Progress in Engineering Application and Technology Vol. 4 No. 1 (2023) 438-450

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Flood Hotspot Monitoring System and Navigation Application

Kerrain Ramasamy[1], Aimi Syamimi Ab Ghafar[1]*,

[1]Department of Electrical Engineering Technology, Faculty of Engineering Technology.
Universiti Tun Hussein Onn Malaysia, Muar, 84600, Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2023.04.01.046
Received 15 January 2023; Accepted 8 February 2023; Available online 8 February 2023

Abstract: The issue of flood in some areas because of poor road infrastructures and drainage system together with environmental aberrations are challenges encountered on roadways. To overcome these problems, a study has been conducted to develop an application called Flood Hotspot Monitoring System and Navigation Application that can display the information of water levels, temperature, relative humidity, rain status, and the location of the node while also read data of route suggestion from google sheet. Furthermore, it can navigate users in the application by using turn by turn navigation features. The application is designed using MIT app inventor to use block-based programming language. The ability of the system is tested and the output of flood monitoring and the route suggestion to the selected destination is displayed on the smartphone together with the text direction shown in the list view. On top of that, System Usability Scale (SUS) questionnaire has been conducted to test the validation of system. The average SUS score achieved is 74.5/100 and this demonstrates that utilizing the application is acceptable

Keywords: Flood Monitoring, Route Suggestion, Navigation,

1. Introduction

Flooding is a major natural hazard that has a significant influence on many locations across the world. Excessive rainfall or the abrupt release of water due to a dam break or glacial lake outburst can trigger floods [1]. A flood occurs when a high volume of water flows into a river in a matter of minutes or hours as a result of heavy rain. Furthermore, flooding is one of the horrible disasters that is happening in Malaysia recently. Heavy rain and continuous rain are the major cause of floods [2]. Flash floods can also be caused by dam failure, ice and snow disintegration, and situations in which a big volume of water is discharged into dry areas [3]. Floods have detrimental effects on traffic, limiting vehicle movement and damaging the overall network of roadways since certain damaged roads become

*Corresponding author: aimi@uthm.edu.my

impassable and must be closed. Some of the vehicles are lost due to floods and some of them stuck in the flood and they don't have a route back to home. This situation makes Malaysian people to suffer during the heavy flood [4]. Many flood-related accidents and delays can be avoided if drivers are aware of the distribution of flooded roadways ahead of time. This necessitates the precise location of flood-affected routes.

The flood occurrences seem to get more frequent in the recent years especially in some cities. For example, Johor, Penang, Kuala Lumpur. The flood affected most of Peninsular Malaysia resulting in many causalities such as vehicles, property, agricultural land and road system. The water level increased drastically at certain area. Based on the study about flood that occurred in Taman Nira Batu Pahat Malaysia 2022. Most of the vehicles are washed away in the flood, many lives have been taken away by the flood. Victim's cars are filled with water and some of the cars are submerged in water and unable to use due to continuous rain [5]. Furthermore, the users are clueless of the water level and the rain status of the surrounding area. Thus, this makes the user unaware of the condition of the area [6]. Other than that, the citizen who came by their own vehicles or public transport to visit the area also unaware about the route condition of the area and get caught in the flood. Moreover, the victims have no idea which route to go if the current route is flooded and they also will be doubtful to choose a route because the route they choose might also have high risk for the victims to get trapped by the flood.

The main objective of Flood Hotspot Monitoring System and Navigation Application is to display and guide safer route suggestions to users. The first objective is, to develop a Flood Hotspot Monitoring System and Navigation Application that can display node location, water level, temperature, humidity, rain status and route suggestion which are retrieved from Google Sheet. Furthermore, to implement the route suggestion in the application by using turn-by-turn navigation feature. Finally, to test and validate the system efficiency using system usability scale (SUS).

The scope to achieve the objectives of this project are to develop Flood Hotspot Monitoring System using MIT app inventor to monitor flood by displaying the value of water level, temperature, relative humidity, rain status, node location and navigate user by route suggestion at Taman Nira, Batu Pahat. Since it is one of the flood hotspot areas. Moreover, to study and conduct research on how to monitor flood and suggest a new route suggestion based on the data in the google sheet and how to read the data from the google sheet through application. Next, to research from the literature review and previous exploration based on flood monitoring and reroute suggestion. Finally, to develop flowchart based on the combination of previous projects but the flood monitoring and navigation application is the major focus.

2. Related Works

Table 1: Comparison of existing project

No.	Title (Ref no.)	Features	Software/Hardware
1.	Development of a Navigation System Using Smartphone and Bluetooth Technologies to Help the Visually Impaired Navigate Work Zones Safely [7].	A smartphone app based on Android (OS). (GPS), Bluetooth technology, (TTS) interface and motion sensors combined to assist in determining a user's location and providing directions. Bluetooth beacons are used to help assess user's location. Deliver communicate audible messages through the TTS interface.	A smart phone app based on Android studio.
2.	Smart Vehicle Navigation System Using Hidden Markov Model and RFID Technology [8].	(GPS) based vehicle location devices used to keep trail of moving vehicles. Efficient of using RFID based on the information about navigation route. Predictive algorithm created for vehicle navigation route.	A programmable gate array board and An FPGA controller is used to command the whole hardware platform.
3.	Autonomous Vehicle Navigation and Mapping System [9].	GPRS modem is used to communicate in between the vehicle and the internet. IMU is combined with GPS, it enhances localization accuracy, via GPRS. Established laser range finder detects obstacles around the vehicle.	The application uses OpenStreetMap software standardized geodata and uses microcontroller.
4.	Vehicle Traffic and Flood Monitoring with Reroute System Using Bayesian Networks Analysis [10].	Evaluate automobile traffic and flooded roads, ArRoad system used, which have network of sensors and real-time picture processing. All data is delivered over the Internet to a cloud platform. Established Bayesian network to show probable reroute regions to escape traffic blockage and flooded regions.	ArRoad system is used up of four primary components: physically linked devices, data processing, cloud service platform, and mobile user interface. Sensors are connected wirelessly using IEEE software.
5.	A Real Time Solution to Flood Monitoring System using IoT and Wireless Sensor Networks [11].	The required parameter is detected by a water level sensor, rain fall sensor and if the water level and rain fall meets the parameter, the signal is generated to alert user. Collect sensor data from the river, such as water level data and rain fall data. Sensor data is sent to a website and an Android app, which send notifications. Program includes a map that displays safe areas around the user as well as the user's current location. Pressure of water, Rainfall measure to detect the levels of the flood in android app and website.	Arduino microcontroller based neuro fuzzy, RaspberryPi microcomputer and android application.

Based on previous studies, multiple studies related to Flood Hotspot Monitoring System and Navigation Application project have been conducted. According to the previous studies, each project uses different type of sensors, software and some of the project contributed both software and hardware in their projects and also cloud storage to store data. Moreover, some of the projects uses algorithm for

route suggestions. However, this project will use MIT app inventor software to create this Flood Hotspot Monitoring System and Navigation Application to implement route suggestion for the users.

3. Methodology

3.1 Software

The software used to implement this Flood Hotspot Monitoring System and Navigation Application is called MIT app inventor. The Massachusetts Institute of Technology (MIT) enables beginners to construct application software (apps) for two operating systems (OS): Android and iOS. It employs a graphical user interface (GUI) similar to that of the languages such as python and Star Logo [12], which allows users to drag and drop visual items to develop Android-compatible apps. This software uses block-based programming language to program the application. Such blocks are typically displayed by symbols that may be moved and dropped to rearrange them [13]. Furthermore, accumulated google sheet data for flood monitoring and navigation is implemented in the MIT app inventor. Thus, the app will function based on the data given by the google sheet.

3.2 System Block Diagram

Figure 1 shows the overall system block diagram of Flood Hotspot Monitoring System and Navigation Application. This block diagram consists of android smartphone and MIT app software which have various types of functions. The input of the system is the google sheet data and the result of flood monitoring system and route suggestion. The output is the MIT app inventor, flood monitoring menu, destination and navigate. These functions are with this MIT app software that can be used to display details about water level, temperature, relative humidity, rain state, node location and route suggestion for the desired destination. The application will navigate based on the google sheet data and display the result of route suggestion on the map in the android smartphone. Thus, if there is any flooded region in the selected destinations, the app will read the data from the google sheet to suggest the possible route to navigate the user to the destination.

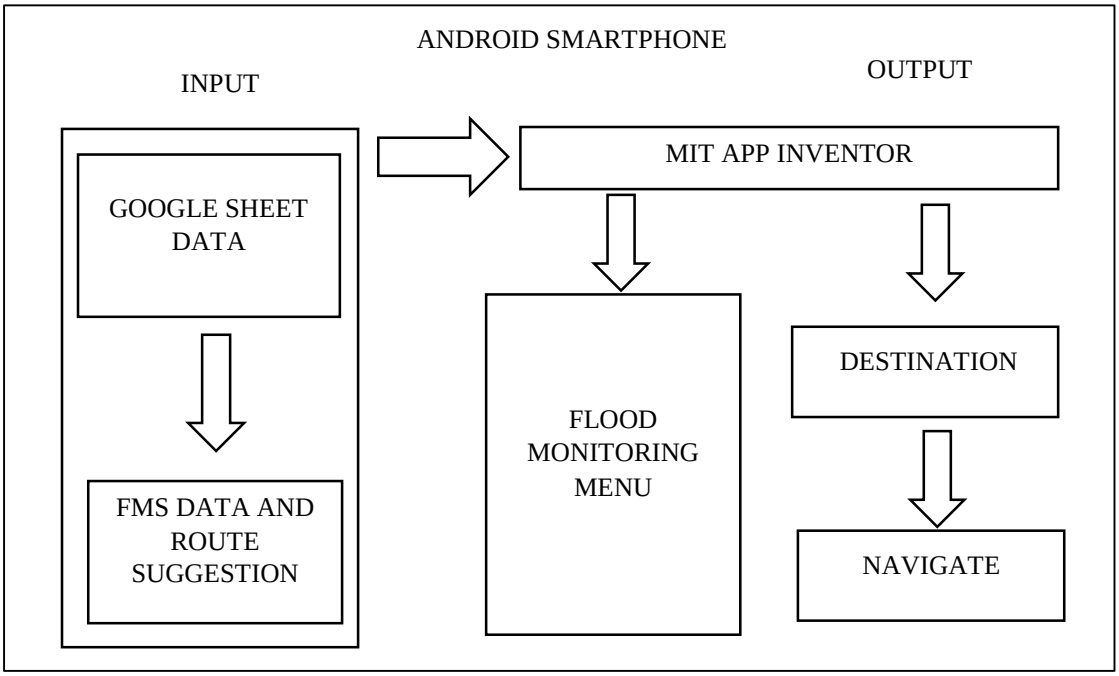

Figure 1: Block diagram of the project

3.3 System Flowchart

The flowchart shown in figure 3.6 describes the working process of the Flood Hotspot Monitoring System and Navigation Application, which starts from initializing global destination to ensure the names of the destination are listed in the application. Next process is to initialize variables for FMS. It is a process of assigning a value to a variable so that it can read the FMS data from google sheet and display on the application. Furthermore, when the user clicks the navigation button, the application will display 'Destination' button and when the user clicks the selected destination, the app will show the destination on the map. On the other hand, after selecting destination, the user can click navigate button to show the route for the selected destination. If the user does not act, no action will be taken and the user will remain on the same screen until the user clicks the button. Thus, when the navigate button is clicked, the application will read the route suggestion data based from the google sheet data. If there is no route available the app will display 'Sorry, destination is not accessible please select different destination.' Thus, if the route is available, the navigation result will be displayed on the map. The application will also display list view on the screen for the user to show directions as a text message. Last but not least, the user can select different destination or exit the navigation page to view the FMS data.

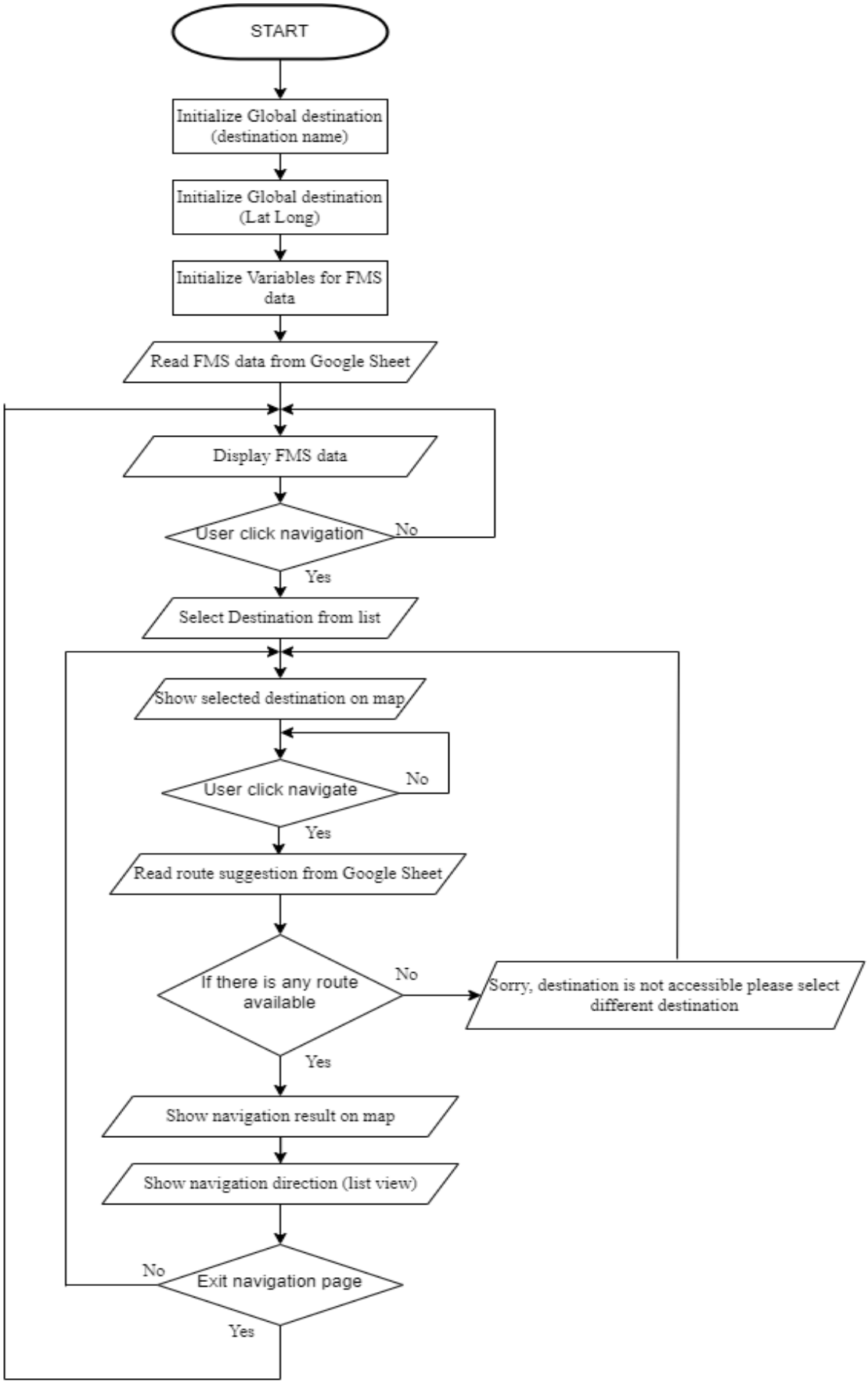

Figure 2: System Flowchart

3.4 Validation of System

To validate the system, some questionnaires are conducted with a number of participants to help develop flood hotspot monitoring system and navigation application in order to validate this study. Moreover, the distributed questionnaire is used from the System Usability Scale (SUS). The most popular survey for gauging user opinions of usability is the System Usability Scale (SUS). It is independent of technology and can be used to assess the system's usability [14]. 10 questions SUS surveys are being distributed for completion. For each testing session, these questions are intended to elicit immediate, unfiltered response from the user and to be swiftly replied with minimal intervention. Utilizing SUS has a number of advantages, one of which is the feedback's dependability and repeatability.

4. Results and Discussion

The implementation and operation of Flood Hotspot Monitoring System and Navigation Application will be illustrated in this chapter. In this section, the actual results of the flood hotspot monitoring system and navigation application are presented in more detail, together with supporting data to confirm the results acquired during the tests.

4.1 Results

Figure 3 displays the result for the monitoring flood. The P14 in the figure defines as nodes selection for point 14. Thus, the application displays the temperature and humidity on the screen which are 23.8 and 86.97, rain status which is 1 and the water level which is 32 for node selection point 14 and for point 1 result that displays 19.4 and 86.96 for temperature and humidity, rain status 1 and the water level is 6 (Flooded). The sensor detects the presence of flood based on the distance from sensor and flood. If the distance from the sensor and flood is below 14cm for the chosen node point it will be labelled as flooded. Thus, this action alerts the user about flood. The analyses of temperature are shown in unit of degree Celsius and humidity is shown in percentage. Regarding the rain status, 1 is defined as 'Yes', meaning it is raining and 0 as 'No' meaning it is not raining. As for water level value is calculated in centimeters. The value of the temperature, humidity, water level and rain status may differ time to time based on the data in the google sheet.

Figure 3: Result of flood monitoring system

Figure 4 shows the result for P16, the application displays the designated location of the destinations on the map so that the user can verify that the chosen destination is accurate. After confirmation, the route suggestion is displayed on the map as seen in figure below upon pressing navigation button. Moreover, the turn-by-turn navigation capability and the map with the node points is also displayed in the application. The application displays the route for the user according to the google sheet data to the destination as tested. Moreover, figure 4 displays the result that has been tested for P1. When the user selects the destination for P1 it shows the selected destination on the map and when the user clicks navigate, the application displays 'Sorry, destination is not accessible please select different destination' as shown in the figure below. This is because the destination is located at the flooded area as you can see the circled area in the map, the circled area indicates that the area is flooded and there is no possible route to reach the selected destination. Based on figure 4 repeated process is tested for P7 to test and to see if the application can propose a different route if the usual one is flooded and the result of the route is displayed on the map. According to the outcome below, the application displayed a different route since the usual route is flooded.

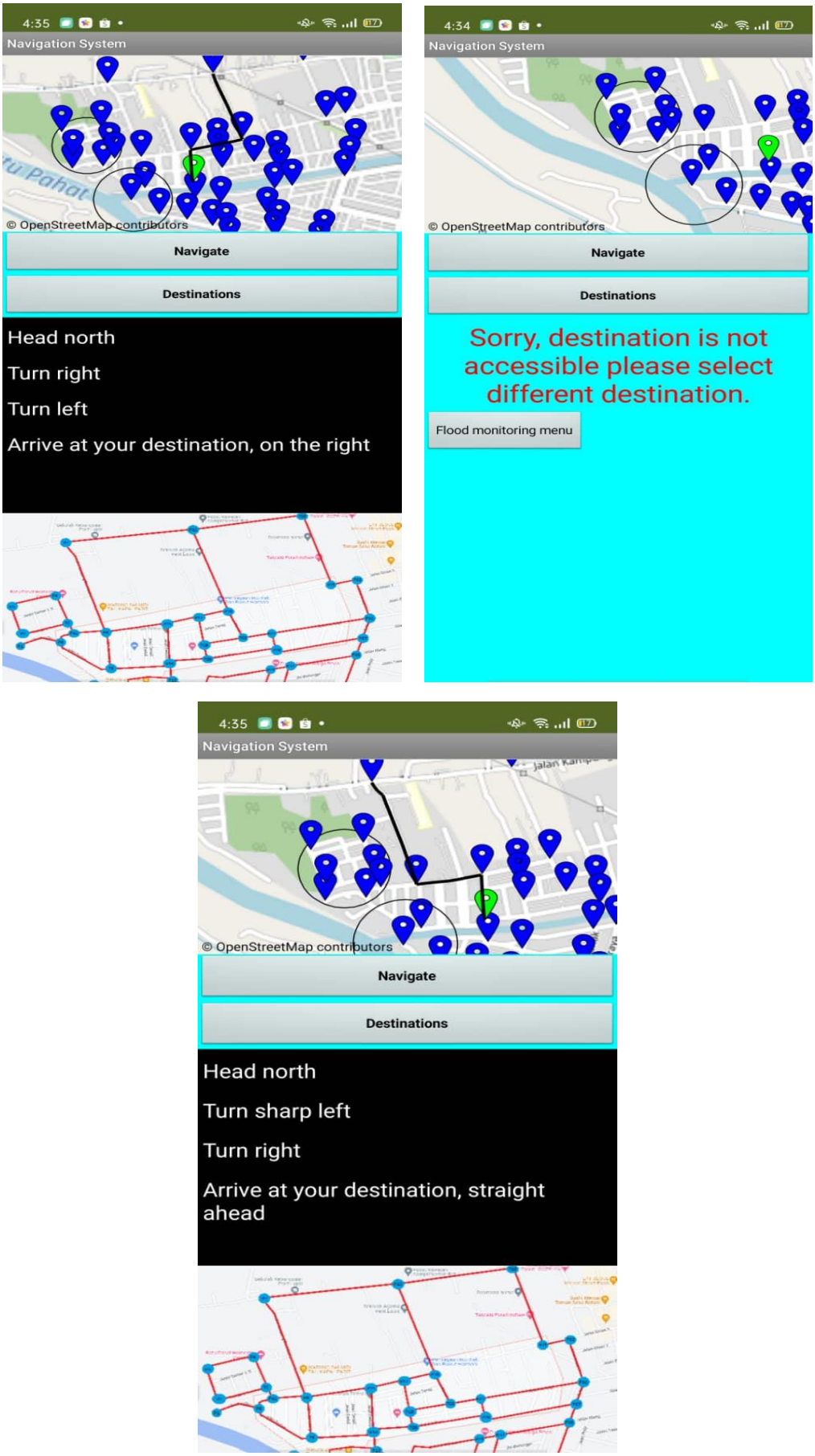

Figure 4: Output Navigation for P16, P1 and P7

4.2 Data analysis

This research has been tested using 3 different destinations to read the route data from google sheet. Based on the table 1 the outcome of route displayed in the application for P7 is same with the outcome route in the google sheet and same distance with 900m. Thus, the app successfully followed the data from the google sheet through the end of the destination. Meanwhile as for P1 the outcome data route by google sheet displayed 0 at the end of the process which means there are no possible route to travel to the destination. The result shown in the application is also same with the data in google sheet. Furthermore, the outcome route for P16 is slightly different between the data route of the google sheet. The route distance calculated for the application is 800m meanwhile the route distance from google sheet calculated is 850m. The application's recommended path is significantly shorter than the google sheet's suggested route data. Thus, this implies that there is a shorter route generated by the API key to the destination because of the limited node placement that does not cover every junction. Better result is anticipated if all junctions are placed and declared with nodes.

Table 2: Performance of application with different destination

No	Destination	Outcome of route by application	Outcome of route by google sheet	Distance (m)	
				Application	Google sheet
1	P7	P14, P15, P8, P7	P14, P15, P8, P7	900	900
2	P1	Sorry, destination is not accessible please select different destination.	P14, 0	0	0
3	P16	P1, P15, P17, P18, P16	P14, P20, P19, P17, P18, P16,0	800	850

Figure 5 displays the respondents SUS rating based on the questionnaire for the Flood Hotspot Monitoring System and Navigation Application. This analysis is performed, to make it simpler to compare ratings for a specific user. As you can see in the figure below, the application average score is 74.5 / 100 and it demonstrates that utilizing the application is acceptable.

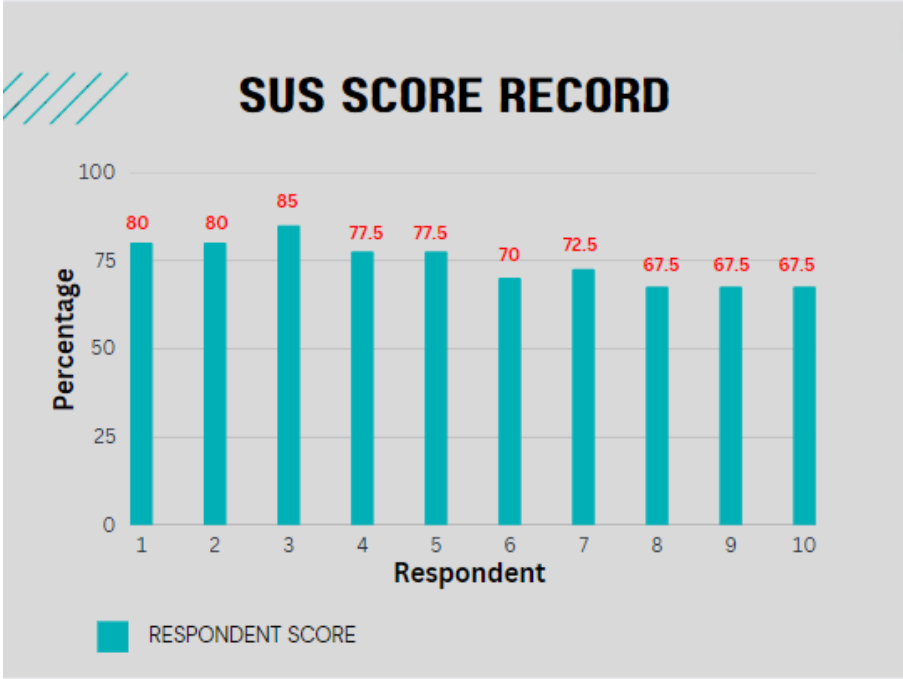

Figure 5: The SUS Score for each respondent

4.4 Discussion

The difficulties of this study are listed based on the data that have been analyzed. The application must be able to handle the Google Sheet's route suggestions well in order to provide identical route suggestion. According to the analysis, the route suggestion provided in the application shows shorter route to the destination than the outcome of the route proposal from the Google Sheet. The route suggested in the application is slightly different from the google sheet. This is because the route suggestion is bound to follow the API key produced from the open route service website.

Thus, the outcome of the result is slightly different from the google sheet. However, testing is made for 3 destinations to perform route suggestion in this application. On top of that, more destinations could be added in this application to show route suggestion but the result of the route suggestion would probably be slightly different from the google sheet.

Conclusion

To sum up, the knowledge and understanding gained from this project will be beneficial for future technological research and development. This work proposed the development of software technology for flood disaster control at Taman Nira Batu Pahat in order to reduce the loss of life and property. This proposed project uses MIT app software to monitor flood and navigate users along a flood-free route to their destination. Thus, the flood hotspot monitoring system and navigation application uses the data that is gathered and stored in the google sheet to operate. However, the route suggestion displayed on the application would be slightly different from google sheet due to the API key because of the limited node placement that does not cover every junction. Better result is anticipated if all junctions are placed and declared with nodes. There are nodes at Taman Nira Batu Pahat to receive the real-time data about flood condition and the data is sent to google sheet. Hence, the software will function as programmed based on the data in the google sheet.

Acknowledgement

The authors would also like to thank the Department of Electrical Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia

References

[1] Arshad, B., Ogie, R., Barthelemy, J., Pradhan, B., Verstaevel, N., & Perez, P. (2019). Computer vision and IoT-based sensors in flood monitoring and mapping: A systematic review. Sensors, 19(22), 5012.

[2] Hapuarachchi, H. A. P., Wang, Q. J., & Pagano, T. C. (2017). A review of advances in flash flood forecasting. Hydrological processes, 25(18), 2771-2784

[3] (2022). Retrieved 17 June 2022, from https://www.nst.com.my/news/2015/09/housing-estates-batu-pahat-hit-flash-floods

[4] Taman Nira Batu Pahat map. (2022). Retrieved 17 June 2022, from https://www.google.com/search?q=batu+pahat+taman+nira&rlz=1C1CHBF_enMY866MY866&oq=bat&aqs=chrome.0.69i59j0i67j69i57j35i39j46i67i131i433j69i60l3.1078j0j7&sourceid=chrome&ie=UTF-8

[5] Hudson, O. (2022). The Methods and Benefits of Flood Monitoring. Retrieved 17 June2022fromhttps://www.azocleantech.com/article.aspx?ArticleID=1476#:~:text=A%20flood%20monitoring%20system%20is,or%20can%20be%20solar%2Dpowered

[6] Asante, K. O., Macuacua, R. D., Artan, G. A., Lietzow, R. W., & Verdin, J. P. (2007). Developing a flood monitoring system from remotely sensed data for the Limpopo basin. IEEE Transactions on Geoscience and Remote Sensing, 45(6), 1709-1714.

[7] Liao, C. F. (2018). Development of a navigation system using smartphone and Bluetooth technologies to help the visually impaired navigate work zones safely.

[8] Stanke, M., & Waack, S. (2015). Gene prediction with a hidden Markov model and a new intron submodel. Bioinformatics, 19(suppl_2), ii215-ii225

[9] Dhanasingaraja, R., Kalaimagal, S., & Muralidharan, G. (2014, March). Autonomous vehicle navigation and mapping system. In Division of Mechatronics, 2014 International Conference on Innovations in Engineering and Technology (Vol. 3, No. 3)

[10] Alipio, M. I., Bayanay, J. R. R., Casantusan, A. O., & Dequeros, A. A. (2017, October). Vehicle traffic and flood monitoring with reroute system using Bayesian networks analysis. In 2017 IEEE 6th Global Conference on Consumer Electronics (GCCE) (pp. 1-5). IEEE.

[11] Patil, S., Pisal, J., Patil, A., Ingavale, S., Ayarekar, P., & Mulla, P. S. (2019). A real time solution to flood monitoring system using IoT and wireless sensor networks. International Research Journal of Engineering and Technology, 6(02), 1807-1811

[12] Component Reference. (2022). Retrieved 17 June 2022, from http://ai2.appinventor.mit.edu/reference/components/

[13] Turbak, F., Sherman, M., Martin, F., Wolber, D., & Pokress, S. C. (2014). Events-first programming in APP inventor. Journal of Computing Sciences in Colleges, 29(6), 81-89.

[14] Brooke, J. (2013) System usability scale (SUS), Usability.gov. Department of Health and Human Services. Available at: https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html (Accessed: January 7, 2023)