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Utilization of Hill Climbing Algorithm in Optimizing the Shortest Route to Tourist Destinations in Surabaya City

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Abstract: Surabaya City holds significant tourism potential with various popular destinations such as Taman Bungkul, the Submarine Monument, and Kenjeran Beach. However, the large number of attractions and limited visiting time often make it difficult for tourists to plan efficient travel routes. To address this issue, this study aims to implement the Hill Climbing algorithm to optimize the shortest path among tourist destinations in Surabaya. The method uses a heuristic approach by iteratively swapping the positions of two locations in the travel route to find an optimal solution that minimizes total travel distance. The developed system features a GUI-based interface, graphical visualization using the networkx and matplotlib libraries, and direct integration with Google Maps to facilitate user navigation. Testing results indicate that the Hill Climbing algorithm can generate more efficient travel routes compared to randomly ordered routes. These findings contribute to the development of intelligent and practical travel planning systems..

Keywords: Hill Climbing, route optimization, tourist destinations, shortest path, graphical visualization.

1. Background

Tourism is an important sector in the development of major cities in Indonesia, including Surabaya, which continues to strive to enhance its tourist appeal. According to (Febrianti et al., 2025), the development of tourism in Surabaya is supported by a wide range of destinations and adequate transportation access, such as railway stations and main bus terminals. Some popular tourist attractions in the city include Bungkul Park, the Submarine Monument, Surabaya City Hall, Kenjeran Beach, the Wonorejo mangrove area, and Surabaya Zoo. This diversity of destinations makes Surabaya an attractive tourist destination for both domestic and international travelers. Access to these locations is supported by adequate public transportation infrastructure, such as Pasar Turi Station, Gubeng Station, Joyoboyo Terminal, and Purabaya Terminal. However, the abundance of destination options and limited visitation time often pose challenges for tourists in planning efficient travel routes. This can result in less-than-optimal travel in terms of distance and travel time, potentially reducing the overall quality of the tourist experience. Additionally, the abundance of destination options often poses challenges for tourists, especially those with limited visitation time or unfamiliarity with the city's geographical conditions. This necessitates efficient route planning to optimize visits in terms of distance and travel time (Furqan & Wijaya, 2020). With numerous location options and limited visitation time, tourists often face difficulties in determining an efficient route sequence. This inefficiency results in increased travel time and costs (D. P. Sari, 2022) and may reduce the quality of the tourist experience. This issue is similar to the common travel optimization problem in large cities (Romadhoni et al., 2024).

One approach that can be applied comes from the field of artificial intelligence, namely heuristic search algorithms. One of these is Hill Climbing, which is known for its simplicity and speed in generating near-optimal solutions (D. P. Sari, 2022). This algorithm works by examining solutions one by one from the left side and selecting the best neighboring solution

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based on the heuristic value. Hill Climbing is widely used in various fields such as logistics route planning, control systems, and project management due to its efficiency in limited search spaces (Nazeriandy et al., 2021; Puspitaputri, 2021; Harahap et al., 2025). Although it is prone to local optimum traps (Irwin Supriadi et al., 2023), its advantages include computational speed, simple logical structure, and adaptability to spatial data.

With this background, the Hill Climbing method was chosen because of its suitability in searching for the shortest route in urban tourist areas. The Surabaya case study was considered relevant because it has the characteristics of a scattered destination with high visitor numbers. This study aims to implement the Hill Climbing algorithm for optimizing tourist routes in Surabaya. The system developed includes interactive graphical visualization features, integration with Google Maps via GPS coordinates, and destination data storage. The novelty of this research lies in the combination of weighted graph methods, interactive digital visualization, and direct integration of spatial coordinates, which have not been widely applied in previous Surabaya tourism planning cases. Previous studies have primarily focused on route optimization in small cities or expert system-based approaches without real-time visualization (Febri Mayang Sari & Permata Sari, 2022; Afero, 2021).

2. Literature Review

2.1 Hill Climbing Algorithm

Hill Climbing is one of the local search algorithms in AI that works by evaluating neighboring solutions from the current solution and moving to the solution with the best heuristic value (Institut & Batam, 2023). This algorithm is included in heuristic search methods because it uses estimated information (heuristics) to navigate the solution space (Matematika & Mipa, 2025). The process begins with an initial solution generated randomly or greedily, followed by swapping the positions of two locations to form a new solution. Solution evaluation is performed by calculating the total distance of all routes (Simbolon et al., 2025). This algorithm is suitable for use because it reduces search complexity compared to brute-force methods.

2.2 The heuristic function

The heuristic function is employed to evaluate the "quality" of a given solution, typically represented in terms of distance or cost. In the context of tourism route planning, the heuristic evaluates the total travel distance across all destinations. An initial solution can be generated either randomly or through a greedy approach, followed by the application of a swap operation, in which two points in the route are exchanged to produce a new solution. According to Andi Sitti Syathirah et al. (2021), the evaluation is performed on each combination of point exchanges, as described by the following formula:

$$r = \frac{n!}{2!(n-2)!}$$

where r denotes the number of possible swap combinations and n represents the number of locations involved. For instance, consider a tourism route involving six locations: the starting point at Gubeng Station, the final destination at Kenjeran Beach, and four mandatory tourist sites Taman Bungkul, Surabaya Zoo, the Submarine Monument, and the Mangrove Forest. Given that there are four tourist spots ($n = 4$) and swaps involve two locations at a time ($r = 2$), the total number of unique swap combinations is six. These six possible swaps are: (1) Taman Bungkul with Surabaya Zoo, (2) Taman Bungkul with the Submarine Monument, (3) Taman Bungkul with the Mangrove Forest, (4) Surabaya Zoo with the Submarine Monument, (5) Surabaya Zoo with the Mangrove Forest, and (6) the Submarine Monument with the Mangrove Forest. These combinations serve as the operators for the optimization process.

2.3 Weighted Graphs in Geographic Information Systems (GIS)

Optimal route planning is typically modeled using weighted graphs, where nodes represent specific location points and edges represent the roads or paths connecting these locations. The weights assigned to the edges correspond to measurable values such as distance or travel time. Geographic Information Systems (GIS) serve as essential tools for spatial mapping and analysis, enabling real-time visualization and computation of the shortest paths between locations. As noted by Harahap et al. (2025), GIS enhances route optimization by integrating spatial data with algorithmic processing, facilitating efficient and accurate decision-making in travel planning.

3. Methods

This study employs an experimental approach by applying the Hill Climbing Algorithm to optimize the shortest route for visiting tourism destinations in Surabaya City, as illustrated in Figure 1. The process begins with the identification of key destination points. The selection of tourism locations for optimization using the Hill Climbing Algorithm is based on the distribution of strategic points throughout Surabaya. These locations include major transit hubs such as terminals and train stations, popular tourist attractions, and one central public facility. A detailed classification of these locations is presented in Table 1, consisting of five terminals/stations, five tourist attractions, and one government facility (Surabaya City Hall).

The second stage involves collecting distance data. This phase focuses on measuring the travel distances between each pair of tourism destinations and major transit points. Based on a reference route table, eleven locations were selected, resulting in ten travel segments representing direct connections between destinations. These include segments from Terminal Osowilangun to Pasar Turi Station, Surabaya City Hall to Kenjeran Beach, and other routes connecting city parks, zoos, and mangrove areas. Table 2 outlines these segments along with the corresponding travel distances, while Table 3 summarizes the total distance (71.8 km), the number of segments (10), and the average travel speed (26.9 km/h). Furthermore, Table 4 highlights the longest and shortest segments, namely Surabaya City Hall–Kenjeran Beach (19.5 km) and Submarine Monument–Gubeng Station (0.7 km), respectively.

The third phase is the implementation of the Hill Climbing algorithm. The optimization process begins with a randomly generated initial solution representing a sequence of destination visits. The Hill Climbing algorithm evaluates neighboring solutions by swapping the positions of two locations in the route. The maximum number of possible swaps is calculated using the combination formula. Each new solution is evaluated based on the total travel distance, and the shortest-distance solution is retained as the current optimal route. This iterative process continues until no further improvement is observed or the maximum number of iterations is reached.

The final phase involves system development and route visualization. The system is built using Python, with a user interface developed using Tkinter to facilitate user interaction. Visualization of the optimized route is accomplished using the networkx and matplotlib libraries, which present the travel graph in a user-friendly manner. The system is integrated with Google Maps by using the GPS coordinates of each destination to provide real-time navigation. Additional system features include CSV data storage, destination and connection management, and activity logging for debugging and result evaluation purposes.

4. Result and Discussion

This study successfully implemented the Hill Climbing algorithm for optimizing the shortest route to tourist destinations in Surabaya. The search process began by determining the starting point, final destination, and mandatory locations to visit. The algorithm generated initial solutions randomly, then iteratively swapped the positions of locations to find solutions with shorter travel distances. This process was repeated until no further improvements were possible or the maximum number of iterations was reached. To improve results, the algorithm is run five times with different initial solutions, and the best result is selected.

Route visualization is performed using NetworkX and Matplotlib, displaying the tourist route graph and highlighting the optimal route in red. Additionally, the application is integrated with Google Maps for real-time navigation. The interface is built using Tkinter, facilitating destination input, connection creation, and data management through a graphical interface. Data is stored in CSV format for easy reloading, with additional features such as destination and connection deletion. Activity logs are provided to assist with debugging.

Hill Climbing has limitations, such as the possibility of getting stuck on local solutions, but the implementation results show good performance for the scale of this problem. Computation time remains fast and the results are relevant to the needs of tourists. Further development could include integration with other algorithms such as Simulated Annealing or

Genetic Algorithm, as well as traffic prediction features, personal recommendations, and improved interface interaction.

4.1 . Output

The system output shows the results of implementing a tourist route search algorithm using Hill Climbing with Python Tkinter, which successfully integrates various important destinations in the city of Surabaya. The system can process input such as the starting location, destination, and waypoints selected by the user, then generate optimal route recommendations that include landmarks, public facilities, and tourist attractions such as Surabaya City Hall, Bungkul Park, Submarine Monument, Surabaya Zoo, and Purabaya Terminal. The user-friendly Tkinter GUI interface allows users to adjust algorithm parameters, perform shortest path searches, and visualize results through Google Maps integration, providing a practical solution for efficient tourist trip planning in Surabaya.

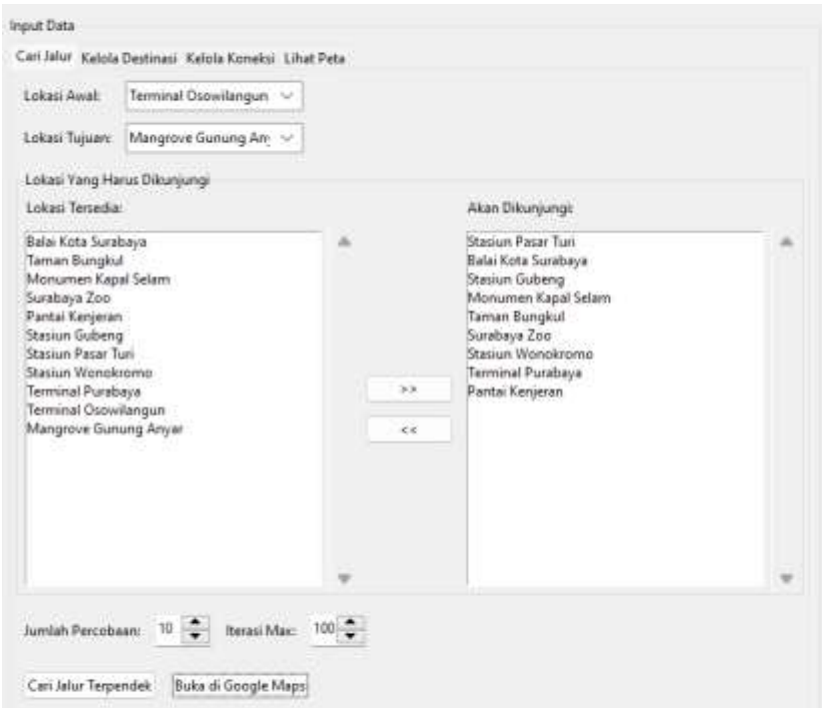

Figure.1 Input Data Program

Figure 1 shows the system displaying various important locations that can be accessed, including landmarks and public facilities such as Surabaya City Hall, Bungkul Park, Submarine Monument, Surabaya Zoo, Kembang Market, as well as train stations such as Gubeng Station and Pasar Turi Station. The program also includes important terminals such as Purabaya Terminal and Osowilangun Terminal, as well as tourist destinations like Gunung Anyar Mangrove. The navigation feature is equipped with arrow controls to help users move between pages and adjust the display of information.

The program's key advantage lies in its integration with external map services via the “Open in Google Maps” feature, enabling users to access more detailed navigation guidance. Overall, the app functions as a comprehensive public transportation information system, helping residents especially those in the Surabaya area plan their journeys more efficiently by providing complete information about terminal locations, stations, and other important sites within a single integrated platform.

Figure 2. Program Route List

Figure 2 successfully generated an optimal travel route with a total distance of 61.20 kilometers connecting eleven strategic locations in the Surabaya area and its surroundings. The recommended route starts from Osowilangun Terminal as the starting point, then continues to Pasar Turi Station, which is the main transportation hub in the city center, followed by Surabaya City Hall as the city's administrative center, and Kenjeran Beach as a beach tourist destination. The journey then proceeds to the Submarine Monument, a historical tourist attraction, Gubeng Station, an important railway station, Bungkul Park, which serves as a public green open space, and Wonokromo Station in the southern part of the city. The route then continues to Surabaya Zoo, the city's zoo, Purabaya Terminal, the main bus terminal, and ends at Gunung Anyar Mangrove, a natural tourist destination. The results of this route optimization demonstrate that the algorithm successfully identified an effective solution for a real-world case in Surabaya, optimizing travel efficiency by minimizing total travel distance while still covering various types of destinations, from transportation facilities, government offices, to tourist attractions.

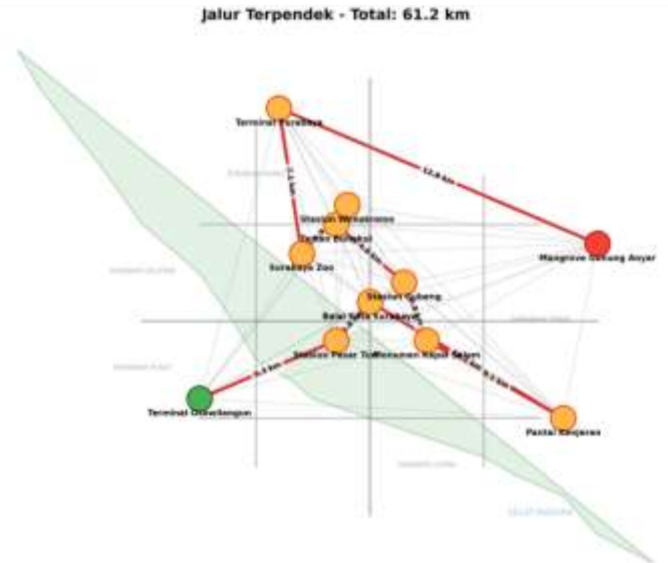

Figure 3. Program Search Results

Figure 3 displays a graphical representation of the route optimization results, with a total distance of 61.2 kilometers. The map shows the geographical distribution of eleven locations spread across the Surabaya area and its surroundings, with each location marked using an orange marker, except for the Osowilangun Terminal, which uses a green marker as the starting point of the journey. The red lines connecting the locations represent the optimal routes to be taken, with some segments displaying distance information between points such as 12.8 km and 9.4 km on specific routes. This visualization confirms that the optimization algorithm successfully identified routes connecting various types of destinations, including transportation terminals (Osowilangun Terminal and Purabaya Terminal), railway stations (Pasar Turi Station, Gubeng Station, and Wonokromo Station), government facilities (Surabaya City Hall), and tourist attractions (Kenjeran Beach, Submarine Monument, Bungkul Park, Surabaya Zoo, and Gunung Anyar Mangrove). The background map shows the geographical context of the Surabaya region with administrative boundaries, helping to understand the spatial distribution of the locations visited in this optimal route.

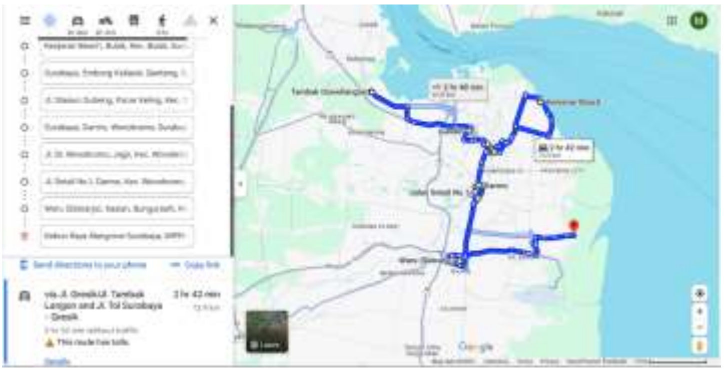

Figure 4. Integration Results with Google Maps

Figure 4 shows the results of integrating the desktop application with Google Maps. The left panel displays a list of locations in the Surabaya area and its surroundings, while the right panel displays an interactive map with the travel route marked in blue. The system successfully displays complete route information, including estimated travel time (2 hours 42 minutes) and distance (72.5 km) from Tambak Osowilangun to various destinations. This integration enables real-time visualization of geographic data and route analysis through the Google Maps API.

Figures 2 to 4 show the visualization results from the GUI-based desktop application developed to calculate and display the shortest routes between tourist destinations in Surabaya using the Hill Climbing algorithm. The routes are displayed in the form of a visual graph, with tourist destination points as nodes and red connecting lines indicating the optimal routes found based on the exchange of positions between locations. This application uses the networkx and matplotlib libraries to display graphical results and the integration of the application with Google Maps, which is used to display travel routes directly on a digital map. This image shows the fastest or shortest route based on the results obtained from the Hill Climbing algorithm, displayed navigably and complete with estimated travel time.

6. Conclusion

This study successfully implemented the Hill Climbing algorithm for optimizing the shortest route between tourist destinations in Surabaya. Using an iterative method of exchanging the positions of two points, the algorithm was able to refine the initial solution into a more efficient route based on the criterion of minimum distance. Route visualization using networkx and matplotlib, along with integration with Google Maps, provides an interactive display that helps users intuitively understand the routes. Despite limitations related to the risk of local optima, the algorithm's performance remains adequate for a limited number of destinations and demonstrates potential as a foundation for developing an artificial intelligence-based travel planning system. For future development, it is recommended to combine Hill Climbing with other methods such as Simulated Annealing or Genetic Algorithm to expand the possibilities of optimal solutions, as well as adding features like traffic prediction, user preferences, and interface improvements to support better travel efficiency.

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