# Sharpest Hill Climbing Algorithm for the Row Puzzle Board in Scout Trail Game

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***Abstract*— Scout is one of the extracurricular activities in Indonesia. Currently, extra-curricular activities have decreased the number of members due to students' interest in other activities at their school. After COVID-19 pandemic, many students were no longer actively participating in Scout extracurriculars. Even though there are many benefits that can be taken in scouting activities, one of which is applying skill material such as learning codes, learning a form of cheating, general public knowledge, and even the ability to survive in protecting something. Scouting activities are the key to the practice of nation building in Indonesia. One way to increase student interest is by utilizing information technology. Scouting activities can be combined into a game with a scouting theme as is commonly played, which is like a educational puzzle to sharpen critical thinking. This research is more about the application of the SAHC algorithm for puzzle cases based on the scout trail game. The application of this method is to find a solution point from a predetermined character position. Interesting games can be used as promotions for students, so students can be interested in scouting activities.**

***Keywords—SAHC Algorithm, Puzzle, Scout Trail, Game, Education***

## I. INTRODUCTION

The world is going rapid changes in the technical, economic, cultural, social, and scientific fields. This causes the emergence of new innovations. The field of artificial intelligence, interactive, and connectivity are going significant changes in the modern educational environmen[1]. At this time, digital education has tried to create new opportunities for education through the delivery of fast and accurate information. It also seeks to improve the skills, experience, abilities, and transition of students from the era of data and information to the era of knowledge and knowledge skills concerning the capabilities and potential in interacting between teachers and students. This can allow students to be involved in digital education because it has an alternative that is identical to reality[2] [3].

Article 3 Number 20 of 2003 in Indonesian State Constitution concerning the National Education System states that National Education functions to develop and shape the character and civilization of a dignified nation in the context of educating the nation's life, aiming at developing the potential of students to become human beings who believe and fear God Almighty. One, having noble character, healthy, knowledgeable, capable, creative, independent, and being a democratic and responsible citizen [4]. When viewed further, scouting education from the past until now has role in the development of character education in Indonesia. The government establishes scouting education as a mandatory extracurricular activity [5].

Scout is one of the extracurricular activities in Indonesia. The scout movement and women's guides in Indonesia are very well known among educational institutions ranging from elementary schools to universities as the Scout Movement [6]. In Indonesian, scout is an abbreviation of "Praja Muda Karana". Scouts have the meaning of a young soul who wants to work. Scouting is an educational activity carried out in an open space with activities that are fun, challenging, creative, and innovative [7].

Currently, extra-curricular activities have decreased the number of members due to students' interest in other activities at their school. After the COVID-19 pandemic, many students were no longer actively participating in Scout extracurriculars. Thus, if it continues, it will result in the disappearance of scouting activities. Even though many benefits can be taken in scouting activities, one of which is applying skill material such as learning codes, learning a form of cheating, general public knowledge, and even the ability to survive in protecting something. Scouting activities are the key to the practice of nation-building in Indonesia [7] [8].

Along with the times and technology, one way to increase student interest is by utilizing information technology. Scouting activities can be combined into a game with a scouting theme as is commonly played, which is like an educational puzzle to sharpen critical thinking. There are several methods to create a puzzle game, including the Steepest Ascent Hill Climbing (SAHC) method, a search method based on the heuristic value of a function that provides a value for the approximate solution, this method is often used for optimization problems.

Research on puzzles has been done before [9][10][11][12]. While this research is more about the application of the SAHC algorithm for puzzle cases based on the boy scout trail. The application of this method is to find a solution point from a predetermined character position. The update of this research is to apply the SAHC algorithm to find the right position on the puzzle in the boy scout trail. The application of this algorithm can provide an easy solution for line puzzle players in the scout trail game. Interesting games can be used as promotions for students, so students can be interested in scouting activities.

## II. PURPOSE METHOD

### *A. Optimation Algorithm*

An algorithm is very effective in solving complex problems. They are especially useful for optimization in complex problems such as line puzzles [13].

Optimization Algorithms (Optimization Algorithms) can be defined as an algorithm for finding the value of x so that it produces f(x) which is the smallest or largest possible value for a given function f, which may be accompanied by some limitations on x where x can be a scalar or vector of continuous or discrete values.

The optimization algorithm is slightly different from the search algorithm. In the search algorithm there is a certain criterion that states whether the element xi is a solution or not. On the other hand, the optimization algorithm may not have these criteria, but only objective functions that describe whether a given configuration is good or not [14].

The optimization algorithm is slightly different from the Heuristic search. In the Heuristic search algorithm, there is a certain criterion that states whether the xi element is a solution or not. On the other hand, the optimization algorithm may not have these criteria, but only objective functions that describe whether a given configuration is good or not. The optimization algorithm can be said to be a generalization of the Heuristic search algorithm or in other words, the Heuristic search algorithm is a special case of the optimization algorithm [14].

There are two groups of heuristic search, namely blind search and heuristic search. Blind search (search without information) has no additional information about circumstances beyond that provided in problem definitions such as Breadth-First Search (BFS) and Depth First Search (DFS) [15]. Heuristic search or information search provides additional information that is more promising for solutions. Heuristic search can find solutions more efficiently than Blind search [16].

The methods in the search technique based on heuristic functions include Hill Climbing, Best First Search, and A* (A Start)[17][18].

### *B. Steepest Ascent Hill Climbing*

Hill Climbing is a local search technique that starts from the initial solution and continues to gradually generate neighboring successor solutions. If the neighbor's solution is better, it will be taken as a solution. The process will continue until it gets the best optimization.

There are several types of Hill Climbing techniques, namely simple hill-climbing, steepest ascent hill climbing, stochastic hill-climbing, and random restart hill climbing[16] [19]. Steepest ascent hill climbing is an algorithm method used for optimization such as short distance search.

This algorithm has a loop that continues to move towards the highest value and ends when it reaches a peak where there are no neighbors with a higher value[15][16]. This algorithm can solve problems such as puzzles and crossword puzzle boards [20] and the memory usage is much minimum so it is easier to implement [21]. In previous studies, this algorithm can produce better optimization values than other algorithms [13]. Here is the pseudo code of the SAHC algorithm:

```
In : Loop Max, Problem
Out : NowSolution
NowSolution ← RandomSolution (problem)
If (NowSolution == GoalSolution)
    Back NowSolution
Else
    Repeat (Loop i=0 ∈ Loop Max)
        CandidateSolution ←HeirSolution (NowSolution)
        If (Val(NowSolution)>Val(CandidateSolution))
            NowSolution ← CandidatSolution
            i = 0
            If (NowSolution==GoalSolution)
                Back NowSolution
            End
        End
    EndLoop
Back NowSolution
End
```

The pseudo-code above describes the logic flow of the SAHC algorithm. Now Solution is the initial initialization, if it is the goal then the process will stop. If it is not then the process continues by generating a different solution (HeirSolution). If HeirSolution is better than NowSolution, then NowSolution is the best solution. The process will continue until NowSolution is a GoalSolution or NowSolution does not change as much as the Max number [21].

## III. IMPLEMENTATION

The author uses the MDLC (Multimedia Development Life Cycle) method from Luther-Sutopo for the implementation phase. This method consists of stages of concept, design, material collecting, assembly, and testing. This method is to build a scout trail game using Action Script 3.0 programming language [22].

### *A. Concept*

Scout Trail Game is an educational game for extracurricular scouts. This game uses the Action Script 3.0 programming language. This game contains several games consisting of a quiz, semaphore, morse, and marching. This game uses Visual Graphic elements that support learning media. However, this paper only discusses one type of game, namely the line-up for the application of the SAHC algorithm.

Line up puzzle is a game of characters in horizontal and vertical squares where players have to sort the characters according to the rules. An optimal puzzle board will be difficult to achieve if there are too many characters to line up. Research related to puzzles has been done before.

In the line-up puzzle session, players must match the position of the character according to the sample image. This game has a predetermined time duration. So that players will be increasingly challenged to complete it. The application of the SAHC method lies in the process of finding the character position. If the character position is correct, then the solution search process will end. But if the position of the character that the player is running is wrong, then the solution search process will continue.

### *B. Design*

The design of the interface or interface has a function to provide an overview of the appearance of the application. A good interface will also provide convenience for users. When the application is opened, it will display the home page. On the home page, there are several menus, such as the start menu to start the game and the instructions menu to view instructions for using the application and settings.

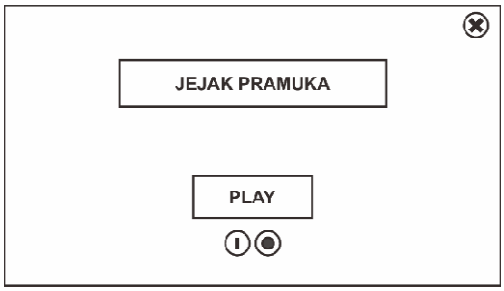



Image 1. Main Menu Design of Scout Trail

When the settings button is clicked, there is a sound and music configuration in the scout trail game

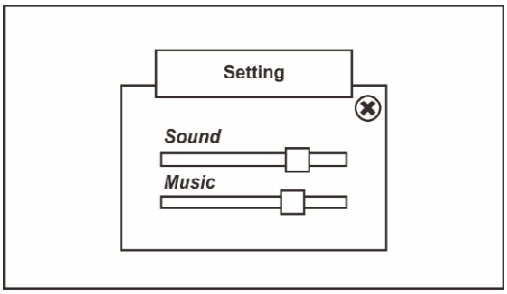



Image 2. Setting Game Design of Scout Trail

When information button is clicked, there are information about the game creator and developer.


Image 3. Information Design of Scout Trail

When the play button is clicked, it will then show map page. The map page has some buttons, such as game stages and score coin, exit, and play.

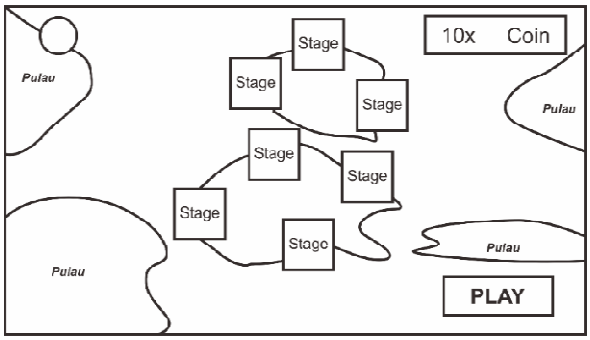



Image 4. Game Map Design of Scout Trail

When play button is clicked, it will show the game display, play button, and back button.

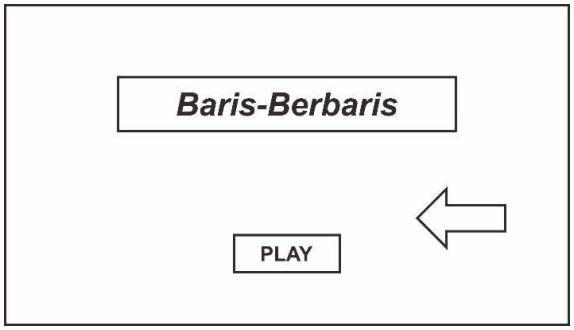



Image 5. Line up puzzle game start page

When the player clicks the play button it will display a map page, in the game page lined up there are several boxes to arrange rows, and photos to give instructions to the game so that players follow the instructions according to the game.

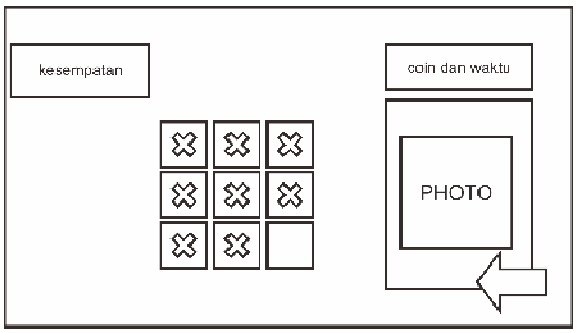



Image 6. Game Win Design of Scout Trail

The flowchart of the application of the steepest ascent hill climbing algorithm in the game Jejak Pramuka (Boy Scout Trail) is described as follows:

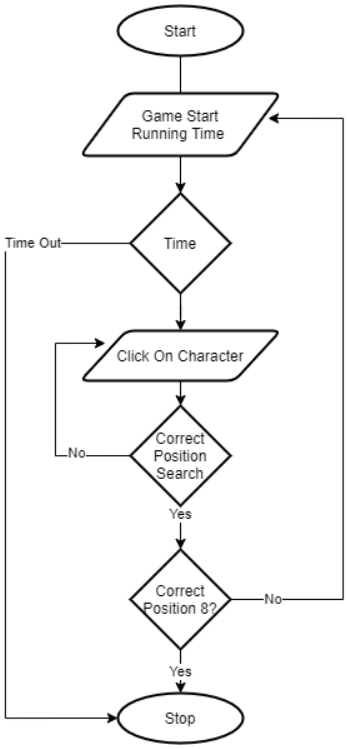
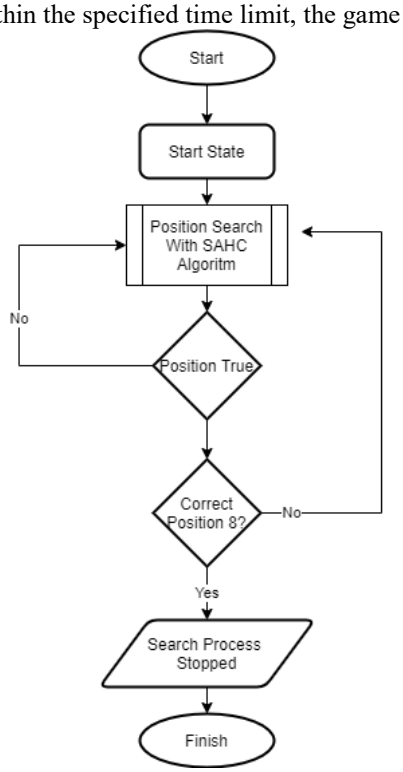



Image 7. Flowchart Game of Scout Trail

Image 7 shows the flow of line up game in boy scout trail, starting from the beginning of the game until the player finds the game solution. When the player does not find a solution within the specified time limit, the game will stop.




Gambar 8. Flowchart of Steepest Ascent Hill Climbing Algorithm on Line Up Puzzle Game

Image 8 is a flowchart of line up game that applies Steepest Ascent Hill Climbing algorithm. This algorithm is applied to the character position in search identification section. If the position of the character is correct then the search process will stop, but if the position of the character is still wrong then the search will continue.

### C. *Material Collecting*

The game is made simple using 2D animation and is given writing to make it more interesting and easier to understand by players. These materials include clip art images, photos, animations, audio, and others. This stage can be done in parallel with the assembly stage. The following below is material collection of Jejak Pramuka (Scout Trail game):

In Figure 9 there is a collection of asset buttons created using Corel Draw X8.


Gambar 9. Asset button

Meanwhile, image 10 below shows the characters of player in Scout Trail.

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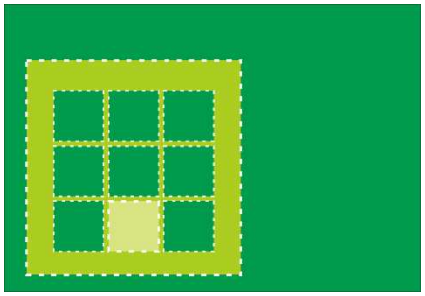
Gambar 10. Characters of player in Scout Trail

This game uses various and different background which is suitable with the locations of boy scouting, for example, mountain or beach.

Gambar 11. Main Menu Background of Scout Trail

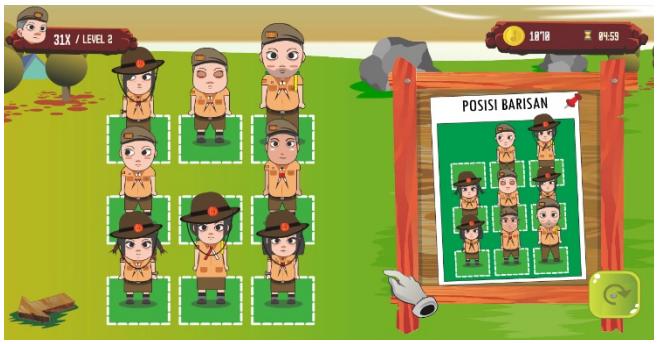


Gambar 12. Background of Line Up Puzzle Game

Figures 11 and 12 are the design images that will be used for the lined puzzle game environment. Where in this game 8 characters must be lined up according to the existing rules.

### D. *Assembly*

The Line Up Puzzle Game page shows the rowing game. There are 9 boxes containing scout members who are standing upright. Beside that, there is a photo image of the row position, in the left corner, there is a scout icon image. There are opportunities to play and the level of players, in the right corner above. Moreover, there are also game points and time. The last, there is a button in the lower right corner which is used to change the line again, on this page players are required to form a line according to the photo of the row position on the side.




Gambar 13. Line Up Puzzle Game

Figure 13 is a line-up puzzle game page. Players must arrange a line of characters according to the position of the specified character. Players must complete the position of the line of characters on time. If it exceeds the specified time limit, then the player must start from the beginning. The application of the SAHC algorithm is found in the search for character positions compiled by players.

*E. Testing*

The beta test phase was carried out by involving 25 predetermined game users. Game users will test the software to determine the quality of the software in terms of functionality, efficiency, usability and portability. The beta testing stage uses the help of a questionnaire containing questions from each software quality factor that is the focus of research. The questionnaire on the beta test was made based on the sub-characteristics of the software quality factors according to ISO 9126, namely the functionality, efficiency, usability and portability factors. This beta test questionnaire before being used has passed the questionnaire validation conducted by three validator experts. Software beta testing was carried out on the USM campus, ITS campus and SMP Negeri 3 Mranggen with 25 users who had been determined. Below are the results of beta testing of each factor :

TABLE I. BETA TEST RESULT

| No | F | E | U | P |
|---|---|---|---|---|
| 1 | 30 | 10 | 40 | 10 |
| 2 | 30 | 10 | 40 | 10 |
| 3 | 30 | 10 | 40 | 10 |
| 4 | 29 | 10 | 38 | 9 |
| 5 | 28 | 9 | 37 | 10 |
| 6 | 27 | 10 | 37 | 10 |
| 7 | 27 | 10 | 38 | 9 |
| 8 | 28 | 10 | 38 | 10 |
| 9 | 28 | 8 | 39 | 9 |
| 10 | 27 | 10 | 37 | 9 |
| Total skor | 284 | 97 | 348 | 96 |
| Skor Maks | 300 | 100 | 400 | 100 |
| Rata Item | 28,4 | 9,7 | 34,8 | 9,6 |
| Presentase | 94,66% | 97% | 87% | 96% |

The calculation of the percentage of software quality factors is then described in the form of a diagram. The percentage diagram of the software quality factor in the beta test can be seen in Figure 14 below:

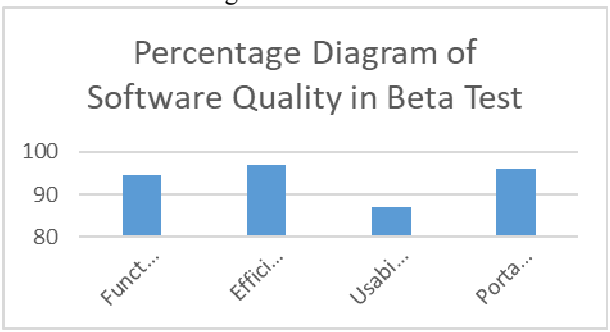



Image 15. Percentage Diagram of Software Quality in Beta Test

The results of the calculation for determining the quality of the software in terms of functionality, efficiency, usability, and portability are then compared with the Likert Percentage Interpretation. The feasibility level of each software quality factor after comparing with the interpretation table of the percentage of software feasibility is as follows:

TABLE II. FEASIBILITY PERCENTAGE

| No | Faktor | Percentage | Feasibility Level |
|---|---|---|---|
| 1 | Functionality | 94,66% | Very Eligible |
| 2 | Efficiency | 97% | Very Eligible |
| 3 | Usability | 87% | Very Eligible |
| 4 | Portability | 96% | Very Eligible |

Calculation of the percentage of total software quality from beta test results data using the formula:

$$\text{Feasibility Percentage (\%)} = \frac{\text{Observed Score}}{\text{Expected Score}} x100\%$$

$$\text{Feasibility Percentage (\%)} = \frac{825}{900} x100\%$$

$$\text{Feasibility Percentage (\%)} = 91{,}6\%$$

The results of data processing in the beta test above state that the software totally has a feasibility percentage of 91.6%. The percentage results are then compared with the Likert Percentage Interpretation table. The results are obtained after comparing the percentage of software feasibility, it can be concluded that the quality of the Scout Trail software has a "Very Eligible" category.

## IV. CONCLUSION

Based on the research results, the Steepest Ascent Hill Climbing algorithm can work well on lined puzzles in the scout trail game. The results of the beta test that the scout trail game had a feasibility percentage of 91.6%. If the results of the feasibility percentage are compared with the Likert percentage, then it falls into the "very feasible" category. This scout trail game can be a medium for interaction in scouting activities. It can increase the

attractiveness of students to participate in scouting activities. In the scout trail game, there are several types of games at each level. For further research development, several algorithms can be applied at another level. So the scout trail game can become a more interesting game to complement the activities of scouting activities.

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