Optimising the tower-defense games with advanced local cultural content and a greedy algorithm

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Abstract. The aims of our games is preserving the local culture of Madura island that many people may have left behind. By utilizing mobile technology that is currently growing rapidly, it is expected that the promotion of local cultural content can be more effective. The game-based application is an attractive media with fun content, so it is normally more easy to attract interest and to be familiar with people. Our contribution is to participate in the campaign of familiarization of local wisdom to re-establish the living tradition of regional cultural values as a national identity. Save The Madura Island game is a strategy game which carries out the Madura culture theme. The app allows players to learn Madurese culture happily by playing a game. Save The Madura Island game is inspired by tower-defense games and uses a greedy algorithm as artificial intelligence which is inserted in character of defense to help the character of defense in determining which enemy is more effective to be attacked first. From the experiments, it was concluded that the use of greedy algorithms in the application proved effective in helping reduce the number of enemies who escaped, which decreased from 41.8% to 30.4%.

1. Introduction

Many research has been done to take advantage of the assistance of smartphones for everyday life so that many activities are helped by applications built on smartphones [1]. Games are digital-app that played on electronic devices. Almost everyone has played this digital-app; there is much evidence linking that playing games can reduce stress and depression. By playing games, the brain will be demanding to process much information, so then the player will temporarily forget all their problems. Games can also be the most appropriate way to release stress for many people. Recorded more than 1.3 billion gamers (people who play games) in this world both from PC games (personal computers), mobile games, tablets or others. The game-app concept which has a double mission beside as a fun and entertaining tools, but also brought an educational mission and local tourism campaign was seen as a cheaper and more effective way when compared to conventional promotional methods.

Madura is one of the islands in Indonesia that is rich in culture and local wisdom, e.g. typical foods, traditional clothing, lot of wonderful tourist attractions, and all traditional things which very much interesting to be explored. The challenge is to overcome the fact that many people still do not know much about Madurese culture and the local wisdom in the cultural symbol of Madura island. This condition is due to the lack of information to promote them into the community. Previously, we have carried out related research to introduce Madura culture, including applying augmented reality technology to Madura batik clothing [2]. In this research, we propose a mobile game based on original...
Madurese culture by taking inspiration from the following game in the hope that more and more people will know Madurese culture.

2. Design and methods

2.1. A greedy algorithm for games

The greedy algorithm works in stages, step by step to produce its best solution. The greedy method looks for local maximums or minimums to determine the optimal global solution. This method is commonly used for solving optimization problems.

There are two types of approaches that can be done with the greedy algorithm in solving problems to determine which enemies should be attacked. The first is to attack the enemy who first entered the range of attack defense characters. The second is based on the selection function based on four enemy attributes within the range of the defense character, and then the defense character will attack the enemy based on the lowest result of the four attribute selection function. We use the greedy algorithm since it can provide a solution that approaches the optimum value in a fairly fast with a simple mathematical function.

Several studies which are using the greedy algorithm in games include a multi-player Pursuit-Evasion game [3], StarCraft real-time strategy game [4]. This algorithm is also an initial reference for the development of new methods for solving problems in the game-app, as Ian Parberry has done in optimizing the memory usage of puzzle games [5].

The purpose of a calculation with many selection functions being targeted or selected is to optimize the results of the global optimum. When only using one selection function, the global optimum results are not necessarily the best solution.

Following the problem that has been analyzed, there are two kinds of greedy approaches that we can propose to do in this game.

1. Greedy by Distance

Greedy by distance is a greedy logic algorithm used to find the closest distance to an enemy, because the closest or smallest distance is the biggest threat to the player.

- Select the enemy who first entered the range to attack the defense character.
- Minimize enemy distance to defense character by selecting the closest enemy (smallest distance) first.

Greedy Element:

- Candidate set: the enemy within range.
- The set of solutions: the enemy that first enters the attack range of the defense character.
- Selection function: select the enemy that has the lowest distance.
- Decent function: all selected enemies are feasible.
- Objective function: attack the enemy that has the lowest distance.

2. Greedy by four attributes

Greedy by four attributes is a greedy algorithm that is used to find the smallest value of an equation:

$$\frac{hp \cdot d} {s} \cdot t \cdot t_i \cdot d \cdot f \cdot h(g)$$  \hspace{1cm} (1)

The purpose of using the formula is so that the selected enemy is the enemy that has the highest potential threat capable of reaching the finish point. Some parameters that are considered are the value of hp (health point), distance to the character of defence, speed of movement. As is known that the enemy with the closest finishing point with these criteria is considered to be the highest threat.

In its implementation, this function must be called frequently all the time. This action needed for responding to the enemy condition which always changing every time. Thus, we will get information whether the enemy is outside the attacking range or within the attacking range. The calculation using the selection function will continue to be done based on the four enemy attributes.
2.2. System design

The greedy algorithm is used to optimize the exertion of character defenses to stem enemy characters from reaching the finish point. Greedy algorithm pseudocode is as follows:

\[
\begin{align*}
S & \leftarrow \phi; \\
Selected & \leftarrow \phi; \\
S_0 & \leftarrow 0; \\
\text{for } i = 1 \text{ to } k \text{ do} \\
& \quad \text{foreach node } w \text{ of seed candidate} \text{ do} \\
& \quad \quad MarginalGain[w] \leftarrow F(S \cup \{w\}) - S; \\
& \quad \end{foreach} \\
& \quad Selected \leftarrow \{w | MarginalGain[w] \text{ maximized}\}; \\
& \quad S = S \cup Selected; \\
& \quad S_0 = S_0 + MarginalGain[Selected]; \\
\text{end}
\end{align*}
\]

Where \( \omega = \text{Greedy by four attributes result} \)

Figure 1 is the Save the Madura Island game flow shown in the form of a flowchart. Our game-flowchart has shown the way how the game will run. Firstly, the player will find two menu choices, which are the main menu and the exit menu, when the player chooses the main menu, then the player will directly move to the level selection menu.

A player will have to choose the level according to the level that he wants to play, level itself is the selection of gameplay that has different routes, the number of enemies, and backgrounds, the background itself is historical places or natural attractions in Madura. When the level has already chosen, the player will move to the gameplay. Player mission is destroying the enemies so they can never reach the finish point (goal). Player build several defense characters which can be placed at a certain place in the playground. After the player has finished playing the gameplay, a result will be obtained, i.e. win or lose, if the result obtained by the player wins, then the player can continue to the next level and return to the level menu or repeat the level and go directly to the gameplay, but if the results obtained the player loses, then the player can only repeat the game or exit the game. Game scenario

Game Save the Madura Island is a strategy genre game that introduces a variety of indigenous Madurese cultures, both from tourist attractions, hero figures and from other things. In this game the player is required to hold the enemy that will steal the cows at the endpoint or goal, the cows themselves are lives owned by the player, and in each level, the player will only be provided five lives. The enemy will continue to appear and try to steal cows as long as the number of waves has not reached zero, the wave itself is a stipulation of the number of incoming enemy hordes that will continue to walk backward until it reaches zero. Players can hold enemies by building defense characters that have different strengths and speeds. If the number of cows reaches 0 then the player is declared lost, but if the player can maintain the number of cows until they do not reach 0 then the player is declared to win and get a star according to the weight of the remaining number of cows.
2.3. Level
In the Save the Madura Island game, eight levels have been built with different road routes, backgrounds, number of enemies, and number of enemy attack stages. The number of stages of enemy attacks are the stages of enemy attacks, where the enemy itself will attack gradually in each level, which at level 1 and 2 there are 7 stages, level 3 and 4 there are 8 stages, level 5 and 6 there are 9 stages, and level 7 and 8 there are 10 stages. At each level the background used is historical sites, icons, and tourist attractions in Madura. At level 1 the background used is the Suramadu bridge, and level 2 is the Agung Bangkalan mosque, the Toroan waterfall is the background used at level 3, at level 4 the background used is the Bangkalan great mosque, level 5 is the fire that never goes out, at the level 6 background used is the grand mosque of Pamekasan, level 7 is the grand mosque of Sumenep, and level 8 which is the last level to use the background of the Lombang beach. Cows are the number of lives of the user has, and at each level, there are five cows. The cow was also associated with player life which appears on the top of the screen, if the cow is reduced, the number of life will also be reduced. The playground at every level has different rules and designs; for example, in level 5 there are two entrances, it would be more difficult for the user to play the game. The background used in this level is Natural Fire Tak Kunjung Padam which located in Pamekasan.

2.4. Defense character
The defense character in the Save the Madura Island game is an attribute that players use to block enemy attacks. The defense character itself is in the form of an original Madurese character who will save cows that the enemy wants to steal, by blocking all enemies that come. The defense character display is taken from Madurese leaders who have struggled to advance Madura, as in figure 2.

![Figure 2. Defense character](image1)

![Figure 3. Enemy character](image2)

Defense characters have different damage, speed, price and skills, as listed in Table 1.

2.5. Enemy character
The enemy is an enemy who will appear in droves and walk from start to goal. The start itself is an entry point for future enemies within the specified time period, and at each level the position and number of starts varies according to the level being played, as in levels 1-4 which only have 1 entrance and levels 5-8 which has 2 entrances, this is because levels 1-4 include easy levels and levels 5-8 including difficult levels. The goal is the final point in the game Save the Madura Island depicted with a cow pen, and at each level the goal position is different. The enemy is described as an invader with various views according to the capabilities of the enemy, as shown in Figure 3.

There are five types of enemies in the Save the Madura Island game. For each enemy, we have been designed to have different abilities, powers, and speeds, detailed, as shown in Table 2.

| Table 1. Defense Character | Table 2. Enemy Character |
|-----------------------------|--------------------------|
| No  | Price | Damage | Speed (s) | skill       | Enemy | Gold | Speed | Life | Ability         |
|-----|-------|--------|-----------|-------------|--------|------|-------|------|-----------------|
| 1   | 100   | 3      | 1         |             | 1      | 50   | 20    | 10   |                 |
| 2   | 150   | 1      | 3         |             | 2      | 40   | 30    | 7    |                 |
| 3   | 150   | 0      | ½         | Slow speed  | 3      | 100  | 20    | 8    | Transparent     |
| 4   | 200   | 0      | 0         | Anti transparent | 4      | 150  | 15    | 30   |                 |
| 5   | 450   | 10     | 1/3       |             | 5      | 500  | 10    | 350  |                 |
3. Results and Discussion
The initial screen that first appeared when the player opened the game Save the Madura Island, as shown in Figure 4. In this step we display the Suramadu Bridge as the background image which connected to Madura Island and Surabaya city. We need to provide information to the player if the Save the Madura Island game is related to Madura island. Some buttons have also been designed to have their respective functions, the play button functions to start the game, the exit button functions to close the game, and the mute button functions to turn on and turn off the background sound of the Save the game.

![Figure 4](image1.png)

Figure 4. An initial screen of the game-app

![Image 5](image2.png)

Fig. 5. A different pop-up image in every game-level

The GUI (Graphical player interface) of game’s level will open if the player clicks on the play button on the start screen or if the player clicks on the menu button on the GUI which showed in figure 7.

![Image 6](image3.png)

Fig. 6. Design of Level-GUI

![Image 7](image4.png)

Fig. 7. In-Game Playground Design

At Fig. 6 there is a background image showing a Madura Island which divided into four sections, this background image is referring to the four districts of Madura Island. In every district, there is two levels game, and we have also designed its playground denoting the characteristics and diversity of tourism place of Madura. Opening-GUI is a UI that will open a few seconds before initial-screen. In-game level pop-up image is designed with various vector images of Madura tourism places with the info of each corresponding place to lead more information to the player.

After completing all the game designs and workflows, the application is ready to be tested on the player. Testing the performance of the chosen algorithm and testing directly on the device needs to be done to ensure system reliability.

The effectiveness of the method will be carried out by testing the results of the greedy algorithm on the game, by playing the game Save The Madura Island with and without using the greedy algorithm, which later the location of the defense character is placed in the same place and at the same time. In the testing stage, the performance of the Save The Madura Island game measure in order to see the advantage of greedy algorithm. In this study, the game will be tested with The enemy parameters, including device, and method. Device testing is a test that aims to prove that the game can run on Android devices. In this study the game will be tested on several Android devices of various sizes and various versions of the Android OS.

| Experiment | Defense Character | Level | Number of Enemies | Enemy Left Greedy | Non-Greedy |
|------------|-------------------|-------|-------------------|-------------------|------------|
| 1          | 2 DC-2            | 3     | 10 enemy-2        | 2 enemy2          | 3 enemy2   |
| 2          | 1 DC-2            | 1     | 5 enemy-2         | 2 enemy2          | 3 enemy2   |

Table 3. Greedy algorithm test
Table 4. Device performance Test

| No | Device          | OS             | Resolution       | Display                          |
|----|-----------------|----------------|------------------|----------------------------------|
| 1  | Motorola Moto E | 4.4.4 (Kitkat) | 540 x 960 pixels | ![Motorola Moto E](image1)       |
| 2  | Lenovo A516     | 4.2.2 (Jelly Bean) | 480 x 854 pixels | ![Lenovo A516](image2)          |
| 3  | Acer Liquid Z220 | 5.0 (Lollipop)  | 480 x 800 pixels | ![Acer Liquid Z220](image3)     |
| 4  | Sony Experia E1 | 4.4.2 (Kitkat) | 480 x 800 pixels | ![Sony Experia E1](image4)      |

Based on the results of the experimental test, the greedy algorithm we conclude that the use of the greedy algorithm in the Save the Madura Island game make the game more effective because it can reduce the number of enemies that escape from 41.8% to 30.4%. From the tests conducted, it also concluded that the game-app could be run properly at variety of Android devices.

4. References

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