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Smart and Intelligent Prayer System for Elderly Muslim with IoT

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Abstract

An assistive and monitoring prayer system has been designed to help elderly Muslims in performing their daily prayers. However, the system has several limitations in the aspect of efficiency, cost, size, complexity, security and usability. In this paper, several enhancements have been proposed to improve the existing smart prayer system including a better approach to retrieve exact prayer times, efficient way to retrieve current date/time, two different sensors used to detect the physical movements, smaller microcontroller with a built-in Wi-Fi module and the fabrication of PCB board. On the monitoring system, this project offers a more user's friendly mobile application with several enhanced features. Reminder and authentication features are added to the mobile application for increased security and usability. The mobile application only allowed authorized or registered users to use the mobile application to view prayer performance of the elderly and send a prayer reminder to the elderly. The proposed system implements Internet of Things (IoT) technology, with a microcontroller communicating with the database through Wi-Fi, and data is modified before being displayed via the mobile application. Experimental testing shows a high level of support for the system's commercialization due to its ability to assist and monitor the elderly with their daily prayers. This new smart prayer system offers a more reliable assistive and monitoring system for elderly Muslim.

1. Introduction

Praying is one of the five pillars of Islam [9]. Prayer must be performed five times a day and each prayer must be performed at a specific time. Different prayers have different numbers of cycles which are made up of physical movements with Quran recital in between [15]. Once Muslim reach the age of puberty, daily prayer is an obligation and needs to be performed during the lifetime. According to research on identifying the age of puberty, puberty normally begins between the ages of 8 to 13 for females and 9 to 14 for males [3]. The senior generation in Malaysia increased from 7.0 to 7.3 percent between 2021 and 2022 [6]. With the number of elders increasing year after year, technology must be used to assist them in performing their daily life tasks independently, including prayer. This is also due to the elderly having a variety of challenges during performing their daily prayers. This involves issues remembering the current cycles, forgetting to perform particular prayers, and confusing with the repetition of pillars.

In this paper, the enhancements from the previous work are proposed to develop a better prayer system for elderly. Specifically, the system included the monitoring system that implements the IoT platform to monitor and assist the daily prayers of the elderly. The system has reduced the size and cost by choosing a smaller

microcontroller with a built-in Wi-Fi module and removing all the unnecessary components. Besides the prayer times are retrieved from a trusted website through API's key and keep them in the database. The proposed system is made up of three main parts: i) a smart prayer mat that check the sequence of the physical movements performed by the elderly and provide audiovisual aid for elderly while praying, ii) cloud storage to store prayer times retrieved using API's keys and prayers record for monitoring purposes, iii) a mobile application that allow the caretakers to view prayer performance of the elderly that has been recorded into the database and allow the caretakers to send the reminder to the elderly remotely.

2. Related Works

Some related research papers are being reviewed and studied in order to improve the existing prayer system. Each project's outcome will be summarized, and all advantages and limitations will be compared.

2.1 Smart Prayer Mat

2.1.1 Textile-Based Pressure Sensor to Assist Elderly with Cognitive Impairment in Praying Activity

In this work [11], a smart prayer mat with a controller box and a pressure sensor on the top of the mat to detect the pressure of the forehead during prostration position is designed, as shown in Figure 1. The system additionally consists of a speaker that provides audible cues after completing a cycle. Given that there will be two times of prostration in a Rakah, the system will take pressure input from the forehead using the pressure sensor and increase the Rakah by one when two prostrations have been accomplished. The speaker will then produce cues immediately after the second prostration of each cycle. The entire system mainly consists of two inputs: a real time clock (RTC) module for obtaining current and accurate time and a pressure sensor for detecting the prostration. While the system's output consists of an MP3 player module that cues the current number of Rakah and a MicroSD card module that stores the date, as well as the start time and time for each completion of Rakah (second prostration).

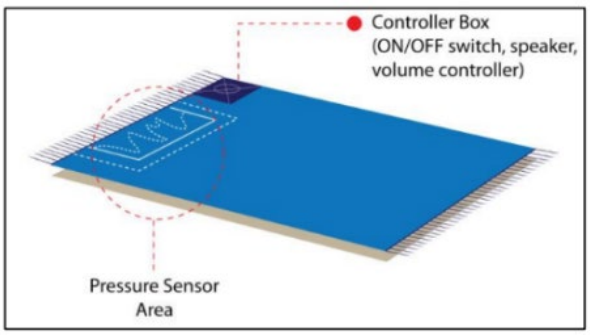

Fig. 1 *Design of the smart prayer mat [11]*

2.1.2 A Smart Mat for Assisting Muslim in Praying

The following research article [13] is about an intelligent prayer mat that uses 5 sensors distributed into three different areas to detect current position rather than a single sensor, as shown in Figure 2. The entire system is made up of three different units: a control panel, a sensing array, and a processing unit. The control panel features various buttons for selecting the information to be displayed, as well as a buzzer that serves as an alarm and a display. The processing unit is made up of multiple components, including a real time clock (RTC) module, a GPS receiver, and a digital compass. The GPS receiver and digital compass identify the Qibla direction as well as all prayer times. RTC module is utilized to obtain the start time of the prayer while retrieving the actual and correct time. Once all of the pillars have been completed in the correct order, the Rakah counter will increase by one. Every position is determined by 5 sensors, which are distinguished by the amount of pressure received by the pressure sensors.

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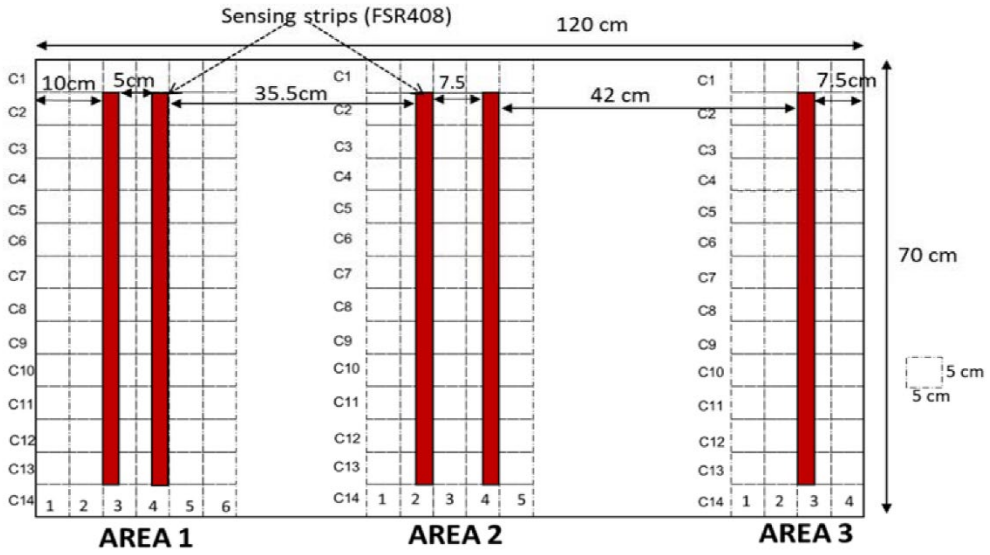

Fig. 2 *Position of sensors on the prayer mat [13]*

2.2 Smart Prayer System for Children

The improvised prayer mat system for children has been designed in this paper [14] with full implementation of IoT. The system has been split into two parts: a smart prayer mat and a web application. Figure 3 shows the electronics parts embedded on the prayer mat. A selected period of prayer time is saved on the SD card to determine whether the chosen prayer matches the real prayer time. Five leds indicate the type of prayer: Subuh, Zuhur, Asar, Maghrib, or Isya. The buzzer serves as an alarm, while the 7-segment display shows the Rakah counter which will be counted as the second prostration completed through the touch of the forehead on the FSR sensor. Furthermore, an external RTC module is used to retrieve the current actual time.

It is utilized in conjunction with an external Wi-Fi module to offer Wi-Fi connectivity to the main controller, which will be used to save the start and end time of the children's prayers into the database. The data will then be altered so that it may be viewed in the web application properly. Figure 4 shows the web application developed for the system. The parents will be able to review their children's prayer performance throughout the week, month and year using the same web application.

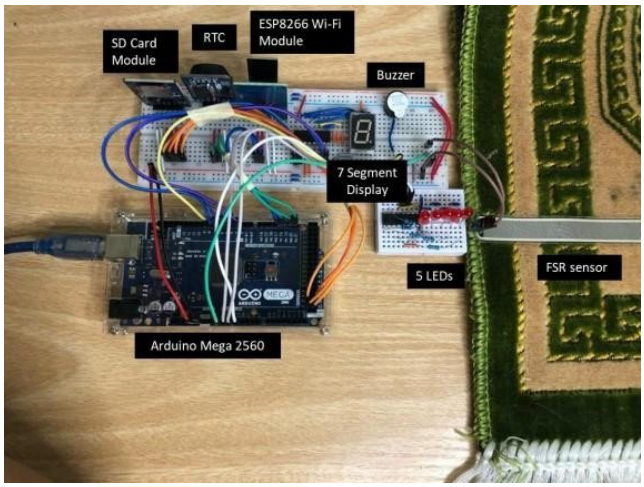

Fig. 3 *Electronics components on the smart prayer mat [14]*

		Subuh	Zuhur	Asar	Maghrib	Isyak
28-09-2021	Start Time	6:150	13:45	-	-	20:21
	End Time	6:23	13:55	-	-	20:35
29-09-2021	Start Time	6:35	-	17:15	-	20:21
	End Time	6:43	-	17:30	-	20:35
30-09-2021	Start Time	-	13:50	17:15	19:44	20:21
	End Time	-	14:5	17:30	19:59	20:35
01-10-2021	Start Time	6:35	13:45	17:15	19:43	20:21
	End Time	6:43	13:59	17:30	19:56	20:35
02-10-2021	Start Time	-	-	17:15	-	-
	End Time	-	-	17:30	-	-
03-10-2021		No Record Found				
04-10-2021		No Record Found				

Fig. 4 *The web application designed to monitor the prayer performance of the children [14]*

2.3 Smart Prayer System for Elderly

There are two related papers describe prayer systems for elderly muslim which Assistive Prayer Monitoring System for Elderly Muslim [15] and Prayer Monitoring System for Elderly Muslim [10]. These research papers describe a prayer system that consists of two major components: hardware and software. For the hardware, all of the components are embedded together to accomplish certain tasks. It contains a microprocessor to manage the inputs and outputs, a LCD display, a speaker, a DFPlayer and two sensors (FSR and IR) to detect the current pillars, as shown in Figure 4. Furthermore, this prayer system can help the elderly because it will assist them to perform their prayer. To establish the direction of the Qibla, a digital compass is included. The LCD will display all of the relevant information for guiding the pillars to be performed, the Rakah counter, Qibla direction and the MP3 (DFPlayer with the speaker) player will recite the Quran based on the pillars.

However, the system still relied on a separate Wi-Fi module to provide Wi-Fi connectivity for the main controller to the database. Once the prayer is done, the system will update the date and time of the prayer performed to the database for monitoring purposes. A web application is developed on behalf of the software to track the performance of the prayer. Caretakers can use this web tool to track whether their elderly has performed a certain prayer or not, as well as the time the prayer was performed.

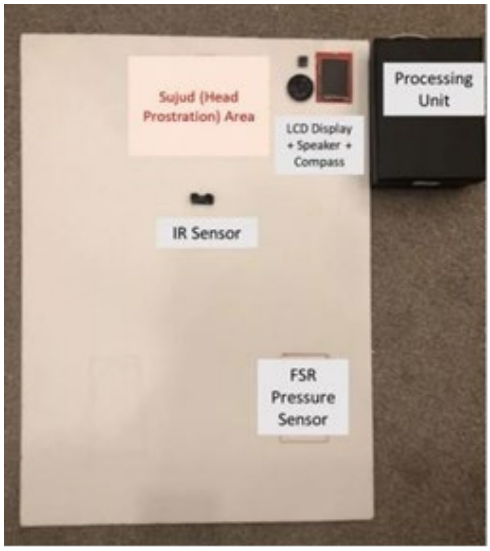

Fig. 5 *The prototype of the prayer monitoring system [15]*

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Based on all of the preceding studies and research articles, all of the advantages and limitations are identified in order to design a better aiding and monitoring prayer system for the elderly in this project. The benefits are considered for improving and designing a new prayer system for elderly to ensure that the new version preserves along with upgrades all of the positive characteristics. These include the Rakah counter, pillar determination, sequence verification, data storage system, and mobile/web application. In contrast, the improvised prayer system will include all those enhancements. For example, the correct controller is chosen with a built-in Wi-Fi module, eliminating the requirement for an external Wi-Fi module. Following that, the extraction of accurate prayer times is updated daily using API keys obtained from a reliable website and stored in the cloud. This encourages a less time-consuming and more adaptable system.

The extraction process takes much less time than the calculation method used in a previous project, and the prayer times are constantly updated rather than saved for a set duration of time on a microSD card [17]. Furthermore, an additional function added to this new system is the ability to remind the elderly of unperformed prayers. This improved system is believed to be able to send a reminder to the system remotely using the mobile application, which is not only for monitoring prayer performance. To ensure that the elderly pray correctly and at the correct time, the system ensures that prayers that fall immediately after the prayer period and a minute before the next prayer time should be allowed. The technology will ensure that the elderly pray in the correct sequence, and each pillar will be identified using two input sensors for more accurate detection. Last but not least, this smart system will include audible and visual aids to assist the elderly during prayer.

3. Design Methodology

3.1 System Architecture

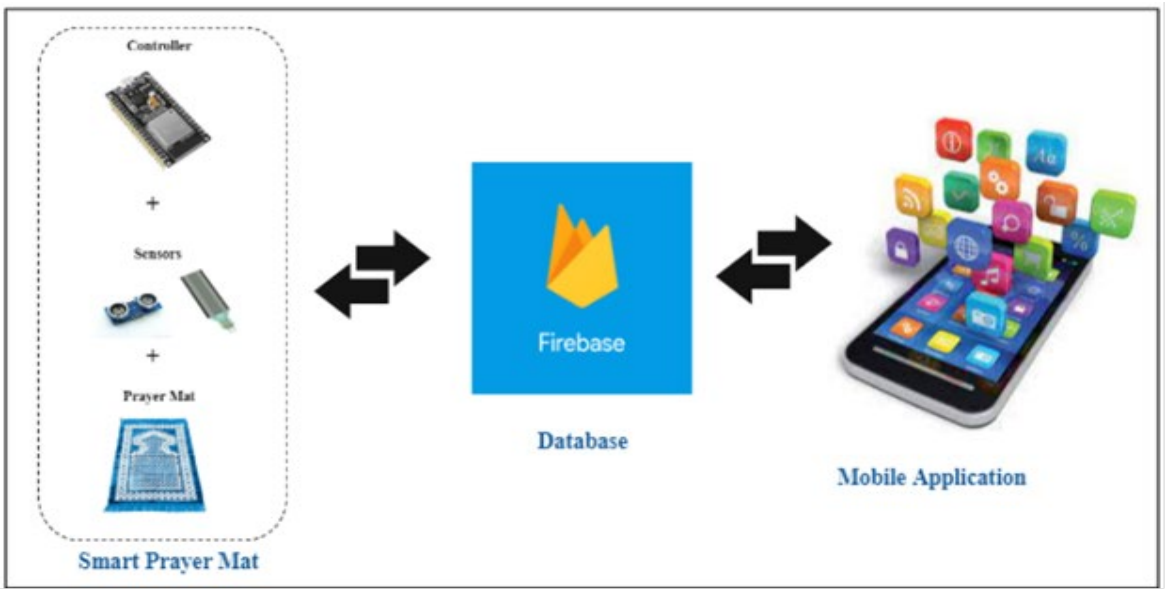

Fig. 6 *System architecture of smart and intelligent prayer system*

Figure 6 illustrates the architecture of the proposed prayer system. In this figure it can be seen that all the components are correlated and able to communicate to each other to perform specific tasks. The designed prayer system is divided into three parts: i) Smart prayer mat, ii) Database, iii) Mobile application

a) Smart prayer mat: An embedded unit that consists of several components such as LCD display, DFPlayer, speakers, buttons, controller, FSR sensor, ultrasonic sensor and IR receiver. TheDFPlayer together with speakers provide audio aid while the LCD display provides visual aid to the elderly during prayer. Buttons and an IR receiver acts as the platform for the elderly to select and start the prayer. Both sensors are used for physical movement determination. A controller is used to manage the input/output devices and send the data through the internet.
b) Database: A database used to store all the prayer times retrieved from JAKIM website using the API's keys. The prayer records are also kept into the database for monitoring purposes.
c) Mobile Application: A mobile application was developed to monitor the daily prayer performance of the elderly and send reminders to the elderly. Only registered and allowed users are able to use the mobile application.

The integration of these three components are done to produce a new Smart and Intelligent Prayer Systemfor Elderly. To program the controller to manage all the inputs and outputs, the software known as Arduino.IDE is used. The programmes are all being verified to check for the error before being uploaded to the controller [1]. For cloud storage, Firebase is chosen as it offers the Real Time Database (RTDB) service which is more efficient because the newest data updates will be instantly received [7]. Besides, firebase is one of the familiar IoT platforms used because it is easy to integrate with the mobile application inventor used which is Kodular. Kodular is chosen because of its enhanced features and it uses block coding instead of written source code [8]. In simple words, this new prayer system improvised the previous work [15] with some enhancements.

3.2 Hardware Design

Smart prayer mat is an electronic device that is integrated on a muslim prayer mat and has the capability of transferring and receiving the data. In this project, the smart prayer mat is said to be similar to other smart systems. It can record the prayer's data and send it to the database together with retrieving the data from the database to perform specific tasks. The designed smart prayer mat is developed with the following objectives:

- To retrieve all prayer times from Jakim website and send it to the database.
- To retrieve correct time and date using online Network Time Protocol (NTP).
- To send the start and end time of the performed prayer.
- To check the physical movements with proper sequence.
- To display the Rakah counter and physical movements that must be performed.
- To check either chosen prayer is done at the correct time or not.
- To provide audio aid during praying.
- To send and read data from the database.

To accomplish all the objectives stated above, an embedded unit is developed with the assembly of electronic components as can be seen in Figure 7(a). The components include a microcontroller, Liquid Crystal Display (LCD), two buttons, force resistive sensor (FSR), infrared (IR) receiver, ultrasonic sensors, speaker and DFPlayer.

ESP32 is chosen as the controller because of the smaller size, large number of input/output pins, built-in Wi-Fi function, cheaper and supports a Micro USB cable for both power supply and communication between the computer and the microcontroller [5]. In this smart prayer mat, four input (FSR, IR receiver, Ultrasonic sensor and buttons) and three outputs (LCD, DFPlayer, Speaker) devices are connected to the ESP32 which acts as the processing unit to manage the input and output devices. Four different sensors are implemented in this smart prayer mat: FSR sensor, ultrasonic sensor, IR receiver and buttons. Both FSR and ultrasonic sensors are used to check the physical movements with correct sequence as illustrated in Figure 8 below and Table 1. The ultrasonic sensor consists of a transducer that can both emit and receive sound waves. When the sound wave collides with an object, it is reflected back to the transducer [18]. To measure the distance, the time stamp for the delivered sound wave to be detected after hitting the target is calculated.

The IR receiver and buttons used to select prayer and start the prayer chosen. The IR remote is used to communicate with the IR receiver. When a button on the remote is pressed, it sends a distinct hexadecimal code [4] to the IR receiver to interpret its meaning. The LCD will display the Rakah counter and the physical movements that should be performed by the elderly. Besides, the DFplayer together with the speaker will act as MP3 player which will produce the audio aids to the elderly during the prayer. The built-in Wi-Fi is used to retrieve the prayer times, retrieve the correct time/date from the internet and send/read data to the database. The Figure 7 (b) shows the prototype of the smart prayer mat with the corresponding position of the components. Only the FSR and ultrasonic sensor are on the prayer mat, the rest are located inside the control unit.

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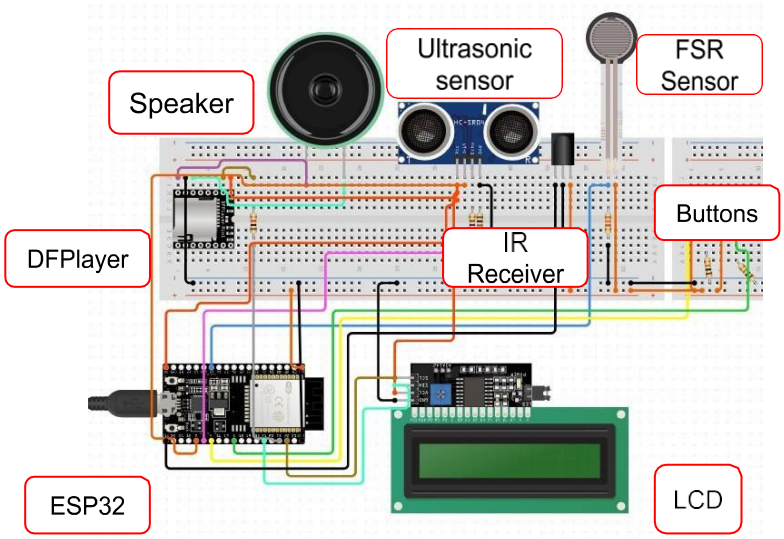

(a)

(b)

Fig. 7 *(a) Hardware design of smart prayer mat; (b) Prototype of smart prayer mat*

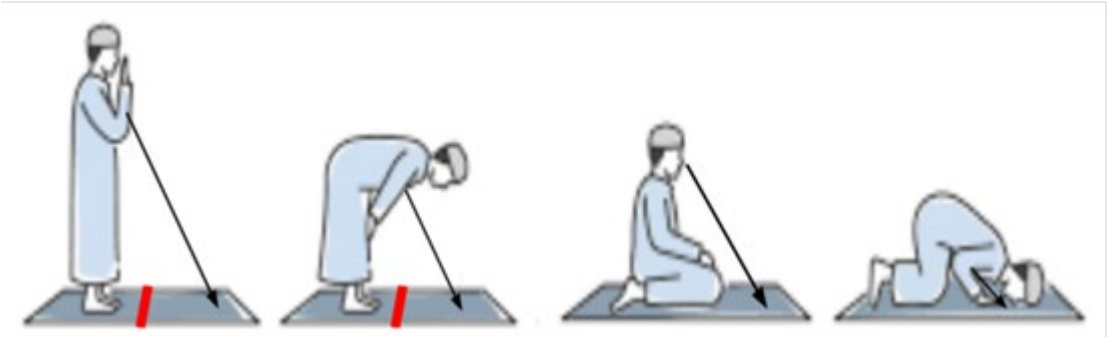

Fig. 8 *Four different physical movements that will be checked*

Table 1 *FSR and ultrasonic condition to detect physical movement*

Physical Movements	FSR sensor	Ultrasonic sensor
Standing	Pressure not detect	Distance > 130cm
Bowing	Pressure not detect	130cm > Distance > 85cm
Sitting	Pressure detected	85cm > Distance > 30cm
Prostrating	Pressure detected	Distance < 30cm

3.3 Software Design

Both database and mobile application is developed with the following objectives:

- To view the elderly's prayer performance.
- To display all the prayer times.
- To make sure only registered caretakers use the app.
- To provide a reminder interface.

3.3.1 Database

Once the system is switched on, the system will retrieve all the prayer time from the JAKIM website through the HTTPS request using the API keys [12] and stored in the Firebase. Then, after elderly choose and start the prayer, the start time is recorded using the NTP and sent to the database. The date obtained from the NTP will be used as the bucket and the prayer chosen will be the tag. The obtained time will be kept as the "start time". After elderly finish their prayer, the NTP is again used to obtain the end time of the prayer and sent to the database which will also be kept into the same bucket and tag as "end_time". Figure 9 shows an example of the data saved into the Firebase database.

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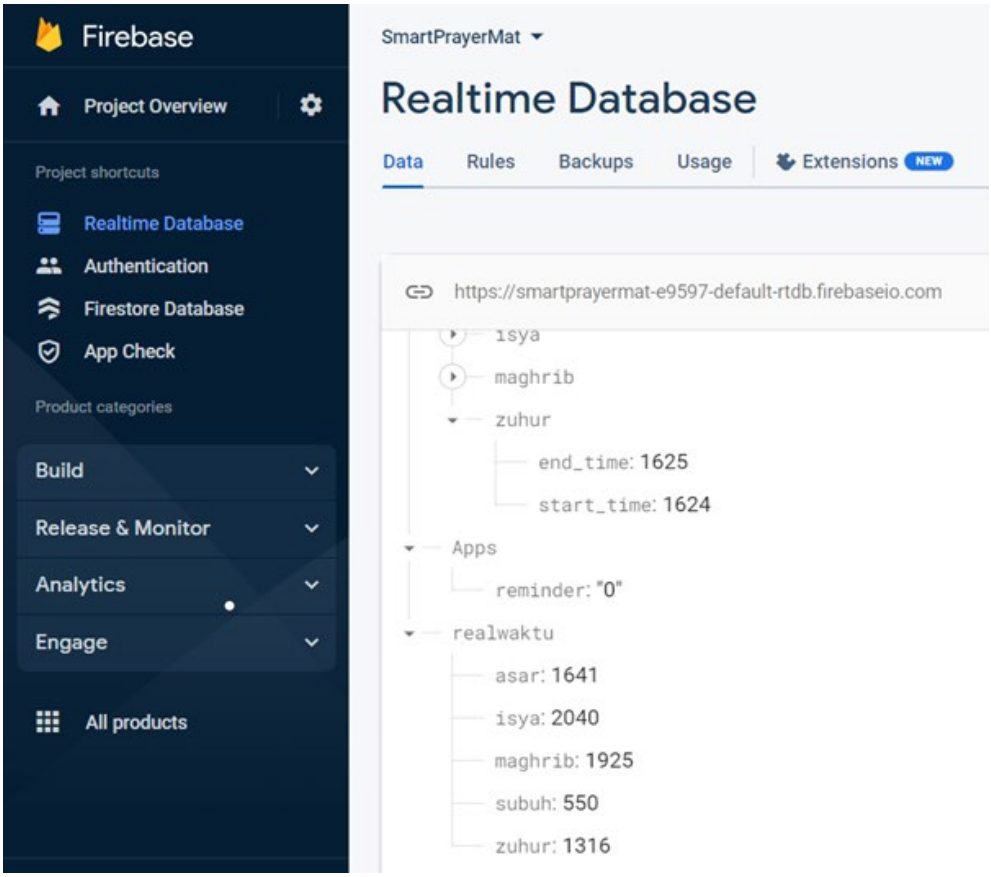

Fig. 9 *An example of recorded data in the Firebase*

3.3.2 Mobile Application

A mobile application is created using the open and online source which is Kodular. The purpose of creating the app is to allow the caretakers to view the elderly's prayer performance and send the reminder in case the elderly forgot to perform their prayer. Some additional features are included which are the user needs to create the account and only allow the registered user to sign in the mobile application before can use the rest of the features. The created mobile application will retrieve that needed information from the database and modify it to be viewed on the screen. The algorithm of these processes is done by the block coding in the Kodular as can be seen in Figure 10 below.

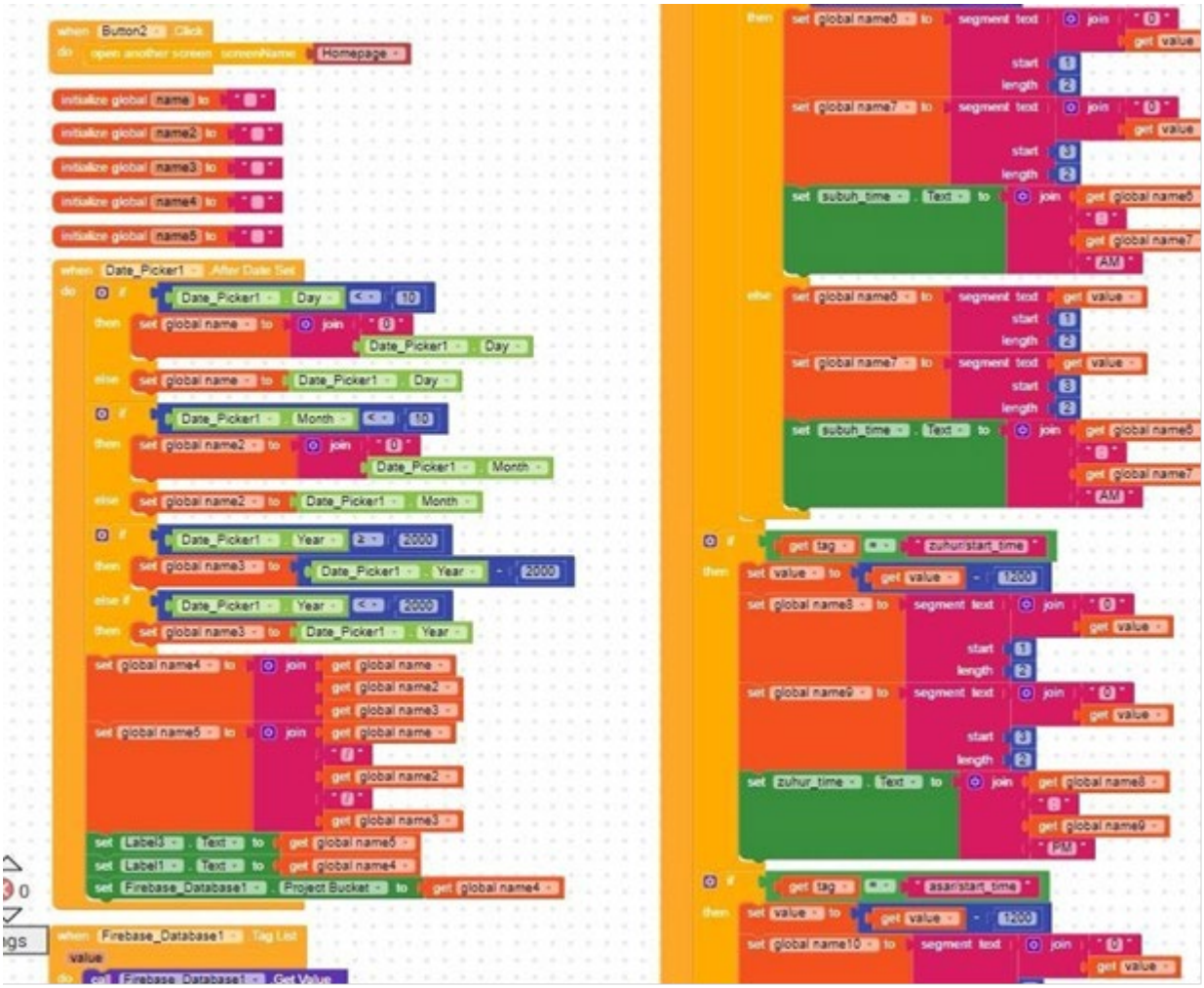

Fig. 10 *An example of the block coding in the Kodular*

4. System Design

In this chapter, the operation of the overall Smart and Intelligent Prayer System for Elderly is described and explained further. The overall system is divided into two parts: hardware system and software system.

4.1 Hardware System

Figure 11 illustrates the block diagram of the hardware system. Initially, several settings are configured when turning on the system. These include the connection of the controller to the Wi-Fi, the retrieval of the prayer time from the JAKIM website, configuration of the database, update of the current prayer time to the database, initialization of the DFplayer and the configuration of the NTP. Then, the system will start the looping with the welcoming display. Once the elderly chooses the prayer to be performed, there is an algorithm to check whether the chosen prayer is in the correct range of time or not. If not, it will restart the loop. If yes, the controller will send the start time with its corresponding date to the database. Then, the system will check the physical movements so that all the physical movements are performed in a proper sequence. Once the prayer is finished, the system will send the end time with the corresponding date to the database before the system restarts the loop. The reminder will read the value from the database with a tag of "reminder" every 5 seconds. If the value changes from "0" to "1", the adhan sound will be produced.

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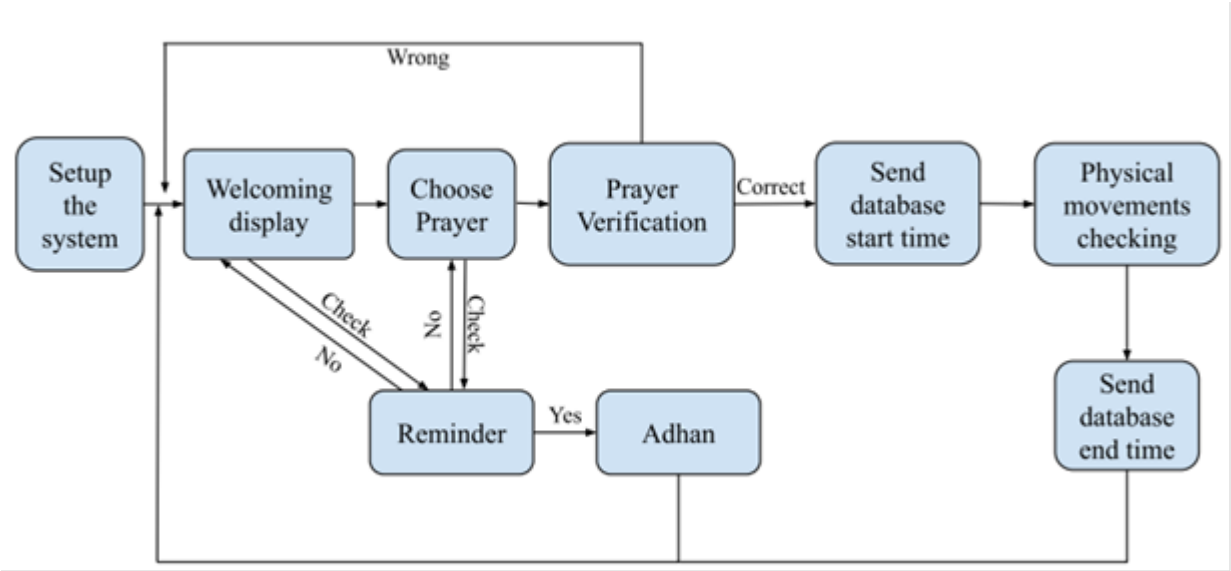


Fig. 11 *Block diagram of the hardware prayer system*

4.2 Software System

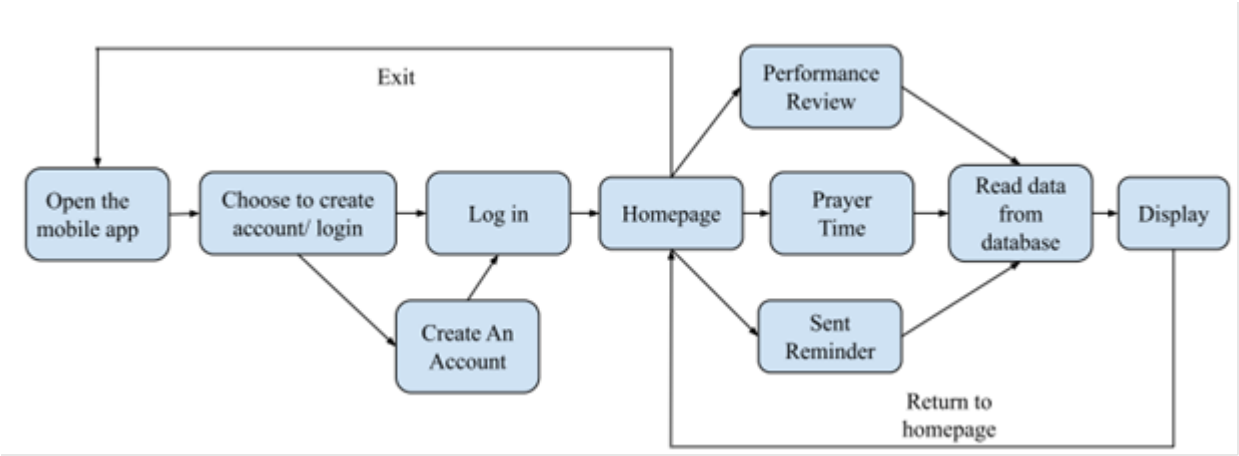
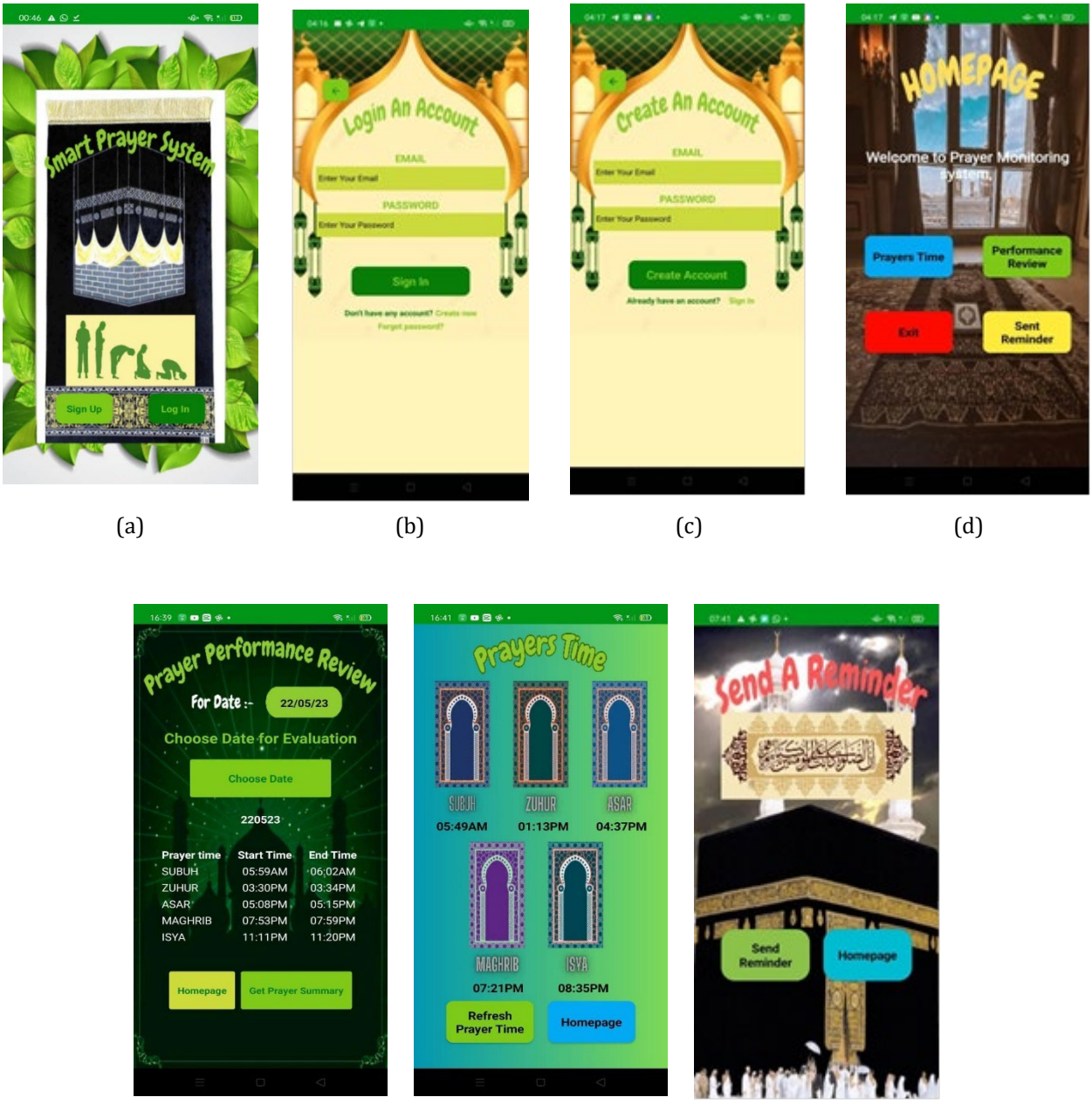


Fig. 12 *Block diagram of the software for the prayer system*

Figure 12 shows the block diagram of the software prayer system. In the first screen, the interfaces allow the caretakers to choose either to login or to create the account. Once the caretakers register an account, the caretakers are allowed to view the prayer performance of the elderly, view the prayer time and send the reminder to the elderly. In the prayer performance page, the caretakers can pick the date to review the performance. The date chosen is modified by the app to retrieve the tag in the database with the same date. Then, the start and end time for all prayers will appear on the screen. On the prayer time page, the mobile apps will read from the database with the tag of "realwaktu" and display in the page. The "realwaktu" tag stored all the retrieved prayer times that has been done by the controller through the HTTPS request to the JAKIM website. For the send reminder page, once the caretakers pressed the button labeled "sent reminder", it changed the value of the tag "reminder" in the database from "0" to "1". The changes of this value will be notified by the system since the value for the same tag is being checked for every 5 seconds before the adhan sound is played. Figure 13 shows several screenshots of mobile application.



(a) (b) (c) (d)

(e) (f) (g)

Fig. 13 *Some screenshots of mobile application*

5. System Evaluation

A performance test was conducted with 10 respondents, comprising both elderly and caretakers, to evaluate the efficiency and functionality of the enhanced Smart Prayer System. The elderly respondents were asked to perform Subuh prayer using the system. They were tested to identify whether the system is successful or failed in assisting them during their prayer. The caretakers are asked to test the mobile application features of the system. They were tested to identify efficiency of the monitoring features of the system. After the testing, the respondents are required to fill up the feedback form.

Based on the feedback form, 90% of the respondents agreed that the improvised prayer system has the ability to assist and check the physical movements sequence performed by the elderly during their prayer. 80% of the respondents believe that the audiovisual aid helped and works well. All the respondents agreed with the system that only allows the specific prayer to be performed at specific times and the reminder function to remind the elderly. Besides, 80% of the respondents agreed that the mobile application developed has the features of viewing the exact prayer time and overall daily elderly's prayer performance. 70% of the respondents mentioned that the

system is easy to use and important because it provides a user-friendly mobile application and would like to purchase the system in future.

However, through this survey the drawbacks of the system can be determined. Some of the respondents said the system must include the setup mode for the distance since every person may have different distance reading for the physical movements detection. One of the respondents also suggested making the system with a rechargeable battery which would make the system more flexible and easy to carry everywhere. 60% of the respondents agreed the price of the system to be less than RM 100, 20% of them preferred to be above RM100, while the rest did not comment on the projected price.

6. Discussion

This Smart and Intelligent Prayer System is developed to assist the elderly during the prayer and monitor the elderly's prayer performance. The proposed system is made up of two elements which are the smart prayer mat and the mobile application. Each element consists of several enhancements. The enhancements on the smart prayer mat are as follows:

- Smaller and cheaper controller is chosen.
- Built-in Wi-Fi to eliminate the external Wi-Fi module and RTC module.
- Two different sensors promote better physical movement detection.
- The prayer times are retrieved from the trusted website.
- Audio and visual aid during the prayer
- Two methods to communicate with the system: button or IR remote.
- Current time and date retrieved using NTP.
- Only allow specific prayer at a particular range of time.
- The development of the PCB board to the system.

The enhancements on the mobile application are as follows:

- Authentication features that only allow registered users to use the application.
- Can view all the prayer times and elderly's prayer performance.
- Can send a reminder to the system.

Since this system is based on the IoT concept, Wi-Fi or internet access is essential [16]. Because of the internet's rapid expansion and superior infrastructure, access to it is now simple. As a result, residents are already comfortable with using the internet in their daily lives. Therefore, it is relevant to establish this system because internet capabilities are not an issue.

7. Conclusions

A smart prayer system for elderly muslim has been developed and enhanced using IoT technology. The system succeeded in assisting the elderly during the prayer and the caretakers were also able to monitor the elderly's prayer performance. This improvised prayer system is said to be a useful assistive and monitoring technology for the elderly muslim. Last but not least, the implementation of this technology to this system benefits both the elderly and the caretakers.

For future work, several improvements could be made, such as the user is able to choose their own region, setup mode to customize the smart prayer according to the user's height and physical ability, differentiate the account ownership between elderly and caretakers and implementing the Artificial Intelligence (AI) technology for detecting the physical movements [2].

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design****: M.N. Irham, Sarina Mansor;* ***data collection****: M.N. Irham;* ***analysis and interpretation of results****: M.N. Irham, Sarina Mansor, Siti Azlida;* ***draft***

***manuscript preparation**: M.N. Irham, Sarina Mansor. All authors reviewed the results and approved the final version of the manuscript.*

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