

Digital bracelet guidance Qibla direction for the blind

Irvan Sofianto¹, Mukhlidi Muskhir¹

¹Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

Article Info

Article history:

Received October 29, 2024

Revised July 21, 2025

Accepted May 19, 2026

Keywords:

Digital Bracelet
Visually Impaired
Qibla Direction
Arduino Nano
GPS Sensor

ABSTRACT

The determination of the Qibla direction is a crucial preliminary step for Muslims prior to prayer. However, individuals with visual impairments frequently encounter challenges in accurately identifying this direction. To address this issue, this research proposes the development of a digital Qibla direction guide bracelet, which aims to facilitate the navigation of blind individuals towards the Qibla direction with greater precision and ease. The system employs an Arduino Nano as the primary microcontroller, a GPS sensor to ascertain the user's location, and a compass sensor to identify the Qibla direction. Moreover, a buzzer is employed as a feedback mechanism, emitting a vibration signal or sound upon the successful determination of the Qibla direction. The experimental outcomes demonstrate that this bracelet is capable of accurately detecting the Qibla direction and providing clear and readily comprehensible guidance for the visually impaired. This bracelet is anticipated to serve as a practical and efficacious solution, enabling the blind to engage in worship with greater autonomy and comfort.

Corresponding Author:

Irvan Sofianto

Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang

Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia

Email: Irvansofianto2109@gmail.com

1. INTRODUCTION

According to the World Health Organization (WHO), approximately 2.2 billion people worldwide suffer from vision impairment, affecting either near or distance vision [1]. Data from the Indonesian Ministry of Health indicates that the visually impaired population in Indonesia constitutes about 1.5 percent of the total population. Given Indonesia's population of over 270 million, the number of visually impaired individuals is estimated to be around 4 million [2]. "Visually impaired" is a general term for a condition affecting an individual's total or partial vision. Vision impairment can result from traumatic injury, premature birth, or accidents [3],[4]. Based on severity, visual impairment is categorized into two types: total blindness (an inability to see at all) and low vision (retaining some, albeit very limited, sight) [5]-[7]. Nevertheless, as Muslims, the visually impaired are also required to perform the prayer facing the Qibla.

Rapid technological advancements have driven the demand for devices that enhance human quality of life. This applies equally to the visually impaired, who require specialized devices to assist with daily activities [8]-[10]. The *Qibla* direction determines the validity of prayer, as all Muslims are required to face the Kaaba when performing their prayers [11],[12]. While determining the Qibla direction is straightforward for sighted individuals, it can be challenging for the visually impaired.

To assist them, there is a need to develop a microcontroller-based system that facilitates determining the *Qibla* direction, whether at home or in unfamiliar locations [13],[14]. The microcontroller utilized in the device design is the Arduino Nano. This device is crucial to the system due to its extensive chip features, compact size, and user-friendly programming language [15],[16]. This device is equipped with a buzzer that emits a beep when the compass sensor has successfully located the correct Qibla coordinates, allowing visually impaired users to simply listen to the direction of the sound from the device. The device is designed to be worn on the user's hand, making it practical to use.

2. METHOD

The device design aims to minimize errors during the fabrication process, ensuring the final product aligns with the initial plan. The research methodology encompasses the design and implementation of both hardware and software components. Hardware design was carried out using SketchUp to create a 3D model for housing the necessary components, while software design utilized Fritzing to generate schematic diagrams and the Arduino IDE to write the programming code. A block diagram serves as the foundation of the device design; a well-designed block diagram ensures that the resulting circuit functions as intended [17]. Figure 1 below illustrates the block diagram of the system used in the device.

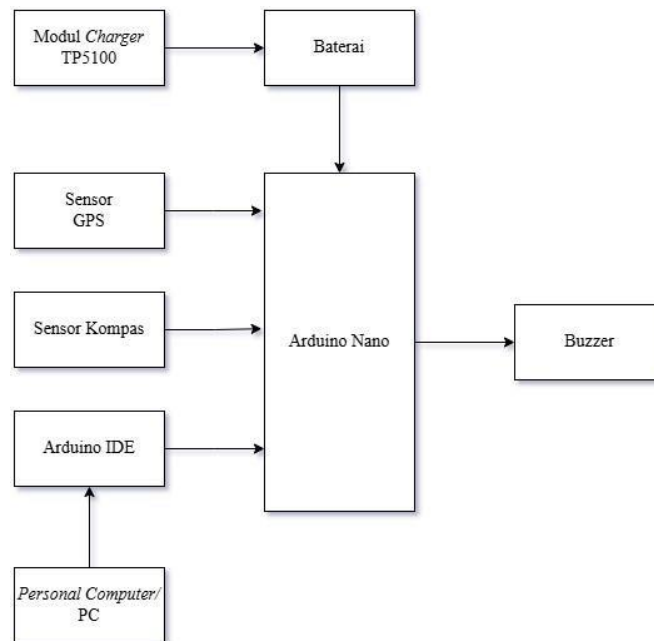


Figure 1. Block diagram of proposed system

Based on the block diagram above, the functions of the respective blocks are as follows: 1) TP5100 Charger Module: A flexible charging chip capable of accommodating either a 2S (two-cell) lithium-ion battery system with a nominal voltage of 7.4 volts or a single-cell 3.7-volt system [18][19]. This module safely and efficiently charges the battery according to its capacity. 2) Battery: An electrochemical cell that generates electric current through internal chemical reactions [20][21]. It serves as the voltage source to power the microcontroller when it is not connected to a PC or computer. 3) Arduino Nano: A compact microcontroller development board equipped with all basic features; it can be mounted directly onto a breadboard to facilitate prototyping [22]. The Arduino Nano acts as the control center for the entire circuit's operation. 4) Arduino IDE: Integrated software serving as a code editor, compiler, and uploader for transferring programs to the Arduino microcontroller [23],[24]. The Arduino IDE is used to program the device for hardware testing. 5) Personal Computer (PC): Serves as the platform for writing programs in the Arduino IDE and performing simulations. 6) GPS Sensor: A device that receives satellite signals to determine an object's geographic position [25]. It is used to obtain the user's latitude and longitude coordinates [26],[27]. This data is integrated with compass sensor data to determine the cardinal direction at that location. 7) Compass Sensor: A magnetic sensor used to detect the Earth's magnetic field and determine cardinal directions [28],[29]. Data from this sensor is converted into digital format, allowing it to be read by the microcontroller and displayed on a computer screen. 8) A buzzer is an active electronic component that produces a specific tone when supplied with voltage [30],[31]. It serves as an audio indicator when the device is aligned with the programmed Qibla direction.

The Qibla-finding device for the visually impaired operates by utilizing a GPS sensor to determine the user's geographic location and a compass sensor to detect magnetic north. An Arduino Nano microcontroller processes data from both sensors to calculate the Qibla azimuth angle based on the user's location. The calculated direction is conveyed to the user via an audible signal from a buzzer, enabling them to orient themselves accurately toward the Qibla. This device makes it easier for visually impaired users to determine the Qibla direction regardless of their location. In general, the process of determining the Qibla direction is carried out automatically through the interaction of hardware and software.

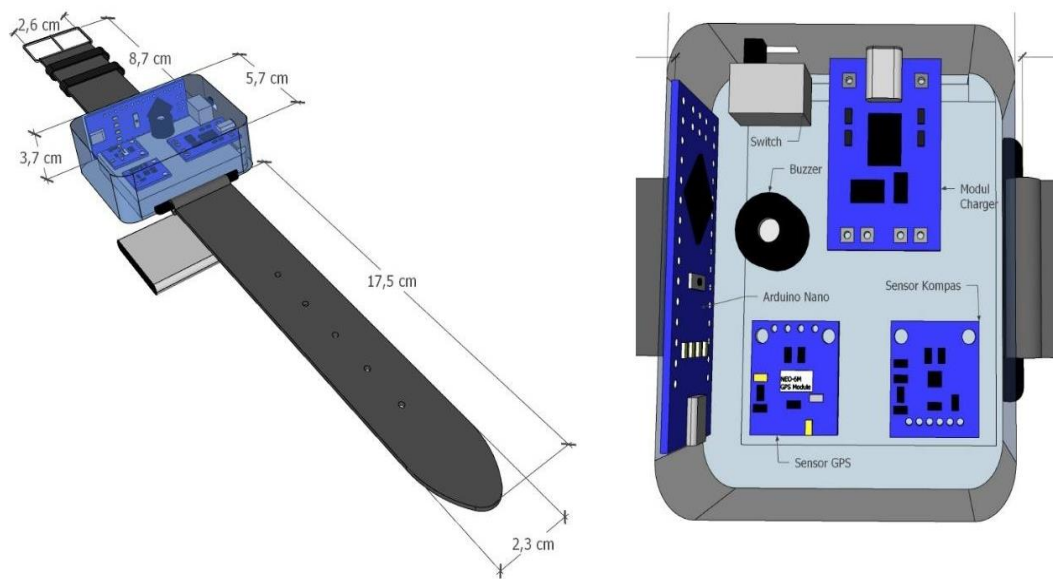


Figure 2. Design of the Qibla-detecting bracelet device.

Figure 2 illustrates the hardware design of the device, involving the 3D modeling of the components to be used. This approach creates a realistic visual model, facilitates the assembly process, and minimizes errors, thereby ensuring optimal results. The components utilized in this design include an Arduino Nano, GPS sensor, compass sensor, buzzer, charging module, and switch. Figure 3 is the overall design of the tool, there is a circuit schematic which aims to determine the connection of each pin on the component used in this research.

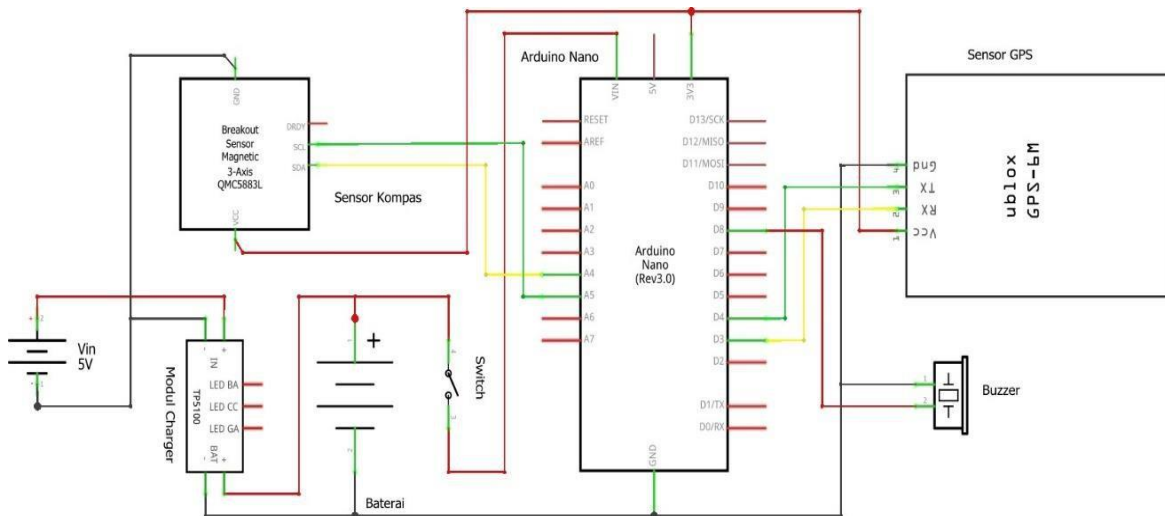


Figure 3. Schematic circuit of the tool

Once the hardware assembly phase is complete, the next step is software development. This stage encompasses writing program code, testing to identify and rectify errors, and integrating the program with the hardware to ensure the system functions as a cohesive whole. Software design in the form of a flowchart is defined as a diagram utilizing graphic symbols to illustrate process flow—displaying specific steps—or as a graphical representation of the steps or sequences within a program procedure designed to perform a specific function [32]. As shown in Figure 4, the design process for the Qibla detector begins with input initialization; specifically, data from the GPS and compass sensors is processed by the microcontroller to calculate the Qibla direction. If the Qibla is detected, the buzzer activates and emits a sound; otherwise, the controller resumes reading data from the sensors.

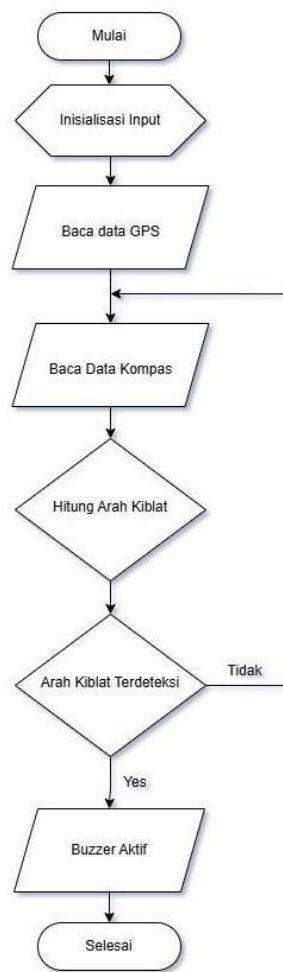


Figure 4. Software design flowchart

3. RESULTS AND DISCUSSION

Testing of this device was conducted to clearly demonstrate the effective integration of the developed hardware and software. The hardware design encompasses the mechanical and electronic aspects of the device's components, including the battery, switch, Arduino Nano, charging module, GPS sensor, compass sensor, and buzzer. Mechanically, the design involved creating a box-shaped casing to protect the interconnected electronic components. The hardware design is illustrated in Figure 5.



Figure 5. Result of the hardware fabrication.

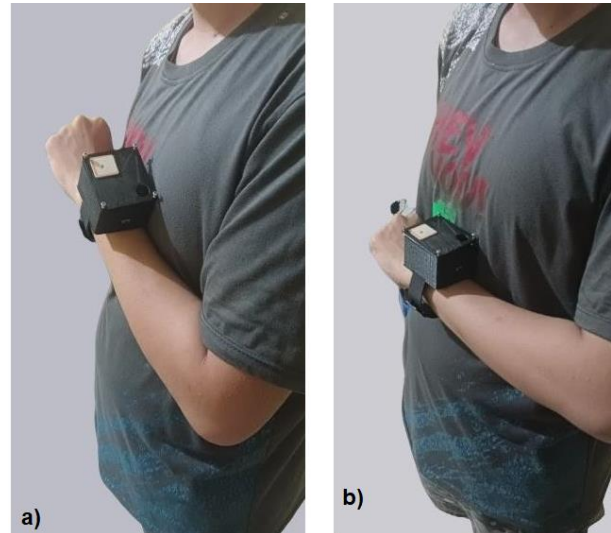


Figure 6. Positioning of the device.

The orientation of the device whether tilted or level significantly affects the accuracy of the degree measurements. A tilted position, as shown in Figure (a), results in a significant discrepancy between the measured value and the compass reference value. To achieve optimal results, the measuring device must be placed in a level position, as shown in Figure (b). The device's positioning is illustrated in Figure 6. The steps for using the device to determine the correct Qibla direction are as follows: a) First, fasten the wristband onto the user's wrist. b) Press the power switch (on) to activate the Qibla-finding device. c) Hold the wrist wearing the band level with the solar plexus, keeping the arm flat. d) The GPS sensor will begin reading the user's location coordinates. Wait a few moments for the sensor to acquire accurate data; the time required may vary depending on geographical or environmental conditions. e) Once the GPS coordinates are obtained, the device uses this data—along with the compass sensor—to calculate the Qibla direction from the current location. f) After the Qibla direction is calculated, the buzzer will emit an audible signal when the user faces the correct direction (the Qibla). g) If the buzzer does not sound, slowly rotate the body until it does, indicating that the Qibla direction has been correctly aligned. A comparison of degree values for the horizontal and inclined positions of the device is presented in Table 1 and the graph in Figure 7.

Table 1. Comparison of Device Position Values

No	Kompas Value	Position Device	Misaligned Positioning Tool (tilted)	Horizontal Position Difference	Incorrect Position Difference
1.	1°	1.05°	10.24°	0.05°	9.24°
2.	27°	27.17°	22.63°	0.17°	4.37°
3.	45°	45.11°	54.85°	0.11°	9.85°
4.	90°	90.75°	83.24°	0.75°	6.76°
5.	115°	114.89°	125.74°	0.11°	10.74°
6.	176°	176.33°	188.29°	0.33°	12.29°
7.	271°	270.85°	256.46°	0.15°	14.54°
8.	313°	313.13°	337.91°	0.13°	24.91°
9.	333°	332.91°	340.88°	0.09°	7.88°
10.	359°	359.13°	347.69°	0.13°	11.31
Error rata-rata				0.20°	11.18°

It is evident that measurement accuracy is superior when the device is held flat compared to when it is not. The discrepancy in compass sensor readings while in the flat position is minimal, averaging 0.20°, whereas the sensor's tolerance range is 1–2 degrees. Conversely, using the device in a tilted position significantly impacts the readings, resulting in an average deviation of 11.18°—a figure that far exceeds the sensor's tolerance. Therefore, it can be concluded that the compass sensor must be used in a flat position to ensure readings remain within the specified tolerance limits.

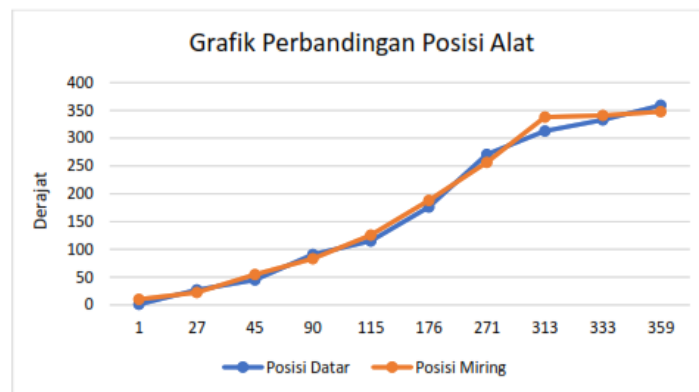


Figure 7. Graph comparing device positions.

The coordinate testing and GPS module acquisition process aimed to compare the GPS module's output with reference data from Google Maps, as well as to test two initial activation modes: Cold Start and Hot Start. The results of the coordinate testing are presented in Table 2.

Table 2. Coordinate Comparison Test

No	Location	Latitude (Google Maps)	Longitude (Google Maps)	Latitude (Modul GPS)	Longitude (Modul GPS)
1.	Kos Patenggangan Gang E	-0.891890	100.34579	-0.891890	100.34579
2.	Kos Kuning Gajah VII	-0.897136	100.34610	-0.897103	100.34607
3.	Lab. Konversi Energi FT-UNP	-0.898047	100.34885	-0.898190	100.34872
4.	Dekanat FT-UNP	-0.897569	100.34925	-0.897643	100.34927
5.	Rooftop Lt.4 gedung tepadu FT	-0.898056	100.35018	-0.898142	100.34996
6.	Mesjid Al-azhar UNP	-0.898491	100.35092	-0.898492	100.35083
7.	Mesjid Agung Nurul Iman	-0.95459	100.36235	-0.954496	100.36227
8.	Mesjid Raya Sumatera Barat	-0.92459	100.36217	-0.924470	100.36222
9.	Mesjid Al-Hakim	-0.96049	100.35342	-0.960318	100.35321
10.	Mesjid Raya Gantiang	-0.95447	100.36954	-0.954503	100.36962

The Table 2 shows that the data analysis reveals a relatively small and insignificant discrepancy; this difference is attributable to factors such as environmental conditions, the number of detected satellites, and the algorithms employed by each system. Nevertheless, the discrepancy remains within acceptable tolerance limits for Qibla-finding applications.

Acquisition testing under two conditions will be conducted at various locations with differing characteristics to evaluate the module's performance across diverse situations. GPS requires more time to acquire a satellite signal when starting from a completely powered-off state (Cold Start) compared to starting from a state where it has previously acquired a signal (Hot Start). Testing indicates that the time required for the GPS to acquire a satellite signal is significantly influenced by the surrounding environment. The discrepancy in the Qibla direction determined by various devices and Qibla-finding applications is minimal, remaining under 2 degrees. However, the largest deviation was observed at the Nurul Iman Grand Mosque; this is likely attributable to environmental interference hindering GPS satellite signal reception and the influence of strong magnetic fields affecting the digital compass's directional accuracy.

Test results demonstrate that the device possesses a high level of accuracy, with an error rate of only approximately 0.07%. Nevertheless, the device's performance is heavily influenced by environmental factors such as magnetic fields, electric fields, and the presence of tall buildings. Therefore, to achieve optimal measurement results, it is recommended to use the device in open areas free from electromagnetic field interference.

4. CONCLUSION

Test results indicate that the accuracy of the compass sensor on the wristband is significantly affected by environmental magnetic field interference, particularly indoors. Using the compass sensor in a

flat position yields readings closer to the reference values than using it in a tilted position. Furthermore, GPS data acquisition is hindered by the presence of tall buildings, trees, or walls surrounding the user. Nevertheless, the coordinates generated by the GPS sensor are reasonably accurate when compared to those from Google Maps. Overall testing of the device for determining the Qibla direction—benchmarked against the Qibla Finder application—reveals an average measurement error of only 0.034%, indicating excellent performance.

REFERENCES

- [1] S. Zafar *et al.*, "Assistive Devices Analysis for Visually Impaired Persons: A Review on Taxonomy," *IEEE Access*, vol. 10, pp. 13354-13366, 2022, doi: 10.1109/ACCESS.2022.3146728.
- [2] D. Kleinberg, R. Yozevitch, I. Abekasis, Y. Israel and E. Holdengreber, "A Haptic Feedback System for Spatial Orientation in the Visually Impaired: A Comprehensive Approach," *IEEE Sensors Letters*, vol. 7, no. 9, pp. 1-4, Sept. 2023, Art no. 6005804, doi: 10.1109/LSSENS.2023.3307068.
- [3] A. Rahman, M. A. R. Azim, and S. Heo, "Take my hand: Automated hand-based spatial guidance for the visually impaired," in *Proc. CHI Conf. Hum. Factors Comput. Syst.*, 2023, pp. 1-16.
- [4] A. Raymond, L. V. M. Costillas, W. D. C. Advincula, and N. T. Bugtai, "Haptic feedback to detect obstacles in multiple regions for visually impaired and blind people," *Sensors J.*, vol. 33, no. 6, pp. 1799-1808, 2021.
- [5] J. Madake, S. Bhatlawande, A. Solanke and S. Shilaskar, "A Qualitative and Quantitative Analysis of Research in Mobility Technologies for Visually Impaired People," *IEEE Access*, vol. 11, pp. 82496-82520, 2023, doi: 10.1109/ACCESS.2023.3291074.
- [6] A. Kisa, R. R. A. Bourne, J. D. Steinmetz, S. R. Flaxman, P. S. Briant, H. R. Taylor, S. Kisa, T. Vos, S. K. West, and J. B. Jonas, "Trends in prevalence of blindness and distance and near vision impairment over 30 years: An analysis for the Global Burden of Disease Study," *Lancet Global Health*, vol. 9, pp. e130-e143, Dec. 2020.
- [7] R. C. Joshi, N. Singh, A. K. Sharma, R. Burget and M. K. Dutta, "AI-SenseVision: A Low-Cost Artificial-Intelligence-Based Robust and Real-Time Assistance for Visually Impaired People," *IEEE Transactions on Human-Machine Systems*, vol. 54, no. 3, pp. 325-336, June 2024, doi: 10.1109/THMS.2024.3375655..
- [8] W. S. M. Sanjaya, A. Roziqin, D. Anggraeni and M. F. B. Zaman, "Designing an Autonomous Qibla Finder Mobile Robot Utilizing the Second al-Biruni's Method from Kitab Tahdid Nihayat al-Amakin," *2023 IEEE 9th Information Technology International Seminar (ITIS)*, Batu Malang, Indonesia, 2023, pp. 1-6, doi: 10.1109/ITIS59651.2023.10420068.
- [9] N. K. Syakirin, R. Mardiaty and A. E. Setiawan, "Qibla-Finding Robot based on Vector and Fuzzy Logic Methods for Accurate Directional Alignment," *2024 10th International Conference on Wireless and Telematics (ICWT)*, Batam, Indonesia, 2024, pp. 1-6, doi: 10.1109/ICWT62080.2024.10674710.
- [10] A. Asrin, G. I. Hapsari and G. A. Mutiara, "Development of Qibla Direction Cane for Blind Using Interactive Voice Command," *2018 6th International Conference on Information and Communication Technology (ICoICT)*, Bandung, Indonesia, 2018, pp. 216-221, doi: 10.1109/ICoICT.2018.8528769.
- [11] W. S. Mada Sanjaya, A. Roziqin, D. Anggraeni and M. F. B. Zaman, "The Integration of the Third Abu al-Wafa's Method for Developing an Autonomous Qibla Finder Mobile Robot," *2023 International Conference on Information Technology Research and Innovation (ICITRI)*, Jakarta, Indonesia, 2023, pp. 145-150, doi: 10.1109/ICITRI59340.2023.10250120.
- [12] W. S. M. Sanjaya *et al.*, "Determining Qibla Direction using al-Biruni's First Method from Kitab Tahdid Nihayat al-Amakin with The Implementation Based on Board Arduino MCU, GPS Module, and Digital Compass," *2019 International Seminar on Application for Technology of Information and Communication (iSemantic)*, Semarang, Indonesia, 2019, pp. 513-518, doi: 10.1109/ISEMANTIC.2019.8884330.
- [13] W. b. Malik, M. Atique-Ur-Rehman, M. Ahmad and M. I. Javed, "E-Compass Based Autonomous Qibla Rotation Platform for Moving Vehicle," *2019 International Conference on Applied and Engineering Mathematics (ICAEM)*, Taxila, Pakistan, 2019, pp. 37-41, doi: 10.1109/ICAEM.2019.8853739.
- [14] Y. Tawil, "A Hardware Implementation Of An Open-source Qibla Direction Finder With Tilt Compensation Using 9-DOF IMU And GPS," *2023 Innovations in Intelligent Systems and Applications Conference (ASYU)*, Sivas, Turkiye, 2023, pp. 1-6, doi: 10.1109/ASYU58738.2023.10296590.
- [15] A. R. F. Gani and A. R. F. Gani, "Design and implementation automatic prayer mat facing the Qibla in vehicle using microcontroller Arduino," in *AIP Conference Proceedings*, 2022, vol. 2659, no. 1 : AIP Publishing LLC, p. 130001.
- [16] S. Lubis, F. I. Pasaribu, W. S. Damanik, M. A. Siregar, I. Siregar, and E. S. Hasibuan, "The Design and Qibla Direction by Using the Hmc 5883 L Sensor as a Compass Rhi in the UMSU Science Laboratory (OIF)," *Budapest International Research in Exact Sciences (BirEx) Journal*, vol. 2, no. 3, pp. 376-381, 2020.
- [17] M. Yuhendri, A. Aswardi, and A. Ahyanuadi, "Implementasi Pompa Air Tenaga Surya Menggunakan Inverter Boost Satu Fasa," *INVOTEK J. Inov. Vokasional dan Teknol.*, vol. 20, no. 3, pp. 1-10, 2020, doi: 10.24036/invotek.v20i3.813.
- [18] M. R. Alfiansyah, M. Yuhendri, and J. Sardi, "Supervisory control and data acquisition system for solar panel based on Internet of things (IoT)," *J. Ind. Autom. Electr. Eng.*, vol. 01, no. 01, pp. 145-154, 2024.
- [19] F. Azizah and M. Yuhendri, "Solar Panel Monitoring and Control System Using Human Machine Interface," *Andalasian Int. J. Appl. Sci. Eng. Technol.*, vol. 2, no. 03, pp. 149-158, 2022, doi: 10.25077/aijaset.v2i03.64.
- [20] A. Yadu, S. S. Brahmadathan, S. Agarwal, S. D. B., S. Lee and Y. Kim, "On-Device Personalized Charging Strategy With an Aging Model for Lithium-Ion Batteries Using Deep Reinforcement Learning," *IEEE Transactions on Automation Science and Engineering*, vol. 21, no. 4, pp. 5037-5047, Oct. 2024, doi: 10.1109/TASE.2023.3307168.
- [21] R. Firanda and M. Yuhendri, "Monitoring State Of Charge Accumulator Berbasis Graphical User Interface Menggunakan Arduino," *JTEIN Jurnal Teknik Elektro Indonesia*, vol. 2, no. 1, pp. 11-16, 2021.
- [22] M. Wagner and A. A. Fröhlich, "Securing Cyber-Physical Systems Against GPS Spoofing Attacks Using Confidence Attribution," *2023 International Conference on Software, Telecommunications and Computer Networks (SoftCOM)*, Split, Croatia, 2023, pp. 1-6, doi: 10.23919/SoftCOM58365.2023.10271629.
- [23] P. Kaewket and K. Sukvichai, "Investigate GPS Signal Loss Handling Strategies for a Low Cost Multi-GPS system based Kalman Filter," *2022 19th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)*, Prachuap Khiri Khan, Thailand, 2022, pp. 1-4, doi: 10.1109/ECTI-

- CON54298.2022.9795494.
- [24] A. Akhmediya, A. Mirmanov, N. Nabiyev, S. Bostanova, T. Serikov and K. Ibrayev, "Assessing Battery Life and Accuracy of Modern GPS Trackers for Herd Horse Breeding," *2023 IEEE International Conference on Smart Information Systems and Technologies (SIST)*, Astana, Kazakhstan, 2023, pp. 109-113, doi: 10.1109/SIST58284.2023.10223581.
 - [25] X. Wei and L. Wang, "SigFeaDet: Signal Features-based UAV GPS Spoofing Detection using Machine Learning," *2023 IEEE 29th International Conference on Parallel and Distributed Systems (ICPADS)*, Ocean Flower Island, China, 2023, pp. 2202-2209, doi: 10.1109/ICPADS60453.2023.00297.
 - [26] Y. Shuai and Z. Chao, "Research on GPS Spoofing Signal Identification Technology Based on Inertial Information Assistance," *2023 IEEE 2nd International Conference on Electrical Engineering, Big Data and Algorithms (EEBDA)*, Changchun, China, 2023, pp. 953-956, doi: 10.1109/EEBDA56825.2023.10090570.
 - [27] M. S. U. Z. Siddique, S. Mohammad, T. Bhowmick, M. M. Khan and R. Dey, "Development of Low-cost GPS Tracker System for Coastal Area of Bangladesh," *2022 6th International Conference on Computing Methodologies and Communication (ICCMC)*, Erode, India, 2022, pp. 1534-1539, doi: 10.1109/ICCMC53470.2022.9754036.
 - [28] C. Fan *et al.*, "Bio-Inspired Multisensor Navigation System Based on the Skylight Compass and Visual Place Recognition for Unmanned Aerial Vehicles," *IEEE Sensors Journal*, vol. 22, no. 15, pp. 15419-15428, 1 Aug.1, 2022, doi: 10.1109/JSEN.2022.3187052.
 - [29] S. Wahyuni, M. Latif, A. S. Romadhon and A. I. Sudianto, "UGV Path Tracking Base On Implementation GPS and Compass," *2024 IEEE 10th Information Technology International Seminar (ITIS)*, Surabaya, Indonesia, 2024, pp. 139-144, doi: 10.1109/ITIS64716.2024.10845480.
 - [30] N. Gogoi, J. Kirchner and G. Fischer, "Energy harvesting from a piezo buzzer with Schottky diode and complementary MOSFET full-bridge rectifiers," *2022 IEEE International Symposium on Applications of Ferroelectrics (ISAF)*, Tours, France, 2022, pp. 1-3, doi: 10.1109/ISAF51494.2022.9870144.
 - [31] D. Banerjee, P. Banerjee, B. Goswami and R. Ghosh, "Deriving an electrical model of a two terminal piezoelectric buzzer from its impedance response," *2018 IEEE Applied Signal Processing Conference (ASPCON)*, Kolkata, India, 2018, pp. 114-118, doi: 10.1109/ASPCON.2018.8748588.
 - [32] I. Sandrya and Asnil, "Battery Charger Control System Employing a Buck Converter with Visual Studio Interface," *J. Ind. Autom. Electr. Eng.*, vol. 01, no. 01, pp. 46-52, 2024.