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## Computer Utilization as a Balanced Opponent in Dam-Dam-An

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Dam-dam-an is a traditional game played by two players using a board with the size of 8×8 as a media. Each player gets 16 pieces that can be moved one step forward or leaped over opponent's piece. The goal of this game is to eliminate all of our pieces as soon as possible. It is exciting to have a challenging opponent, yet it is difficult to find a skillful one. A way to solve this problem is using intelligent computer. This paper presents the result of our research about the computer utilization as balanced opponent in dam-dam-an game using Alpha-Beta Pruning. Alpha-Beta Pruning is a best-step searching algorithm which works by considering and assessing every possibility while excluding the less useful steps. The implementation is developed using C# programming language based on Windows Runtime. Some features were added to make this game more exciting, particularly intelligence level selection (easy, medium, and hard), human or computer opponent selection, undo function, pausing menu, save-load the game, and setting the turning time. This game was validated by twenty respondents which were categorized based on their skill. Each respondent played against the computer thrice and the results were recorded. The results showed that the number of winning between the computer and each player are almost the same. It shows that the computer opponent may prove itself to be a challenging opponent for human player.

**Keywords:** Alpha-Beta Pruning; Artificial Intelligence; Dam-Dam-An; Game

**Document Type:** Research Article

**Affiliations:** Informatics Engineering Department, University of Surabaya, Surabaya 60293, East Java, Indonesia; Raya Kallrungkut 60293, Surabaya, East Java, Indonesia

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# Computer Utilization as A Balanced Opponent in Dam-Dam-an

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Dam-dam-an is a traditional game played by two players using a board with the size of 8x8 as a media. Each player gets 16 pieces that can be moved one step forward or leaped over opponent's piece. The goal of this game is to eliminate all of our pieces as soon as possible. It is exciting to have a challenging opponent, yet it is difficult to find a skillful one. A way to solve this problem is using intelligent computer. This paper presents the result of our research about the computer utilization as balanced opponent in dam-dam-an game using Alpha-Beta Pruning. Alpha-Beta Pruning is a best-step searching algorithm which works by considering and assessing every possibility while excluding the less useful steps. The implementation is developed using C# programming language based on Windows Runtime. Some features were added to make this game more exciting, particularly intelligence level selection (easy, medium, and hard), human or computer opponent selection, undo function, pausing menu, save-load the game, and setting the turning time. This game was validated by twenty respondents which were categorized based on their skill. Each respondent played against the computer thrice and the results were recorded. The results showed that the number of winning between the computer and each player are almost the same. It shows that the computer opponent may prove itself to be a challenging opponent for human player.

**Keywords:** Dam-dam-an, Artificial Intelligence, Game, Alpha-Beta Pruning.

## 1. Introduction

Psychologically, one of our needs is to have entertainments<sup>1</sup>. Eventhough it is not primary needs, it is always sought. A game has an ability to give us recreation, decreasing our stress, and regaining our focus<sup>2</sup>. Besides that, playing a game can improve our cognitive, emotional, and social skills<sup>3</sup>. An example of games is draughts, a two-player strategy board game involving diagonal moves of uniform game pieces and mandatory captures by jumping over opponent pieces. The name "draughts" is derived from the verb 'to draw' or 'to move'<sup>4</sup>. Because of its popularity over the world, each region creates their own variation, and gives them a name. For examples, Ghanaian draughts is called Damii, Brazilian draughts is called Derecha, and Indonesian draughts is called dam-dam-an.

Dam-dam-an has lots of variations too. Some regions have their own rules and board. As an example, dam-dam-an which is going to be discussed here is the one which came from a region in Kediri, East Java. It is a turn-taking based traditional game, played by two players using a board with the size of 8x8 as the media. The board has no unique layout and can be replaced with chess board. Each player gets 16 pieces that can be moved one step forward or leaped over opponent's pieces. If a piece is at the end of the board, it can't be moved, except leaping over opponent's piece. The goal of this game is to eliminate all of our pieces as soon as possible. The game ends when there is a player whose entire pieces are eliminated or when a player can't do any moves.

Since this game is played by two players, there is a possibility that a player can't find a balanced opponent when needed. A quick observation showed that lots of players had a problem in finding an opponent, or a balanced one. This problem can be solved by utilizing computer as a balanced player. Therefore, an action research was conducted to develop an application of dam-dam-an game. In this application, computer plays a role as a balanced opponent. A balanced computer opponent is one that behaves as humanly as possible, which means that the computer is not allowed to use its god-like ability to see further than we can, and sometimes screwed up when distracted, just like a human<sup>5</sup>. Besides that, a research states that the use of computer in dam-dam-an game can also improve player's mental rotation, spatial ability, and visual memory<sup>6</sup>.

## 2. Methodology

This project is categorized as an action research, since it is built to evaluate that utilizing a computer to play dam-dam-an can help the players to find a balanced opponent<sup>7</sup>. It adopts system development life cycles the research methodology, consisting of four stages: analyzing, designing, implementing, and testing<sup>8</sup>.

The first stage is analyzing the current conditions to understand the players' problems. It is done by doing an interview with twenty dam-dam-an players, ranged from twenty to forty years old, about their problems in finding an opponent in dam-dam-an. To make the analysis simpler, the respondents are selected using simple random sampling technique<sup>9</sup>. Afterwards, similar games are observed to find features that are implementable in dam-dam-an.

All the problems found in the analysis phase were used as considerations in the next stage, designing. There are three things that need to be designed: the data storage framework, workflow of computer player, and user interface. Data storage framework is designed to discover how the variables used in the game are stored. Workflow of computer player is designed to utilize the computer as a balanced opponent. User interface is designed to make the game easy to operate.

After the game had been designed, it was developed using C# on Windows Runtime platform. The purpose of using Windows Runtime platform is to make this game playable on Windows 8 Family and above with only one-time implementation.

Lastly, verification and validation were done to make sure that it runs as it supposed to be and no longer do something which can cause problems to the players<sup>10</sup>. The game and the computer player were verified with functional testing method to make sure that it has been correctly and completely developed<sup>11</sup>. Validation was done to assess whether the game solved the

problems in finding a balanced opponent or not<sup>12</sup>. The game was validated by giving a chance to twenty players which was previously interviewed to play against the computer. Firstly, players were categorized based on their skill in playing dam-dam-an to create a balance match when playing against the computer. Then, players were required to play three times against the computer with the same difficulty as their category, and the result of the matches were recorded. Afterwards, they were interviewed once more about their assessment whether this game had already helped them finding a balanced opponent or not.

### 3. Results and Discussion

An interview with twenty players was required to obtain information about their problems in finding a dam-dam-an opponent. The respondents were chosen with simple random sampling method, ranged from twenty to forty years old and are able to play dam-dam-an. The result of the interviews with twenty people is more than half of them (65%) could not find an opponent. On the other hand, a quarter who found an opponent, tended not to have a balanced opponent. The rest of them did not have a problem in finding a balanced opponent. The result's data is presented in a graph which can be viewed on Figure 1.

Those are the main reason why a computer needs to be utilized as a balanced opponent in game dam-dam-an. A computer needs an intelligence to find the best move from the given state<sup>13</sup>. There are lots of methods which can be used to find the best move in dam-dam-an, one of them is Minimax<sup>14</sup>. Minimax is a best move searching algorithm which is suitable on a deterministic, turn-taking, two-player, zero-sum games of perfect information<sup>15</sup>. Deterministic means that the game is fully observable without any randomness. Zero-sum game means that the utility values at every state of the game are always equal and opposite, for instance when the game has ended, player one wins the game (+1), and on the other hand, player two loses the game (-1).

Minimax is appropriate if seen on its purpose towards a two-player perfect-information game like dam-dam-an<sup>16</sup>, but it requires lots of memory space and time when it does a deep search<sup>17</sup>. Therefore, an optimization is necessary to make minimax runs faster and uses smaller memory space. A way to optimize minimax is by implementing Alpha-Beta Pruning. Alpha-Beta Pruning is an optimization algorithm that prunes pointless nodes to be observed further<sup>18</sup>. The higher the branches are pruned, the greater the reductions in tree size. In a best case, Alpha-beta pruning can

reduce the number of nodes which need to be examined from  $NN$  to  $\sqrt{N}\sqrt{N}$ <sup>19</sup>, causing a great saving in memory usage and time needed. The reduced time and memory usage can be used to search up to twice deeper than the original minimax algorithm<sup>20</sup>.

To enrich the game, some features need to be added. Based on the observation on the features of two games: Dama (downloaded from Google Play Store), and Checkers Free (downloaded from Google Play Store), here is the list features which are going to be implemented in dam-dam-an:

- A player can choose the difficulty of the computer opponent.
- A player can undo his moves.

- A player can set the time-per-turn.
- A player can save and load the game.
- A player can play against the computer, or another player on the same device.
- A player can pause the game.

Concerning the results of the analysis, data storage needs to be designed. The design shows that dam-dam-an needs a permanent storage and three temporary storages. The permanent storage is used for saving games. It is required to store all the information used in the current session into a single file. The three temporary storages: search tree, move history, and board state history; are used when the game is running. Search tree is used by the searching algorithm to find an optimal move. Move history is used to store the moves required from the current board state to the board state in children's node, allowing the algorithm to recall the moves used to go to the optimal move. Board state history is used to store all the board state from the beginning of the game until the current state, allowing the players undoing their moves.

Not only the data storages which need to be designed, but also user interface. The game contains of six pages: "Home", "VS Computer", "VS Human", "Configuration", "Help", and "Arena", the game itself. A computer's difficulty can be configured in "1 Player" page. "Time-per-turn" and "Allow undo" can be configured in "Configuration" page. The rest of the features can be found in the "Arena" page. To those who are new to dam-dam-an and/or this application, a "Help" page is provided and accessible from the "Home" page.

After the game has been designed, the game is ready to be developed. The permanent storage is saved into a file automatically by the game when a player saved the game. On the other hand, three temporary storages are implemented as a class and objects that is used in the game. The user interface is built based on the requirements stated in the design stage.

The last stage is verifying and validating the game. Verification with black-box method is done until it found no error and the game runs as expected. Then, the game is validated by twenty players who previously interviewed by playing against the computer three times, and have the results recorded. The result shows that the difficulty of the computer is quite balance with the players' skill. The match data from twenty players against the computer can be seen on Figure2. Even though some of the total winning of the computer and the player does not match, it only has small range of difference.

Finally, eighteen players who previously had a problem in finding a balanced opponent were interviewed for the last time to see if this game solved their problem. Fourteen out of Eighteen players said that it is enough to be used as a balanced opponent. On the other hand, four players were not satisfied with the results since they think that the computer player was easier or harder.

## **4. Conclusion**

Based on the testing results, minimax with alpha-beta pruning optimization can be implemented in dam-dam-an, and has been successfully utilized as a balanced opponent based on the validation.

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**Figure captions**

Figure 1. Problems in finding an opponent in dam-dam-an

Figure 2. Total Winning Based on The Difficulties

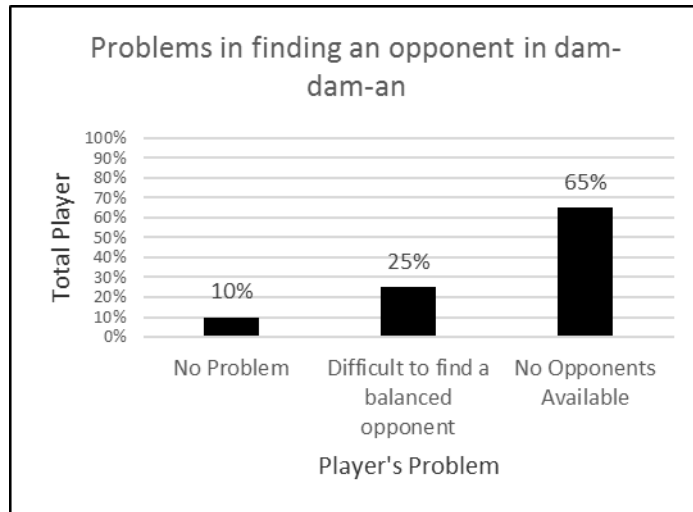


Figure 1. Purnomo et al

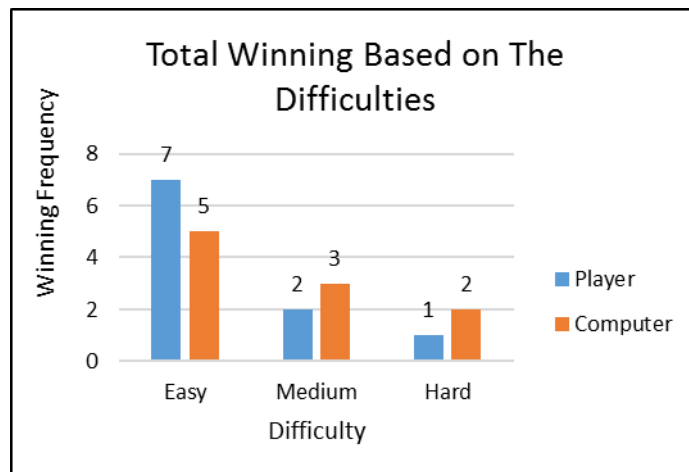


Figure 2. Purnomo et al