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Implementation of Artificial Bee Colony Algorithm to Generate NPC Behavior in Survival Horror Game "Left Alone" As A Media Introduction to House of Cut Nyak Dhien

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Abstract. Cut Nyak Dhien is a female warrior who contributed to the Dutch colonialism in Aceh, the remaining legacy of his house which has become a history museum in Banda Aceh. As time goes by and the development of technology products, young people begin to forget the history that has built its nation, and one of the forgotten history is the struggle Cut Nyak Dhien during his life.

To preserve the history of Cut Nyak Dhien then needed a means for young people to learn the history without having to visit directly to the museum. Game content is one of the popular entertainment media. This research explains how to design NPC search behavior in games and also explains how to build educational game genre survival horror. Left Alone is a desktop-based survival horror genre education game built with Unity 5 game engine. The player will complete the mission at the location housed in Cut Nyak Dhien's home, the design level is made as closely as possible to the original house, so players can learn and understand the implicit history . The enemy's character uses an artificial intelligence system that will search for the presence of players.

Implementation of artificial intelligence in this study applied to NPC by utilizing Artificial Bee Colony algorithm, this algorithm is used as generator of search behavior, this research focused on desktop platform.

Key-words: *Artificial Bee Colony, NPC, Game Survival Horror*

1. Introduction

This Game takes the virtual object of The House Cut Nyak Dhien in Aceh which is one of the national heroes of Indonesia from the Aceh province. The House of Cut Nyak Dhien is a cultural heritage site located in the village Lampisang subdistrict PeukanBada Kabupaten Aceh Besar precisely Jalan Banda Aceh – Meulaboh or in km 7.6 adjacent to the office of BPCB Aceh in the west which is 100 meters and only takes 20 minutes from downtown Banda Aceh to go to the site of this cultural heritage [1].

All objects in the house are either paintings, furniture, manuscripts, letters and weapons used in the time of Cut Nyak Dhien will be remade in 3D and used as an asset to then be used in the game. So the player will understand the contents and history of the house Cut Nyak Dhien without having to go directly to its location in Banda Aceh.

Figure 1. The House of Cut Nyak Dhien

2. Literature Study

The game Media uses several algorithms to simplify movement, intuition and mind set players and also opstacle barriers.

The use of the Bee Colony Algorithm method in its development in the media game is examined by Juniardi Nur Fadila, Fresy Nugroho, Eko Mulyanto Yuniarno and Supeno Mardi Susiki Nugroho from the Institute of Technology Sepuluh Nopember (ITS), Surabaya in the year 2016 [2]. The AI development in this study lies in how organizing the movements of a group of NPC-like bees that can attack multiple targets within a wide area of coverage. There are several functions in the use of Bee Colony Algorithm after conducting experiments on this research, i.e. NPC can move towards target without colliding, if target move where NPC will find and follow target movement, if there is more than one target then NPC will choose the most optimal target and the last NPC can avoid from various obstacles.

Heru Santoso Djamaluddin [3] in 2016 at the Islamic State University of Maulana Malik Ibrahim Malang discussed the use of the Boids and Artificial Bee Colony algorithms in the THAWAF simulation. This simulation was done using Unity and using Artificial Bee Colony on the NPC pilgrims, which allowed the congregation to surround the Kaaba by following the leader of the group who has the role of bees for the road seeker.

From the research done can be concluded that by using the Boids and Artificial Bee Colony method for NPC congregation to behave dynamically that is flexible behavior according to the circumstances of the environment.

Research by Michael Alexander Syauta [4] in 2013 as a thesis at the Computer University of Indonesia, Bandung. The research implemented the Bee Colony Optimization algorithm to complete Rubic's Cube simulation.

The constructive movements carried out by bees are limited to 1 step in each cubic iteration, the number of allowed movements is 12 i.e. U, U ', D, D ', F, F ', R, R ', L, L ', B, B ' and the number of these movements is used as the Bee parameter.

In this research, the results of BCO algorithms in solving the problem of Rubik's Cube in the worst case is longer than other algorithms, because there is a possibility of getting stuck in the optimum local. In terms of the BCO algorithm space is more efficient when compared to other algorithms because the maximum number of vertices that are traced at each depth is linear depending on the number of bees.

Hani Nurhayati, Muhammad Faisal and Mutaqiyuddin Romadhoni [5] using Fuzzy Sugeno to control the increase of level based on the input result of time, misplacement, and help. The level of the game indicates the speed of the player in memorizing the verses of the Surah. Test results show that the use of Fuzzy Sugeno can determine the level of the game in accordance with with player statistics in solving the puzzle.

This survival-horror game research was completed by Frits Septian Johannes, Ruben Yanisah Singgih and Jason [6] from Bina Nusantara University, Jakarta. This survival horror Game uses a first-person perspective and implements 5 measured human factors and 8 golden rules from Schneiderman and Plaisant as a reference in designing the interface of the game.

Level development is done using mission objective that will change after the previous level is completed, place setting in this game is taking location in a former hospital named Red Hills Asylum.

Robby Marta, Dhika Bayu Segara, Cito revive Satrio and Agustinna Yosanny [7] at Bina Nusantara University, Jakarta in 2013. This first point-of-view (FPS) game uses Unreal Engine as a game creation media, has a basic concept of action-shooting games and has a futuristic and imaginative storyline, the main task of the game is to defend the area from enemy raids that force to go deeper, the game will end when the player manages to stop all enemies.

3. Artificial Bee Colony

Artificial Bee Colony is an optimization algorithm that is inspired by the intelligence of bee behaviour in search of food sources (Karaboga, 2005). The Artificial Bee Colony algorithm is a meta-heuristic algorithm that was first introduced by Karaboga in 2005, this algorithm is specifically based on models proposed by Tereshko and Loengarov (2005) for the feeding of honeybee colonies. In this algorithm consists of 3 important components, namely:

(1) *Employed Bee*,
(2) *Onlooker Bee*,
(3) *Scout Bee*.

In Artificial Bee Colony algorithm The food source describes the solution to the optimization problem which is described as NF, then the nectar on the food source illustrates how well the fitness value in the solution. The amount of Employed Bee or Onlooker Bee equals the number of food sources.

According to Karaboga, the general scheme of the Artificial Bee Colony algorithm is as follows:

Initialization Phase
REPEAT
Employed Bees Phase
Onlooker Bees Phase
Scout Bees Phase
Memorize the best solution achieved so far
UNTIL (Cycle = Maximum Cycle Number or a Maximum CPU time)

3.1. *Scouting Phase*

In search of food sources, bee colonies send Scout troops to find new food sources when the current food source has run out. The search pattern by bee seekers is done AceK from the current position to the next position so mathematically can be explained as in the equation (1).

$$X'_i = X_i + rand[-1\ 1] \tag{1}$$

X'_i = Next bee position

X_i = Current bee posisition

If a search is limited in space with radius (R) then the equation will turn into equation (2)

$$X'_i = X_i + rand[-1\ 1] \times R \tag{2}$$

During the search, for each team member is expected to minimize the collision on the bees. If the position to be reached by the bees obstructed by the presence of obstacle or obstruction, then the bee will have to find a new position by doing a recalculation. An agent is said to collide the position distance of the agent against a smaller barrier than the sum of the two radius (r) of the object.

Thus (d_ij) the minimum distance of bees against obstructions or other bees must be as large or larger than $r_{bee} + r_{obs}$ (3)

(4)

Equations (4) are compared to the lower 0 values resulting in a C value.

$$C = \min_0 (d_{ij} - (r_{bee} + r_{obs})) \tag{5}$$

The equation (5) becomes the basic requirement for the position selection for the equation (2). If the value of C is less than 0, then the bees are required to re-search the new position according to the equation (6).

$$X'_i = f(x) = \begin{cases} X_i + rand\ [-1\ 1] * R, & C < 0 \\ X'_i, & C \geq 0 \end{cases} \tag{6}$$

3.2. *Onlooker Phase*

The Scout bees have gained a position, returned to the nest and reformed the data that had been obtained in the position to the Bee observer who was in the hive. In this study, the data used was taken from the parameters attached to the target and the parameters attached to the bees themselves. The parameters taken and given to another bee are bees distance to the current target. To measure the distance of bees to the target, used Euclidian equation.

$$d^2 = (x_j - x_i)^2 + (y_j - y_i)^2 \tag{7}$$

$$d = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2} \tag{8}$$

3.4. *Employed Phase*

When bee seekers have given the information it obtained to bee observers and bee observers have already analyzed the data received from a Bee Scout then the information that has processed the Bee Observer is forwarded to the worker bees. By worker bees, the data becomes a reference for moving to take food that is on target. Every time the worker bees return to the nest by carrying food, the worker bees inform the observer that the food available on the target has been reduced.

$$n = \begin{cases} X_i + rand\ [-1\ 1] * R, & n < 0 \\ n - 1, & n \geq 0 \end{cases} \tag{9}$$

If the Nectar (n) on the target has timed out, then the colony redeployed the searcher to renew the position of the food source by using the equation (2).

4. Design System

Game design is the process of imagining the game, defining how the game works, describing elements used in game creation (concept, function, artistry etc.), and transmitting information about the game to the team that created it. The design of the game is a skill to combine between aesthetics and functional elements of a game (Ernest Adams, 2010) [8].

4.1. Map Design

The map used in this game is based on the interior map photos obtained in the residence of Cut Nyak Dhien, the design of the folder pictured as Figure 2.

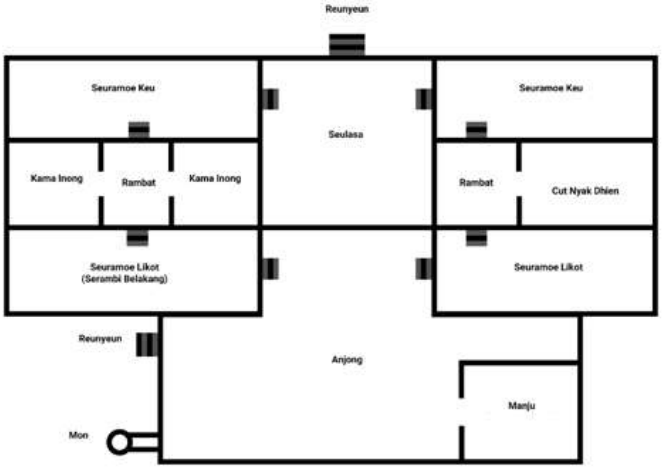

Figure 2. Map Design

There are several rooms in the house of Cut Nyak Dhien :
A. Seulasa (Selasar) is a part of the room that connects the main stairs with Seuramoe Keu.

B. Seuramoe Keu (front porch) is a room that is usually used to accept male guests, there are two Seuramoe Keu namely the right of the map and Seuramoe Keu on the left of the map, Seuramoe Keu on the left of the map contains photographs of the struggle during the Dutch colonial era, while the right contains chairs to accept male guests.
C. Seuramoe Likot (porch of the rear) is a room to accept female guests, Seuramoe Likot also has two rooms like Seuramoe Keu, that is to the right of the map and the left of the map. Seramoe Likot Kiri contains photographs during the Dutch colonial period, while the right side contains tables and chairs for the meeting to compose tactics with the warlords.
D. Anjong (dining room) is a dining place that contains a dining table and a closet that showcases the weapons used in the past such as swords, spears and rencong. This space also serves as a liaison between Seuramoe Likot and Wells and Manju.
E. Cut Nyak Dhien Room is the private room of Cut Nyak Dhien, contains several tables and one mattress that has 5 layers of mosquito net that has each layer has its own color and meaning for the ACEH nobility.
F. Kama Inong (room Dayang) is a room for women who live in the house of Cut Nyak Dhien. Contains 2 cabinets and one mattress without mosquito nets.
G. Vines is a connecting room between the rooms and the foyer, there are two vines in this House, that is next to the room of the ladies and next to the room Cut Nyak Dhien.
H. Manju (Maid room) is the room reserved for the waiter Cut Nyak Dhien, there are 2 mattresses and 1 cupboard here.
I. Mon (well) is a well located near the Anjong and has a height of 4 meters, whose purpose is that the Dutch soldiers can not throw poison.
J. Reunyeun (Stairs) is a staircase, there is a large staircase next to the lobby and a large staircase in the Anjong, while the other 7 stairs are small stairs that are the connecting between the rooms.

4.2. Finite State Machine Design

Design of FSM in this game is to regulate NPC behavior, while the main character follows the user command that plays the game. Finite State Machine game design is shown in figure 3.

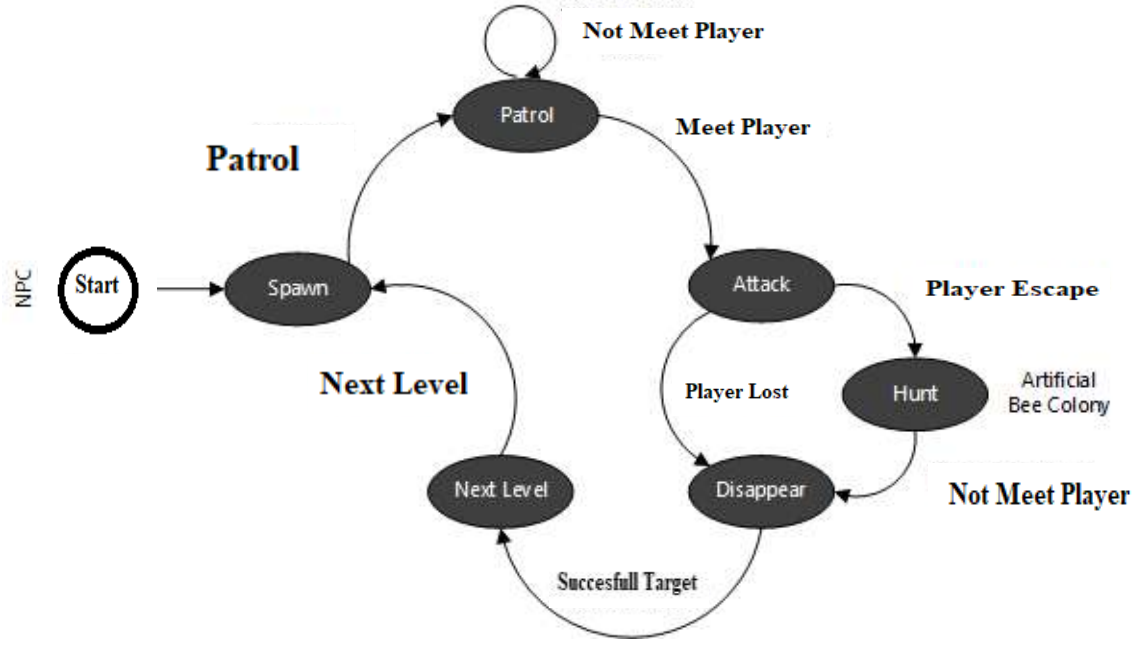

Figure 3. Finite State Machine Design

NPC will spawn when the game is at a certain level based on the story, then NPC Patrol in a room in the game, if not meet player then NPC will continue patrol so that when meeting player, NPC will try to chase and attack. When the player escapes, this is where the Artificial Bee Colony algorithm will be applied so that the NPC will do the state "hunt" to chase the player, if the player dies or the player manages to blur, then the NPC will disappear and the objective or level in the game will change to the next level.

5. Implementation

This test was done to see how the process was performed by the Artificial Bee Colony to achieve the target. This trial uses 5 NPC's spread and is at a certain coordinate as shown by Image 4, as for the initial coordinates of the Player and the 5th NPC.

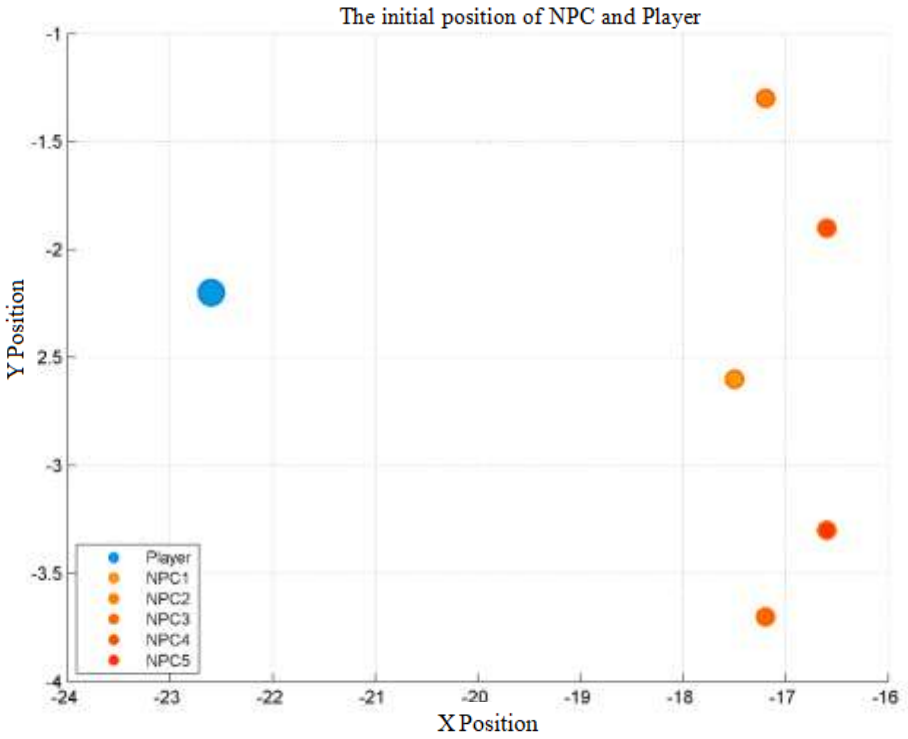

Figure 4. The initial position of NPC and Player before testing

Player Position:

X = -22.6 Z = -2.2
Stopping Distance = 1.8

NPC Position:

X1= -17.5	Z1 = -2.6	(NPC1)
X2= -17.2	Z2 = -1.3	(NPC2)
X3 = -17.2	Z3 = -3.7	(NPC3)
X4 = -16.6	Z4 = -1.9	(NPC4)
X5 = -16.6	Z5 = -3.3	(NPC5)

The Player is at the Blue Point (-22.6,-2.2) and becomes the destination point for all NPCS that exist at the time of the trial, each NPC has a moving speed of 2f. The positioning is based on the Scouting Bee colony phase, where NPC is considered to be spread to target.

When the game is run, this algorithm will be activated when the player is within the range of the NPC chase, so the NPC will move around the path towards the player's location. Any data on NPC movements such as X position (x), Y position (y), and NPC distance to player (j) will be recorded, as for the result of this algorithm experiment contained in the test data, obtained NPC distance data to the target as shown in Figure 5.

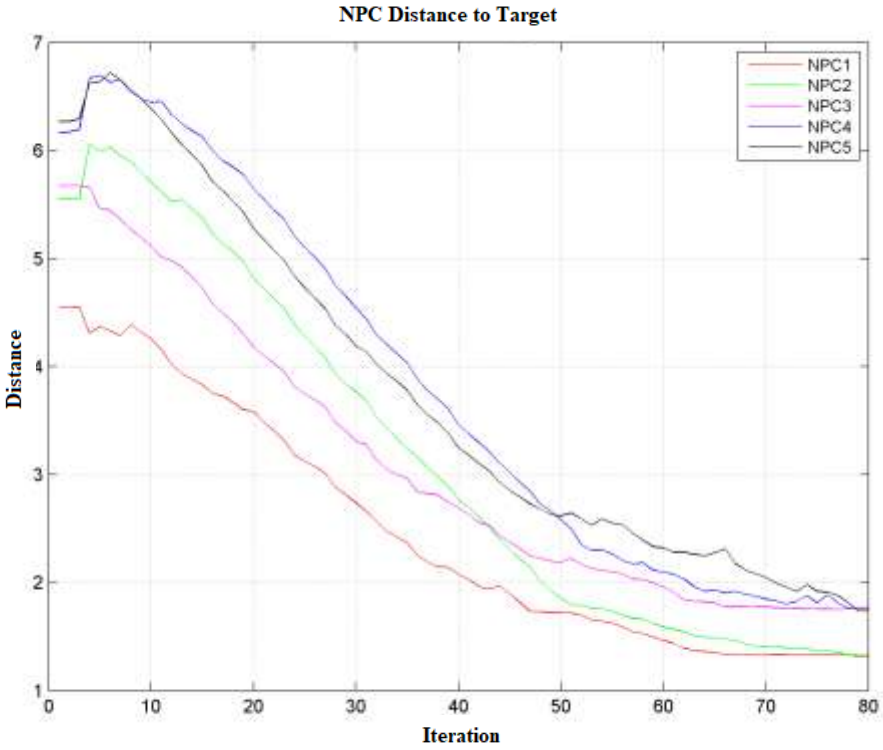

Figure 5. System Experiment Results

Seen on the chart, the NPC distance to the player continues to decline every time the iteration, until the iteration to 80 the distance NPC to the player has passed the value of stopping distance (1.8) which means that NPC has reached the maximum value to approach the player position.

From Figure 5 It can also be seen that the number of iterations of NPC to the player is always aligned, at the iteration to 10 the distance of all NPC to the player ranges from 4-6.5, iteration to 40 the distance of NPC ranges between 2-3.5, in the iteration to 80 distance NPC ranges between 1.3-1.7 and based on the observation of the

After 80 iterations, the results of all NPC's have reached the closest position to the player as illustrated in Figure 6.

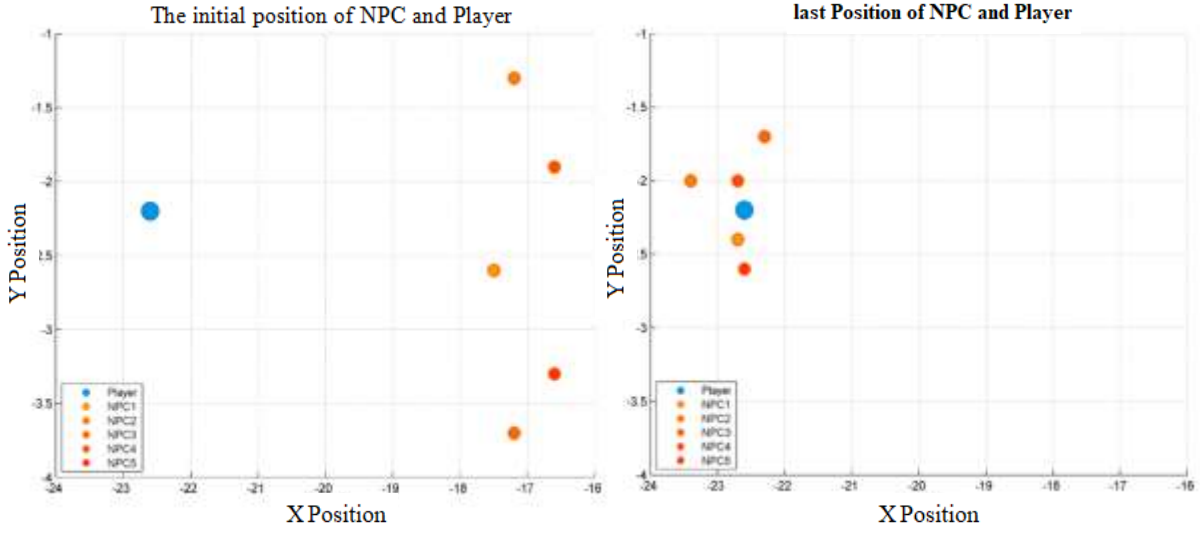

Figure 6. Comparison of NPC's initial position and final position with Player

At the beginning of the experiment, the NPC position is exactly as it is in Figure 6 (left).

Player Position:
• Player (-22.6,-2.2)

Initial NPC Position:
• NPC 1 (-17.5,-2.6)
• NPC 2 (-17.2,-1.3)
• NPC 3 (-17.2,-3.7)
• NPC 4 (-16.6,-1.9)
• NPC 5 (-16.6,-3.3)

Initial distance NPC to player:
• NPC 1 (4.54)
• NPC 2 (5.55)
• NPC 3 (5.67)
• NPC 4 (6.17)
• NPC 5 (6.27)

After running the algorithm and experiencing 80 iterations, the NPC position becomes closer to the player as depicted in Figure 6 (right).

Final NPC Position:
• NPC 1 (-22.7,-2.4)
• NPC 2 (-23.4,-2)
• NPC 3 (-22.3,-1.7)
• NPC 4 (-22.7,-2)
• NPC 5 (-22.6,-2.6)

Final distance NPC to player:
• NPC 1 (1.31)
• NPC 2 (1.33)
• NPC 3 (1.77)
• NPC 4 (1.76)
• NPC 5 (1.73)

NPC's final position to the player becomes closer and the distance NPC to the player has passed the stopping distance value, meaning Algorima Artificial Bee Colony successfully worked well because NPC has reached the target position by grouping.

6. Conclusion

Based on the results of analysis, design and implementation of the Left Alone games are as follows:P used the Artificial Bee Colony algorithm was successfully applied as a search behaviour generator on NPC. Indicated by a system test in the table. 4.4, at the beginning of the test the distance of each NPC to the player is:

• NPC 1 (4.54), NPC 2 (5.55), NPC 3 (5.67), NPC 4 (6.17), NPC 5 (6.27).

In the process of searching the shortest path to the player location during 80 iterations, each NPC managed to reach the maximum distance with the final distance value of NPC to the player as follows:

• NPC 1 (1.31), NPC 2 (1.33), NPC 3 (1.77), NPC 4 (1.76), NPC 5 (1.73)

From the results of this research, obtained the result that the final distance value of NPC to the player has passed the value of stopping distance (1.8) which means the research has gone well.

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