# Non-Playable Character Movement Controls For Tour Guides And Tourist Activity Simulation Using Artificial Bee Colonies


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***Abstract*—Indonesia has various wonderful location, makes it a tourist destination. The large number of tourist sites makes potential visitors need to conduct initial information searches for having expectations of the site. One of the information that can be used is a tourist simulation using interactive media for matching expectation with the experience. Simulation of the mass tourist with tour guide may encounter error when a tourist of tourist group collided with another tourists or object in the game environment while following the tour guide. This study discusses the implementation of a tourist group with tour guide simulation enabled by artificial intelligence. The Artificial Bee Colony algorithm is used in this study to prevent Tourists as Non-playable characters (NPC) from colliding with surrounding objects and other NPCs. The results of this study show that the success rate for NPCs in avoiding other NPCs is 100%, NPCs in avoiding objects around them is 89%, and NPCs reach the target point by 80%.**



***Keywords— Tourism, visualization, Simulation, Artificial Bee Colony***


## I. Introduction

The tourism potential in Indonesia is so significant, and it has become one of the sectors favored by the government as an economic driver [1]. Various kinds of tourism, such as natural, cultural, historical, culinary, and other tourism, can attract local, national, and even foreign tourists.

The form and type of tourism can affect the type of tourists who come. There are four types of tourists, namely: the drifter, the explorer, the individual mass tourist, and the organized mass tourist [2]. The first two types are the forerunners of the term “backpackers” in the world of tourism [3], while mass tourists are tourists who are members of groups. Both groups formed at tourist sites (unbound) or those managed by organizations (bonded) [4].

Mass tourists usually use a tour guide to provide an optimal experience and utilization of time. Tour guides can provide additional knowledge beyond the information on the web because they are very knowledgeable about tourist sites and can also provide the best routes and locations when doing tours. The tour guide will lead the group during the visit.

With advances in information technology, tourists can look for information regarding prospective tourist sites to be visited digitally [5]. Several tourist attractions, especially popular ones, already have digital information that is complemented by visualization from previous visitors, providers of tourist attractions, and other parties. Visualization can be in the form of images [6], videos, or interactive media such as games [1], augmented reality [7], and others.

The use of games in visualizing tourist attractions as information has an advantage that other visualization media do not have, namely, a more realistic experience for potential visitors. The challenge for this information type is when the potential visitors use the mass tourist type game mode. When potential visitors choose the role of tour guides and tourists as followers or Non-Player Characters (NPC), errors will occur to NPCs, such as colliding with one another and being obstructed by objects in the game environment.

To ensure that NPCs do not experience errors during the simulation, we added an artificial bee colony (ABC) algorithm to move NPCs who are members of the mass tourist to follow the tour guide. We use ABC because it has a simple structure, does not require many parameters, and is easy to implement [8]. To test the implementation of the ABC algorithm, we use the game that simulates tourism, namely Jawa Timur Park 1, located in Batu City, East Java, Indonesia.

## II. Related Work

Several studies have been carried out in tourist simulations using artificial intelligence. Arif [1] in his research used games as a simulation of the experience of traveling to provide recommendations for alternative tourist sites to prospective visitors. The result of research show that alternative sites will be generated automatically based on preference value for each alternative as a reference for the player.

The swarm algorithm using artificial intelligence is an algorithmic model created based on observations of animal behavior in a group [9]. Rong [10] in his research, used a simulation of fish swarms combined with virtual reality to develop marine ecotourism to eliminate the lack of interaction between the fish and the viewer, reducing the tourism experience.

Innamul [11] in his research used the ABC algorithm in a historical tourism game "left alone" as an educational medium for Indonesia's national hero, Cut Nyak Dhien. This research successfully implemented NPC player become closer to target position after 80 iterations.

## III. Design and Method

### A. Artificial Bee Colony

At ABC, artificial search bee colonies (agents) search for good quality artificial food sources. In other words, ABC seeks a good solution for solving a particular problem. The application of ABC begins with turning the optimization problem under consideration into a problem of finding the best parameter vector that minimizes the objective function. Furthermore, artificial bees find the initial solution vector population randomly and then improve it iteratively by using a strategy: moving towards a better solution through the nearest search mechanism by ignoring bad solutions [12].

The ABC model consists of four important components [12]:

- Food sources. Representative of the solution for the problem that tried to solve. Each food source produces nectar in proportion to the suitability of the solution to the problem.
- Worker bees look for a new food source that has more nectar than the previous food source in the vicinity of the previous food source. This search is random but utilizes information known from other food sources.
- Onlooker bees watch the waggle dance of worker bees and learn the location of food sources. In practice, this is achieved using a Roulette Wheel Selection Algorithm, which results in a greater probability of selecting food sites that have higher nectar.
- Scout bees choose food sources randomly to replace abandoned food sources that cannot be repaired further through a predetermined number of tracks.

### B. Artificial Bee Colony Algorithm

This study uses the ABC algorithm to ensure that tourist groups can approach tour guides without getting hit by obstacles. Here is the procedure

- Scouting Phase

While searching for new nectar as a food source, the bee colony assigns scout bees. This search is done randomly. Likewise with the NPC when looking for a tour guide (target point). NPC will search for target point randomly. This search can be explained mathematically as in equation (1).

$$X_i' = X_i + rand[-1\ 1]\ x\ R \tag{1}$$

Where

$X_i'$ = initialization of the i-n possible solutions

$X_i$ = value of the smallest possible solution based on parameter i

R = predefined radius

There are usually not only one scout bees assigned to look for nectar. When searching, it is hoped that the bees will not collide with other bees by avoiding and looking for new positions. Collisions occur when the calculated value of the minimum distance between the bees and other bees ($d_{ij}$) is smaller than the total radius (r) value of the bees and other bees ($r_{bee} + r_{obs}$). The same formula is applied to the simulation of this research, where the value of the minimum distance between an NPC and other NPCs/other objects cannot be less than the r total of NPCs and other NPCs/other objects. The calculation of this difference is called the C value which can be explained in equation (2)

$$C = \min_0(d_{ij} > (r_{bee} + r_{obs})) \tag{2}$$

Where

$$d_{ij} = \sqrt{(x_j - x_i)^2 - (y_j - y_i)^2}$$

when in the movement of the bees there is a collision, then the bees will look for a new position. At the NPC, if C < 0, then the NPC looks for a new position using equation (3)

$$X_i' = f(x) = \begin{cases} x_i + rand[-1\ 1]\ \text{x}\ R, & C < 0 \\ X_i', & C \geq 0 \end{cases} \tag{3}$$

- Onlooker Phase

Scout bees have got a position that does not collide with other bees. The bees return to the hive and inform the observer bees of the new position they have obtained. The treatment of NPCs in simulation is slightly different. After getting a new position, the NPC compares the NPC's initial position to the target point with the NPC's new position to the target point. The NPC takes the new position parameter as the basis for knowing that the NPC is getting closer to the target point. To measure the distance of the NPC to the target point, the Euclidian equation is used as follows:

$$d^2 = (x_j - x_i)^2 + (y_j - y_i)^2$$

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

- Employed Phase

The information obtained by observer bees from scout bees becomes the basis for sending worker bees to collect nectar. Each worker bee that brings food and returns to the hive automatically informs the observer bees that the available nectar has decreased. This happens continuously until the nectar runs out. The nectar that keeps decreasing is likened to the distance between the NPC and the target point that is getting closer. So, equations 2, 3, and so on are repeated until the distance between the NPC and the target point = 0.

The process of repeating the NPC procedure to the target point described above can be seen in the flow chart of Figure 1.

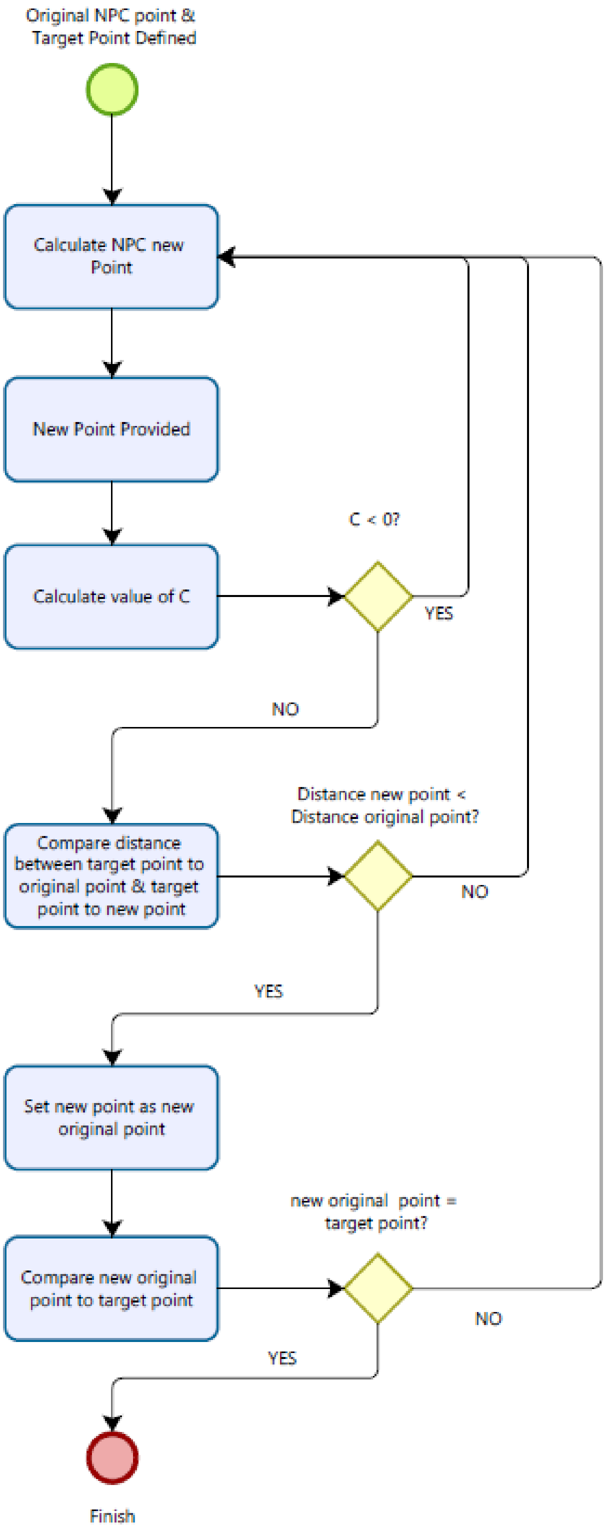


Fig. 1. Artificial Bee Colony Algorithm Flow Chart

## IV. Result and Discussion

Jawa Timur Park 1 is an educational and recreational tour. Figure 2 is an initial view of this simulation application. Apart from the simulation, potential visitors will also receive additional information, namely the price of the entrance ticket.


Fig. 2. Initial Screen Simulation Jawa Timur Park 1

The scenario in this game application is that the user can direct the tour guide to the available rides and tourists will move closer to the tour guide. Examples of rides and tourists can be seen in Figure 3.

Fig. 3. One of The Rides in Jawa Timur Park 1 being visited

Testing was carried out using three different groups with the various number of NPCs in them, 5, 10, and 20 NPCs. Each group is measured its success using three criteria as follows:

- C1 = NPC can avoid obstacles in the form of objects
- C2 = NPC does not collide with other NPC
- C3 = NPC arrives at the target point.

In addition, for C3, we also measure the time it takes for the NPC to reach the target [13].

### *A. NPC Group Result*

The results of the first group test (5 NPCs) were only C2 which got 100% success rate, while C1 was 80%, and C3 was 60%. The average success rate in the first group is 80%. The results of each criterion can be seen in Figure 4.

The test results for the second group (10 NPCs) were the same as the first group. C2 and C1 got the same success rate of 100% and 80% respectively. the results of C3 are slightly better with 80% success rate. The average success rate in the second group was 83%. The results of second group can be seen in Figure 5.

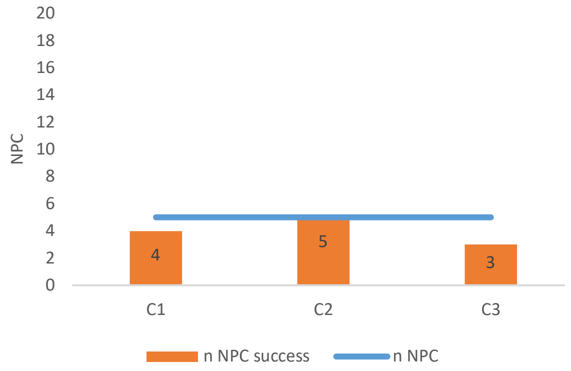


Fig. 4. Result of Group with 5 NPCs

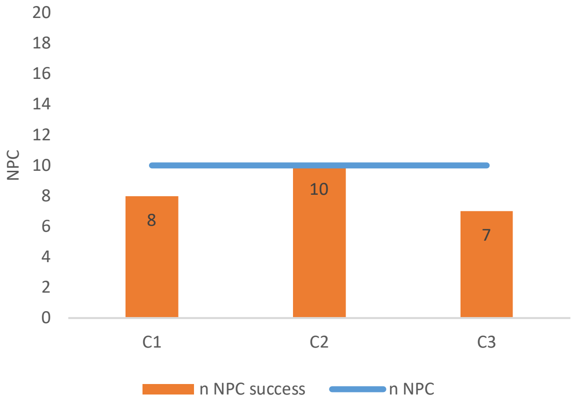


Fig. 5. Result of Group with 10 NPCs

The test results of the third group (20 NPCs) also showed that C2 had a 100% success rate, while the results of C1 and C3 were better when compared to the results of the first and second groups with each criterion getting a success rate of 95% and 90%. The average success rate in the third group is 95%. The results of third group can be seen in Figure 6.

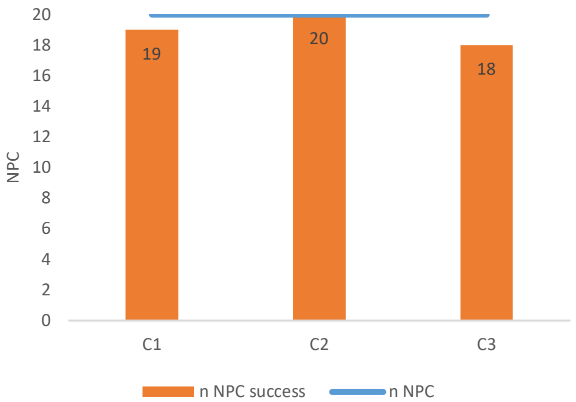


Fig. 6. Result of Group with 20 NPCs

### B. *Criteria Test Result*

Test result for each criterion shows that C2 has the best success rate for each number of NPCs in the group, namely 100%, which means that each NPC succeeds in not colliding with other NPCs (see table 1). While C1 and C3 showed a better success rate when tested with 20 NPCs (see table 2 and table 3).

TABLE I. C2 TEST RESULT DATA

| Criteria | n NPC | n NPC Success | Success Rate |
|---|---|---|---|
| C2 | 5 | 5 | 100% |
| C2 | 10 | 10 | 100% |
| C2 | 20 | 20 | 100% |
| **Total** | **35** | **35** | **100% (avg)** |

TABLE II. C1 TEST RESULT DATA

| Criteria | n NPC | n NPC success | Success Rate |
|---|---|---|---|
| C1 | 5 | 4 | 80% |
| C1 | 10 | 8 | 80% |
| C1 | 20 | 19 | 95% |
| **Total** | **35** | **31** | **89% (avg)** |

TABLE III. C3 TEST RESULT DATA

| Criteria | n NPC | n NPC success | Success Rate |
|---|---|---|---|
| C3 | 5 | 3 | 60% |
| C3 | 10 | 7 | 70% |
| C3 | 20 | 18 | 90% |
| **Total** | **35** | **28** | **80% (avg)** |

Total test in this study were nine times with an average combined success rate of 90%. Test Result data can be seen in table 4.

TABLE IV. NPC DATA TEST CRITERIA BASED

| Criteria | n NPC | n NPC success | Success Rate |
|---|---|---|---|
| C1 | 5 | 4 | 80% |
| C2 | 5 | 5 | 100% |
| C3 | 5 | 3 | 60% |
| C1 | 10 | 8 | 80% |
| C2 | 10 | 10 | 100% |
| C3 | 10 | 7 | 70% |
| C1 | 20 | 19 | 95% |
| C2 | 20 | 20 | 100% |
| C3 | 20 | 18 | 90% |
| **Total** | **105** | **94** | **90% (avg)** |

### C. *Time To Reach Target Point Result*

The time it takes for NPCs to reach the target point increases with the number of NPCs being simulated. This happens because the more NPCs, the greater the chance of collisions between NPCs so that more iterations are needed to reach the target. The same thing was also shown in the simulation experiment conducted by [13], where the evacuation time increases with the increase in the number of people being evacuated. The difference in testing time with the number of NPCs can be seen in Figure 7.

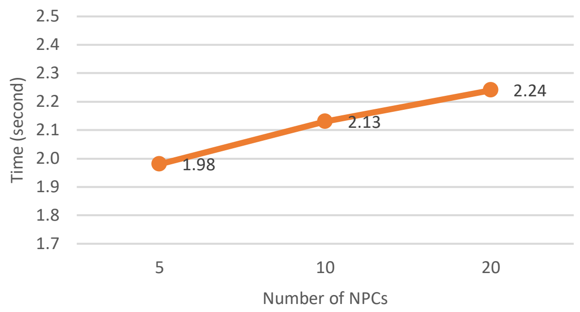


Fig. 7. Time needed for NPCs to arrive at the target point

## V. Conclusion

Tourism simulation is expected to be one of the considerations for prospective tourists in determining their tourist destinations. Simulation using interactive media visualization must resemble the original conditions of the tour. This study tries to solve the possibility of failure using simulations for group tour visits led by tour guides using the ABC algorithm. The three criteria tested show a fairly success rate with an average of 90%. C3 is a criterion that has the lowest success rate, so it can be used as a topic for further research discussion to increase success.

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