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Determination of Route Suggestions Based on Flood Monitoring System

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Abstract: Flooding is one of the catastrophic and frequently occurring natural disasters that cause extensive damage to life, infrastructure, and the environment. Floods are one of the common natural hazards in the Asian region. In addition, the massive flood caused many roads to be closed and caused the public to be strained. This incident has caused many vehicles to congest the rest and drive past congestion incidents. Water overflow from the floods that hit the area has caused road congestion too. Road congestion has caused many road users to be stranded, and some are willing to fight the current to avoid getting caught in this flood. Besides, many road users need to know which road to avoid getting caught in the downpour. In this project, a method to determine shortest route suggestion based on flood monitoring system is developed to overcome this problem. MATLAB software is used as the simulation tool to generate the route suggestion. The flood monitoring system data is extracted from Google Sheets. The system uses the data input to identify the best route for users to travel to their destination during the flooding period. The Directed Graph (DA) algorithm finds the shortest path for all nodes by using the destination source and location obtained based on Google Maps. The shortest path data from MATLAB are saved to the Google Sheets, giving the directions in the most concise way for each node. Its main aim is to develop an intelligent system capable of routing people from one place to another to avoid the congestion caused by floods.

Keywords: Route Suggestions, Flood Monitoring System, MATLAB, Directed Graph algorithm.

1. Introduction

Flooding is one of the catastrophic and frequently occurring natural disasters that cause extensive damage to life, infrastructure, and the environment. Floods are one of the most common natural hazards in the Asian region. In the last few years, thousands of lives have been lost, directly or indirectly, by flooding. In fact, of all-natural risks, floods pose the most widely distributed natural risk to life today. In December 2021, floods hit the peninsula of Malaysia. This phenomenon occurs during the period of east monsoon winds coming from the peninsula's east coast. The floods have caused a lot of

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infrastructure damage in the affected areas. In addition, this massive flood caused many roads to be closed and caused the public to be stranded. This incident has caused many vehicles to congest the rest and drive past congestion incidents. The motivation of this project is the importance of river flood events in urban areas, which cause many lives and property damage. Knowledge of the river basin's response to rainfall events in the form of runoff is vital in engineering practices for urban planning and management.

Floods are recurring phenomena that cause the same situation to happen again. Major floods are the most significant cause of why road congestion often happens. The sharp rise in water levels has resulted in traffic congestion, and severe road congestion for a very long period due to floods will cause stress or trauma to users. To avoid road congestion, users need to find other alternatives to avoid getting stuck in such congestion, such as looking at maps, Waze, or other apps that show safer directions.
Knowing that floods are part of human life and natural phenomena can't be fully controlled, it is essential to focus on and improve knowledge about prevention. To achieve this issue, more specific and scientific work must be developed to better understand flooding phenomena and their related geographical characteristics.

According to this paper, to create road suggestions that are based on flood monitoring data, Directed Graph algorithm will be used. The algorithm will take in data regarding the area that it is evaluating and will return the risk level associated with that location based on the input data provided. Flooding risk is determined based on water depth, flow rate, temperature, humidity, and rainfall conditions at a given location based on that data. Once the risk level is determined, the algorithm can then return a list of possible road routes that the user can take to reach their destination safely if there is flooding at the current location.

The objective of this project is to determine where each sensor node should be placed to cover the stated routes. It is used to determine if the road is flooded or not. The node is displayed on the map at the junction of each route. The distance in Google Maps determines the short path connection on the map with the placement sensor's node. The Directed Graph technique was implemented into the project using Matlab. The algorithm's evaluation is to assess whether the road is flooded and to locate the shortest path for all nodes. The data is then stored in a Google Sheet.

This study will focus on the area that is prone to flooding in Taman Nira, Batu Pahat. [2] The study focused on the use of Matlab for flood modelling. For the model to be developed, rainfall, water level, temperature, and humidity data must be gathered and utilized as input variables. The system will decide whether the node is inundated based on the given threshold. The collected data will be used to build a model for flood simulations in Matlab. Matlab simulations display each node's route and distance along all pathways. The distance and route data are transferred to Microsoft Excel for future reference.

2. Related Works

In this section, the topic is being focusing related to the algorithm that are used to develop Determination of Route Suggestions Based on Flood Monitoring System. This project is a simulation based on modelling using Matlab as a simulation tool and Directed Graph Algorithm as the algorithm to finding the shortest path for each node in the map.

2.1 Directed Graph Algorithm

Shortest Path Methods (SPM) have become a popular tool for solving optimization problems in various fields such as network routing, communication networks, and resource allocation. In computer networking, shortest-path algorithms are used for route discovery. They reduce the overall cost of setting up a network[4]. One of the most common methods used in the shortest path problem is the Directed Graph (DA) algorithms, develop by R. Guy and L.

The Directed Graph (DA) or digraphs algorithm solves the shortest path problem by calculating the shortest cost to reach all nodes in the graph starting from a given source node. The Directed Graph (DA) algorithms will be working with a graph $G = (V, A)$ consists of a finite vertex V which contains n vertices, together with an edge set $A \in (i, j)$. An edge of a directed graph is an ordered pair vertex (i, j) from i and j. It assumes, without losing generality, that $V = \{1,2,3, \dots \dots \dots, n\}$[5].

2.2 Study of existing system

A study of the existing system has been conducted on the paper. The study is conducted so that system developer can analyze and identify the method, advantages and software of the existing system to use it as reference when developing the system. The three existing related systems that have chosen in this paper is The Shortest Path Finder for Tsunami Evacuation Strategy using Dijkstra Algorithm, The Application of Apriori Algorithms in Predicting Flood Areas and Flood Prediction Using Flow and Depth Measurement with Artificial Neural Network in Canals. Based on the review, the comparison is shown in Table 1.

Table 1: Comparison of existing project

No	Title	Author/Year	Method	Advantages	Software
1	The Shortest Path Finder for Tsunami Evacuation Strategy using Dijkstra Algorithm.	Pratiwi, A. F. Riyanto, S. D. Listyaningrum, R. Aji, G. M. 2020	Dijkstra Algorithm	- Have a low complexity. - Solves the single-source shortest path problem.	MATLAB
2	The Application of Apriori Algorithms in Predicting Flood Areas	Harun, Nur Ashikin Makhtar, Mokhairi Aziz, Azwa Abd Zakaria, Zahrahtul Amani Abdullah, Fadzli Syed Jusoh, Julaily Aida 2017	Apriori Algorithm	- Intuitive and easy to communicate to an end-user. - Simple and easy-to-understand the algorithm.	MATLAB
3	Flood Prediction Using Flow and Depth Measurement with Artificial Neural Network in Canals.	Nikhil Binoy, C. Arjun, N. Keerthi, C. Sreerag, S. Nair, Ashwin H. 2019	Artificial Neural Network	- High accuracy. -Independence fromprior assumptions.	Qt Creator

3. Materials and Methods

The purpose of this paper is to discuss the feasibility and benefits of using a flowchart to determine route suggestions for driving while navigating through flooded roads. To fully understand the benefits of this method, it is important to understand the purpose of a flowchart. A flowchart is a visual representation of the steps in a decision- making or problem-solving process. Each step in the flowchart is represented by a box that contains the information about the action that needs to be taken to complete the task. As shown in this Figure 3.1, the first step in this process is to determine the source node and end node in the maps. The source node represents the location that is considered as the start point of the route while the end node represents the location where the route ends. In the next step, the distance each node obtains from the maps. This value is then used to estimate the travel time between the segments. Based on these values, the adjacency list is then created to determine the best possible route options. Once the maps are generated, the next step is to link the source and destination nodes using the shortest path algorithm (Directed Graph Algorithm). After the paths are discovered, the optimal route is then selected based on the chosen criteria. The criteria based on the data input such as water level, rain condition, temperature, and humidity levels, etc. are used to determine the best route since it has the highest expected travel time, and it is the safest route by avoiding flooded areas. In this project, MATLAB is used to generate the maps and to create the shortest path algorithm for finding the best route based on the input criteria. If the road is flooded, the system will recommend an alternative route that is safe and fastest to travel to the destination.

After that, MATLAB will update the new adjunction list that will be used in the next routing cycle to determine if there is a better way to accomplish the task. MATLAB will visualize the maps to show the different routes and how they connect to the start and end points. Finally, MATLAB will use the travel distance matrix to calculate the travel time for each node. Based on this information, it will generate a list of possible routes that achieve the set objective and then choose the best one based on the parameters that were specified in the program. After that, MATLAB will create an output file that will contain information about each possible route as well as the distance required to travel between each segment. This information will be converted into Excel and saved as Google Sheets in the Drive for further analysis.

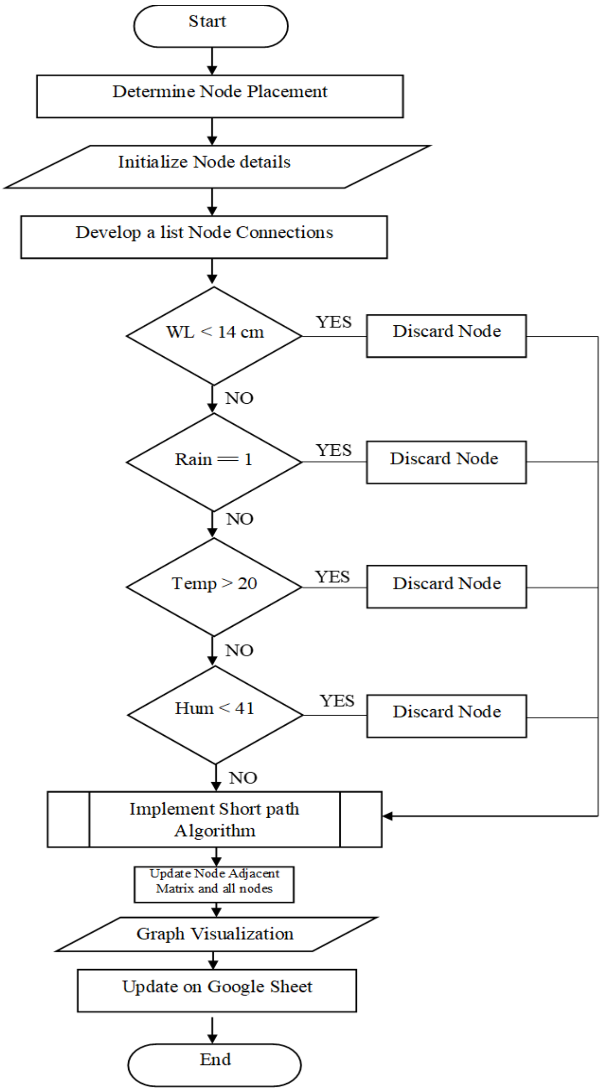

Figure 3.1 Flowchart Determination of Route Suggestion Based on Flood Monitoring System

3.1 Study Area

The study area is Taman Nira, Batu Pahat, Johor, in the southern part of Peninsular Malaysia. Batu Pahat is of average size with 1973 km^2 and a population of approximately more than 300,000 residents. Figure 3.2 shows the location of Taman Nira located at 1°51.9134 N and 102°55.4607 E near Batu Pahat River. Batu Pahat river drainage length is 12 km with sub-catchment area is 103.0 km^2. It originated from two rivers, Sungai Simpang Kanan and Sungai Simpang Kiri, and flows through Batu Pahat River until it reaches the waterway Pantai Minyak Beku on the coast of Johor. The focus is to produce the floodplain modeling for regularly flooded area in Taman Nira which is close to Batu Pahat River.

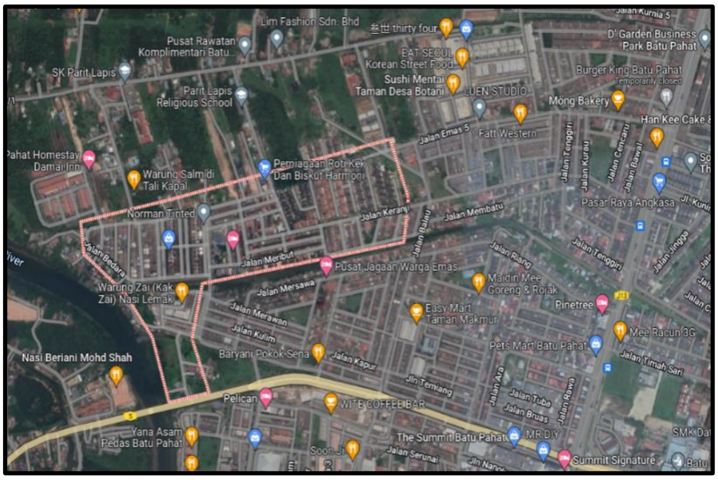

Figure 3.2 Taman Nira, Batu Pahat

Figure 3.3 shows the intersection may not have a base map as the plotting point in the maps. The node has the coordinates and distance measurements that correspond to the feature in the location data maps.

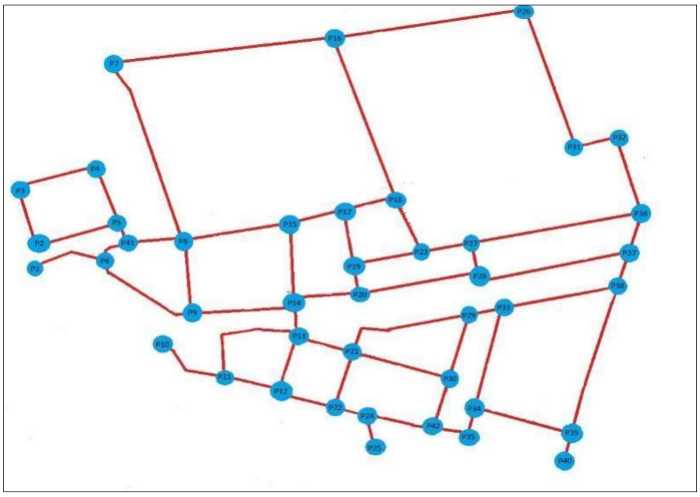

Figure 3.3 Mapping node of possible intersection without map background

3.2 Data Preparation

The data input in this project is using a previous flood monitoring dataset that was extracted into a data array in proposed modeling. The data has 4 categories which are water level, rainfall[3], temperature and humidity data. Each of the data has its limitations to determine flood prone. The limitation is stated on the flowchart.

3.3 Graph Representations

The simulated model flood event is using MATLAB. In this simulated scenario, each node in the road network is connected to one or more nearby sensor nodes that generate measurements of water depth, rainfall, temperature, and humidity. After the adjacency matrix of distance is obtained, we run the shortest path function in MATLAB to identify key intersections where water level measurements are taken after a flood event.

MATLAB displays graphs in the toolbox and data for all node paths in the workspace. Figure 3.4 is a graph of Taman Nira based on Figure 2.3.

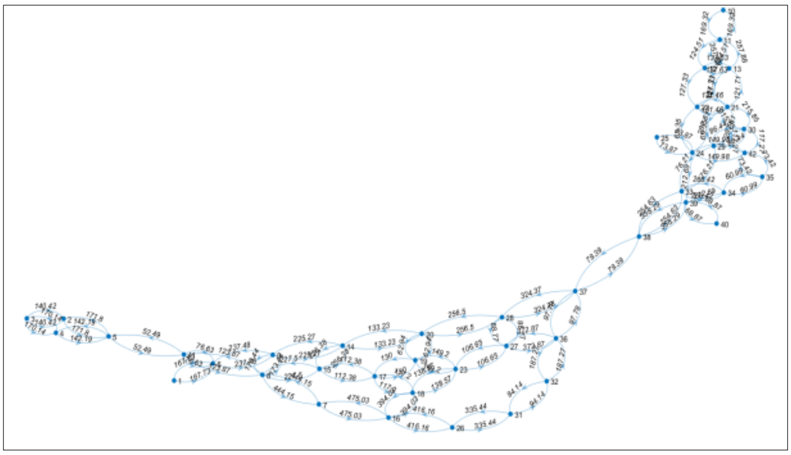

Figure 3.4 The plotting graph in Taman Nira,Batu Pahat.

3.5 Importing data to Google Sheet.

Once the MATLAB generated the shortest path to reach the target node. On the workspace, it shows the data of the path obtained. It shows the distance for the start node to reach the end destination. Using the function $xlswrite\ (filename, A)$,[4] MATLAB will save the data as Google Sheets for future reference.

4. Results and Discussion

The shortest paths are found by using MATLAB as the simulation based on Directed Graph (DA) algorithm. From MATLAB, the result of the numeric matrices is transferred to Excel and saved to Google Drive. There are three conditions in the simulation study: (1) Normal condition (No Flood), (2) Flooded condition (Some area is flooded).

4.1 Normal Condition (No Flood)

Based on Figure 3.1, the nodes are obtained in coordination with Google Maps; meanwhile, the destination for the nodes is taken from the start nodes to the end nodes. In this method, the path from the start node to the end node of each route is computed using the shortest path algorithm.

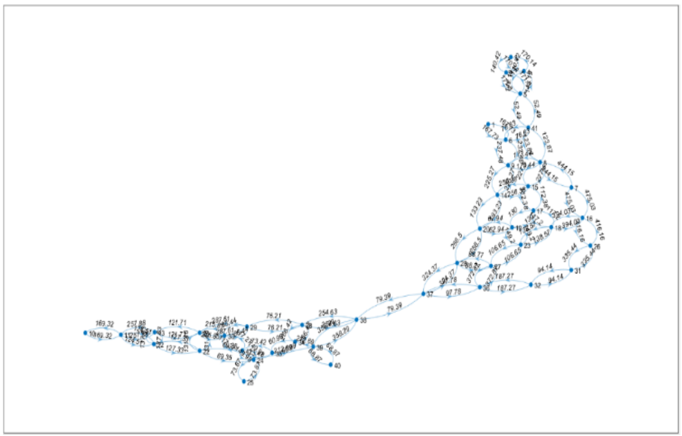

Figure 4.1 The connected graph without any flooded area.

The simulation results show the path routes of the Directed Graph algorithm to obtain the shortest path in flood evacuation maps. Based on the data that has been collected, a mapping has been obtained for the nodes to find the best way to avoid the flood by calculating the distance from the node to the nearest point before the flooded area.

For example, we want to determine the path from P2, P3 and P18 to P35. The algorithm will give the shortest paths between the nodes P1, P2 and P3 and P18 by calculating the distance between each pair of nodes. Table 2 shows the results for this condition when no flood.

From the results, we can see in Table 4.1 that the algorithm successfully determined the paths between these nodes. For example, we want to determine the path from P2, P3 and P18 to P35. The algorithm will give the shortest paths between the nodes P1, P2 and P3 and P18 by calculating the distance between each pair of nodes. We can see from the results that the shortest distance between the nodes P18 to P35 is 1319.79 m, P2 is 2122.4 m, and P3 is 2262.82 m.

Table 2: Results of Shortest route and Distance when no flood.

Source Node	Destination Node	Shortest Route	Distance (m)
P2	P35	P2→P5→P41→P8→P9→P14→P20→P28 →P37→P38→P33→P34 →P35	2122.4
P3	P35	P3→P2→P5→P41→P8→P9→P14→P20 →P28→P37→P38→P33→P34→P35	2262.82
P18	P35	P18→P23→P27→P28→P37→P38→P33 →P34→P35	1319.79

4.2 Flooded Conditions (Some are Flooded)

Figure 4.2 below illustrates the directed graph of flooding detection. Simulations show what happens when the water level goes below 14 cm. The algorithm detected flooding when the water was more profound than 14 cm. After the algorithm detects the condition of water level, it cuts the road for people to cross.

It can see that the nodes P1, P2, P3, P4, P5, P6, P9, P10 and P11 are marked as blocked on the graph. It indicates that those nodes will not be able to follow the path since the directed graph algorithm has blocked it. To determine the path from P14 to the P1, P7 and P5. The algorithm will give the shortest path results between the nodes by calculating the distance between each pair of nodes.

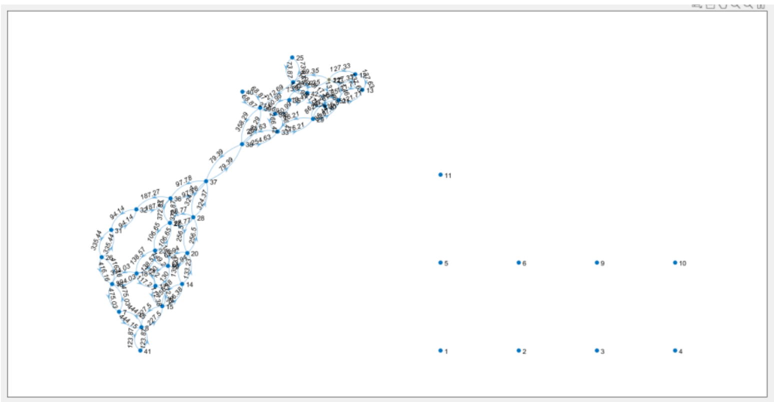

Figure 4.2 The connected graph when flooded is detected.

From the result, we can observe that the algorithm has detected that the area is affected by the flooding and marked some paths as blocked on the graph. Based on the results, we know that when the area is flooded, the directions the node can follow are limited, and it cannot travel freely across the network. We can see that P14 wants to go to the P5 node but cannot get there. It is most likely because the P5 node is marked as blocked due to the flooding in the area.

From the condition analysis result, we see that P14 want to go to P7 because there is an alternative path available which is P14→P15→P8 →P7, but the distance to travel to P14 is more significant than cross P9, which if P14 want to go P7 crossed P9, it only 842.89 m crossed P15 which is 928.03 m. Therefore, P14 will choose the shortest path to P7, a detour using P9 to avoid being blocked by the flood.

From Table 3, we can observe that if P14 wants to go to P1, the value of the distance is Inf which means no path goes through P1. It's the same situation for P2, P3, P4, P5, P6, P9, P10 and P11. While, for all the rest of the nodes in the graph, their value is not Inf which means that they have a path of at least one of them exists; meanwhile, the value 'Inf' indicates that they do not have a path going through themselves.

Table 3: The results for this condition when no flood.

Source Node	Destination Node	Shortest Route	Distance (m)
P14	P1	The shortest route is not found!	Inf
P14	P5	The shortest route is not found!	Inf
P14	P7	P14→P15→P8→P7	928.03

4.2 Discussions

From the result, we can see the distance for both conditions: flooded and not flooded. We can see that within the distance to not be flooded, all nodes can connect and have distance to reach the destination. Meanwhile, for flood condition, we can see that only certain nodes can reach the destination because there are isolated nodes far from each other. We also see that the (lower) distance for the nonflood condition can reach the destination and vice versa for the flooded condition the destination cannot be reached due to the long distance between some nodes. After all, this graph provides good information for determining which node is closest to our destination and how many intermediate nodes need to connect to reach our destination.

5. Conclusion

To solve this problem, a directed graph has been applied to determine the path of all the nodes that the vehicle can go through when the areas are flooded. First, sensor inputs for water level, rain, temperature, and humidity are used to determine if the area is flooded. Then, based on the collected data, the algorithm can determine which areas are deeply flooded and which areas are flooded with shallow water. Then, based on the data detected by the sensor, the algorithm can determine which roads can be safely moved without flooding the vehicle. Finally, the directed graph creates a path between all nodes that can be safely traversed in the floodplain. The paths of all nodes are recorded in an Excel table based on the road network used for simulation and can be used by the user as a base map to efficiently navigate flooded areas.

In summary, the model prototype in MATLAB is used for this purpose because the combination of processing and graphics makes it easier to visualize the output data as well as more efficient in solving problems efficiently. The goal of finding the shortest path between all nodes was achieved, and the detailed output of the simulation was saved in Excel and converted to a Google sheet for further use.

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