Finite State Machines for Building Believable Non-Playable Character in the Game of Khalid ibn Al-Walid

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Abstract. The character recognition game Khalid ibn al-Walid is an interactive Drama game application with the perspective of First Person Shooter introducing a hero in Islam named Khalid ibn al-Walid. To make the game interesting, the Non-Playable Character must be given artificial intelligence so that it can behave intelligently and make the game atmosphere more lively. One of the simple artificial intelligence that is applied in NPC games is Finite State Machine (FSM). In this game, FSM is applied to the enemy behavior of the character Khalid ibn al-Walid. The trial results show that NPC can behave independently and smartly in Search Player, Move To Player, Wait to Attack and Attack.

1. Introduction

The lack of technological innovation in conveying the story of heroism is one of the causes of the lack of interest in the introduction of hero figures for adolescents and students, one of which is Khalid ibn al-Walid. Many young people who prefer receiving information with the sophistication of technology that is widely used today, one of which is video games. This also becomes one of the new challenges to create a media that aims to convey the story of heroism to be more desirable.

At present there are many historical games in circulation. One of the famous historical games is Blitzkrieg. Blitzkrieg is a game that elevates the history of World War II [1] [2]. Unfortunately, most historical games raise world histories. It's still very rare a game that elevates Indonesia's history. Some games that tell the history of Indonesia that have been made include PALAWA, P10NER, and Kartini Travel. PALAWA is a game that is a fundamental idea to be developed in this study with the figure of General Sudirman, PALAWA has a mission that must be completed in accordance with the historical chronology of Palagan Ambarawa, namely: the Magelang battle, the Jambu village incident, the ambarawa fortress attack, and the Ambarawa battle [3]. P10NER is a game that tells the history of the battle of 10 November [4], and Kartini's Journey is an RPG game that takes the story of R. A. Kartini in her lifetime [5].

Khalid ibn al-Walid's game has an action genre and a first person shooter (FPS) sub-genre with user views from the arena of the game on non-player characters (NPCs) that require artificial intelligence (AI). AI in FPS games generally consists of planning paths, picking up items, using items, and fighting. Specifically for warring NPCs are also expected to have specific strategies like humans [6]. The strategy in question can be in the form of a strategy of chasing the opponent, attacking the opponent or avoiding the opponent. In this research, NPC uses the Finite State Machine (FSM) method. FSM is most commonly used in AI games because its advantages are simple, efficient, easy to develop, and reliable in overcoming a wide variety of situations [7]. The use of FSM is used to design the character's behavior from the game so that the behavior is consistent and realistic, reacting appropriately to the actions of other characters.

The results of this study propose a new approach in the form of a game application as an alternative tool to study the story of Khalid ibn al-Walid.

2. Related Works

There are several researches related to the research development of 3D game application Khalid ibn al-Walid. Nyimas Ariny Sabilarrusyda developed the mobile game application history of Uthman Ibn Affan
based on the monotone chain convex hull algorithm [8]. This game application uses the Android platform, has a genre of strategy and is based on 2D environment and has a story for learning the history of Utsman bin Affan’s best friend.

David Fahmi Abdillah developed a VR first person shooter game based on November 10, 1945 with motion controller [9]. This game application uses a desktop platform, has an arcade genre and is based on a 3D environment. This game provides learning related to the history of the 10 November 1945 war in Surabaya, Indonesia, which is celebrated every year as a hero day.

Other research has also developed the Application of the K-Nearest Neighbor Algorithm for Puzzle Games of Human Body's Learning System on Virtual Mannequin [10]. This game application uses a desktop platform, has a puzzle genre and is based on a 3D environment using the K-Nearest Neighbor Algorithm method.

The research developed by this author uses a desktop platform, has an arcade genre, with an interactive drama approach, is based on a 3D environment and provides history and example from the best friend Khalid ibn al-Walid.

3. **System Design**

Research conducted on productive age groups who are used to playing games. Because the side effects of using a Virtual Reality device can cause motion sickness, so people who are used to playing games (seeing fast movements from a visual screen) are less likely to have motion sickness on them. In taking the results of the test using the unstructured interview method with success parameters, namely how complete the respondent tells the story of Khalid Bin Waleed based on the story that has been implemented in the game. In addition to getting the results of how good the playability of the game using the questionnaire method that was prepared previously.

3.1 **System Flow**

The player can be connected to the game by using Virtual Reality (VR) device which then generates VR View from the VR device. User interaction in the game is done by providing input data through the Motion Controller and Tracking Sensor devices. Both of these roles have a role to record user movements which later the movement will be converted into an input value. Furthermore, these two roles pass the data to the VR device where this data will then be processed by the system or game to be translated into interaction on the game. Then the VR device will output the visual game that will be seen by the player. From the overall system diagram, the results are obtained, the player playing a VR game with the input controller interaction provided.

![Figure 1 System Flow](image-url)
3.2 Game Flow Design

The game consists of several parts, namely: Player, Motion Controller and Sensor, Virtual Reality Hardware, Games. The player will provide input to the game and will also receive visual output provided from the VR device. Motion Controller and Sensor are two devices that will record the interaction value of the player which will then be converted into an input value. The input value is then passed on to the Virtual Reality device to be processed and processed into the game. Virtual Reality Hardware is the main device that will receive input data from the Motion Controller and Sensor devices. This device will process the data that has been received from the two devices to the game. At the same time, this device will perform visual output from the game. The game contains gameplay that is the result of processing input data from the Player and Story which is a visual part of the game visualized by the Virtual Reality device.

Figure 2. Game Flow Design

3.3 Storyline

The storyline of the game consists of 6 chapters, each chapter has its own topic and story. There are 6 topics: prologue, the caravan, the war of the mountain uhud, the ditch war, deep inside his mind, a new journey. The story in this game is explained in the following table.

| Chapter   | Title       | Story                                                                 |
|-----------|-------------|----------------------------------------------------------------------|
| Chapter I | Prologue    | This is an opening story of Khalid ibn al-Walid. It tells the player from the birth of Khalid ibn al-Walid and Fast Forward from the outline of the events in the whole story. |
| Chapter II| The Caravan | It tells about the cause of the uhud war that is the anger of the Quraysh army who want to take revenge against the believers for defeating them in the Badr war. And it also tells the player about the attack of the believers in the trade caravans of the Quraysh in order to take back the rights of the believers who have been deprived by the Quraysh |
| Chapter | Title | Story |
|---------|-------|-------|
| III     | War of The Mountain (Uhud War) | After the conflict and the anger of the Quraysh army that surged. Begin the decision to declare war or battle on the faithful again. This is the most famous war in Islamic history, the Uhud War. In Uhud war, Khalid ibn al-Walid as the leader of the Quraysh army succeeded defeating the believers. |
| IV      | The Ditch War | After the Uhud battle, there was also a war known as the trench warfare. In this war, the faithful are in very unfavorable conditions for defeating Quraysh army. But the strategy conducted by the Prophet Muhammad on the advice of one of his friends to make a ditch so as to create regional conditions that make the faithful can run a good defense strategy. Because of the trench that was made, the Quraysh army could not penetrate the city of Medina and eventually returned home without any results. |
| V       | Deep Inside His Mind | From these 2 wars the faithful did get defeated. But from these two battles, the defeat of the faithful is like someone who is on the edge of a cliff but he does not fall into the abyss, meaning that the faithful are indeed defeated, but the defeat they get is always not absolute. There must be a way out for the faithful in every war. So this makes Khalid ibn al-Walid doing a deep thinking why every attempt to bring down the believers, is always unsuccessful as a whole, there is always a gap and momentum gained by the faithful to survive or survive. So this is where Khalid ibn al-Walid believed that Allah always helps the faithful, even though it is impossible for the believers to win, but the believers can always get out of the problem. With that also Khalid ibn al-Walid also came and joined the faithful. |
| VI      | A New Journey | The journey of new life and spirit of Khalid ibn al-Walid after moving to become a believer, Khalid ibn al-Walid prepared going to Medina to meet the Prophet Muhammad. Previously, Khalid had shared his thoughts to his friends, such as Abu Sofyan. And from there also Khalid was rejected by his friends because of his decision to shock the Quraysh, remembering that Khalid was one of the people who hated Islam very much, who also fought the faithful and the Prophet Muhammad, suddenly decided to join the believers. Lots of questions that arise from the amazement of his friends to Khalid, until finally Khalid was invited to visit one of the quraish figures, Ikrimah. As it turned out, Ikrimah gave Khalid the right to choose his own way. In the evening, Khalid packed his armor and brought his horse to Medina to meet with the Prophet Muhammad for a new life. |

3.4 Artificial Intelligence for NPC
In this game there is an Enemy NPC that plays a character that can be attacked by a player with attack interaction. The NPC Enemy has a special behavior, where the NPC will search the player's location and approach the player when the player is outside the NPC’s reach. Then when it reaches its destination, the NPC can execute an Attack Rate attack. If the player is out of NPC range, then the NPC will cancel the attack and walk back to search the player. FSM of enemy soldiers can be shown in figure 3.
One of the other NPCs that interacted with players at the beginning of the game was a Narrator named Abdul. The behavior is that the narrator searches for a point, then after finding the intended point, then goes to that point, and if it arrives then stops. Likewise, if the player is out of reach, the narrator will stop. And if the position of the narrator does not move anymore then his behavior changes to look for more points. In detail, the narrator's behavior is shown in the following figure.

![Figure 3. FSM of Enemy Soldiers](image)

Interactable NPCs generally have idle behavior then if the player gives a trigger then interactable will talk and if the narration is finished then the behavior will again become idle again. FSM of interactable FSM is shown in the following image.

![Figure 4. FSM of Narrator](image)

![Figure 5. FSM of Interactable NPC](image)
FSM of Non Interactable NPC has two conditions namely play animation and stop. If the animation ends, the state stops and if the NPC does not play the animation, it plays the animation again. This is shown in the following figure.

![Figure 6. FSM of Non Interactable NPC](image)

4. Implementation
The test includes a discussion of several test scenarios, test results, and analysis of test results. Testing scenarios consist of several scenarios, where each scenario is conducted to get the results of functional testing of the game, the system, and the delivery of stories in games with a VR environment. The scenarios used to test the functional game are the Movement Gesture, Grab Object, Attack Movement and FSM of NPCs.

4.1 Testing of Movement Gesture Function
The initial condition is that the player enters the Virtual Reality environment to start play the game. Then, the player has to make a wave like a wave of a hand when someone is walking with the motion controller in the player's hand, then the player's position changes according to the direction of the player's movements in the VR world.

4.2 Testing of Grab Object Functions
Scenario testing of the Grab Object function is run with the initial conditions that there are Interactable Objects that have been prepared. The player has to draw his hand to the virtual world by moving his hand in the real world holding the motion controller towards the Interactable Object. Then after the hand in the virtual world detects that the object that is in range is Interactable Object, then the player presses and holds the trigger button on the motion controller so that the Interactable Object can be held by the player for playing the game. Figure 7 is the condition when the Grab Object function is successfully used, then the object will stick to the player's hand.

![Figure 7. Grab Object Function Testing](image)
4.3 Attack Movement Function Testing

The scenario of testing of the Attack Movement function is done by preparing several NPC (Non-Player Character) that have behavior as enemies. After the enemy has been spawned into the virtual world, the player can do an attacking movement in the game by swinging the sword at the enemy. When the Attack Movement algorithm is made, if the player attacks in the game, the system will perform data processing, whether the swing speed of the sword of the player exceeds the minimum value to conduct attacks, if it exceeds, then it will be checked again if the slash speed meets the minimum value, whether the slash the sword is at a range of attacks against enemy NPCs. If it is at an attack distance, the Deal Damage function will be conducted to the enemy.

![Figure 8](image1.png)

**Figure 8.** (a) Successful Attacking and Enemy died. (b) Failed Attacking and Enemy did not Die

4.4 FSM Testing

The scenario prepared for the FSM testing of AI Enemy is to bring up an enemy into the game, then test each condition in accordance with the state that has been implemented into NPC. In the first FSM testing scenario, which is the state where NPC will detect the location of the player and walk towards the player. If the NPC is within range of the player, the NPC will stop running towards the player. Figure 9a is when NPC approaches the player.

![Figure 9](image2.png)

**Figure 9.** (a) Enemy/NPC Moves To Player (b) Enemy stopped if player was far

After the NPC has reached the attack distance to the player, the NPC will stop and then enter the state whether the NPC can attack or not in accordance with the Attack Rate set. As in Figure 9b, the NPC stops when it reaches the range of the player. Furthermore, when the NPC state has enabled the NPC to attack, then the NPC will attack (Figure 10a).
Figure 10 (a). NPC are Attacking (b) The enemy is walking again

If after AI attacks the player moves away, the AI will return to find the player's position and walk to the player's current location (Figure 10b). Following are the conclusions from FSM's Black Box Testing.

| No | Test Case of FSM | Condition | Result |
|----|------------------|-----------|--------|
| 1  | Search Player    | Enemy Soldiers as NPC can search player | Valid |
| 2  | Move To Player   | Enemy soldiers as NPC can move to player | Valid |
| 3  | Move To Attack   | Enemy Soldiers as NPC can move to attack player | Valid |
| 4  | Attack           | Enemy Soldiers as NPC can attack player | Valid |
| 5  | Find Point       | Narrator as NPC can determine location to find the player | Valid |
| 6  | Walk             | Narrator as NPC can walk toward player | Valid |
| 7  | Stop Walking     | Narrator as NPC can stop walking if it is in front of a player | Valid |
| 8  | Idle             | Interactable NPC can be idle while narration is end | Valid |
| 9  | Talk             | Interactable NPC can talk while player give a trigger. | Valid |
| 10 | Play Animation   | Non Interactable NPC can play animation | Valid |
| 11 | Stop             | Non Interactable NPC can stop play animation | Valid |

5. Conclusion

The conclusion from the results of this study is that the Enemy Soldiers as Non-Playable Characters in this game can behave intelligently using the Finite State Machine method that is running the conditions of Search Player, Move To Player, Move To Attack and Attack well. Likewise for other NPCs, the Narrator can conduct his behavior well through the Find Point, Walk, and Stop Walking states. Interactable NPC can perform Idle and Talk behavior properly. As well as Non Interactable NPC can also run Play Animation and Stop Playing Animation behavior well.
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