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Hand Gesture and IoT App Controlled Mobile Robot with Obstacle Detection

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ABSTRACT

Traditional robot systems use wired connections, RF transmission, or Bluetooth with physical controllers, which is inflexible and require operators and robot to stay close to each other. In this work, a mobile platform for an arm robot is developed using a gyro-based system integrated with IoT application. The mobile robot is built with WiFi connectivity and an obstacle detection algorithm to avoid collision. The robot can be navigated by using two masters i.e. user hand gestures measured by a gyroscope module or via an IoT mobile application designed by using MIT App Inventor. The master-slave system architecture consists of the master that sends the control's reference commands to a real-time cloud database and the slave robot's controller that uses the commands from the cloud to move the robot. The results of the indoor floor test showed that the robot moved according to the instructions given by the masters in the forward, backward, left and right directions at two different speeds and stopped the navigation when moving closer to an obstacle at a predetermined distance limit. The successful results proved the practicality of the master-slave control, the established wireless communication, software and hardware interfaces and the IoT integration.

1. INTRODUCTION

In many industrial and service applications, robotic arms are often fixed in one place, which limits their ability to move freely and reduces overall flexibility and efficiency (Yamamoto et al., 2021). Traditional control systems use wired connections, RF transmission, or Bluetooth with physical controllers (Gore, et al., 2019), which have become less practical in modern environments where robot's movement across different locations is needed. These conventional systems also require operators and robot to stay close to each other, making operations more difficult and less natural.

Recent mobile robotic platforms have been designed to work in various types of environments and offer more flexibility than traditional static robots (Song et al., 2023). These robots became smarter and

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more efficient when combined with wireless and IoT technologies, which allowed real-time monitoring, cloud-based control, and data sharing (Bhala et al., 2023), (Munasinghe et al., 2019). They were especially useful in dangerous and difficult workplaces such as in agriculture, industrial factories and disaster areas (Xiang et al., 2024).

In the manufacturing industry, the application of mobile robots in tasks such as material transfer, machine monitoring and maintenance work has proven to reduce dependence on human operators and further save production time. In agriculture, they are used to monitor crops, spray pesticides, and harvest crops. During disasters, they are used for search and rescue, deliver supplies, and inspect building damage (Jing et al., 2022). Meanwhile, in terms of mobile robot control, various control methods have been introduced to meet the needs in various environments and requirements. For example, a hand gesture control method developed by Ullah et al. (2019) utilized MPU6050 sensors (accelerometer and gyro sensors) to measure tilt movements of human hand gesture and converted them to forward, backward, left, and right commands for their robot. In the work by Koh et al. (2023), the information of moving obstacles measured by a 2D range scanner was used to estimate the obstacle trajectory for their obstacle avoidance method in an indoor environment. Their proposed method aimed in simplifying the complexity of detecting and tracking dynamic obstacles (Lee et al., 2021) when using low-cost sensors for obstacle avoidance strategy.

Many studies supported the idea of building gestures and application-based mobile robots. Works by Kale and Sakhare (2020), Mhetre et al. (2023) and Yunus (2022) used RF communication for the transmission of the user's hand gesture data measured by accelerometer sensor to be sent to motor controller. These studies have shown the development of hardware that realized gesture-controlled mobile robots but have not demonstrated the interoperability and efficiency of the wireless communication for real-time control of their robots. Similar study by Sriram and Palaniswamya (2019) applied an image recognition of user's hand gesture as an easier way for the disabled or senior citizens to select the predefined mobile robot paths for task execution of the robot. On the other hand, a wireless communication platform that can continuously changes its transmission rate was introduced by De Sant Ana et al. (2023) to generate better precision and accuracy of their autonomous mobile robot trajectory based on sensor and control data. This method provides better control results when compared to using a fixed data rate in numerical analysis tests for trajectory accuracy, thus demonstrating the importance of having a reliable and suitable communication platform for increasingly challenging robotic applications.

In addition to the various wireless communication platforms available for mobile robot applications, current technology also demands the use of Internet of Things (IoT) to provide flexible access to robot control and execution, directly by users. The use of IoT is very broad as it can be embedded in a variety of devices from home electronics to industrial machines as long as they are connected to the Internet, enabling communication of data and information in near real time (Younis & Alwan, 2023). Study related to using IoT include work by Roy et al. (2024) who developed an IoT platform in wristband device that collect physical pressure, oxygen level and pulse rate of the user as a protection device for women when attacked by a stranger. Other studies related to healthcare monitoring were done by Mujeeb Rahman et al. (2023) and Buthelezi et al. (2022) where their measurement devices collect user's physiological measurements such as electrocardiogram, oxygen saturation, body temperature, pulse rate and etc. for patients staying at home or in remote areas. However, these studies involve measuring and displaying data on smart devices only, which is different from IoT applications for robotic systems that involve more complex components including physical sensors and robot actuators.

Therefore, in this work, a mobile robot carrying a robot arm shown in Fig. 1 which was previously developed by Hisam (2025) was proposed using a master-slave wireless controlled method. By bringing the robot arm to the user's desired destination, it can increase the usability of the robot to perform tasks in different locations, thus reducing the cost of using multiple robots. The wireless master-slave robot control system consists of an IoT app as the first master and a hand gesture measurement device as the second

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master that were used to navigate a mobile robot named MoBOT as the slave to a destination according to the user's commands. For the implementation of IoT features, a mobile application was designed using MIT App Inventor to send commands from anywhere as long as internet access is available. The IoT application enables the master and the slave controllers to send or receive data and commands via internet and cloud database.

Fig. 1. Previously developed 4-DoF robot arm

2. WIRELESS GESTURE-BASED MOBILE ROBOT SYSTEM

The work aimed to develop a wireless, gesture-based control system for a mobile robot, addressing the limitations of fixed robotic arm setups and wired controls. The work consists of three main phases which includes investigation of suitable open-source software platform for IoT application, development of the hardware and software interfaces and programming of the master and slave, and verification of the robot performance. In the first phase, literature investigation was done to compare the specifications of different open-source software platforms available in the market where MIT App Inventor was identified and chosen for the next phase. The robot hardware was designed and assembled, and the controllers of the master device and slave robot were programmed to convert sensor data to the equivalent input for moving the motors of the robot in phase 2. An IoT application using MIT App Inventor as the main master has also been developed in this phase. Finally, the prototype was tested in phase 3 to verify the performance of MoBOT when using hand-gesture based controller and the MIT App Inventor as the two masters.

2.1 Phase 1: Wireless connectivity options and IoT platforms

In this phase, the work investigated the best way to connect the master device and the slave robot wirelessly as well as selecting the suitable open-source software platform for IoT application. Three common wireless connection types were investigated i.e. Bluetooth direct master-slave, MAC address connection, and WiFi-based cloud connectivity. Bluetooth method offers cost effective and fast communication over short range but requires pairing, while MAC address connection allows devices to connect with each other on a network but lacks security. Meanwhile, WiFi uses radio waves for transferring data in short distance and allows devices to be connected with internet which offers access to cloud platforms like Firebase for long-range control and monitoring, making it more flexible for users (Younis & Alwan, 2023). After comparing all options, WiFi was chosen as the most suitable method due to its wide availability and compatibility with the required features.

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The comparison between MIT App Inventor, Kodular, and ThingSpeak as available open-source software platforms for IoT application are listed in Table 1. MIT App Inventor is a user-friendly with drag-and-drop features and supports real-time control through WiFi and Bluetooth, though it requires installing and updating APK files manually and works best on older Android versions. Kodular offers more advanced tools and easier updates via QR code but it is challenging to learn (Roy et al., 2024). ThingSpeak is good for visualizing sensor data but its limitation in transmitting real-time signal could cause delayed and lost signal data. Based on simplicity and functionality, MIT App Inventor was chosen to be used for designing the master control via IoT application. MIT App Inventor has been integrated with Google Firebase, as it is easy to use, offers powerful integration capabilities, and supports real-time control functions (Younis & Alwan, 2023).

Google Firebase works as the main communication system to provide real-time database for data transfer between the master and slave. It is connected to two master devices as input; the master that measures the hand gestures of the user wearing the glove device and the master MIT App Inventor's IoT app. The master hand glove controller converts its MPU6050 sensor data to the equivalent user's hand gesture angle and send it to the cloud to be retrieved by the slave robot to move the mobile robot according to the commands. The slave robot or MoBOT could move at two speeds, turn left and right using differential motor control, and stop if an object is detected in its path by the ultrasonic sensors.

Meanwhile, the MIT App Inventor master uses block-based programming as shown in Fig. 2, which is easy to understand and modify. Each block handled an event that updated the database in real time to provide smooth and quick communication between the application and the robot controller.

Table 1. Comparison between three open-source software platforms

Criteria	**MIT App inventor**	**Kodular**	**Thing Speak**
Page design	Simple and focuses on the function design. Best for basic app development and IoT integration.	Highly customizable. Suitable for advanced app user interface (UI).	Dashboards for visualizing IoT data (charts, graphs) like things board.
User interface	Beginner-friendly. Drag-and-drop block-based programming.	Drag-and-drop programming require extra knowledge for complicated designs.	Limited to data presentation. Primarily used for monitoring.
Cloud Service Provider	Supports Google Firebase cloud data storage.	Able to connect to external cloud services such as Firebase. IoT data visualization must be setup manually.	It has its own clouds. Limited cloud function.

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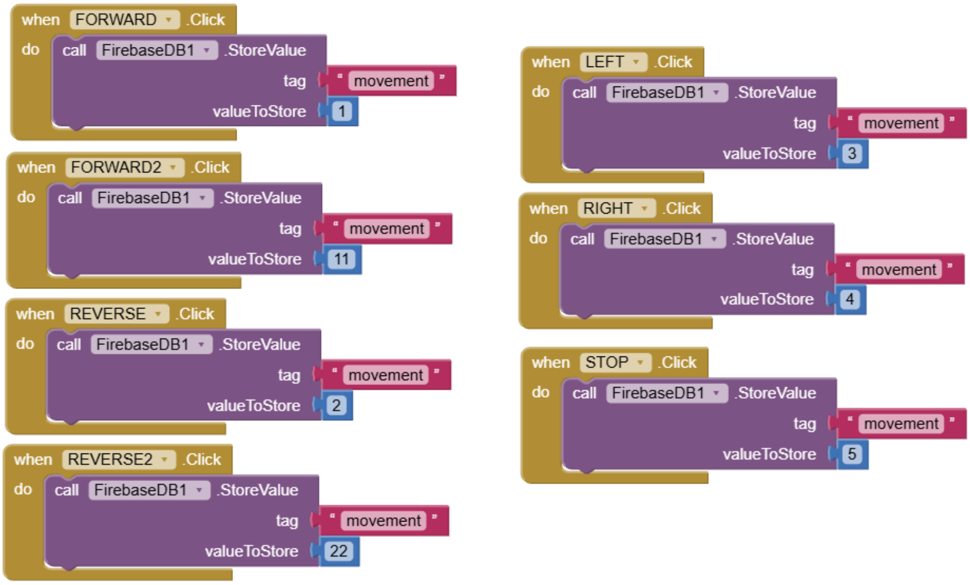

Fig. 2. Part of the coding created using the MIT App Inventor for sending data to slave controller

2.2 Phase 2: Integration of hardware and software platforms

An ESP32 Dev Board serves as the main controller board for both the master and slave units, with its built-in WiFi and Bluetooth enabling wireless communication and data transfer through Firebase cloud. Arduino IDE was used to write and upload the programming codes to the ESP32. The hand gesture master as shown in Fig. 3(a), is a wearable glove that houses a controller board and an MPU6050 module consisting of a 3-axis accelerometer and gyroscope sensor. The master controller converts the user's hand gesture into tilt angles in 3-axis directions before sending them to the cloud. Only θ_x and θ_y were used.

For the IoT master, MIT App Inventor was used to design a mobile control application for users to direct the robot's movements using user-friendly IoT app on mobile devices. Google Firebase acts as a cloud-based real-time database to store and transfer commands between the master, slave, and MIT Inventor application, ensuring complete remote control functionality. The user interface (UI) in Fig. 3(b) shows the motor direction and speed buttons in the IoT application, resembling a robot control console. The control buttons include Stop (ST), Left (LT), Right (RT), Forward Speed Level 1(FR), Forward Speed Level 2(FR2), Backward Speed Level 1(BK), and Backward Speed Level 2 (BK2). When the user presses any of these buttons, the app sends commands to the Firebase database and the slave controller will retrieve the commands from the cloud to move the motors of MoBOT in real time remotely. To ensure that the user has full control over the robot's movements, the IoT master has been programmed as the main control master that can override the commands sent by the hand glove master.

Fig. 3(c) shows the slave unit consisting of a mobile robot with two ultrasonic sensors, a controller board, a motor driver, two DC motors, and it carries a robot arm on it. Slave controller uses data from the cloud to drive the robot's wheels using L298N motor driver via differential control. L298N motor driver pin settings use a combination of ENA and ENB pins to set the motor speed, and IN1–IN4 pins for the motor direction. For higher speeds (FR2, BK2), the same pin directions are used with higher ENA and ENB values. Meanwhile, ultrasonic sensors installed at the front and back of the robot are used to detect obstacles and used by the programming to stop the motor to avoid collision when obstacle is detected within 20 cm from the robot.

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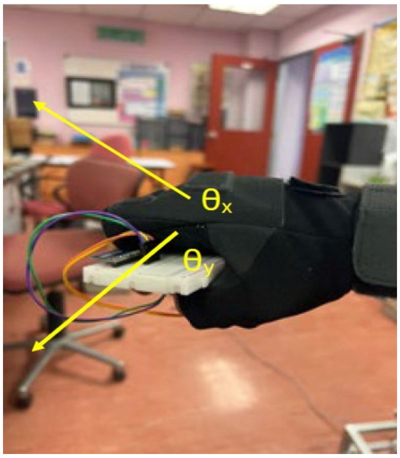
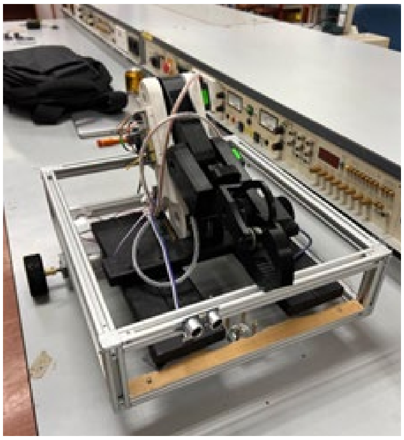
Figure 4(a) shows the architecture of the hand glove master unit which receives input from the MPU6050 accelerometer and gyroscope modules. Through its built-in WiFi module, the ESP32 microcontroller sends the converted angle data to the Firebase real-time database under the previous “movement” bucket in Fig. 2. Next, Fig. 4(b) shows the architecture of the slave robot that uses the ESP32 to read commands from the Firebase database.



(a) Master hand glove

(b) UI of Master MIT Inventor App



(c) Slave mobile robot

Fig. 3. Masters and slave of MOBOT

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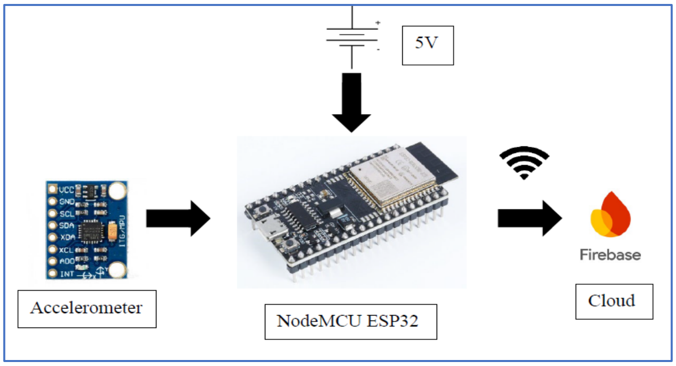
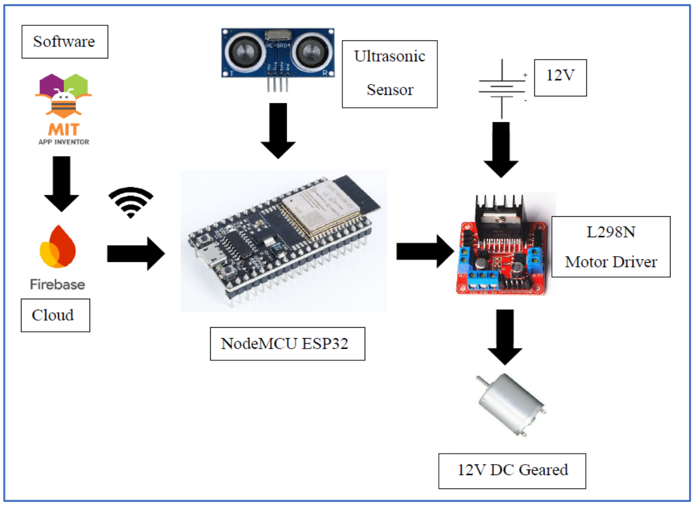


(a) Master hand gesture for sending command



(b) Slave MoBOT controller for receiving command

Fig. 4. The architecture of the master hand glove and slave units

2.3 Phase 3: Validation through simulation and experimental tests

The final phase was testing and validating the IoT and MoBOT systems to ensure that all master and slave units were functioning properly. First, through the master using hand gestures, testing was performed to ensure that the master could send data to Firebase and the slave robot could follow the instructions accordingly. For the IoT app as the master, data was sent to Firebase via MIT App Inventor to generate commands to the slave robot. This was followed by testing the robot in real time with obstacles to test the obstacle detection algorithm and MoBOT's actions to avoid collisions. Any issues detected during validation were addressed through hardware and software fixes.

Motor differential control was used in the project to manage the turning movement of MoBOT by adjusting the speed and direction of the motors on each side as in Table 2. This method allows the robot to turn left or right without using a steering mechanism, by simply changing the rotation of the motors. *VM* represents the speed amount of the motor rotation. The maximum speed that the motor can achieve is represented as 1*VM* which is equivalent to 255, the maximum value of an 8-bit processor. Decreasing the

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value will slow down the motor speed thus helping in controlling the movement of the MoBOT more efficiently, especially during turns. If the *VM* value is positive, the motor will rotate in the forward direction while for a negative *VM*, the motor will rotate in the opposite direction. This is an important strategy when moving a robot using differential motor control, where one motor moves forward and the other moves backward to rotate the robot around a point.

Table 2. Motor differential control

MoBOT movement	Angle Accelerometer	Left Wheel Speed	Right Wheel Speed
Stop	70 ° < θ_x < 110 ° & 70 ° < θ_y < 110 °	-	-
Left	θ_y < 70 °	−0.5 *VM*	1 *VM*
Right	θ_y > 110 °	1 *VM*	−0.5 *VM*
Forward1	90 ° < θ_x < 139 °	0.5 *VM*	0.5 *VM*
Forward2	140 ° < θ_x < 180 °	1 *VM*	1 *VM*
Backward1	50 ° < θ_x < 89 °	−0.5 *VM*	−0.5 *VM*
Backward2	0 ° < θ_x < 49 °	−1 *VM*	−1 *VM*

3. RESULTS AND DISCUSSION

3.1 Confirmation of two-speed levels

A basic test was conducted to evaluate the time required for the robot to reach a 4-meter-long track. The calculated speed values in Table 3 confirm that the slave controller and motor driver have responded according to the two desired speed levels, FR and FR2, as programmed in the slave controller.

Table 3. Two-speed levels

Speed Level 1	Speed Level 2
FR Normal Speed 1: $FR = \frac{4\,m}{25\,s} = 0.16\,m/s$	*FR2* Faster Speed 2: $FR2 = \frac{4\,m}{15\,s} = 0.27\,m/s$

3.2 Motor driver output voltage for different MoBOT directions

Fig. 5 shows the measured voltage signals sent to the right and left motors from the motor driver for different directions. L298N motor driver generates high power PWM to run the motor and uses H-bridge circuit to control the speed and directions. During the forward movement, both the right and left motors received equal PWM signals, shown in green line, with a voltage level of around 11.96V to 11.98V. This indicates that both motors were rotating in the same direction and at the same speed, allowing the robot to move straight forward. The consistent voltage level between both motors confirmed that the robot maintained balance and did not drift to either side. For backward movement shown in red lines, both motors received equal signals but the PWM polarity was reversed to rotate the motors in the opposite direction.

When the robot performs a turning motion, a different PWM signal is applied to each motor to create the differential control. For a right turn, the left motor continues to move forward (green waveform), while the right motor is reversed (red waveform). This causes the robot to rotate or spin to the right around its midpoint. The voltage levels remain nearly the same, indicating that the turn is balanced and controlled by direction rather than speed difference. The opposite method is used to control both motors for a left turn.

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This turning behavior demonstrates a turn in place which is efficient for mobile platforms operating in confined spaces.

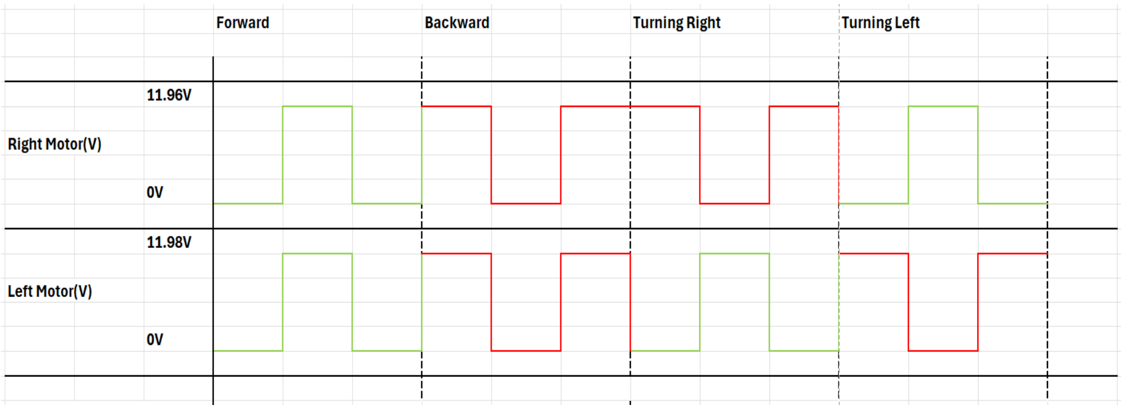

Fig. 5. Measured output voltage from the motor driver for different motor directions

3.3 Motor driver output voltage in the presence of obstacles

Fig. 6 shows the measured voltage signals sent to both the right and left motors for a forward direction when the front ultrasonic sensor detects obstacles at two different distances from the MoBOT. When the obstacle is more than 20 cm from the robot, the actuating voltage sent to the motors keep the robot moving forward. When the obstacle reached 20 cm or less, the output voltage drops to 0V as shown in the red line, which triggered the robot to stop. This behavior indicates that the ultrasonic sensor has successfully detected the nearby objects and sent the correct signal to stop the robot in time to avoid collision.

Finally, Fig. 7 shows the snapshots of MoBOT navigation test using the proposed master-slave system. For the MIT app master, the IoT app was displayed on a handheld tab to control the robot like using a robot control console (Fig. 7(e) – 7(i)).

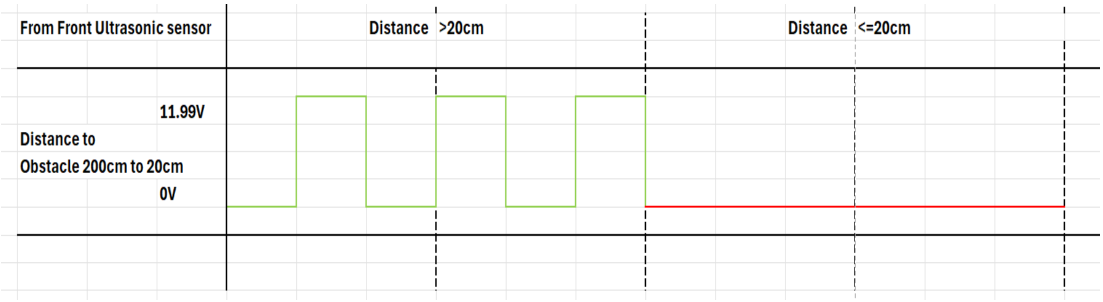

Fig. 6. Voltage output measured from motor driver in the presence of obstacle

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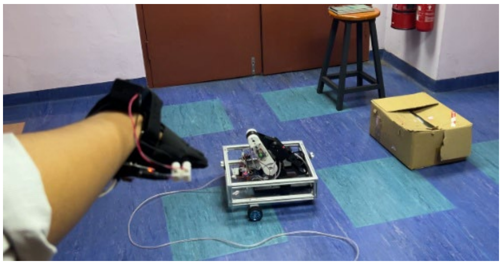
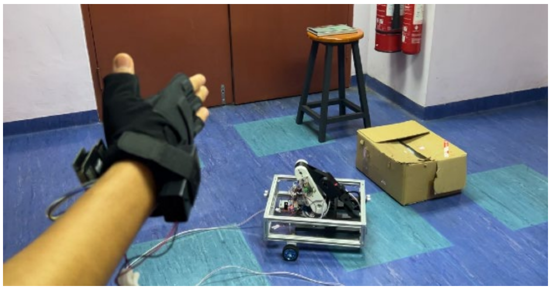
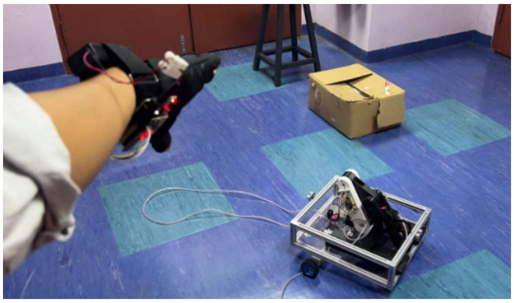
(a) Master hand glove instructed moving backward



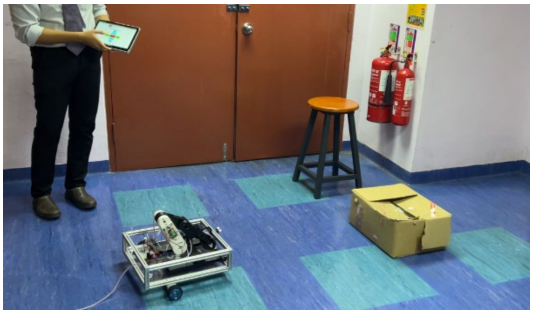
(b) Master hand glove instructed moving forward



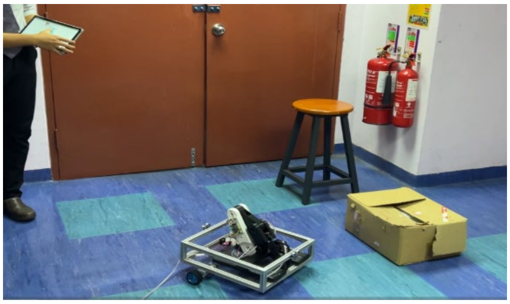
(c) Master hand glove turning right



(d) Master hand glove turning left

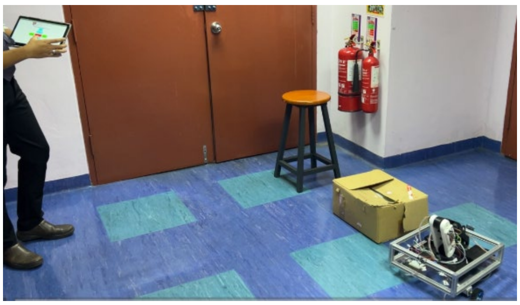


(e) Master MIT App instructed moving forward



(f) Master MIT App turning right

(g) Master MIT App turning left



(h) Master MIT App instructed moving backward

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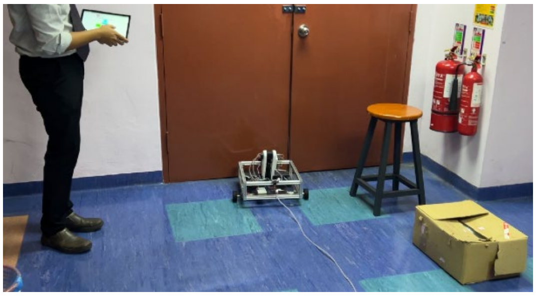

(i) Automatically stopped to avoid the door

(j) Automatically stopped to avoid the wall

Fig. 7. Snapshots of MoBOT navigation using master-slave system

4. CONCLUSION

This work has solved the problem of static robot arms and the execution of robot tasks at a fixed location by developing a wireless master-slave mobile robot system control via an IoT application as the first master and a hand glove device as the second master. The master unit uses a hand glove with an MPU6050 sensor to measure hand gestures, while the slave robot uses a DC motor to move the robot and an ultrasonic sensor to detect obstacles. To ensure user's full control over the robot's movements, the IoT master has been programmed as the main control master that can override the commands sent by the hand glove master. A Firebase cloud database is used to store data sent by the master and retrieved by the slave, allowing for wireless remote control of the mobile robot. The successful navigation results of MoBOT in experimental tests demonstrate the feasibility of both masters for the robot master-slave system, proving the practicality of the wireless communication, software and hardware interfaces, obstacle detection algorithm, speed and direction control, and IoT integration. For future applications in undefined environments, 3D laser sensors can be added for obstacle recognition and used in autonomous obstacle avoidance navigation methods. Furthermore, compact and long-lasting batteries can be used to provide sufficient power supply to the robot for longer usage distances.

5. ACKNOWLEDGEMENTS/FUNDING

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6. CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts.

7. AUTHORS' CONTRIBUTIONS

Muhammad Arif Abd Shukor: Conceptualisation, methodology, formal analysis, software, investigation, validation, visualization and writing-original draft; **Ruhizan Liza Ahmad Shauri**: Conceptualisation, methodology, supervision, funding acquisition, visualization, writing-review & editing; **Zainul Haziman Hisam**: Conceptualisation.

https://doi.org/10.24191/jcrinn.v11i2.631

8. REFERENCES

Buthelezi, N. M., Malele, V., Owolawi, P. A., & Mapayi, T. (2022). IoT Based health monitor for remote patient. In *5th International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems*. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/icABCD54961.2022.9856318.

Bhala, T., Aggarwal, A., Aggarwal, S., Garg, K., & Gupta, A. (2023). Home automation system using Internet-of-Things & Blynk App. In *2023 IEEE Pune Section International Conference, PuneCon 2023*. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/PuneCon58714.2023.10450120.

De Sant Ana, P. M., Marchenko, N., Soret, B., & Popovski, P. (2023). Goal-oriented wireless communication for a remotely controlled autonomous guided vehicle. *IEEE Wireless Communications Letters*, *12*(4), 605–609. https://doi.org/10.1109/LWC.2023.3235759.

Gore, R. N., Kour, H., Gandhi, M., Tandur, D., & Varghese, A. (2019). Bluetooth based Sensor Monitoring in Industrial IoT Plants. In *2019 International Conference on Data Science and Communication, IconDSC 2019*. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/IconDSC.2019.8816906.

Hisam, Z. H. (2025). *Master mechanism design and control for a master-slave arm robot* [Unpublished Undergraduate Thesis, Faculty of Electrical Engineering, Universiti Teknologi MARA]. UiTM Institutional Repository.

Jing, Y., An, T., Wang, T., Li, Y., & Dong, B. (2022). A decentralized robust impedance control method of modular robot manipulators with physical human robot interaction. In *Proceedings of the 34th Chinese Control and Decision Conference, CCDC 2022* (pp. 5490–5495). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/CCDC55256.2022.10033849.

Kale, P., & Sakhare, N. (2020). gesture based automation of a robot car. *International Journal of Scientific Research in Science, Engineering and Technology*, *7*(2), 508–513. https://doi.org/10.32628/ijsrset207296.

Koh, Y., Chang, E., & Choi, M. E. (2023). Collision prevention strategy using sparse 2D spatial information for indoor mobile robots. In *IEEE International Conference on Intelligent Robots and Systems* (pp. 11249–11256). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/IROS55552.2023.10341443.

Lee, H., Yoon, J., Jeong, Y., & Yi, K. (2021). Moving object detection and tracking based on interaction of static obstacle map and geometric model-free approach for urban autonomous driving. *IEEE Transactions on Intelligent Transportation Systems*, *22*(6), 3275–3284. https://doi.org/10.1109/TITS.2020.2981938.

Mhetre, M., Mohekar, N., Mhatre, R., Barhate, Prof. Mi., Modhave, P., Mishra, A., & Senapati, M. (2023). Gesture controlled robot car. *International Journal for Research in Applied Science and Engineering Technology*, *11*(10), 1545–1549. https://doi.org/10.22214/ijraset.2023.56184.

Mujeeb Rahman, K. K., Mohamed, N. N., Zidan, R., Alsarraj, I., & Hasan, B. (2023). iot-based wireless patient monitor using ESP32 microcontroller. In *2023 24th International Arab Conference on Information Technology, ACIT 2023*. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACIT58888.2023.10453847.

https://doi.org/10.24191/jcrinn.v11i2.631

Munasinghe, T., Patton, E. W., & Seneviratne, O. (2019). IoT application development using MIT app inventor to collect and analyze sensor data. In *Proceedings - 2019 IEEE International Conference on Big Data, Big Data 2019* (pp. 6157–6159). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/BigData47090.2019.9006203.

Roy, A., Basu, A., Saha, D., Ali, S. S., & Sain, C. (2024). Cloud server enabled iot integrated smart wrist band for women's protection remotely. In *2024 IEEE Region 10 Symposium, TENSYMP 2024*. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/TENSYMP61132.2024.10752277.

Song, Y., Li, L., Tian, Y., Li, Z., & Yin, X. (2023). A novel master–slave interventional surgery robot with force feedback and collaborative operation. *Sensors*, *23*, 3584. https://doi.org/10.3390/s23073584.

Sriram, K. N. V., & Palaniswamy, S. (2019). Mobile robot assistance for disabled and senior citizens using hand gestures. In *1st International Conference on Power Electronics Applications and Technology in Present Energy Scenario, PETPES 2019 - Proceedings*. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/PETPES47060.2019.9003821.

Ullah, S., Mumtaz, Z., Liu, S., Abubaqr, M., Mahboob, A., & Madni, H. A. (2019). Single-equipment with multiple-application for an automated robot-car control system. *Sensors*, *19*, 662. https://doi.org/10.3390/s19030662.

Xiang, W., Yu, K., Han, F., Fang, L., He, D., & Han, Q. L. (2024). Advanced manufacturing in industry 5.0: A survey of key enabling technologies and future trends. *IEEE Transactions on Industrial Informatics*, *20*(2), 1055–1068. https://doi.org/10.1109/TII.2023.3274224.

Yamamoto, Y., Wakimoto, S., Kanda, T., & Yamaguchi, D. (2021). A soft robot arm with flexible sensors for master–slave operation. *Engineering Proceedings*, *10*, 34. https://doi.org/10.3390/ecsa-8-11311.

Younis, M. F., & Alwan, Z. S. (2023). Monitoring the performance of cloud real-time databases: A firebase case study. In *AICCIT 2023 - Al-Sadiq International Conference on Communication and Information Technology* (pp. 240–245). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/AICCIT57614.2023.10217953.

Yunus, M. S. M. (2022). *Wireless controlled mobile robot based on hand gestures* [Unpublished Undergraduate thesis, Faculty of Electrical Engineering, Universiti Teknologi MARA]. UiTM Institutional Repository.

https://doi.org/10.24191/jcrinn.v11i2.631