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HEURISTIC GREEDY ALGORITHM FOR OPTIMAL TOURIST ROUTE RECOMMENDATION IN PATI REGENCY

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Abstract: Tourism in Pati Regency currently lacks an integrated digital information system, resulting in suboptimal dissemination of information and trip planning. To address this issue, a tourism website for Pati Regency was developed, equipped with a recommended tourist route feature. This study aims to design and develop a web-based tourism information system that provides destination information based on categories, media galleries, and promotional YouTube videos, as well as a Patiways feature that allows users to select multiple tourist destinations. The system then calculates the most efficient visiting order using a greedy heuristic algorithm, based on the selected starting point. The system was developed using the Waterfall method, consisting of analysis, design, implementation, and testing phases. The system design is illustrated through UML diagrams such as Use Case, Activity, and Class Diagrams. With this system, the distribution of tourism information becomes more effective, and tourists can plan trips with optimized routes. Additionally, the website is expected to serve as a digital promotion medium that contributes to increasing tourist visits to Pati Regency.

Keywords: heuristic greedy; recommendation route; tourism; waterfall

Abstrak: Pariwisata di Kabupaten Pati saat ini belum memiliki sistem informasi digital yang terintegrasi, sehingga penyebaran informasi dan perencanaan perjalanan wisata masih belum optimal. Untuk mengatasi permasalahan tersebut, penelitian ini mengembangkan sebuah website pariwisata Kabupaten Pati yang dilengkapi dengan fitur rekomendasi rute wisata terbaik. Penelitian ini bertujuan untuk merancang dan membangun sistem informasi pariwisata berbasis web yang mampu menyajikan informasi destinasi wisata berdasarkan kategori, galeri media, serta video promosi YouTube. Selain itu, sistem ini dilengkapi dengan fitur unggulan bernama Patiways yang memungkinkan pengguna memilih beberapa destinasi wisata dan secara otomatis memperoleh urutan kunjungan paling efisien menggunakan algoritma heuristik greedy berdasarkan titik awal perjalanan. Pengembangan sistem dilakukan menggunakan metode Waterfall yang meliputi tahapan analisis kebutuhan, perancangan sistem, implementasi, dan pengujian. Perancangan sistem direpresentasikan menggunakan diagram UML, meliputi Use Case Diagram, Activity Diagram, dan Class Diagram. Dengan adanya sistem ini, diharapkan penyebaran informasi pariwisata menjadi lebih efektif, wisatawan dapat merencanakan perjalanan dengan rute yang optimal, serta website dapat berfungsi sebagai media promosi digital yang berkontribusi terhadap peningkatan kunjungan wisatawan ke Kabupaten Pati.

Kata kunci: heuristik greedy; pariwisata; rekomendasi rute; waterfall

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INTRODUCTION

Tourism plays a strategic role in driving national economic growth. In 2019, this sector contributed 4.7% to the Gross Domestic Product (GDP), generated approximately USD 16.91 billion in foreign exchange earnings, and created employment for more than 20 million people [1]. The development of information technology has also opened new opportunities in tourism promotion, one of which is through the utilization of websites. This medium enables the wide and interactive dissemination of information supported by multimedia elements such as images, videos, and audio, which can increase the interest of potential tourists [2].

The development of web-based tourism information systems not only serves as a means of providing destination information but also functions as an effective digital promotion medium for local governments and tourism industry stakeholders. Through such platforms, various tourist destinations, cultural activities, and regional events can be widely published, thereby potentially increasing tourist interest and visitation numbers.

However, most existing web-based tourism information systems still focus primarily on presenting static information and destination promotion. These systems generally do not integrate decision-support features that assist tourists in planning their trips efficiently, particularly in determining the visiting order of multiple destinations based on the starting point and geographic conditions. As a result, tourists often have to plan travel routes manually or rely on general navigation applications that are not specifically designed for local tourism contexts. To support the development of a structured, easily managed system capable of integrating intelligent features such as tourist route recommendations, the CodeIgniter framework was selected as the development tool. CodeIgniter is characterized by its lightweight and fast performance and applies the Model–View–Controller (MVC) architecture, which facilitates structured development and long-term system maintenance. The use of this framework is expected to support the implementation of a stable and integrated tourism information system.

Based on these conditions, this study aims to design and develop a web-based tourism information system using the CodeIgniter framework and the Waterfall development method, which includes the stages of requirements analysis, system design, implementation, and testing. The developed system is equipped with a flagship feature called Patiways, which provides recommendations for the best tourist routes based on the user's starting location and selected destinations. This feature is expected to improve the accessibility of tourism information, support destination promotion, and facilitate more efficient travel planning for tourists.

Several previous studies have examined the development of tourism information and recommendation systems. Goel and Rizvi developed a web-based tourism recommendation system using a hybrid approach that combines content-based filtering and collaborative filtering to provide personalized destination recommendations to users [2]. Perayoga applied the Dijkstra algorithm in a web-based shortest route search system for tourist destinations in Temanggung Regency to help tourists find the fastest routes to tourist locations[3].

Several studies have focused on the development of tourism websites as in-

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formation and promotional media. Previous works include the introduction of cultural tourism websites to improve community welfare and preserve local culture [4], the design of comprehensive tourism information systems covering destinations, transportation, and accommodation to support regional tourism growth[5][6], as well as web-based tourism village information systems aimed at enhancing promotion and information accessibility with proven functional feasibility[7]. In addition, tourism information systems have also been developed to facilitate tourist access to destination information and supporting services such as ticket booking, restaurants, and accommodation [8].

The novelty of this research lies in the integration of a tourist route recommendation feature based on a greedy heuristic algorithm that is directly implemented within a local web-based tourism information system. Unlike previous studies that emphasize destination information provision or shortest-route computation separately, this research integrates multi-destination route planning, user-defined starting point determination, and route visualization into a single integrated system. This approach provides a practical contribution in the form of context-aware and application-oriented decision support for tourist travel planning in Pati Regency.

METHOD

The research method used in this study refers to the Waterfall software development model. This model adopts a linear approach in which each stage of the development process is carried out sequentially, starting from planning and modeling, followed by implementation and testing. Each phase must be completed before proceeding to the next stage, resulting in a structured and systematic development flow[9]. The workflow of the Waterfall model is illustrated in Image 1.

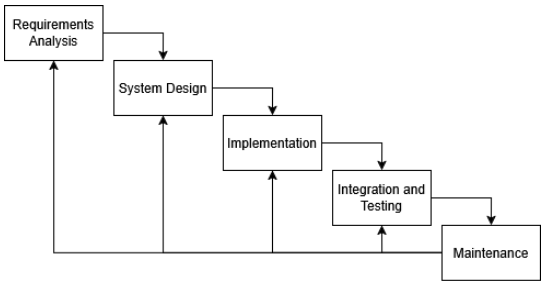

Image 1. Waterfall Method

This research employs the Waterfall development model, which allows users to understand the initial system design and evaluate its functionality before full deployment. The development process follows sequential stages, including requirement analysis, system design, implementation, testing, and maintenance. Functional requirements of the Pati Regency tourism information system were identified through interviews and observations, followed by system architecture design using UML diagrams[10]. The system is implemented with integrated modules for tourism and event data management and route recommendation using the Haversine formula and a greedy heuristic algorithm, tested using black-box testing in a web-based environment, and periodically evaluated to ensure functional stability and usability [11].

Heuristic Algorithm

In solving optimization problems, heuristic algorithms emphasize finding sufficiently good (near-optimal) solutions in a shorter computation time. This approach differs from exact algorithms, which may require longer processing time to obtain optimal solutions[12].

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Heuristic algorithms contribute to improved operational efficiency by minimizing total travel distance. Various optimization methods can be applied using this approach, including Ant Colony Optimization (ACO), Campbell–Dudek–Smith (CDS), the Greedy Algorithm, Particle Swarm Optimization (PSO), and Genetic Algorithms.

Greedy Algorithm

The greedy algorithm constructs a solution incrementally by selecting the locally optimal choice at each step, which can efficiently produce near-optimal solutions for certain classes of optimization problems[13].

Haversine Formula

The Haversine formula is a fundamental equation in navigation used to calculate the shortest distance (great-circle distance) between two locations on the Earth's surface, which is assumed to be spherical, using latitude and longitude coordinates. Although this formula provides a reasonably high level of accuracy, it does not account for elevation variations such as hills or terrain depth[14]. The Haversine formula is presented in Equation (1).

$$\text{Jarak}=2\times R\times \arcsin\left(\sqrt{\sin^2\left(\frac{\Delta lat}{2}\right)+\cos(lat1)\cdot\cos(lat2)\cdot\sin^2\left(\frac{\Delta lon}{2}\right)}\right) \quad (1)$$

Use Case Diagram

A Use Case Diagram is a visual tool in UML that specifically illustrates how users interact with a system within relevant usage scenarios[15].

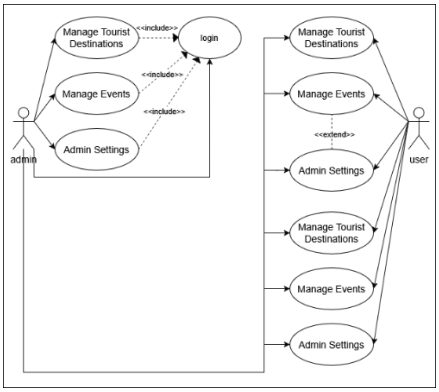

Image 2. Use Case Diagram

User interactions in the Pati Regency Tourism Website are represented through a Use Case Diagram involving two actors: the Administrator (Admin) and Visitors (user). The Admin manages tourism content, including destinations, multimedia jumbotrons, routes, events, and system settings. Meanwhile, Visitors can access tourism information, view destination details, watch promotional content, use travel planning features, search locations, and obtain updated event information with countdown periods.

Activity Diagram

The Activity Diagram focuses on the activities executed by the system rather than the actions performed by actors, thereby illustrating how the system operates in carrying out its functions.

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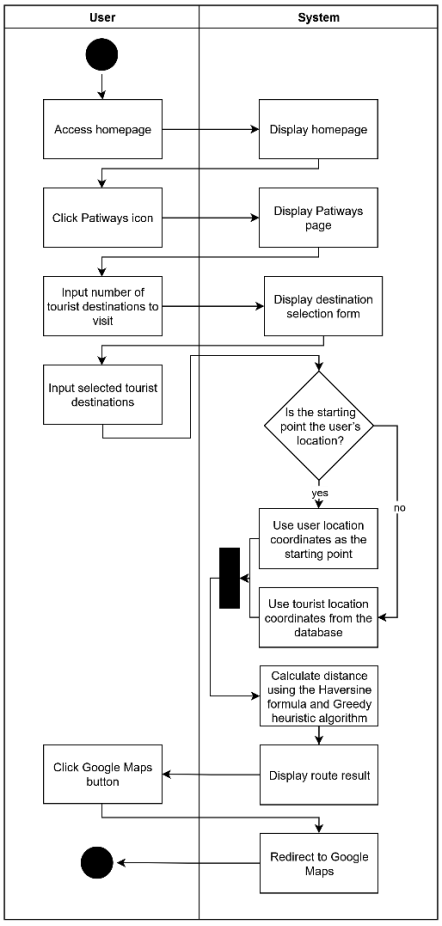

Image 3. Patiways Activity Diagram

RESULT AND DISCUSSION

Haversine Formula Calculation

The tourism information system developed in this study integrates several key elements, including tourist destination data, category management, and promotional media in the form of YouTube videos. The integration of these elements enables the system to function not only as a medium for information dissemination but also as an interactive platform that supports digital promotion of regional tourism. Similar approaches have been adopted in previous studies, which demonstrate that tourism websites can enhance information accessibility and the attractiveness of local tourist destinations through the presentation of multimedia content and structured information[4] [5] [6] [8].

The primary feature that distinguishes the system is its automatic travel route recommendation, which assists tourists in efficiently planning visits to multiple destinations. After users select a set of destinations, the system utilizes geographic coordinate data to determine the most efficient visiting order by applying a greedy heuristic algorithm, enabling the generation of travel routes with optimized distance and travel time without requiring manual calculations.

To compute distances between selected tourist destinations, the system employs the Haversine formula, which calculates the great-circle distance between two locations based on latitude and longitude coordinates. A real-world example involving five tourist destinations with the user's current location as the starting point illustrates the process, where distances are calculated iteratively, the nearest destination is selected at each step, and the procedure continues until all destinations have been visited.

Table 1. Tourism Data

No	Nama Wisata	Longitude	Latitude
1	Waduk Seloromo	110.9543263	-6.7004132
2	Pantai Banyutowo	111.0468076	-6.4553819
3	Nasi Gandul Pati	111.043164	-6.758444
4	Makam Syekh Ahmad Mutamakin	111.0576424	-6.6070343
5	Embung Mini Jrahi	110.938258	-6.578224
6	Current Location	110.865671	-6.784319

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Table 2. Distance Comparison Using the Haversine Formula

Name	User Location	Waduk seloromo	Nasi gandul	Makam syekh	Embung Mini Jrahi
Waduk Seloromo	13.5 km	-	-	-	-
Pantai Banyutowo	41.6 km	29.09 km	33.70 km	16.90 km	18.17 km
Nasi Gandul Pati	19.8 km	11.74 km	-	-	-
Makam Syekh Ahmad Mutamakin	28.9 km	15.42 km	16.91 km	-	-
Embung Mini Jrahi	24.2 km	13.70 km	23.14 km	13.57m	-

The system generates the visiting order: Waduk Seloromo, Nasi Gandul Pati. Makam Syekh Ahmad Muttamaqin, Embung Mini Jrahi, Pantai Banyutowo. To maintain fast responsiveness, the system limits destinations to nine points, while the greedy heuristic evaluates only the nearest unvisited location at each step, resulting in linear processing time growth. Although this approach makes locally optimal decisions and may not always yield the global optimum, it produces practical, easy-to-follow routes that significantly reduce travel distance and time, making it suitable for tourists who prioritize efficiency and usability over absolute mathematical optimality.

Implementation

The implementation stage represents the process of applying the previously designed system architecture. This section presents the implementation results along with a discussion of several key modules that have been developed. The home page is the initial interface displayed when users first access the Pati Regency tourism information system. This page is designed to provide an overview of the website's content and its main functionalities.

Image 4. Introduction to Patiways

Patiways Page

The Patiways page is designed as an interactive feature that assists users in efficiently planning tourist travel routes within Pati Regency. Users can specify the number of destinations to be visited (up to nine points), after which the system automatically generates the optimal travel route based on the selected starting point. The interface includes an input form, a "Generate" button, and step-by-step guidance to simplify use, eliminating the need for manual route planning.

Patiways Recommendation

This page displays the recommended tourist travel route based on the locations selected by the user. The system automatically orders tourist destinations according to the starting point and the shortest distance using a greedy heuristic algorithm. This recommendation aims to improve travel efficiency by reducing

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time and distance, thereby making the tourist journey more optimal.

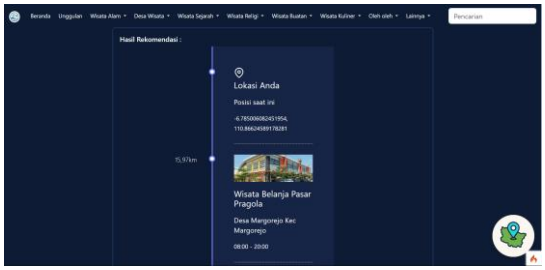

Image 5. Patiways Recommendation

System Testing

System testing of the Pati Regency tourism information website was conducted using the *black-box testing* method to ensure that all core system functions operate according to user requirements, without considering the internal structure of the program code.

Table 3. Blackbox Testing Results

Feature	Expected Result	Test Result
Login	Admin successfully accesses the dashboard	Pass
Add Destnation	Tourist destination data is successfully saved to the database	Pass
Edit Destination	Tourist destination information is updated correctly	Pass
Delete Destination	Tourist destination data is removed from the database	Pass
Add event	Event data is successfully saved to the database	Pass
Delete event	Event data is removed from the database	Pass
Detail Tourist destination	Detailed information of the tourist destination is displayed	Pass
Patiways page	The Patiways feature introduction page is displayed properly	Pass
Route Search	The optimal tourist route based on the Greedy Heuristic algorithm is generated and displayed	Pass

CONCLUSION

The testing results indicate that all system functions operate stably and produce outputs that meet user requirements without logical or interface errors. Overall, these findings demonstrate that the application of the greedy heuristic algorithm in the tourism information system improves the efficiency of tourist route planning, particularly in regions such as Pati Regency where tourist destinations are geographically dispersed.

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