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Optimizing the Personnel Position Monitoring System Using the Global Positioning System in Hostage Release

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Abstract— In the contemporary era of globalization, maintaining public order depends on strong security measures. Addressing security challenges, particularly in hostage release scenarios, requires rapid and appropriate responses, highlighting the need for efficient personnel deployment. This research proposes an advanced solution using a GPS Tracking System which uses a sequential method by utilizing digital photos from GPS satellites to monitor the movement of individuals and objects. Specifically applied to the Sandra rescue mission, our research uses the NodeMCU ESP8266 component, which integrates GPS and Wi-Fi functions while considering wind direction. Tests performed demonstrated an impressive success rate of 98.6%, demonstrating the effectiveness of our real-time personnel positioning approach.
Keywords— Distance Monitoring; GPS Tracking System; Blynk

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I. INTRODUCTION

Hostage rescue is an emergency that requires a rapid and coordinated response [1]. Real-time detection and monitoring of the position of rescue personnel has a central role[2]. Amid an emergency such as a natural disaster or rescue incident, timeliness and accuracy of information regarding the location of rescue team members can make the real difference between safety and danger, between life and death [3]. However, in its implementation, the upper command has limitations in monitoring and supervising location personnel sent to the field[4]. So, we need a system that can monitor the position and location of these personnel [5], [6]. IoT technology plays a significant role in providing effective and efficient solutions. Through the implementation of IoT-based NodeMCU ESP8266 technology, which enables wireless connections to the internet, this research aims to optimize personnel position monitoring strategies in hostage rescue missions [7], [8]. NodeMCU ESP8266 is a popular and versatile microcontroller module based on the ESP8266 chip. This module is specially designed for IoT (Internet of Things) projects and can connect to the internet via Wi-Fi [9], [10]. The NodeMCU ESP8266 can control various electronic devices, retrieve data from several sensors, and communicate via a Wi-Fi network with servers or other devices [11], [12] .

IoT (Internet of Things) tasks include the development, implementation and management of systems that connect various physical devices to the internet to exchange data and carry out functions automatically [13]. This involves designing and setting up sensors to collect data from the physical environment, programming microcontroller devices or IoT modules to process that data, and developing applications or platforms to monitor and control devices remotely [14]. These tasks include data analysis, network security, and overall system maintenance, ensuring IoT(Internet of Things) devices operate efficiently, safely, and reliably [7]. GPS primarily provides precise location information, essential in various applications, including vehicle navigation, scientific research, mapping, weather monitoring, and military security[15] . With its ability to provide accurate geographic coordinates in real time, GPS is also used in related technologies such as smartphones, tracking devices, and security applications. It allows people to determine their position on the earth and access various location-based services [16].

In this research, the NodeMCU ESP8266, which is a microcontroller module based on the ESP8266 chip, is used as the core of the system that allows internet connections via Wi-Fi [9]. The ESP8266 NodeMCU module links IoT (Internet of Things) devices and servers, enabling real-time data exchange and control [17]. In addition, GPS (Global Positioning System) is also integrated into the system to monitor the position of rescue personnel accurately [18]. With GPS, personnel positions can be tracked precisely on the map, facilitating coordination and quick

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emergency decision-making [19]. The combination of NodeMCU ESP8266 and GPS optimization with sequential methods in the context of IoT provides an effective and innovative solution to increase the success of rescue operations by ensuring real-time and accurate monitoring of personnel positions[20], [21], [22].

II. RESEARCH METHOD

Creating a personnel position monitoring system is the main emphasis of the experimental research methodology being used. This entails creating a system architecture combining several sensors' information [19]. The creation of data processing algorithms enables the actual application of the system in hostage release simulations and real-time tracking of employee positions [23]. System testing is done after design to assess the outcome. System analysts ensure that research objectives are met by documenting and evaluating test outcomes[24] . Research Method Flowchart is shown in Figure 1.

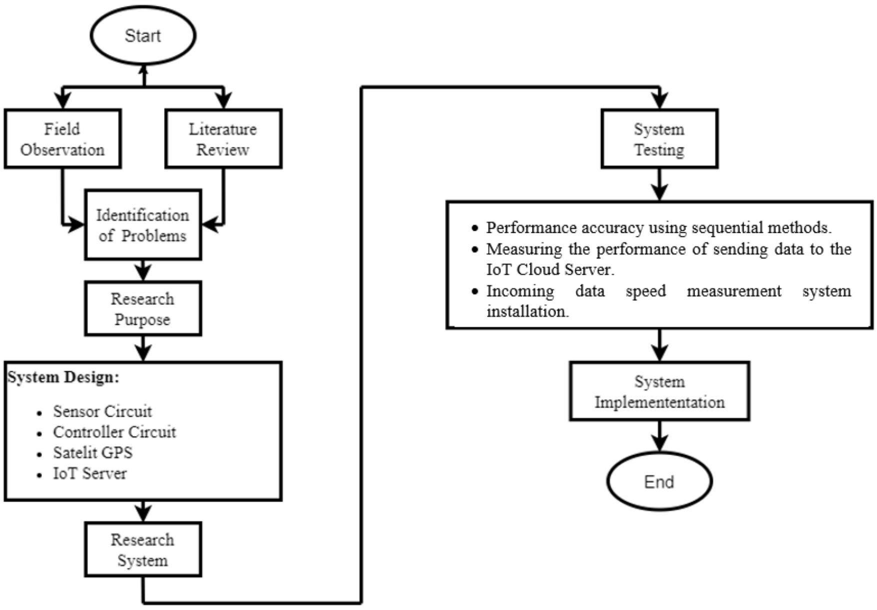

Fig 1. Research Method Flowchart

Several stages of this research process are depicted in Figure 1 above. The first step in this process is to search several journals to find relevant material, ideas from previous research, and site observations [25]. Next, the problem is identified, the system is created, tested, and implemented, data is collected, and data analysis is performed [20].

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Previous research and technical ideas related to the system problem will be studied and examined during the literature stage to understand the connected concepts and technologies [1]. The system will be tested at the system testing stage to ensure all parts function according to requirements and standards. The system will be evaluated to measure GPS performance and ensure that it can determine location accurately at the GPS Performance Measurement stage using a sequential method [26].

Next, an assessment will be carried out to measure server network performance in the Cloud Server Performance Measurement step to ensure the system can function as it should. The system will be practiced and integrated directly at the System Implementation stage to provide training. Furthermore, analyzing the data collected during the personnel position monitoring training in hostage release is the final step before everything is finished [1].

A. Tool System Design.

Three major components make up this system block diagram: input (input), process (process), and output (output/result). Receiving data that will be sent to the processing unit for additional processing is the responsibility of the input block. The system's central component, the process section, serves as a tool for interpreting and carrying out program commands in response to input. The output block is in charge of creating the processing process's output in the interim[27]. The tool block diagram is shown in Figure 2 for visual aids.

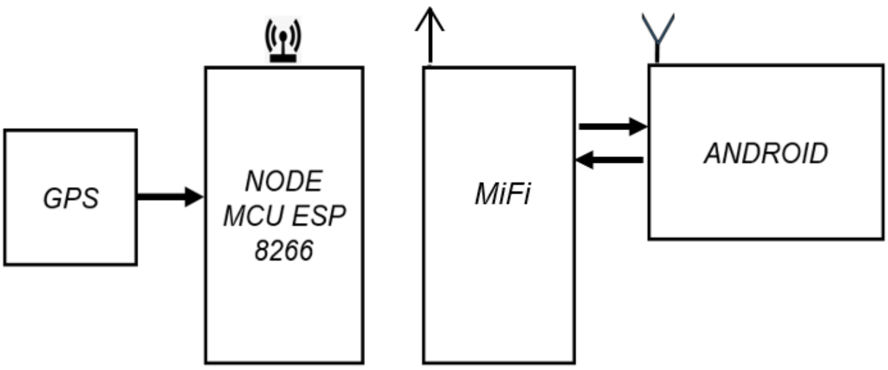

Fig 2. Tool Block Diagram

A GPS (Global Positioning System) module and an ESP 8266 MOD Node MCU module are used as the sending device in the design of the data-sending circuit. A periodic antenna receives the data the transmitting device emits and streams it to the MiFi module, which acts as a receiving device [9]. After processing the data, The recipient receives it, processes it, and shows the pertinent information on the monitor, in this case, an Android smartphone [28]. This sophisticated module makes the data distribution system more responsive and efficient in delivering real-time global position data. The overall system is shown in Figure 3.

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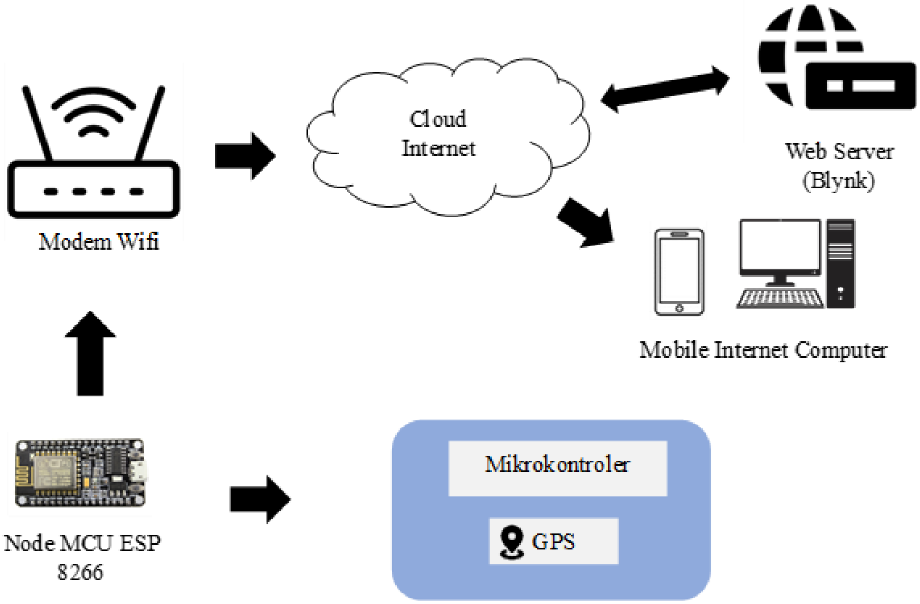

Fig 3. Overall system

Figure 3. The device system's process, which makes use of a microcontroller and GPS, is depicted in the flowchart. This system has multiple primary parts, including an internet connection, a GPS, and a microcontroller. A microcontroller linked to the internet is the first step in the process. Data from the internet is received by the microcontroller, which processes it [5], [29]. Following processing, the microcontroller transmits the data to the GPS to determine the device's location. Following the microcontroller's data transmission, GPS generates location-related information for the device [30]. The microcontroller sends data to the server, Blynk, using location data, among other essential tasks. The microcontroller, GPS, and internet connection are only a few parts connected to it in the diagram. Together, these parts provide precise position data and carry out required tasks [28], [31]. GPS and Wi-Fi process flow detects location shown in Figure 4.

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Fig 4. GPS and Wi-Fi process flow detects location

Figure 4 shows how the GPS and Wi-Fi systems interact to locate the hostage. The flowchart includes several stages, from reading the hostage's location to sending data messages to the GPS activation and deactivation system. GPS and Wi-Fi systems connect and read the hostage's location by locating the hostage using the received GPS and Wi-Fi data. Once the hostage location is found, the system sends a message to Blynk to track the path of the hostage location. If the mission is complete, the system stops the GPS. This diagram shows how the GPS and Wi-Fi systems work together to locate the hostage and stop the GPS by sending a message to Blynk. GPS control process flow is shown in Figure 5.

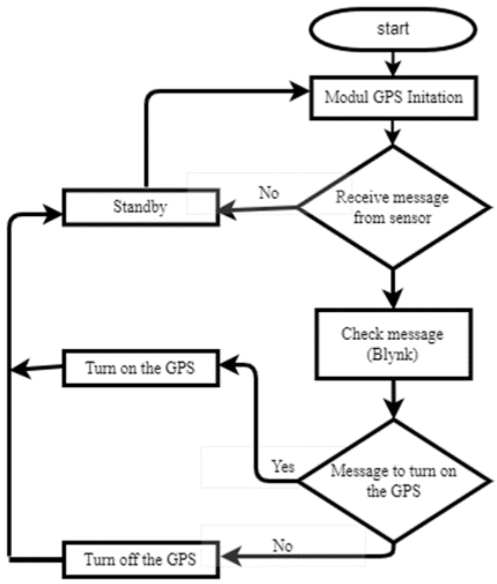

Fig 5. GPS Control Process Flow

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Figure 5 shows the process for sending messages via GPS. The process begins by activating GPS and sending a message to Blynk via the GPS module. After the message is sent, the message will be received by the recipient and can be known through messages that come to Blynk.

B. Tool Design.

Researchers carefully create detailed mechanical and schematic tool designs at this design stage. This design is like a photo or drawing that clearly explains the shape of the device to be made. All circuit parts are placed on the right side of the telescope and then covered so they cannot be seen. These designs use easy-to-understand images, such as sketches or models, which aid communication between researchers and tool makers[21], [30]. Details of the circuit placement can be seen clearly in Figure 6.

Fig 6. Design the Placement of the Entire Circuit

In designing the tool, the components used include the Node MCU ESP 8266 MOD module, the Ublox Neo-6M GPS Sensor, and a voltage source from the battery. The schematic of the entire design series can be observed in detail in Figure 7.

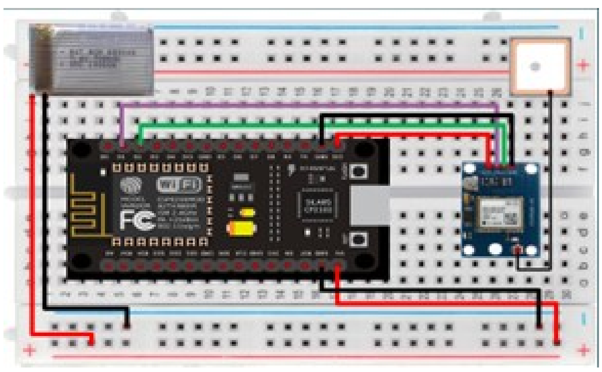

Fig 7. Overall network design

In designing the relationship between the ESP 8266 MOD Node MCU Module and the Ublox Neo-6M GPS Module, the connection between the two pins is as follows [20]. The Vcc pin on the Ublox Neo-6M GPS Module is connected to the 3.3 Volt pin on the ESP 8266 MOD Node MCU Module, which a red cable can identify. The red line is connected to the battery to obtain a voltage source. Next, the ground pin on the Ublox Neo-6M GPS Module is connected to the GND pin on the ESP 8266 MOD Node MCU Module, which is indicated by a black cable. The RX pin on the

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Ublox Neo-6M GPS Module is connected to the D1 pin on the ESP 8266 MOD Node MCU Module using a purple line. Finally, the TX pin on the Ublox Neo-6M GPS Module is connected to pin D2 on the ESP 8266 MOD Node MCU Module via a green cable.

C. Software Design.

We are designing applications that can be integrated synergistically with hardware. Thus, both can operate according to the plans and designs that have been made. The appearance design of the Blynk application chosen by the designer can be observed in detail in Figure 8.

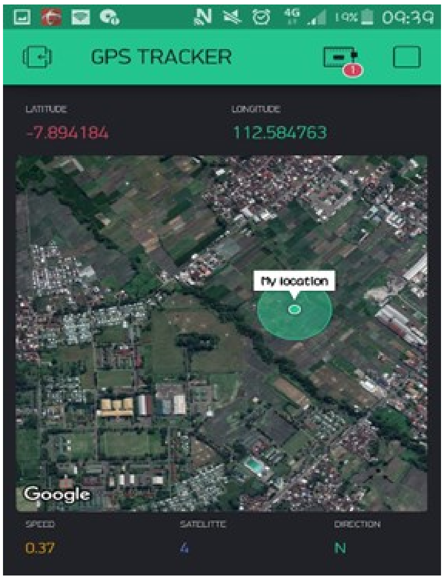

Fig 8. Monitoring Display Design Using the Blynk Application

In this configuration, virtual pin one is connected to latitude data, while virtual pin two is connected to longitude data. Virtual pin three is paired with speed data, while virtual pin four is related to information on the number of satellites received from GPS. Next, virtual pin five is connected to direction data. The V0 input pin is connected to the GPS map visualization component, while the GP14 output pin is connected to the LED as a visual indicator. With this setting, the system can provide information on geographic position (Latitude and Longitude), speed, number of satellites used, and direction. LED indicators provide clear visualization to facilitate the interpretation of data received from GPS. A flowchart is a graphical representation that shows the steps in a process. In initiating this system, data from GPS coordinates is accessed. The NodeMCU ESP8266 microcontroller module reads and transmits GPS coordinates. The data is sent to MiFi and processed for display on the Android device if valid coordinates are received. Otherwise, the system will continue to reread until valid data is obtained. The system is initialized to obtain coordinate data from GPS at the sender. The NodeMCU ESP8266 microcontroller module reads and transmits coordinate data. If valid, MiFi receives and processes data for the Android display. Otherwise, the system continues to reread until valid data is received.

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III. RESULT AND DISCUSSION

In this research, Wi-Fi signal strength testing, GPS cardinal position testing, and accuracy level testing show that this system can maintain strong Wi-Fi signal quality, provide high precision in determining personnel positions via GPS, and achieve high accuracy [32]. The high level of accuracy is optimal in monitoring and recording personnel movements in real-time, validating the system's effectiveness in providing reliable and accurate data for safe and efficient rescue operation[12]. RSRP (Reference Signal Received Power) standardization measures the signal strength received by devices on a cellular network, which is essential in assessing connection quality and network performance[18].

Table 1. Standardization of RSRP (Reference Signal Received Power) [27]

Signal Strength	Color code	Mark *RSRP*(dBm)
Very good		RSRP < - 80
Good		- 81 until -90
Pretty good		-91 until -100
Enough		-101 until -105
Bad enough		-106 until -110
Bad		-111 until -115
Very bad		-116 until -120
No signal		RSPP > -121

Wi-Fi signal strength testing is carried out to determine the strength and stability of the Wi-Fi signal, which is needed to find out and reach the GPS (Global Position System) module (table 1). This test uses the Wi-Fi Analyzer Application and the Mi-Fi module[33].

Table 2. Wi-Fi Signal Strength Distance Testing Results

No	Location	Distance (M)	Strong Signal (Dbm)	Information
1	Klinik Pusdik Arhanud	387	-68	Very good
2	Patung Pusdik Arhanud	610	-74	Very good
3	Simpang Lampu Merah	937	-78	Very good
4	Optik Darma Pendem	1110	-82	Good
5	Tandon Air Bangkon	1190	-74	Very good
6	Polindes Pendem	1290	-76	Very good
7	Masjid Ds.Dawuhan	2000	-82	Pretty good
8	Tpu.Gondang	3090	-86	Pretty good
9	Indomart Pintu 2 Umm	3400	-100	Enough
10	Rusunawa 1 Umm	36200	-100	Enough

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Table 2 shows the results of testing distance and Wi-Fi signal strength in various locations, measuring distance in meters (M) and signal strength in decibel milliwatts (dBm). In the test results, the higher the dBm value, the more muscular the Wi-Fi signal strength. Based on the table, the locations of Pusdik Arhanud Clinic, Pusdik Arhanud Statue, Simpang Lampu Merah, Optik Darma Pendem, Tandon Air Bangkon, and Polindes Pendem show excellent signal strength, with dBm values ranging from -68 to -82 dBm. The locations of Ds.Dawuhan Mosque, Tpu.Gondang, Indomart Pintu 2 UMM, and Rusunawa 1 UMM show quite a good signal strength, with dBm values ranging from -82 to -100 dBm. Next, a directional position test was carried out using a GPS (Global Positioning System) compass, which aims to ensure whether the GPS compass is functioning correctly or not so that it can provide precise information regarding the cardinal directions.

Table 3. Results of Testing The Position of the Cardinal Directions

No	Indonesian	Sing	Inggris	Sing	Derajat
1	Utara	U	North	N	0’ / 360’
2	Utara Timur Laut	UTL	North Northeast	NNE	22.5’
3	Timur Laut	TL	Northeast	NE	45’
4	Timur Timur Laut	TTL	East Northeast	ENE	67.5’
5	Timur	T	East	E	90’
6	Timur Menenggara	TM	East Southest	ESE	112.5’
7	Tengara	TG	Southest	SE	135’
8	Selatan Menengara	SM	South Southest	SSE	157.5’
9	Selatan	S	South	S	180’
10	Selatan Barat Daya	SBD	South Southwest	SSW	202.5’
11	Barat Daya	BD	Southwest	SW	225’
12	Barat Barat Daya	BBD	West Southwest	WSW	247.5’
13	Barat	B	West	W	270’’
14	Barat Barat Laut	BBL	West Northeast	WNW	292’
15	Barat Laut	BL	Northwest	NW	315’
16	Utara Barat laut	UBL	North Northwest	NNW	337’

Table 3 shows the results of testing the position of the cardinal directions expressed in various languages (Indonesian and English) and degrees. Each cardinal direction position is represented in a characteristic abbreviation (such as UTL for North Northeast, NE for Northeast, etc.) and a range of degrees corresponding to that direction. By utilizing this table, the IoT system using NodeMCU ESP8266 can accurately identify and record the position of personnel in Sandra's rescue based on cardinal directions. Testing the speed of the device using the Ublox Neo 6M GPS was compared with the Garmin 64s GPS as standard. The aim is to evaluate the speed results of the GPS (Global Positioning System) series of tools and ensure whether the tools

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function correctly. This testing is necessary to ensure optimal performance of the GPS, ensuring the device can provide speed data accurately and consistently. Paragraph and Headings. The body text should be in 10-point Times New Roman, with the paragraphs justified on both left and right margins. The first line of a paragraph is indented to 0.63 cm. Within the main body of the paper, up to 3 levels of headings can be used. The level 4 subheading is not recommended but can still be accepted. The following guidelines show you how to use different types of headings.

Table 4. Tool Speed Test Results

Test To	Speed Garmin Km/H	Speed Gps Km/H	Percentage Difference %
1	10	10.30	3
2	15	15.11	0.7
3	20	20.28	1.4
4	25	25.37	1.48
5	30	30.89	2.96
6	35	35.5	1.42
7	40	40.22	0.55
8	45	45.69	1.53
9	50	50.15	0.3
10	55	55.65	1.1

Table 4 shows the speed test carried out ten times with the average error calculated by adding up all the error results obtained in the test. Next, the sum of the errors is divided by the number of trials to get the overall average error.

$$Average\ Error = \frac{Test\ 1 + Test\ 2 + \cdots + Test\ 10}{Total\ Test - 1} \times 100\ \% \qquad (1)$$

$$= \frac{3 + 0.7 + 1.4 + 1.48 + 2.96 + 1.42 + 0.55 + 1.53 + 0.3 + 1.1}{10 - 1} \times 100\ \%$$

$$= 1{,}4\ \%$$

Next, an accuracy level test was carried out to assess the extent of the accuracy of the GPS (Global Positioning System) using the sequential method. This test aims to determine how accurate GPS is by considering the position and distance between the antenna and the device based on the location and contour of the land. This evaluation is essential to conclude how accurate GPS is in providing the required position data, thus affecting the reliability of systems that use GPS average errors.

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Table 5. Results of Testing the Accuracy using Sequential Method

No	Location	Map Coordinates		GPS Coordinates		Difference (M)		Error
		Latitude	Longitude	Latitude	Longitude	Lat	Long	(M)
1	Red light intersection	-7.901934	112.581250	-7.901767	112.581223	18.53	2.99	21.52
2	Indomaret door 2 UMM	-7.921315	112.599845	-7.921326	112.599846	-1.22	-0.11	1.33
3	Perum S.Putih Mushola Al-Ikhlas	-7.887847	112.577506	-7.887893	112.577560	-5.10	-5.99	11.09
4	Mozza Karoseri Tawangargo	-7.877207	112.575769	-7.877207	112.575806	0.33	-4.10	4.43
5	Tron Pendem Video Screen	-7.901984	112.576415	-7.902018	112.576424	-0.22	-0.99	1.21
6	Location of Punden G. carving	-7.88873	112.565546	-7.888796	112.565224	-7.32	35.70	43.02

Table 5 presents the results of testing the accuracy of tool coordinates with map coordinates, including location data, map coordinates, GPS coordinates, and the difference or error (in meters) between GPS coordinates and the measured map coordinates. The results of this test provide an overview of the tool's accuracy in recording geographic locations based on GPS coordinates. Overall testing was conducted to evaluate the performance of the NodeMCU ESP8266 microcontroller module and the Ublox Neo-6M GPS module to ensure both can function optimally. This test assesses whether the NodeMCU ESP8266 microcontroller and Ublox Neo-6M GPS modules can interact well and produce accurate results. The Blynk GPS Tracker application is shown in Figure 9.

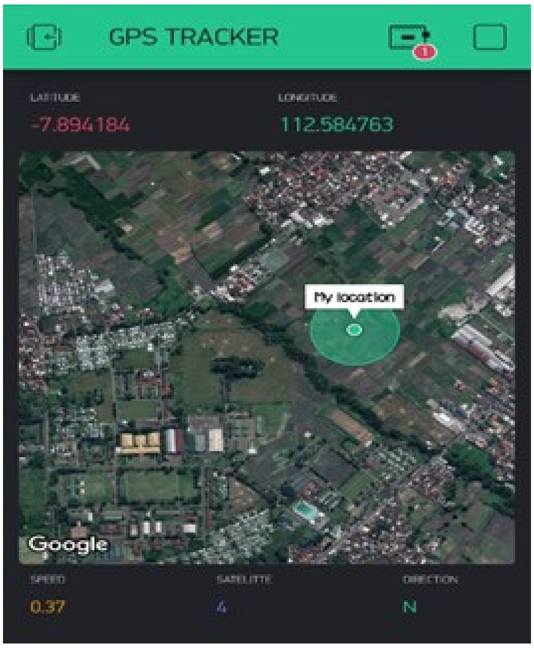

Fig 9. Blynk GPS Tracker application

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The coordinate data received from the GPS module directly reflects the device's physical location. After several tests, the GPS module continued to provide regular geographic information (displaying location data generated by the sensor itself), such as latitude and longitude. In addition to location-specific information, the module also provides real-time information about the direction and speed of the device, thereby improving the overall functionality of the tracking system. Consistent with the research objectives, the results of this experiment establish essential relationships, confirming the success of the research objectives. Specific geographic coordinates, such as latitude -7.894184 and longitude 112.584763, highlight the system's ability to collect and transmit precise location data over time.

Speed data, displayed at 0.37 km/h (km/h), and the “N” for the “North” direction indicator on the Blynk app screen further confirm the system's effectiveness in providing complete information during operation. Additionally, understanding of these results is enhanced when relevant tables and figures are included in the analysis. Visual representation of coordinate data, speed measurements, and direction indicators provides visual reinforcement for numerical results, increasing overall understanding and reliability. Recognizing the strengths and limitations revealed through the testing phase is essential. The system's success rate is consistently high at 98.6, while the error rate remains low at 1.4%, indicating its reliability. However, to better understand system performance, it is essential to consider possible limitations, such as environmental factors that affect GPS signal reception. Summarizing the practical importance of these results, the successful integration of the GPS module into the monitoring system provides the basis for a deeper understanding of its impact. As well as meeting the research objectives, this technology has positive implications for wider emergency use, underscoring the potential benefits of improving real-world operations by significantly enhancing safety and efficiency.

Analysis of the results is essential to confirm and validate the hypotheses proposed in this study. It aims to answer initial hypotheses and provide meaningful insights into practical implications in the field and beyond. By interpreting the results, this section seeks to explain the broader significance of the findings [34]. Our results reveal noteworthy relationships and gaps compared with the studies described in the literature review [35]. Comprehensive analysis allows us to see how our findings align with or differ from previous research, thereby contributing to collective knowledge in the domain.

However, a cautious approach is needed in interpreting these findings, given the limitations inherent in this study. Identifying and recognizing these constraints, such as sample size limitations or methodological considerations, is critical to better understanding the results. This section will explicitly outline any constraints to ensure comprehensive and transparent interpretation. The implications of these results extend beyond the scope of the research, not only

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impacting a particular field of inquiry but potentially influencing related fields. Discussion of these implications provides a framework for understanding the practical applicability and relevance of the findings in real-world scenarios[36]. From now on, this discussion will show potential opportunities for future research. Identifying gaps or unanswered questions from this research will guide future investigations and contribute to continuing knowledge development in this area. By providing a roadmap for future research directions, this section ensures continued scientific inquiry into the subject. The results and discussion sections integrate seamlessly to offer a comprehensive interpretation beyond their presentation, facilitating a differentiated understanding of the research results.

IV. CONCLUSION

The GPS tracking system developed using the NodeMCU ESP8266 and GPS components has experienced significant improvements through the application of the Sequential method for optimization. This method allows the system to make sequential adjustments and process tracking data more efficiently, thereby improving real-time tracking accuracy. By applying the Sequential method, the system shows an increase in the success rate which now reaches 98.6%, while reducing the error rate to only 1.4%. The integration of wind direction into the Sequential optimization algorithm has contributed to improving the system's ability to more accurately monitor environmental conditions, which is critical in hostage rescue operations. As a result, efficiency and safety in hostage rescue missions have increased dramatically, reflecting the strategic use of advanced technology in the face of real challenges.

Author Contributions: *Dodo Irmanto*: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Supervision. *Sujito*: Software, Investigation, Data Curation, Writing - Original Draft. *Aripriharta*: Investigation, Data Curation. *Dekki Widiatmoko*: Investigation, Data Curation. *Kasiyanto*: Investigation, Data Curation. *Saodah Omar*: Software, Investigation.

All authors have read and agreed to the published version of the manuscript.

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Data Availability: The data cannot be openly shared for the protection of study participant privacy.

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Informed Consent: There were no human subjects.

Animal Subjects: There were no animal subjects.

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