 020009). AIP Publishing LLC.
- [4] Lanham, M. (2017). *Augmented reality game development*. Packt Publishing Ltd.
- [5] Egenfeldt-Nielsen, S., Smith, J. H., & Tosca, S. P. (2019). *Understanding video games: The essential introduction*. Routledge.
- [6] Miller, C. H. (2019). *Digital Storytelling 4e: A creator's guide to interactive entertainment*. CRC Press.
- [7] Rabin, S. (2019). *Game AI Pro 360: Guide to Architecture*. CRC Press.
- [8] Petrosyan, L. A., & Yeung, D. W. K. (2020). *Game Theoretic Analysis*. World Scientific Publishing Company Pte Limited.
- [9] Arif, Y. M., & Hariadi, M. (2012). *Integrasi Hierarchy Finite State Machine dan Logika Fuzzy untuk Desain Strategi NPC Game*. MATICS.
- [10] Kahfi, M., (2017). *Penerapan Metode Finite state machine (FSM) Pada Game Agen “Zamburu Khatulistiwa” Tactical RPG Berbasis Android*, Thesis STMIK Widya Cipta Dharma.
- [11] Bimantoro, T., & Haryanto, H. (2016). *Pemodelan perilaku musuh menggunakan Finite State Machine (FSM) pada game pengenalan unsur kimia*. *Journal of Applied Intelligent System*, 1(3), 210-219.
- [12] Kam, T., Villa, T., Brayton, R. K., & Sangiovanni-Vincentelli, A. L. (2013). *Synthesis of finite state machines: functional optimization*. Springer Science & Business Media.
- [13] Halpern, J. (2019). *Games and Game Engines*. In *Developing 2D Games with Unity* (pp. 1-12). Apress, Berkeley, CA.
- [14] Späth, P. (2019). *Learn Kotlin for Android Development*. Apress.
- [15] Chandler, H. M. (2020). *The Game Production Toolbox*. CRC Press.
- [16] Gupta, S., Bagga, S., & Sharma, D. K. (2020). *Hand Gesture Recognition for Human Computer Interaction and Its Applications in Virtual Reality*. In *Advanced Computational Intelligence Techniques for Virtual Reality in Healthcare* (pp. 85-105). Springer, Cham.
- [17] Gorrieri, R. (2019). *Axiomatizing Team Equivalence for Finite-State Machines*. In *The Art of Modelling Computational Systems: A Journey from Logic and Concurrency to Security and Privacy* (pp. 14-32). Springer, Cham.
- [18] Andrea, R. (2018). *Combination of Finite State Machine (FSM) and Sugeno Fuzzy for Game Agent in “Battle of Etam Earth”*. *Advanced Science Letters*, 24(11), 8663-8667.
- [19] Singh, K., Singh, A. V., Khatri, S. K., & Som, S. (2019, January). *Artificial Intelligence Based Path Finding and Decision Making in First Person Shooting Game*. In *2019 Third International Conference on Inventive Systems and Control (ICISC)* (pp. 168-171). IEEE.
- [20] Agarwal, B. B., Tayal, S. P., & Gupta, M. (2010). *Software engineering and testing*. Jones & Bartlett Learning.

Authors' Profiles



Reza Andrea, M.Kom earned his Bachelor's degree from Computer Science, Mulawarman University in 2012. In 2013 he was involved in a game development project as a leader of Bibir Design Studio and he was awarded the best 2D game developers of Indonesia Game Show (IGS). In 2014, Reza Andrea earned his Master's Degree in Business Engineering from Department of Computer Engineering, STMIK Eresha, Jakarta. Now, he is a lecturer in Software Engineering Department in Polytechnic Agriculture of Samarinda and Expert Staff of Research Department in STMIK Widya Cipta Dharma..



Drs. Azahari, M.Kom., was born in Tanah Grogot on November 3, 1964. Completed formal education in elementary school (1979), junior high school (1982), senior high school (1985) in Tanah Grogot, Paser Regency, East Kalimantan. Continuing Bachelor studies at the Syariah High School (STIS) Samarinda, the Department of Religious Courts graduated (1993), and Masters studies at the Eresha School of Information Management (STMIK) Jakarta. Informatics Engineering Study Program graduated (2011) Thesis: Support System for Scholarship Selection Decisions in East Kalimantan Province. Lecturer at Widya Cipta Dharma College of Information Management (STMIK) Samarinda, East Kalimantan Province. From 1994 until now. and also served as vice-rector for student affairs.

How to cite this paper: Reza Andrea, Azahari, " Development of "Explores the Tenggara City" Using Autonomous Response of Adaptive NPC", International Journal of Modern Education and Computer Science(IJMECS), Vol.13, No.1, pp. 49-58, 2021.DOI: 10.5815/ijmecs.2021.01.04