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RESEARCH ARTICLE

Automated Rescuing Boat Tracking System Using Raspberry Pi

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ABSTRACT

During floods, safety boats will be dispatched to help flood victims. The location tracking system is important to ensure the safety of the victim. Therefore, this project is conducted to track live locations and monitor flood survivors wirelessly. In tracking the victim's location, a small and compact computer, called a Raspberry Piis installed on the boat and the recorded data has been uploaded online. This will help firefighters to monitor the location of the boat easily and help the victims navigate the boat to a safe place. A safety camera is installed to help firefighters monitor the situation as well. For system validation, various tests are conducted on-road, swimming pool and Panchor river in Muar, Johor, Malaysia. Hence, the performance on road is accurate. In fact, the recorded speed reading is similar to the speed measured by Google Maps. At the Pagoh Higher Education Hub (HPTP), Johor, Malaysia swimming pool, it is observed that, the faster the boat speed, the shorter the time required to complete a 50 meters trip. Finally, the river testing has shown that the boat speed increases when the boat moves in the same direction as the water current and slows down if the boat and river currents move in opposite directions.

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Introduction

In Malaysia, annual northeast monsoon is one of the most challenging seasons especially for northeast state such as Kelantan, Terengganu, Johor and Pahang. During this season, heavy rain will pour down and will cause flood most of the time. In 2018, Pahang had encountered a large number of flood victims. Nearly 12,000 people had to evacuate their homes [1]. This proves that flood's enormous disaster is something that we should not be taken lightly.

As one thing, fast moving flood water will whisk people backwards. Therefore, water from floods may bring waste, chemicals and sewage that can cause injuries, diseases, infections and generally harm health.

Often however, during flood rescue missions, problems arise. In 2015, during the northeast monsoon, 230,000 people had been evacuated from their home at Kelantan, Pahang and Terengganu. At the same time, 21 were reported dead. This issue can be solved if there were sufficient rescue boat to evacuate the victims in time [2]. Sometimes, problems arise among the victims themselves.

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Some of victims were too afraid to leave their home and belongings. These problems affect fire and rescue department and cause trouble during rescue operations.

During the evacuation, the important thing to consider is to ensure all the victims are safe. This can be achieved if we have a good tracking system that can accurately locate the victims on real-time basis. In rescue operation, fire department could possibly dispatch out the rescue boats to increase the possibilities of saving the victims. Natural disasters have a significant impact on human life in terms of life losses and wealth as well. The GPS mounted at the rescue boat can detect the location of rescue boat and upload the collected data inside cloud storage. The fire department will then be able to access the data by going to the cloud. This is one of the benefits of the internet of things (IoT) technology.

A tracking system for detection, monitoring and tracking of survivors under critical condition using raspberry pi was proposed by Vithiya *et al.* [3] and Bindu *et al.* [4]. In their report, they proposed a project on how survivors are traced in remote areas using the raspberry pi system and IOT focusing on constant tracking of safety parameters. In 2015, Shinde *et al.* was developed an advanced vehicle monitoring and tracking system based on raspberry pi [5]. The system is established to detect school vehicle in live time from any location A to location B, and provides the traveler with a safety environment. Next, in 2017, Saha *et al.* [6] proposed a Global Positioning System (GPS) based surveillance robotic system using Raspberry Pi for security application. This GPS system is wirelessly controlled via the web browser and Android apps.

In 2018 a system based advanced communication for disaster management had been created [7]. This system includes a helical antenna for the same ISM frequency spectrum to relay signals up to a distance of 15 km without the aid of any access points or substations. In 2015, Kashmir had undergone a devastating flood incident at river in Jhelum [8]. In order to prevent such incident to happen again, K. V Ashok *et al.* had proposed an integrated weather and flood alerting system using raspberry pi. In 2019, a flood alert system had been created [9]. The system allows users to obtain technical data on monitoring of flooded roads via SMS based services in real time. Next, Sakib *et al.* was developed an intelligent flood monitoring system for Bangladesh using wireless sensor network [10]. The researchers had developed a flood management system based on a neuro-fuzzy controller using a wireless network.

Another application of IoT is a real time tracking and alert system for laptop through implementation of GPS, GSM, motion sensor and cloud services for antitheft purposes [11]. This research shows secure, efficient and inexpensive way to quickly monitor laptop by using GPS application, GSM module, sensors and web services in case of burglary. Kumar *et al.* [12] had utilized the GPS antenna and the new IoT technologies to automatically record an incident, and thus, necessary actions may be taken to reduce possibilities of accident and save human life. This research was based on IoT technology, which utilizes the usage of smart phones and the implementation of sensors into automobiles to provide rapid care and improve safety. Finally, another project had been done to prevent and curb the possibilities of natural disaster. Hence, Jayaram *et al.* [13] had conducted a project to alert response team upon forest fire.

In India, a new flood management has been proposed using Recommendation Based Rescue Operation (RBRO) method [14]. Interestingly, this method utilizing network from the flood victim via cellular, social or internet connection and then verified by local agent for further rescue decision. A team lead by Bajpai *et al.* [15] proposed a special neural-network model to predict the Rajasthan Summer Monsoon Rainfall (RSMR) occurrence, where it help the people to make earlier preparation if the flood will happen soon. This had been done by collected rainfall data from water resources department in particular area of India.

Based on the literature studies, this paper will presents a development of an automated rescuing boat tracking system using Raspberry Pi. The developed system will locate the location of safety boat through Global Positioning System (GPS) and display at the map in web system, which can be use by search and rescue team for monitoring purpose.

Materials and Methods

A thorough software and hardware development have been conducted. The Raspberry Pi has been programmed using Python language to make the system able to locate precisely the location of the boat via GPS locater. The data were then uploaded to the internet by implementing the concept of Internet of Things (IoT), where the data captured is organized to the server and displayed in website. By doing this, the rescue team could monitor the progress of flood victim towards the safe location. To monitor the location and surrounding of safety boat during flood incident, a camera module and Wi-Fi modem have been attached on the boat.

Next step, project testing has been done to ensure the system can run successfully and accurately. The tracking system and camera were tested at different places and various conditions such as on road, in swimming pool and in Panchor River. This is needed to ensure that the system can well adapt and perform efficiently in calm water conditions as well as in the rough conditions. After the project testing, a detailed troubleshooting had been conducted to improve the performance of the system. Figure 1 illustrates the workflow of the whole system.

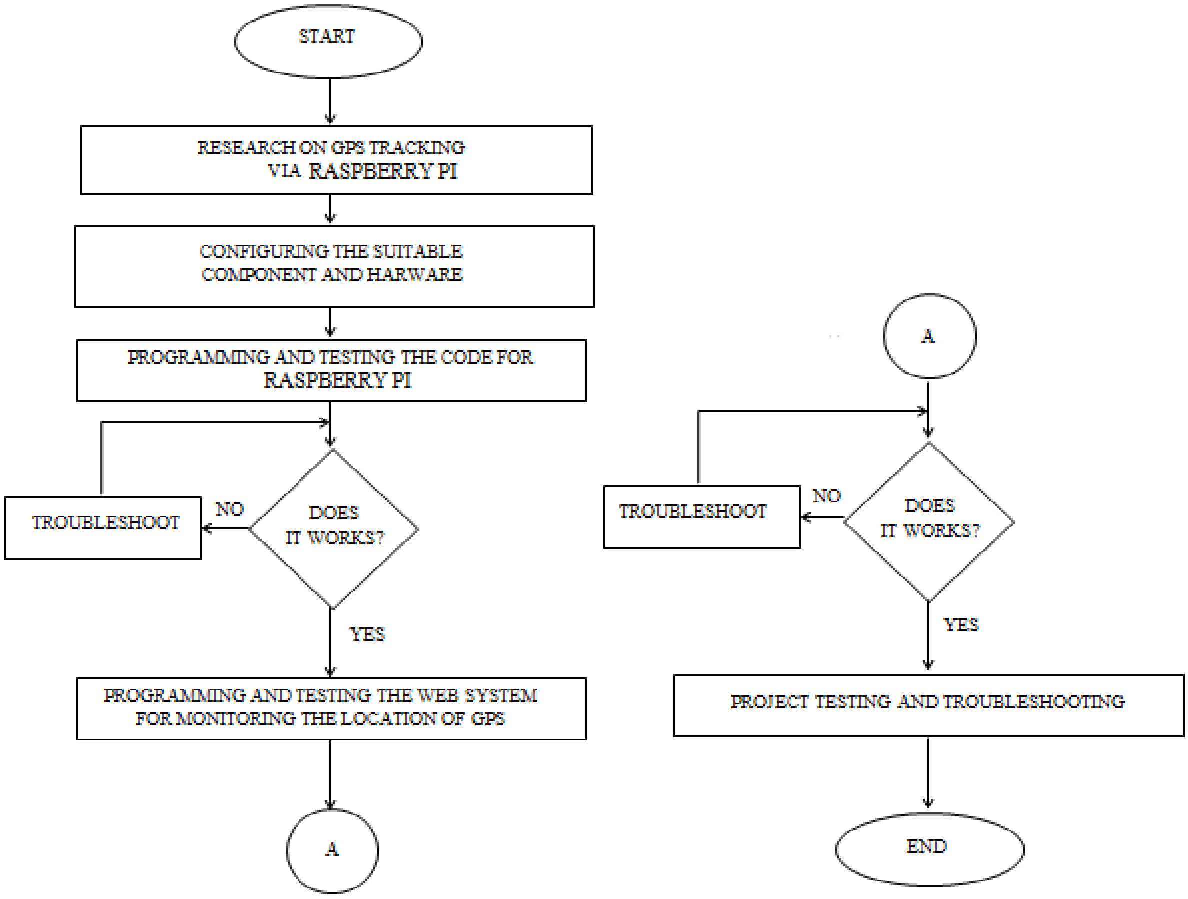

Figure 1. Workflow of the safe boat tracking system

Referring to Figure 1, before working on this project, deep study related to Raspberry Pi system, GPS tracking and implementation of IoT was conducted. Afterwards, the hardware components have been configured. to ensure the system will run without any problem. After the component configuration completed, Python language coding has been programmed and tested at the Raspberry Pi. The program's code was then troubleshoot for any error occurs. Next, web system was developed to enable rescuer to monitor the location of safety boat. The web system was undergone several troubleshooting to make sure of its smooth and exquisite run. After the website has been setup, the Raspberry Pi was connected to the web system via IoT technologies. The full assembled hardware and was then troubleshoot to fix any error.

Figure 2 illustrates the block diagram for the project system. In the block diagram, the raspberry pi function as the main processing unit which is attached with other electronic components. The raspberry pi works as the brain of the system and it is powered by 5V power supply. The raspberry pi will process all the data received from the inputs. The location coordinate, which is one of the input to raspberry pi, comes from the GPS module which receives location signal data from satellite. It will then transfer the signal to the raspberry pi. This is very important process to get the location of the safety boat during floods. The next input mechanism is the camera. The camera attached to the raspberry pi will capture the surrounding data video and send the data to the raspberry pi. Both the input devices connected to the raspberry pi will also receive 5V power supply as the components are connected together with the raspberry pi. These data will then be uploaded to the website via Wi-Fi module through the attached wireless modem. The flood victim on the boat can also monitor the exact live location of their boat via the 5 inch LCD screen attached on the boat. This will help flood survivor to see the direction of the boat while it is moving. For the website system were used the initial state, HTML and several others methods to collect data from raspberry pi and transmit it to the web system.

Table 1 shows the list of main hardware used in developing the tracking system. The components were assembled and connected manually to make sure no misconnection is made. Then, the components have been arranged and setup as in Figure 3. Referring to Figure 3, the location data from satellite firstly will be obtained by the GPS module. Then, the GPS module will deliver the data to the raspberry pi for the next process. Another component connected to the raspberry pi is the camera module. Its main function is to produce live footage output, which could help authorities to monitor the current location of the safety boat. Another output is the LCD screen which is connected via HDMI port to display the current location for the user on boat. Finally, the Wi-Fi module which is the bridge for transferring the data between raspberry pi and the web will help to provide a working internet connection to enable Raspberry Pi to send data to the web.

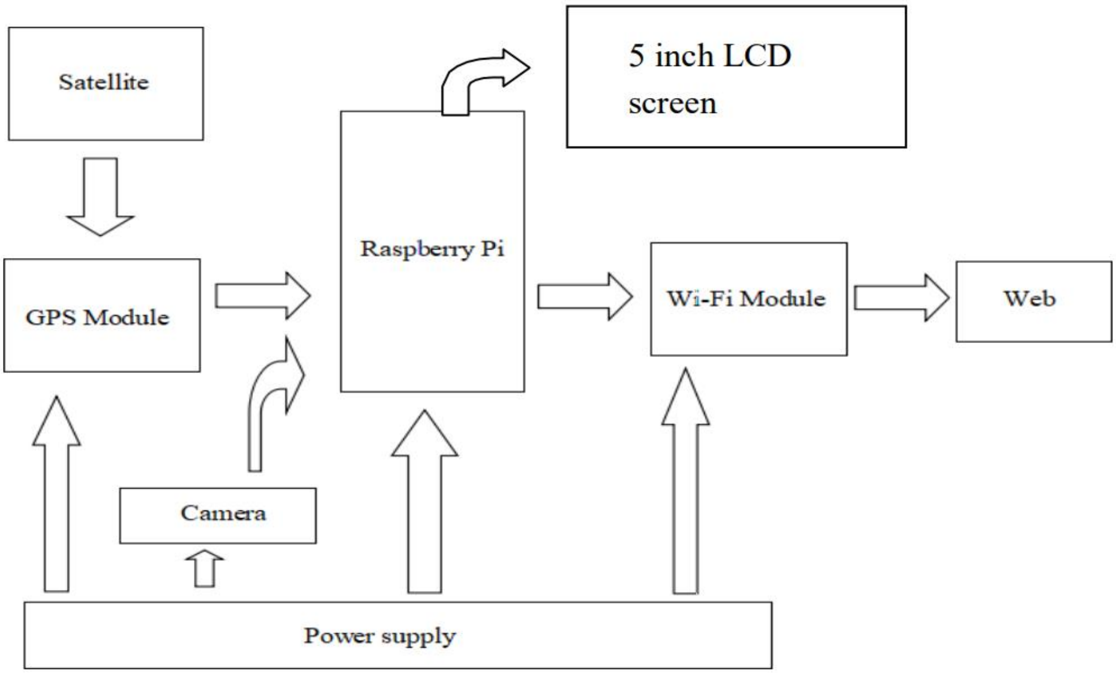

Figure 2. Block Diagram of the safe boat tracking system

Table 1. List of main components used in boat tracking system

No.	Name of components	Quantity
1	Raspberry Pi 3 model B+	1
2	Raspberry Pi camera module	1
3	GPS module	1
4	Wi-Fi module (internet modem)	1
5	5VDC power supply unit	1

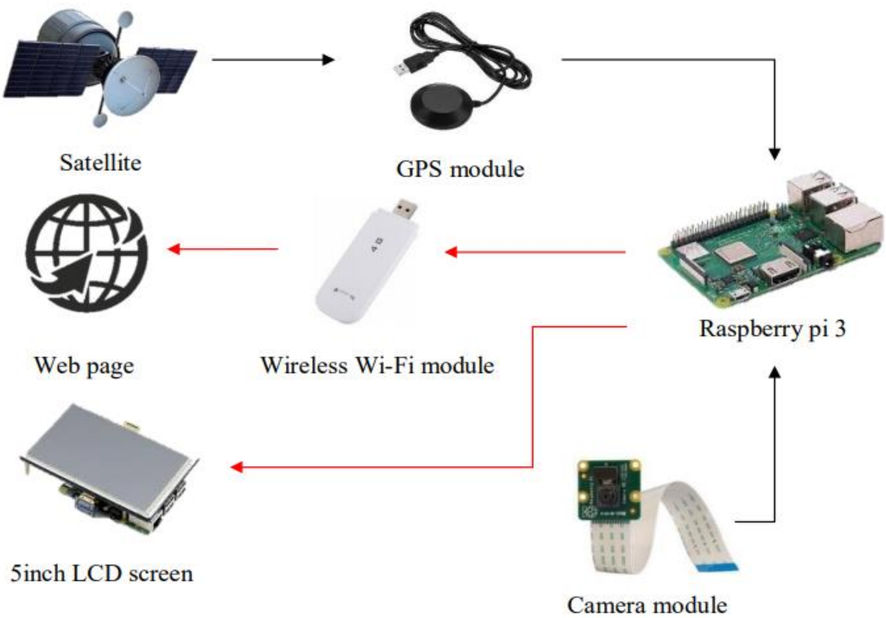

Figure 3. Experimental setup of the project

Results and Discussion

This section discusses the outcome of the project. The main highlights are the outputs that were obtained upon completing the project. It consists of the results from GPS data and the testing of the whole system in different conditions. Table 2 shows the reading of the collected GPS signal. The GPS is placed and kept at the same location but the time measured by the GPS varied with the interval between the next data set to 1 minute. The coordinate results can be seen almost constant and accurate with the error between maximum and minimum values of 0.0000612 and 0.000012166 for latitude and longitude, respectively. The table 2 also shows the altitude value for current location with the error approximately 5 meters. Figure 4 shows the map plotting of the system captured from Initial State website. The purple line in the Figure 4 shows the displacement of the system when moving. The test was conducted at Panchor, Johor. The system moves at the average speed of 50km/h on road by car. The altitude, current coordinate and safe location coordinate are also displayed at the Initial State website.

The tracking system has been tested in several conditions and for various performances. The first condition is 3km trip from SK Kota Raja, Panchor to safe point (UTHM Campus). Then, the system had been tested at Panchor River where the boat needed, firstly, to move against the water current and secondly, to follow the water current. Finally, the Automated Rescuing Boat Tracking System Using Raspberry Pi had been tested at HPTP swimming pool with different speeds for 50 m run. During on road testing, the straight road without junction and traffic light was used. Based on the recorded data, the time taken to cover 3 km from the starting location to the safe location is 223 s for the speed 50 km/hr and 156 s for the speed of 70 km/hr. Figure 5 shows the initial state plotting of the system during the test. Figure 6 shows the speed in kilometer per hour against the time consume to reach to the safe location.

Next, the system performance had been compared for two different conditions of the road and the time taken to reach to the safe location for both conditions were evaluated. Base on the collected data, the time taken to reach 3 km distance from starting location to the safe location is 190.1 s for the straight-line road and 205.4 s for normal road with junction. The drop in speed on normal road conditions is due to traffic light and junctions as the car will reduce its speed at junctions or completely stop at traffic light. Figure 5 shows the straight-line road plot on initial state and figure 7 shows the road with junction and traffic light. Figure 8 shows the speed against time consumed to reach safe location for different road conditions.

Table 2. Coordinate result of the GPS at Initial State

Date	Time	Latitude	Longitude	Altitude
2020-07-10	07:38:45	5.5488975°	100.485800167°	5.3m
2020-07-10	07:39:45	5.5488667°	100.485801333°	6.0m
2020-07-10	07:40:45	5.5488333°	100.485797167°	6.2m
2020-07-10	07:41:45	5.5486667°	100.485791667°	5.9m
2020-07-10	07:42:45	5.5488433°	100.485792333°	6.0m
2020-07-10	07:43:45	5.5488945°	100.485803833°	6.1m
2020-07-10	07:44:45	5.5488937°	100.485791833°	5.5m

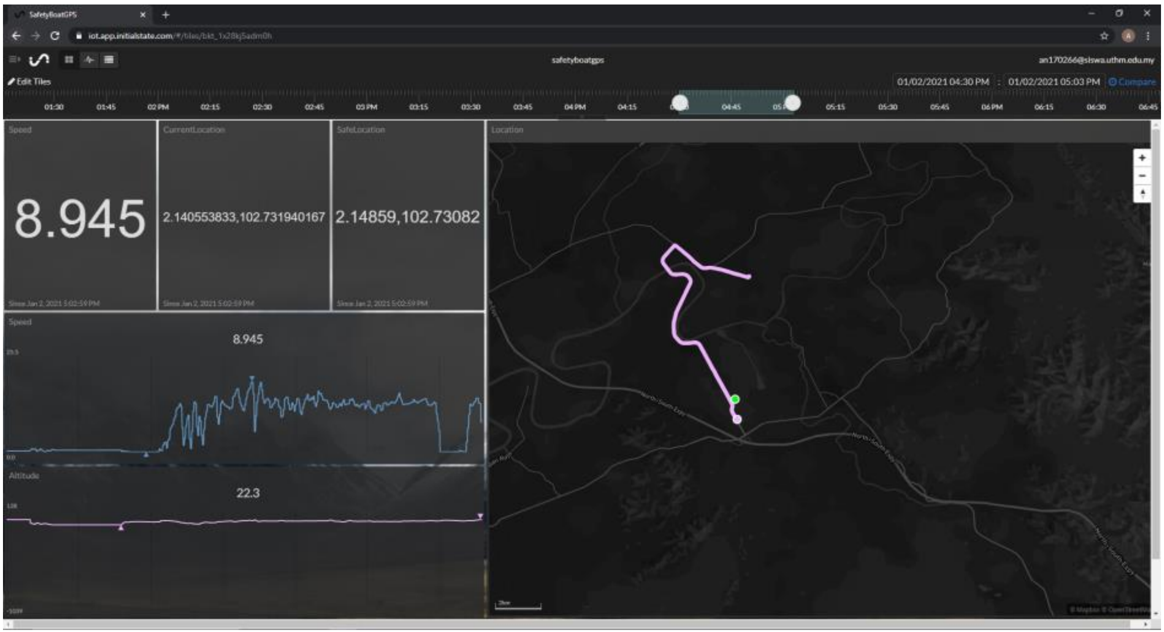

Figure 4. Map plotting of the system

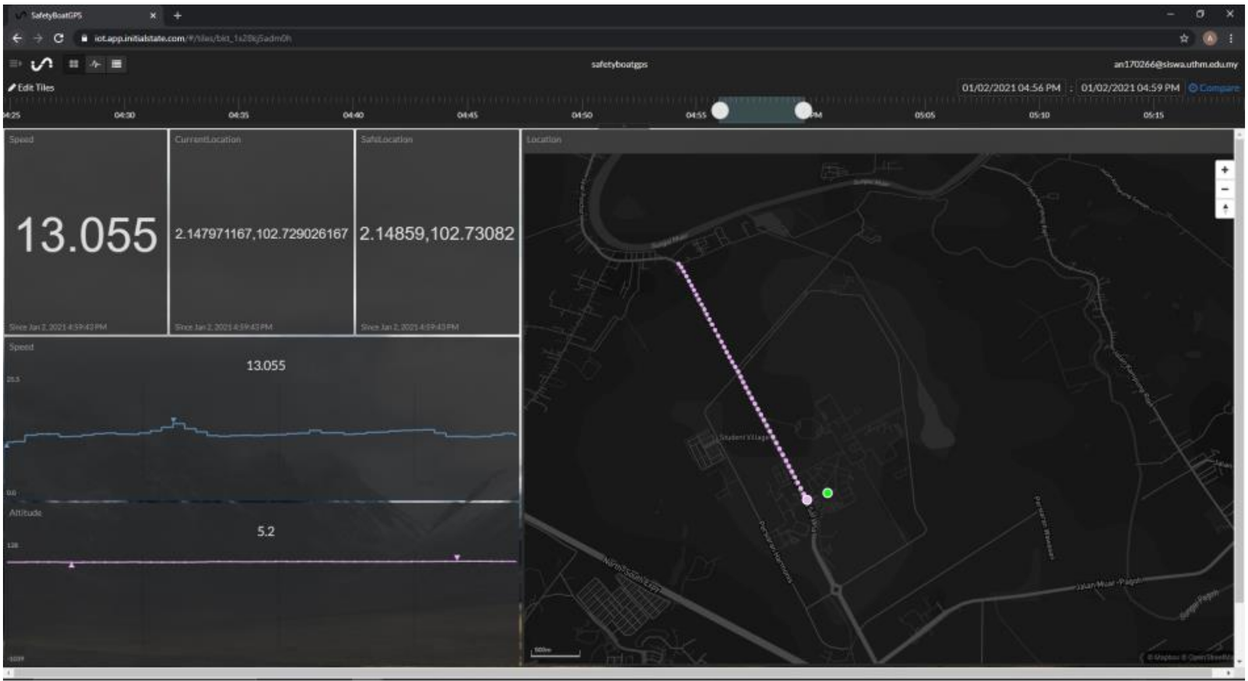

Figure 5. The initial state plotting of the system during the test on straight line road

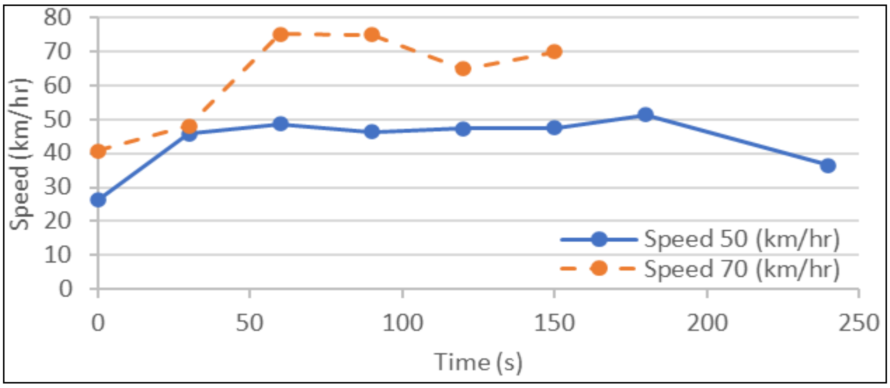

Figure 6. Speed in m/s against the time consume to reach the safe location

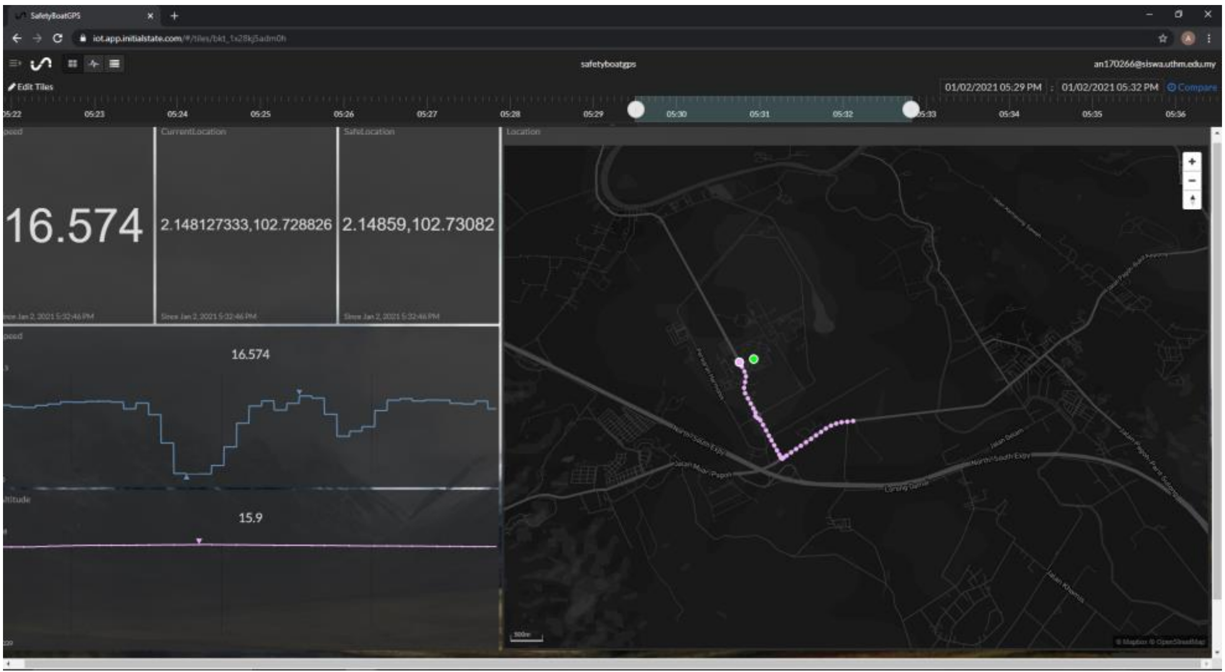

Figure 7. Road with traffic light and junction plot on initial state

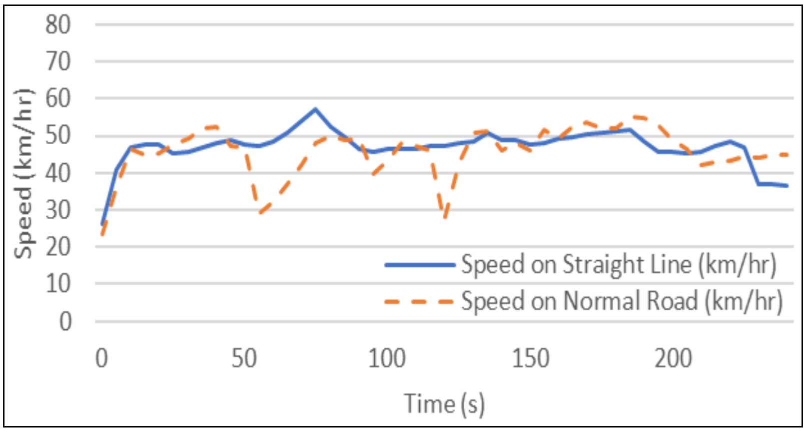

Figure 8. Speed against time consume to reach safe location at different road condition

After the completion of the tracking performance on road, the system has been tested in HPTP swimming pool with various speeds of the boat which are normal speed and faster speed. This test has been conducted to evaluate the performance of the motor boat when the condition is ideal, means no disturbance from water current. Table 3 shows the data recorded which is the time taken to complete a trip of 50meters and average speed of the boat in swimming pool condition. Figure 9 shows the boat speed against time consumed to reach safe location at different boat speed.

Table 3. The time taken to complete a trip of 50m and average speed of the boat

Trip	Time Taken (s)	Average Speed (km/hr)
Normal Speed	90	2.05
Faster Speed	69	4.22

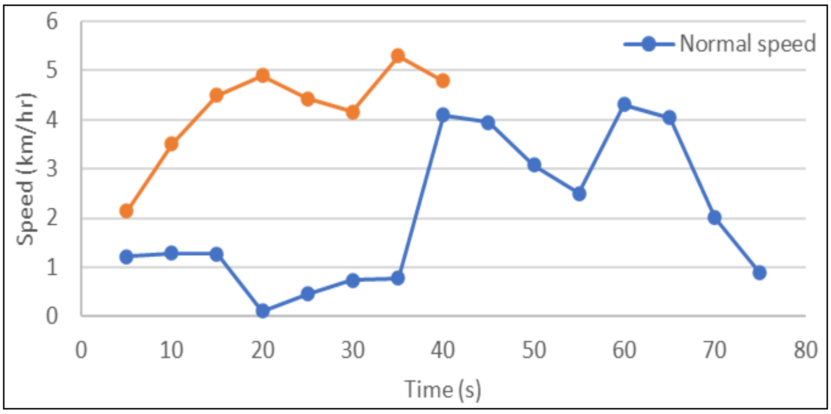

Figure 9. Speed against time consume to reach safe location at different boat speed

Finally, after completing the measurement in HPTP swimming pool, the tracking system is tested in Panchor River. In Panchor River, there are two conditions under which the system had been tested: when the boat go against the river water flow and when it goes along the river water flow. Both trip distance is kept constant at 350 meters. The boat's speed is also kept constant. Based on the measurements done, the time taken to reach safe location with various water conditions at Panchor River is 562 seconds for the condition of against river water flow and 274 seconds for following river water flow. Both water conditions show how that the water flow direction affects the speed of the boat. The time taken for both conditions differ hugely. Thus, the time taken when following water flow direction is nearly half the time taken when the boat goes against the water flow direction. For instance, when the boat follows the water flow direction, the speed recorded is 1.6 times greater than the speed when the boat is against the water flow direction.

Figure 10 shows that the testing is conducted in Panchor river and Figure 11 shows the speed against time consumed to reach safe location at different water condition at Panchor River. Table 4 shows the results of speed against time consumed to reach safe location for different water conditions at Panchor River.

Figure 10. The testing is conducted in Panchor river

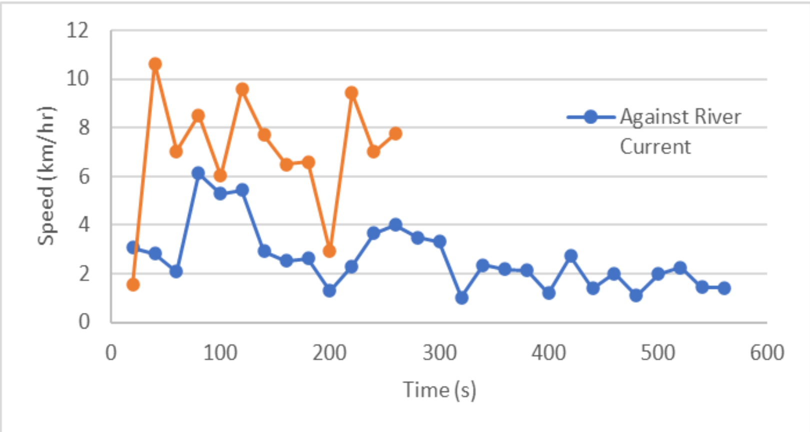

Figure 11. Speed against time consume to reach safe location at different water condition at Panchor River

Table 4. Speed against time consume to reach safe location at different water condition at Panchor River

Water Condition	Time Taken (s)	Average Speed (km/hr)
Against River Current	562	2.65
Following River Current	274	7.02

Before conclusion, the author did analyse all the collected data to evaluate the performance of the safety boat system in clearer view. Table 5 shows the comparison of average speed for different condition in water. The fastest average speed occurs when user follows river water flow direction with the faster speed of the motor. The table also shows that faster boat motor mode could produce double speed and complete 50m trip at HPTP swimming pool in half of the time taken by the boat when using the normal speed. In river condition where the boat goes against the river water flow direction, the average speed is reduced to nearly half compared to the condition where there is no water. Fastest speed occurs when the boat following the river water flow direction. More than 1.6 average speed compared to the condition where there is no water. It had also been noticed that from all conducted experiments, the location given by GPS presents some inaccuracy. It could obviously be seen during the testing in swimming pool, where the system moves in straight line, but the GPS showed some misplaced of the current location. This situation is still acceptable as the distance of the inaccuracy location is less than 4 meter. In fact, in real situation, a normal person within this distance should be able to see the victim in front of him.

Table 5. Comparison of the data collected

Condition	Average Speed (km/hr)
Normal speed at swimming pool (no current)	2.05
Faster speed at swimming pool (no current)	4.22
Faster speed against river current	2.65
Faster speed following river current	7.02

Conclusion

As conclusion the automated tracking system for the safety boat has successfully performed its task of providing current location of the boat and footage of the current view in front of the boat to authorized person through website. The system is very interactive with its user-friendly interface and easy to understand. Furthermore, it keeps updating the location of the boat in every 5 seconds. The boat also can increase its speed to shorten time taken to reach safe point if it follows the river water flow direction. This project has achieved its objectives successfully. Some suggestions for improvement in future are improving a user-friendly interface application at the raspberry pi to display the data for flood survivors location tracking and providing a mounting system on the safety boat to place the raspberry pi.

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