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Othello Game Application Design Using Heuristic Techniques

Leo Benny[1], Lusi Herlina[2]
[1]Information Engineering, Institut Teknologi Manajemen Internasional (ITMI)
[2]Information System, Institut Teknologi Manajemen Internasional (ITMI)

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ABSTRACT

Othello is a popular board game and is played by two players. Problems arise when there are no friends to play with or the player does not have a game device. To solve this problem, an Othello game application can be developed, so that players can play Othello against the computer. Research applies heuristic techniques in the game Othello. The heuristic technique calculates the number of player chips (points) that the computer can turn over on each tile or square. This number of points is then multiplied by the coefficient value of 1.5 if the square is on the side of the game, while the points obtained from the box in the corner of the board are multiplied by the coefficient value of 3. In the end, the computer will choose the box with the highest heuristic value. Thus, the heuristic technique will prioritize the placement of the pieces in the corner of the board, the side of the board and then the placement of the pieces in the middle of the board. The application applies artificial intelligence to the computer by using heuristic techniques, so that the computer will prioritize the placement of chips at the corners and edges of the board whenever possible**.**

Corresponding Author:

Leo Benny
Department of Information Engineering,
Institut Teknologi Manajemen Internasional (ITMI)
Jl. Komp. Asia Mega Mas Jl. Timah Putih No.16, Sukaramai II, Kec. Medan Area, Kota Medan, Sumatera Utara 20224
Email: leobenny21@gmail.com

1. INTRODUCTION

Computer games are growing rapidly in the era of information technology. A game can be played quickly, easily and cheaply by using computer games. One of the very famous and popular board games is Othello (Noever and Noever, 2022; Primanita et al., 2020). Othello is a simple chess game using a black and white board and pieces (Ashlesh et al. 2020). The game board is divided into small squares with the same number and size as the medium for placing the game pieces. The pieces are black and white. Othello game can be played by two players. If there is a player who wants to play, then the player needs to invite his friend, meet physically and the player must bring the game device. Problems will arise if there are no friends to play with or the player does not have a game device. To solve this problem, the Othello game can be made into a game application, so that players can play Othello alone (against the computer), anytime and anywhere without the need to physically interact directly with the game object, except through a computer intermediary (Brown et al., 2020; Song et al., 2019).

Each player moves by turn in the Othello game. The game will end when the entire game board is completely filled. The player with the highest number of chips on the game board will be the winner. Artificial Intelligence (AI), or more commonly referred to as artificial intelligence, is designed as opposed to the player (Ciolino et al., 2020; Liskowski et al., 2018). Techniques that can be used to design AI as opposed to players are heuristic techniques. The Greedy algorithm is widely used in the Othello game, where the computer will choose the tile that can eat the most player chips (Goecks et al., 2020). If the Greedy algorithm will only choose the move that produces the largest score at that time, then the heuristic technique provides further consideration, namely considering the location of the pieces on the sides and corners of the board. The points obtained from the box on the side of the board are multiplied by 1.5 points, while the points obtained from the box in the corner of the board are multiplied by 3 points (Kastha, 2020; Chang et al., 2018). Thus, the heuristic technique will prioritize the placement of the pieces in the corner of the board, the side of the board and then the placement of the pieces in the middle of the board (Moy et al., 2020). The hope from the application of heuristic techniques is that the selection of the best alternative at each step will end with the best results.

Othello is a game that uses a board of 8 x 8 squares, between two players with black and white chips. The goal of this game is that both players try to have the highest number of chips at the end of the game, so that they can be declared the winner. The general rules of the Othello game are as follows (Schrittwieser et al., 2020):

The game starts from the position of the board with the arrangement of black and white chips, namely two black and two white chips right in the middle of the board with a diagonally intersecting position, with the black chip tilted to the right-upper and the white side tilted to the left-up. The black player takes the first step by placing a black chip in an empty box where he can sandwich a white chip between two black chips, namely between the black chip that is already on the board and the black chip that has just been placed, may flank horizontally, vertically nor diagonally, for example in the "d3" box. The wedged white pieces are turned over into black pieces. Next it is the white player's turn to move by placing a white chip in an empty box where he can sandwich a black chip between two white chips, namely between the white chip that is already on the board and the white chip that has just been placed, may flank horizontally, vertically or diagonally, for example in the box "c3". The black chip stuck in no. 4 above, all turned into white chips. Thus both players take turns putting their pieces together in an empty box where he can flank his opponent's puck, and turn his opponent's puck into his own. Both players may not put their pieces in a box that is already filled, or in an empty box where he does not flank his opponent's puck. The box one that is already filled so that no new chips can be placed. The small circle mark shows an empty square flanking the white chip by the black, so black can step in there. A red cross and all the empty squares outside it, indicate an empty square that is not flanked by a white chip by a black, so black should not go there. If the player does not have a box in which he can step, then he must 'pass' that is to give his turn to his opponent. If neither player has a square in which he can move, usually when the board is full, the game is over. The player with the most number of chips is the winner.

Greedy is the most popular method for solving optimization problems. The greedy principle is "take what you can get now!". Greedy's algorithm forms a step-by-step solution. Many options need to be explored at every step. Greedy requires every step to be made the best decision in determining the choice. Each step is a local optimum with the hope that from the optimum step the remaining steps will lead to a global optimum solution (global optimum) (Ranjitha et al., 2020).

Previously the greedy algorithm would only choose the move that produced the highest score at that time. For example, there are two boxes that can be filled at this time, when trying to fill the first box, it is found that 4 points will be obtained, and when filling the second box, 7 points are obtained, of course greedy will choose the box that produces 7 points. However, it turns out that the 7 points are mostly obtained from the boxes in the middle, while the other options that are worth 4 points get a lot of points from the boxes on the sides of the board, and this is more profitable. By using a heuristic technique, it can be added that the points obtained from the squares on the sides will be multiplied by 1.5 points from the squares in the center of the board will be multiplied by 1, and the points from the squares in the corners will be multiplied by 3 (Thakoor & Jhunjhunwala, 2018). This calculation is used to determine the choice of the computer in the game Othello. Thus, the

heuristic technique will prioritize the placement of the pieces in the corner of the board, the side of the board and then the placement of the pieces in the middle of the board. The hope from the application of heuristic techniques is that the selection of the best alternative at each step will end with the best results.

2. RESEARCH METHOD

The design of the Othello game application using this heuristic technique is carried out using the system development life cycle methodology, also known as Waterfall. The Waterfall method is the oldest software development method because it is natural. The Waterfall method is the earliest SDLC approach used for software development (Nugraha et al., 2022). The sequence in the Waterfall Method is serial, starting from the planning, analysis, design, and implementation processes on the system (Sobieski, 2022). In this methodology, initially an analysis of system requirements is carried out and followed by system design. These two stages are repeated several times, until a suitable system is obtained. After that, proceed to writing program code (coding) and after coding activities, testing is carried out on the results of the software design.

3. RESULTS AND DISCUSSIONS

The analysis process will discuss the Othello game process, analysis of decision making with heuristic techniques, determination of the highest value and analysis of system modeling. The application modeling is designed using the Unified Modeling Language (UML). Use cases are UML diagrams that can be used to analyze and model systems. The use case actor is the user who plays the application. Use case The game consists of a use case. Input the name, the use case is starting a new game, the use case is showing the location of the valid pieces. The Highest Value use case includes the Delete All Values use case. The activity diagram starts when the user presses the "Game" button and ends when one of the players wins. Sequence diagram of the system can be seen in Figure 1.

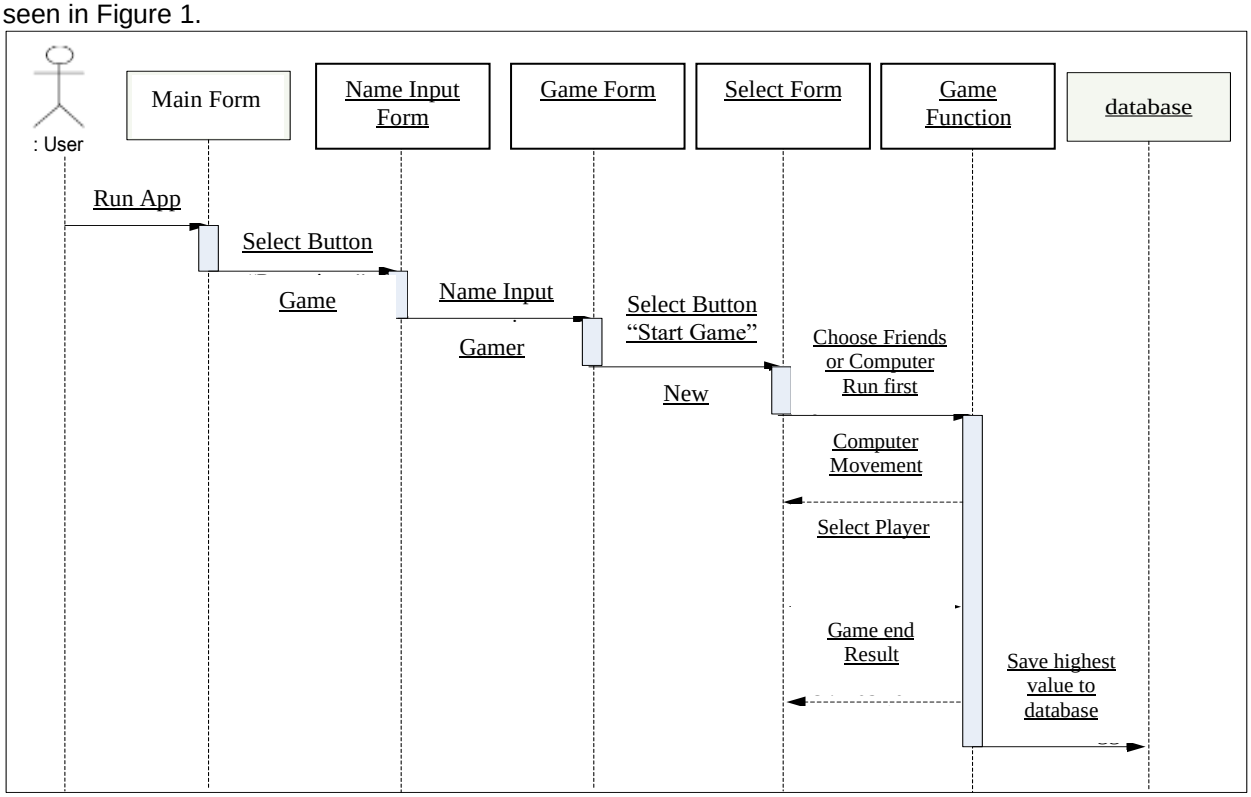

Figure 1. Sequence Diagram of the System

Figure 1 shows a sequence diagram of the system, starting from the main form, where the user runs the application. Then the user presses the "Game" button and the Input Name form appears. The player enters the player's name, and the Game form appears. Users can play Othello against the computer on the game form. To start a new game, the player presses the "Start New Game" button, and the Select form will appear. Players choose to go first (white chip player and computer black chip) or go after computer (black chip player and computer white chip) on the Select form. Then the game continues with rotating movements between the player and the computer until the final result of the game is obtained. The final result of the game is then stored in the database as the highest score.

The design of the Othello game application using heuristic techniques is carried out using the Microsoft Visual Basic.NET 2008 programming language. The database design is carried out using Microsoft Access 2010. In the software, there is a table that is used to store the highest value. The table stores the game log time (date and time when the game ended), player name, time spent in the game, user chip count and computer chip count. Storing data to tables using SQL transactions in the form of "Insert" syntax. Table 1 shows the design of the Value table.

Table 1. Value Table Design

No.	Field Name	Types
1.	TimeLog	*DateTime* (*General Date*)
2.	Name	*Text* (30)
3.	Game Time	*Date Time* (*Short Time*)
4.	Number of User's Chips	*Number* (*Byte*)

The results of the implementation of the Othello game application design using heuristic techniques are as follows:

1. The Main Form will appear when the application is run, as shown in Figure 2.

Figure 2. Main Form Display

2. Figure 2 shows the Main form which contains buttons to access other forms. To play, click the “Game” button, and the Input Name form will appear as shown in Figure 3.

Figure 3. *Form Name Input* Display

3. Figure 3 shows the name input form. For example, input name is “Enrico” and click the “OK” button on the Input Name form. Next, the Game form will appear as shown in Figure 4.

Figure 4. Game Form Display

Figure 4 displays the Game form containing the game time, number of black and white chips, and game history.

4. Users can see the number of player chips and the number of computer chips. Users can also see the running time of the game on the Game form. To view valid tiles that can be occupied by player tiles, check the checkbox "Show valid chip locations". Click the “Start New Game” button on the Game form, and a Select form will appear to determine as shown in Figure 5.

Figure 5. Select Form Display

5. In Figure 5, if the user selects the button "Players go first", then the game will take place as shown in Figure 6.

Figure 6. Game Form Display

6. Figure 6 shows a game where the player goes first. If the user wants to see valid moves that can be made or the location of valid pieces on the game board, then check the checkbox "Show valid pieces" and the tiles that can be occupied by the user's pieces will be marked, as shown in Figure 7.

Figure 7. Display of Valid White Chip Layout

7. Figure 7 shows the location of a valid white chip. If the player cannot walk, a messagebox will appear, as shown in Figure 8 and the player's turn will be passed (pass).

Figure 8. Player Pass

8. If the computer cannot run, a messagebox will appear, as shown in Figure 9 and the computer's turn will be passed (pass).

Figure 9. Computer Pass

9. Figure 9 displays a message if the computer cannot run. The game will end when all the tiles have been occupied by the computer and player chips, as shown in Figure 10.

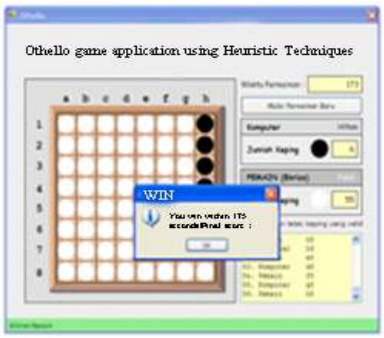

Figure 10. Game Over

10. Figure 10 displays a message that the game has ended. If the player wins and the time it takes to beat the computer is in the top 20 lists, a message box will appear, as shown in Figure 11.

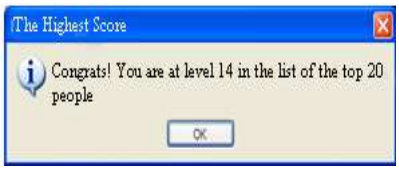

Figure 11. Players Enter on the Top 20 List of Scores

11. Figure 11 displays a message that the player has entered the top 20 list. The highest score form will appear after the player's confirmation message is entered in the list of the 20 highest scores. This form includes the name of the player, as shown in Figure 12. The highest score form can also be accessed through the Main form by clicking the "Highest Score" button.

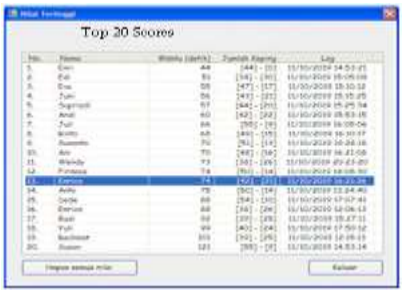

Figure 12. Highest Score Form

12. Figure 12 shows the top twenty scores. Click the "About" button on the Main form, and the About form will appear as shown in Figure 13.

Figure 13. Form 'About' Display

The advantages of the game software built are as follows:
1. The application applies artificial intelligence to the computer by using heuristic techniques, so that the user can play Othello against the computer.
2. The application can display valid tiles that can be occupied by the player's or computer's chips.
3. The application displays the user and computer movement history.
4. The application can display the best 20 scores based on the time taken by the player to beat the computer.

The weaknesses of the built Othello application are as follows:
1. The application cannot be run online over the network.
2. The application cannot be played on a smartphone.

Players can only play on an 8 x 8 square Othello board.

4. CONCLUSION

After completing the design of the Othello game application using heuristic techniques, several things that can be concluded are as follows, The heuristic technique is implemented in the Othello game by counting the number of pieces that can be turned over in each square. For each square in the corner, the heuristic value is multiplied by 3, while for each square on the side of the game, the heuristic value is multiplied by 1.5. Thus, the heuristic technique will prioritize the placement of the pieces in the corner of the board, the side of the board and then the placement of the pieces in the middle of the board.The Othello game software is designed through coding activities using the Microsoft Visual Basic .NET programming language, by applying artificial intelligence to computers using heuristic techniques.

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