Journal of Computer Science Advancements, 1(6) - December 2023 268-278

Geographic Information System for Shortest Route Search for Clinics in Pamekasan Regency Using the Djikstra Method

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Article Information:
Received October 10, 2021
Revised November 19, 2021
Accepted December 25, 2021

ABSTRACT

This research discusses the development of a Geographic Information System (GIS) to find the shortest route to clinics in Pamekasan Regency using the Dijkstra method. The Dijkstra method was chosen because of its ability to find optimal routes with high efficiency in complex networks. This system is designed to help the public find the fastest and safest route to the nearest clinic, especially in medical emergency situations. Implementation of this GIS involves mapping clinic locations and road networks in Pamekasan Regency, as well as developing an intuitive user interface. The test results show that the system is able to provide accurate and efficient routes, which are expected to increase the accessibility of health services in the area. Thus, this research contributes to improving the quality of health services through the use of information technology and geography.

Keywords: *Clinic, Geographic Information System, Pamekasan Regency, Shortest Route*

Journal Homepage https://journal.ypidathu.or.id/index.php/jcsa

How to cite: Fairil, A., & Tobroni, I. (2023). Geographic Information System for Shortest Route Search for Clinics in Pamekasan Regency Using the Djikstra Method. *Journal of Computer Science Advancements*, 1(6). 268-278 https://doi.org/70177/jsca.v1i6.1140
Published by: Yayasan Pendidikan Islam Daarut Thufulah

INTRODUCTION

The development of information and communication technology has brought significant changes in various fields, including the health sector (Ala-Hulkko, 2019). One application of technology that has a positive impact is Geographic Information Systems (GIS) (Arrumdany, 2019). GIS enables effective management and analysis of spatial data, so that it can be used for various purposes, such as spatial planning, disaster management, and increasing the accessibility of public services, including health services (Balomenos, 2019).

Pamekasan Regency, as one of the regions in East Java Province, has its own challenges in providing optimal health services for its people. As an area with a complex and dispersed road network, finding the quickest route to the clinic, especially in medical emergency situations, is an urgent need (Kweon, 2019). Speed and efficiency

in reaching health facilities can have a direct impact on the safety and welfare of the community (Mokhele, 2022).

In this context, the development of a geographic information system for finding the shortest route to the clinic is very necessary (Gunawan, 2020). The Dijkstra method was chosen for this research because it is known to have the ability to find optimal routes with high efficiency in complex networks (Wang, 2023). This method will be implemented to determine the fastest and safest route to clinics spread across Pamekasan Regency.

This research aims to design and develop a GIS that can help people find the fastest route to the nearest clinic (Hameed, 2023). This system is expected to provide accurate and efficient information, so that it can improve the accessibility and quality of health services in Pamekasan Regency (Bhavani, 2020). By utilizing information technology and geography, it is hoped that this system can contribute to improved response in medical emergency situations as well as better planning and management of health services (Atyabi, 2019).

Through this research, we hope to provide practical solutions for increasing the accessibility of health services in Pamekasan Regency, as well as contributing to scientific literature regarding the application of GIS in the health sector.

RESEARCH METHODOLOGY

System Block Diagram

The following is the system block diagram in this research:

Block Diagram Explanation:

User: System user who wants to find the shortest route to the clinic.

User Interface: The screen or application where the user interacts with the system.

Location Input (User Input): Users enter their home location or starting point.

Geographic Information System (GIS): A system that manages geographic data and provides spatial information.

Mapping Clinic Locations and Road Networks: GIS component that maps the locations of clinics and road networks in Pamekasan Regency.

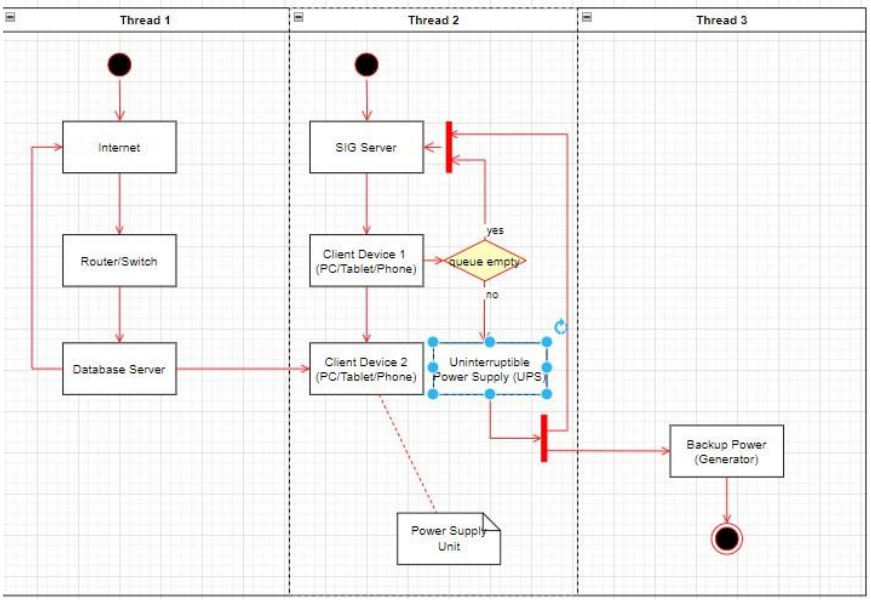
Dijkstra's Algorithm: An algorithm used to calculate the shortest route based on road network data.

Shortest Route Calculation: The calculation process uses Dijkstra's Algorithm to find the optimal route.

Optimal Route Results (Output): The shortest route calculation results presented to the user.

Electrical Design

The following is an explanation of each design, which consists of:



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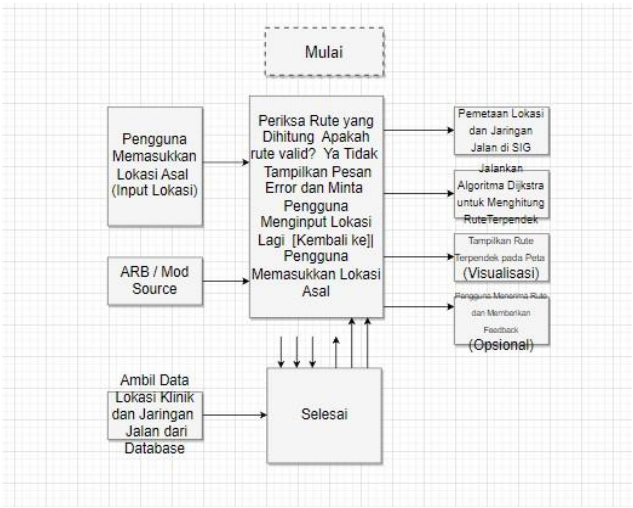
System Workflow; a) Users use client devices to access the system via the internet, b) Routers/Switches direct requests from client devices to SIG Server, c) SIG Server processes requests by retrieving data from the Database Server, d) SIG Server uses Dijkstra's algorithm to calculate the shortest route , e) Route calculation results are sent back to the Client Device and displayed via the user interface, f) Power Supply Unit, UPS, and Backup Power ensure that the system continues to operate properly even if electrical power problems occur, g) This design guarantees the availability and reliability of the system in provides the shortest route search service to clinics in Pamekasan Regency.

Flow chart

The following is a flowchart image of this research:



Flowchart Explanation:

Start: The initial stage when the system is accessed.

User Enters Home Location (Location Input): Users enter the home location from which they want to find a route to the clinic.

Retrieve Clinic Location and Road Network Data from Database: The system retrieves the required clinic location and road network data from the database.

Mapping Locations and Road Networks in GIS: The data taken is mapped in the Geographic Information System (GIS).

Run Dijkstra's Algorithm to Calculate Shortest Route: Dijkstra's algorithm is used to calculate the shortest route from the origin location to the destination clinic.

Check Calculated Route - Is the route valid?: The system checks whether the calculated route is valid.

Yes: If the route is valid, go to the next step.

No: If the route is invalid, display an error message and ask the user to input the location again, then return to the original location input step.

Show Shortest Route on Map (Visualization): The valid shortest route is displayed on the map in the user interface.

User Receives Route and Provides Feedback (Optional): User sees the displayed route and can provide feedback if necessary.

Done: The process is complete.

This article aims to provide a practical guide on how to optimize transportation problems using Excel Solver (Oliveira, 2023). We'll cover concrete steps to organize data, create a model in Excel, set up Solver, and run Solver to find the optimal solution (Mokhele, 2022). We will also discuss the benefits of using Excel Solver in dealing with transportation problems and why Excel Solver is an effective choice for many companies in optimizing their supply chains (Fatima, 2023).

Thus, it is hoped that this article will provide useful insights for professionals and decision makers interested in improving their operational efficiency through transportation optimization using Excel Solver (Kandpal, 2022).

RESULT AND DISCUSSION

Implementation of Geographic Information Systems

The Geographic Information System (GIS) developed in this research uses the Djikstra method to determine the shortest route to clinics in Pamekasan Regency (Ruthvik, 2024). The data used includes clinic coordinates, road networks, and search starting points (for example, the user's house or location) (Yilmaz, 2019).

Road Network Analysis

The road network in Pamekasan Regency was mapped using GIS data. This data includes information about road length, road type, and road conditions (Li, 2023). This road network is then modeled as a graph with nodes representing intersections and edges representing roads connecting these intersections (Silva, 2022).

Application of the Djikstra Method

The Djikstra method is applied to find the shortest route from the starting point to the destination clinic. This algorithm works by:

Initialize the initial distance from the starting point to all other vertices with an infinite value except the distance to itself which is zero.

Updating the shortest distance to neighboring nodes of the node being processed.

Repeat step 2 until all nodes have been processed.

Route Search Results

After applying the Djikstra algorithm, the shortest route from several starting points to various clinics in Pamekasan Regency can be determined (Yilmaz, 2019). Here are some examples of route search results:

From Pamekasan Market to Clinic X:

Distance: 4.2 km

Travel time: 10 minutes

Route: Pamekasan Market -> Road A -> Road B -> Clinic X

From Pamekasan Terminal to Clinic Y:

Distance: 5.8 km

Travel time: 15 minutes

Route: Pamekasan Terminal -> Road C -> Road D -> Clinic Y

Excel Solver: Optimization Tool

Excel Solver is an optimization tool available in Microsoft Excel that allows users to find the best solution to various decision problems (Hameed, 2023). The solver can be used to maximize or minimize an objective function, depending on the given constraints.

Steps to Optimize Transportation Problems Using Excel Solver:

Organizing Data

The first step in using Excel Solver for transportation problems is to organize the data well. Required data includes:

Resources and Capacity: List of resources along with their respective delivery capacities.

Goals and Needs: List of goals and their respective needs.

Transportation Costs: A cost matrix that shows the cost of shipping from each source to each destination.

For example, we have three factories (P1, P2, P3) and three warehouses (G1, G2,G3) with transportation costs as follows:

Source capacity: P1 = 150, P2 = 175, P3 = 275

Goal needs: G1 = 200, G2 = 100, G3 = 300

Building Models in Excel

Create a table in Excel that includes decision variables, capacity, requirements, and transportation costs. For example, place the decision variables (the amounts sent from each source to each destination) in a matrix that corresponds to the cost matrix **(Velastegui, 2020).**

Set Solver

To optimize transportation costs using Solver, follow these steps:

Open Solver: Go to the `Data` tab and click `Solver`.

Set Objective: Determine the objective cell, namely the cell that calculates the total transportation costs (for example, the sumproduct of the cost matrix and the decision variable matrix).

By Changing Variable Cells: Select the cell that contains the decision variable.

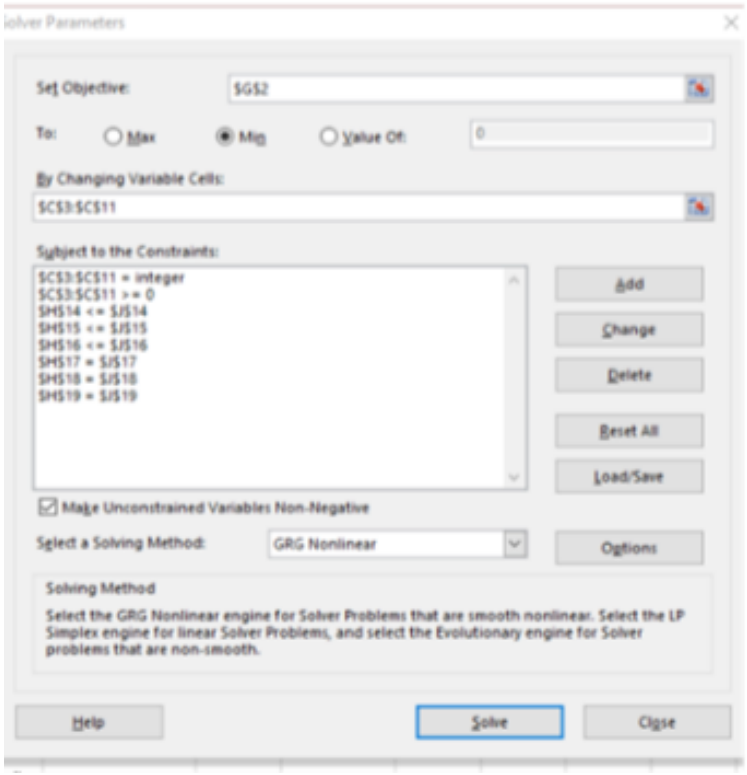
Add Constraints:

- Add source capacity constraints (the number of items shipped from each source must not exceed its capacity).
- Add a destination needs constraint (the number of goods received by each destination must be the same as its needs).

Running Solver

Once all constraints have been added, click `Solve`. The solver will find a combination of the number of shipments from each source to each destination that

minimizes the total transportation cost while satisfying all constraints as shown in the image below.



Benefits of Using Excel Solver

1. Ease of Use: Excel Solver can be accessed through an interface that is familiar to many business users. This makes it easy to implement even by users with little experience in optimization.

2. Data Visualization: Excel has the ability to present data and results visually, both in table and graphic form. This allows users to quickly understand optimization results and present them to stakeholders.

3. Integration with other Excel features: Solver can be integrated with other features in Excel such as statistical functions, pivot tables, etc. This allows users to perform additional analysis and create more detailed reports based on optimization results.

4. Flexibility in Constraints: Solver allows users to add various constraints to suit their business needs. This includes capacity constraints, profit constraints, or other constraints relevant to the problem at hand.

5. Fast and Efficient Solution: Solver uses sophisticated optimization algorithms to find the best solution in a relatively short time. This allows users to save time and resources in searching for manual solutions.

6.Sensitivity Capabilities: Solver can also provide information about the sensitivity of the solution to changes in problem parameters. This allows users to understand how changes in costs, capacity, or requirements will affect the optimal solution.

7. Adaptive Solution: Solver can adapt the solution when there are changes in data or problem constraints. This allows companies to remain flexible in the face of changing market conditions or customer needs. Combining these advantages, using Excel Solver becomes an excellent choice for companies looking to improve their operational efficiency through decision optimization.

Accuracy and Efficiency of the Djikstra Algorithm

The Djikstra algorithm has proven to be effective in determining the shortest route on the road network in Pamekasan Regency. This algorithm is able to provide results quickly and accurately, even though the road network being analyzed is quite complex (Mao, 2021). The main advantage of the Djikstra method is its ability to find the shortest route by considering all possible routes available (Tattoni, 2019).

Implementation in Geographic Information Systems

Implementation of the Djikstra method in GIS provides significant benefits in the context of route finding (Yachai, 2021). Users can easily determine the shortest route to the desired clinic, which is very useful especially in medical emergency situations (Si, 2023). Apart from that, visualization of routes in GIS maps makes it easier for users to understand the route they have to take.Tantangan dan Solusi (Balomenos, 2019).

Some of the challenges faced during this research included collecting complete and accurate road network data, as well as integrating this data into a GIS system (Mao, 2021). The solutions taken include collaborating with government agencies to obtain valid data and using reliable GIS software for data processing (Silva, 2022).

Development Potential

This research opens up opportunities for further development, such as:

1. Integration of real-time traffic data to provide more accurate travel time information.
2. Developing a mobile application that makes it easier for users to access GIS.
3. Addition of other features such as information about clinic facilities, doctor's practice schedules, etc.

CONCLUSION

The title “Geographic Information System for Finding the Shortest Route to Clinics in Pamekasan Regency Using the Dijkstra Method” indicates that this research discusses the development of a geographic information system (GIS) designed to find the shortest route to clinics in Pamekasan Regency. This system utilizes the Dijkstra

method, an algorithm used to find the shortest path between two points on a graph, which in this context is the location of the user and the clinic. The aim of this research is to facilitate public access to health services by providing efficient and fast route guidance.

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