A Convenient Proper Saf Arrangement Monitoring System for Congregational Salah in The Mosque

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ABSTRACT

Congregational salah in mosques is essential in Islam and achieving perfect saf for the congregation is crucial. A perfect saf is defined as an arrangement of perfectly aligned congregation with no distance between individuals in every row. Currently, there are methods devised to check or verify the saf arrangement reported in existing works. These include passive methods using a line on the carpets or floor of the mosques, as well as active methods such as using laser and Light-Dependent Resistor (LDR) to detect alignment for each saf. However, both approaches lack feedback on saf alignment and distance between individuals. This paper presents a system to check for saf misalignment and provide feedback to the imam. The system uses an array of Force Sensing Resistors (FSR), a microcontroller with a saf number display and LED indicators. The microcontroller is connected to the internet and Firebase for data transfer. The main display used is a television (TV) installed with Android TV operating system and is connected to the Internet. It uses the data in the Firebase to display the status of the saf alignment and the distance between the individuals within a saf. The TV SafAr Android app displays the position of each foot in each saf as well as the guidelines for the perfect saf. Each foot is indicated with green or red color for correct and incorrect positions respectively. The result from the conducted experiment shows that the system was able to detect the feet alignment and distance between individuals and provided feedback to the imam. *Keywords – Congregational Salah, perfect saf, display saf status, saf monitoring, FSR Sensor.*

INTRODUCTION

Salah is important to worship, and it is the main pillar of one's faith in Muslims. There are two methods in performing salah, individually and in a congregation. A hadith narrated by Al-Bukhari, Prophet Muhammad S.A.W once said, Islam encouraged Muslims to perform congregational salah [1].

> *"Congregational prayer more primary than individual prayer with 27 times."*
> (Al Bukhari)

One of the conditions emphasized in congregational salah is the perfection of the saf for the congregations. A hadith narrated by At-Tabrani in Al-Aswath, Prophet Muhammad S.A.W state the importance of perfect saf is offered to the Muslins that align and closed the gap in saf [2]. Figure 1 shows the example of perfect and imperfect saf.

As mentioned in the hadith, the first element of perfect saf is saf alignment. Alignment defines in this paper as a position of feet in the y-direction. This element will consider the saf status whether it is straight or not based on a reference line. The second element for a perfect saf is the distance between Muslims defined as position feet in the x-direction. This element focuses on distance left and right between Muslims. One perfect saf must be considered aligned and closed the distance

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between Muslims [3]. As shown in Figure 1 below, the illustration of x and y direction represents distance between individuals and alignment of the saf.

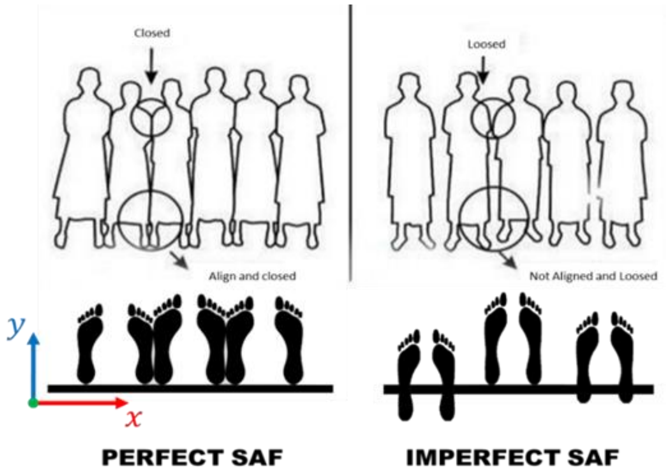

Figure 1. Illustration of perfect and imperfect saf.

Until now, many approaches have been used to assist in perfecting the saf during congregational salah at the mosque. As an example, a Majority of mosques in Malaysia use microphone and speaker to inform the congregations to straighten and close their saf [4]. This method will rely on a person's common sense and knowledge to follow the instruction. Sometimes, they do not recognize the status of the saf, resulting in them ignoring it and proceeding to salah [5]. These include passive methods using line on the carpets in the mosques which are lack of feedback to the imam (congregation leader) on the state of the saf.

In the reported works there are problems in active approach in checking and verifying the saf arrangement [6] – [8]. Zahari Abu Bakar et.al (2021), report a method using LDR (Light-Dependent Resistor) and laser connected to the smartphone apps through Bluetooth connection. Then, Amirul Akmal et.al (2020) used FSR (Force Sensitive Resistance) integrated with LED indicator. Taufan Rakhmawan et.al (2018) using a high-end approach by using Kinect camera and LCD Projector as display. All these three methods lack efficiency for multiple saf used and their use are only limited to a small congregation. Hence, the current / available methods to check and verify the saf arrangements, both passive and active, are unsatisfactory.

For the benefit of the Muslim community, the solution to the issues needs to be investigated. In order to address this issue, this paper proposes a new approach to using FSR sensor array, connected to the Wi-Fi network then Television (TV) as main display for feedback to the Imam and congregations. This includes design and develop this system with hardware and software part.

The outline for this paper is as follows: Section 2 discusses the materials and methods of checking and verifying the saf arrangement such as detection, processing element and display of the system. Section 3 discusses the results of the proposed method and finally Section 4 concludes the paper.

METHODOLOGY

This chapter presents the methodology implemented to achieve the objectives. The proposed saf status determination concept is presented first, followed by proposed conceptual design. The system's schematic diagram follows next. Then the processes involved in the system are divided into three that consist of selected component, schematic circuit for the whole system, development of SafAr apps. All the processes are substituted into two main processes, which are Hardware Development and Software Development.

Propose Saf Status Determination Concept

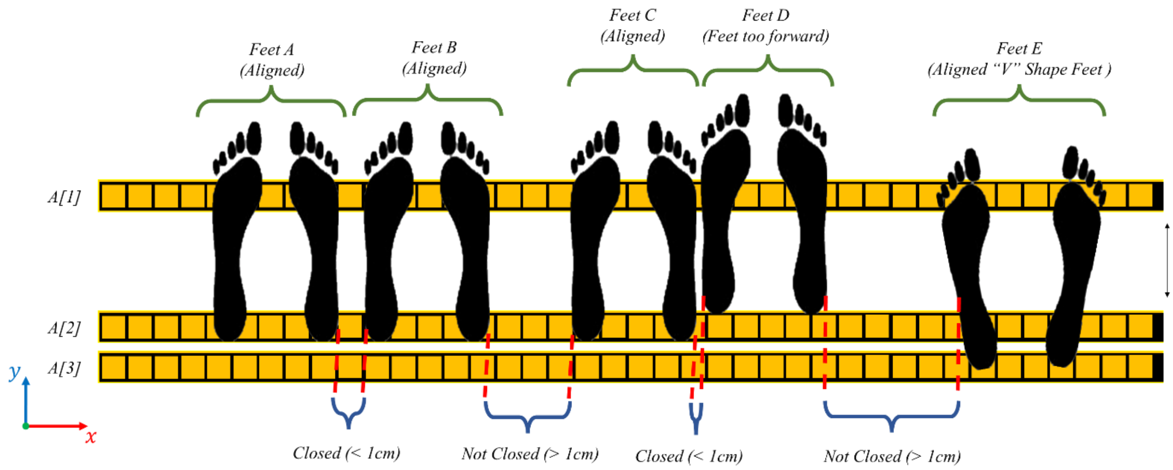

Figure 2. Sensor Arrangement Configuration.

Figure 2 above shows the arrangement for FSR array to determine the saf status. The detection concept sensor configuration uses 40 columns approach for all three rows. This approach is to detect multiple feet shape with capabilities to detect the feet position alignment. The distance between bits for this configuration is only 1cm.

This configuration can detect almost all shapes of feet without any specific size of feet. Another advantage of the fourth configuration is it can detect if the feet are too forward or too much backward with the three-row configuration approach. Then, this configuration can overcome the heels miss-placed issue due to all columns in the second row being placed with a 1cm distance between bits. In the meantime, the close distance between the bits gives small disadvantages to the Feet E with "V" shape feet as shown in Figure 2 above, the first row (A [1]) will be HIGH on multiple bits and the second row (A [2]) only detect the single bit.

The concept behind the design is use three FSR array for alignment detection, and 40 bit each array to detect the distance between Muslims in saf. Implementation of three FSR array can detect the alignment and check the distance between heels using address of each bit. The status for each foot is detected based on the condition show in Table 1 below. By implementation of this concept, the saf status can be determined. According to Table 1, Row1 (A [1]) and Row2 (A [2]) must be stepped on, but Row3 (A [3]) must not be stepped on due to its function to detect feet if feet are outside of saf. The proposed concept can determine the distance status between feet based on the FSR sensor bit step between the feet. As shown in Figure 2 above, if the distance between feet is less than 1 bit which equal to 1cm, the system will detect each foot was closed. Meanwhile, if the distance between feet is more than 1 bit, which greater than 1 cm, the system detects each foot was not closed

Table 1 Saf Status Algorithm

Row1 (A [1])	**Row2 (A [2])**	**Row3 (A [3])**	**Status**
HIGH	LOW	LOW	Feet Aligned
LOW	LOW	LOW	No Foot Detected
HIGH	HIGH	HIGH	Foot Too Backward
HIGH	LOW	LOW	Foot Too Forward
ELSE			Not Aligned/Not Closed

Also shown in Figure 2, the configuration was made with a distance between (A [1]) and (A [2]) is *l*. It stands for length based on dimension from previous studies [9]. *l* in this paper is equal to 20cm. Then distance between (A [2]) and (A [3]) is 1cm. Based on determination concept show in Table 1, Figure 2 shows Feet A, B, and C were aligned. Meanwhile, Feet D and E is too forward and too backward respectively. In terms of distance, between Feet A and B, also Feet C and D was closed. Nevertheless, Feet B and C, including Feet D and E were not closed.

Conceptual Design

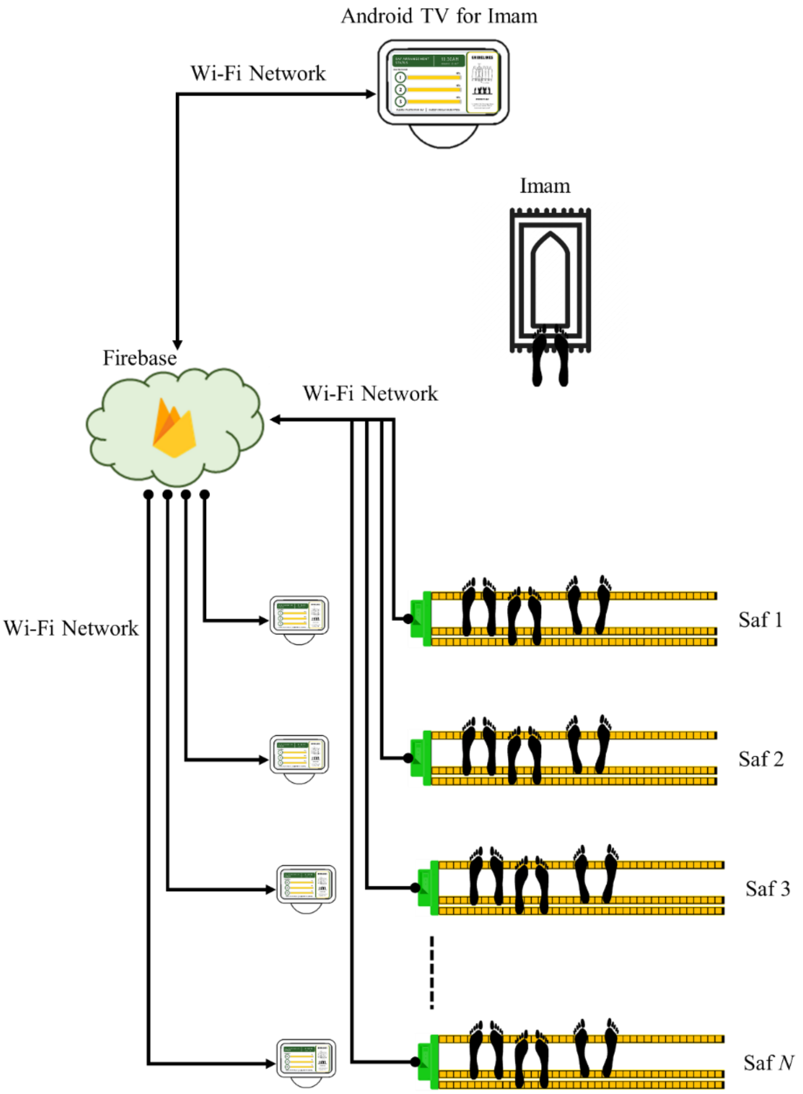

Figure 3. System Schematic for Implementation Concept.

According to Figure 3, it shows the concept of the saf monitoring system. A concept for detection is by using FSR sensor array to check the alignment and distance between feet in a saf. Multiple bits of FSR sensor connector to shift register to reduce the usage pin for transmit the data to the microcontroller and function as one device represent one saf.

The main indicator proposed is using Television (TV) with Android TV OS (Operational System). This TV was installed with Saf Monitoring Apps to display the guideline of the perfect saf and status for each saf. This Android TV apps provide the feedback to the Imam for further action and Congregations to correcting saf. Wi-Fi connection was used to communicate the device to the Saf Monitoring Apps. Each device represents each saf was transmit the saf status data to the database for centralizing the data, then Saf Monitoring Apps fetch the data to be displayed.

System Schematic Diagram

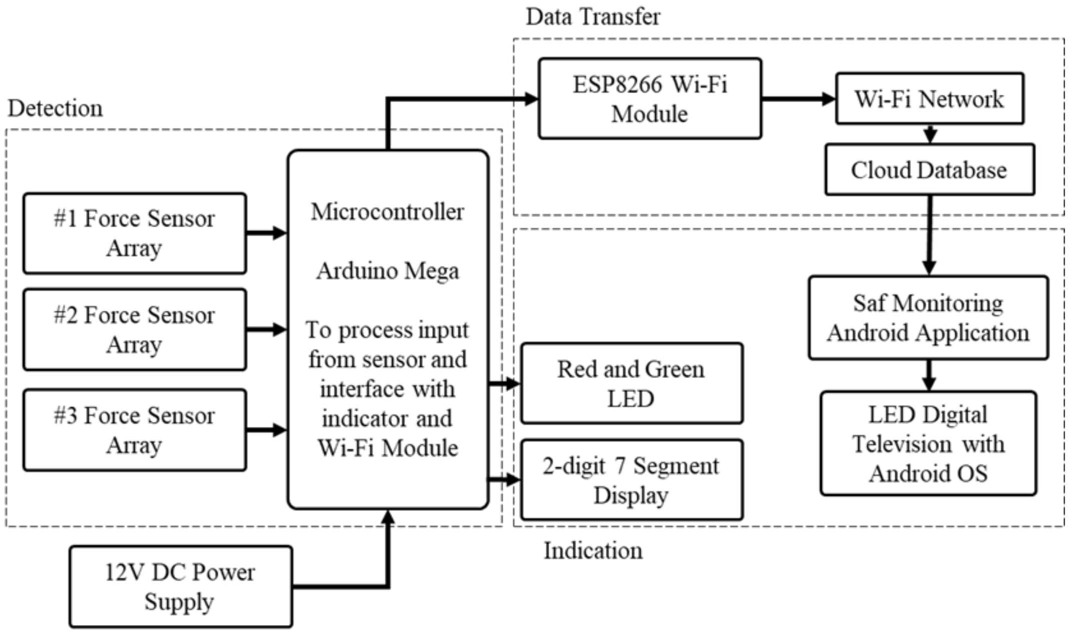

Figure 4. Proposed System schematic diagram.

The system schematic diagram in Figure 4 above shows the three sub-systems of saf arrangement monitoring system. The Detection sub-system detects the alignment in y-direction and distance between adjacent congregation in x-direction using FSR sensors. Three arrays of FSR sensor were used in this sub-system as mentioned in the proposed saf status determination concept sub-chapter. The configuration of the FSR sensor array can read the position status of each foot on the saf.

The second sub-system sends the processed data from the microcontroller to the display sub-system via Wi-Fi connection to the cloud database. Wi-Fi connection was selected because it can provide wireless communication between saf detection device and the display. This capability is crucial for real-world application, where the saf in the mosque are in large area, the latency of data transfer between saf detection device will be high if used wired communication. Besides that, the wireless communication increases the modularity of the system, compared to wired communication where the wiring process will take some time to cover all saf in the mosque.

Then, the third sub-system retrieves the data from cloud database and display the data on LED Digital Television via SafAr Android TV Apps. Most of the Mosque in Malaysia use television as interactive media to communicate with the people inside the Mosque. The television works as an information board and all announcements can be displayed on the television. This includes the instruction to straighten and tighten the saf [10]. These opportunities give the advantages for this system real-world application. Red and Green Led was used to indicate the overall status for each saf, and 2 digit 7-segment to display the number of each saf.

Hardware and Software Development

The hardware and software development of the proposed system are discussed in the following section, starting with the design of the detection sub-system, followed by selected component and module. Circuit and mechanical design followed next. Then, development of SafAr Android TV Apps discusses in the end of this sub-chapter.

Design of Detection Sub-System

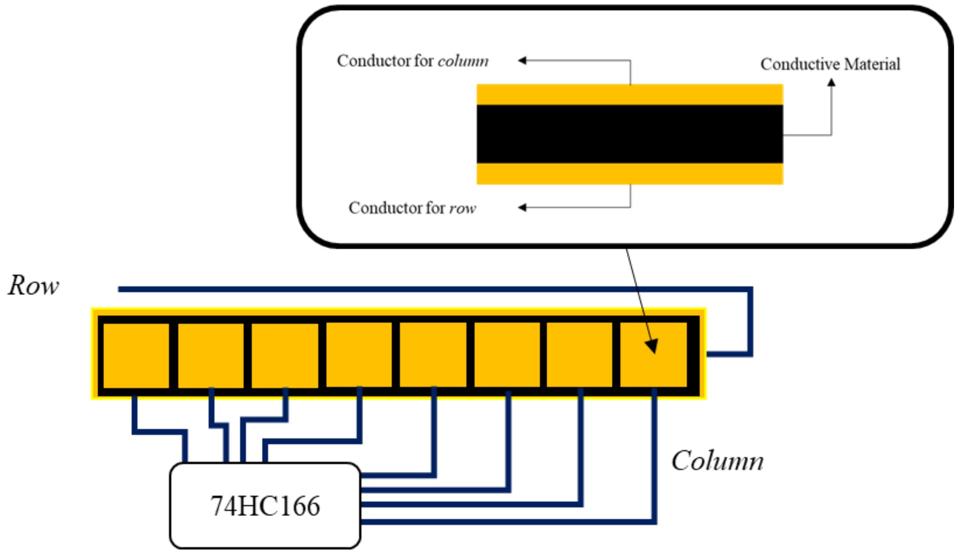

Figure 5. Single Row of FSR Sensor.

Figure 5 shows the FSR sensor that was fabricated using velostat as conductor material sandwiches by copper tapes represent one bit of sensor for column and row for the array. The array size is 3 x 40 with 40-bit FSR for single row. Also shown in Figure 5 above, eight-bit FSR sensor connected to 74HC166 shift register to reduce microcontroller pin usage. This FSR sensor can detect force in minimum 20kg. The size for one modular FSR sensor was 30cm (L) x 240cm (W) x 0.2cm (H). The detailed specification of the FSR sensor developed in this paper as shown in Table 2.

Table 2 Specification for FSR Sensor

Properties	Specifications
Minimum Required Force	20kg
Resistance Range	50KΩ - 200Ω
Material used	Copper and Velostat
Size for 1 array	10mm (L) x 2400mm (W) x 2mm (H)
Size for 1 bit	10mm (L) x 50mm (W) x 2mm (H)
1 Module Length	2.4 meters
Number of arrays required for 1 module	3 Array
Resolution for 1 array	1 x 40

As shown in Table 3 below, the ATMega 250 microcontroller used as main brain to process whole system, paired with ESP-01 as data transfer module to transmit and receive data through Wi-Fi signal. Green and Red LED as initial indication and 2-digit 7 Segment to display saf number. Then, LED TV with Mi TV Stick as main display, operate with Android Operational System to run developed Apps.

Table 3 Component and Material Used

Function	Component
Controller	ATMega 250 Arduino Mega
Data Transfer Module	ESP-01
	Mi TV Stick
Indication	Green and Red LED
	2-digit 7 Segment
Display	LED Television
Material	PLA (Polylactic Acid) for casing
	Nitrile Butadiene Rubber for Mat

Circuit and Mechanical Design

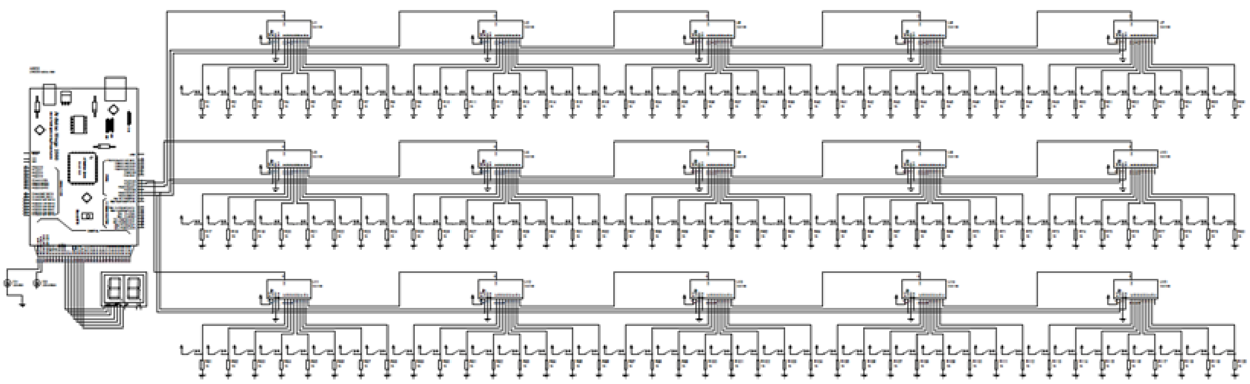

Figure 6. Whole system schematic circuit.

Figure 6 shows a whole circuit based on the size for one module. It consists of 40 bits of FSR sensor for 3 rows, making it total up to 120 FSR sensor for this prototype size. This single module used in this prototype utilizes 15 pieces 74HC166 Shift Register IC and fabricate on PCB Board. This circuit develop in modular to ease the extension process for fit on the real Mosque area. All the components for this system were fitted in one casing printed using PLA (polylactic acid) material. The design for the casing is shown in Figure 7 below.

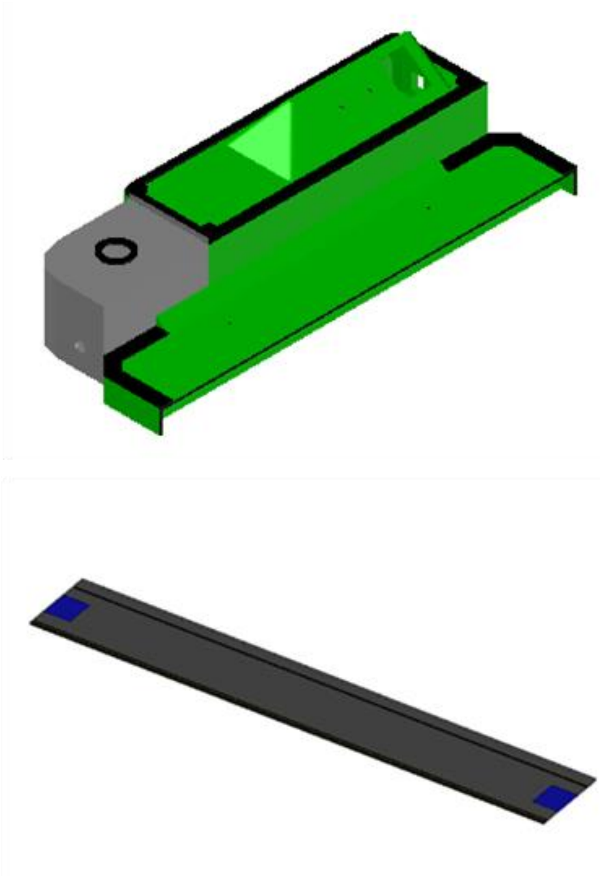

Figure 7. Casing Design (Top) and Mat Design (Bottom).

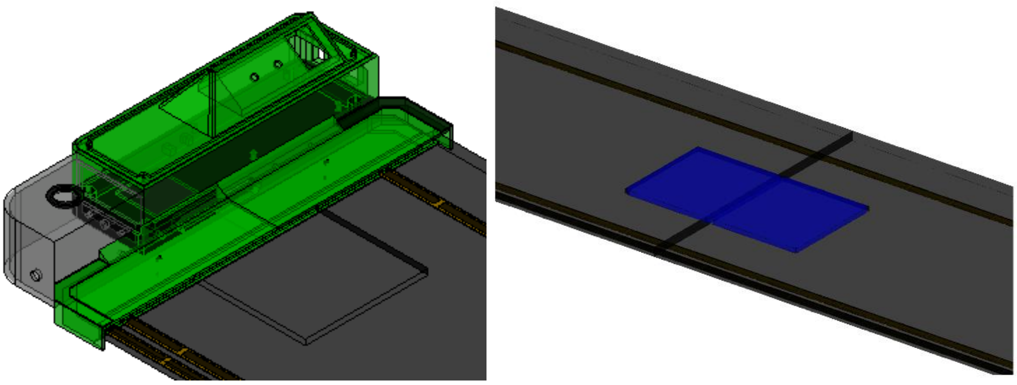

Figure 8. Assembly of all part and additional mat.

In Figure 7 (Bottom) shows the mat design for the system. It has been developed in modular to ease the extension based on the saf length for the mosque. Each mat module consists of 3x40 bits of FSR sensor. Figure 8 above shows the assembly of casing with mat part.

Development of SafAr Android TV Apps

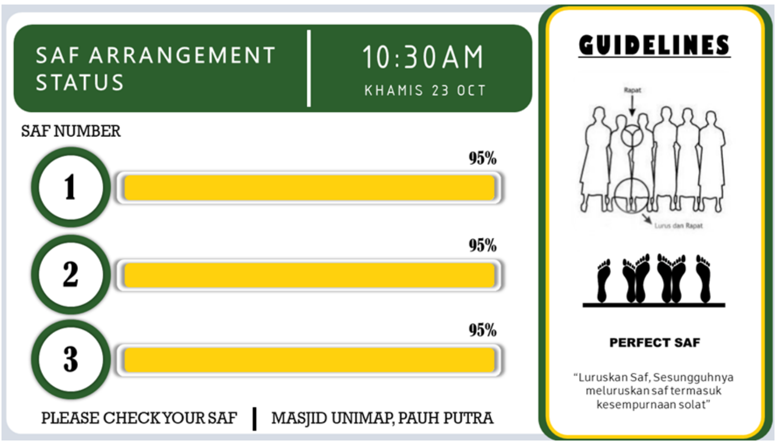

Figure 9. User Interface for SafAr android TV apps.

SafAr Android TV apps act as main indication for congregations in saf to monitor the status of the saf. The apps contain two pages, the first page is splash-screen to display the logo of the system with time and date. Then the second page displays the guideline for perfect saf and shows the saf status based on data retrieved from database. Figure 9 shows the second page of the SafAr apps.

RESULTS AND DISCUSSIONS

The results were presented in four sections, namely the setup for experiment, followed by sensor functionality testing data. Proper Saf alignment detection based on feet placement test follow next, and lastly the SafAr apps display testing.

Experiment Setup

The prototype was tested in indoor area with tiled floor. The experimental setup is show in Figure 10 below. The setup consists of the prototype itself and the LED TV run SafAr apps as main indicator. In this setup, the FSR sensor array for Row 1 (A [1]) and Row2 (A [2]) are placed under the green mat, meanwhile the Row 3 (A [3]) are outside the green mat. The green mat in the experimental setup shows the limit of the feet placement. The last row (A [3]) of sensor will detect the position of the feet/foot beyond the green mat. The experiment was run using four persons with various weight and size. The data collected started with a single person with additional subject added up to four people.

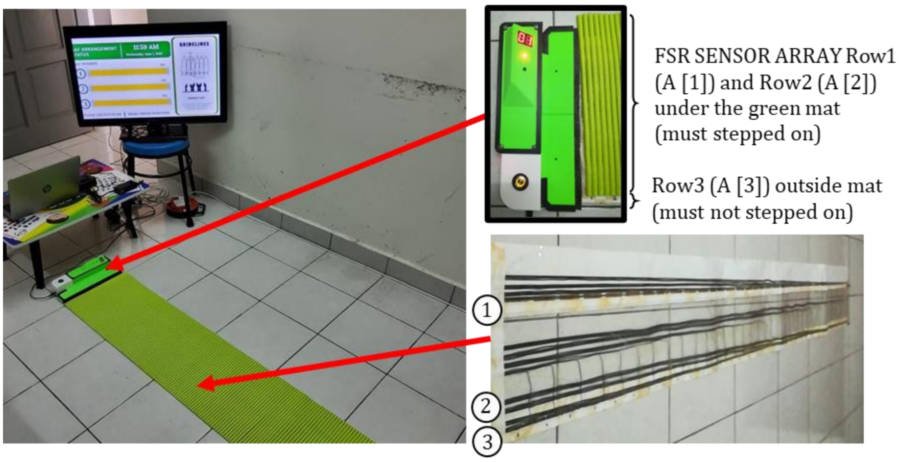

Figure 10. Setup for Experiment.

Sensor Functionality Testing Data

The data from FSR sensor was sent to the microcontroller by using shift register. It shifts the data one bit at a time based on row and column. It starts with row 1 column 1 until column 40, then moves to the second row. This process is repeated until the third row has been covered.

This process results in binary (0 and 1) data array matrix of 3 row and 40 columns. The configuration of 0 and 1 in this result were based on Table 1 above represent HIGH and LOW. The FSR array data recorded for each bit of sensor due to the placement of the individual foot on the FSR shown in Figure 11 and 12 below.

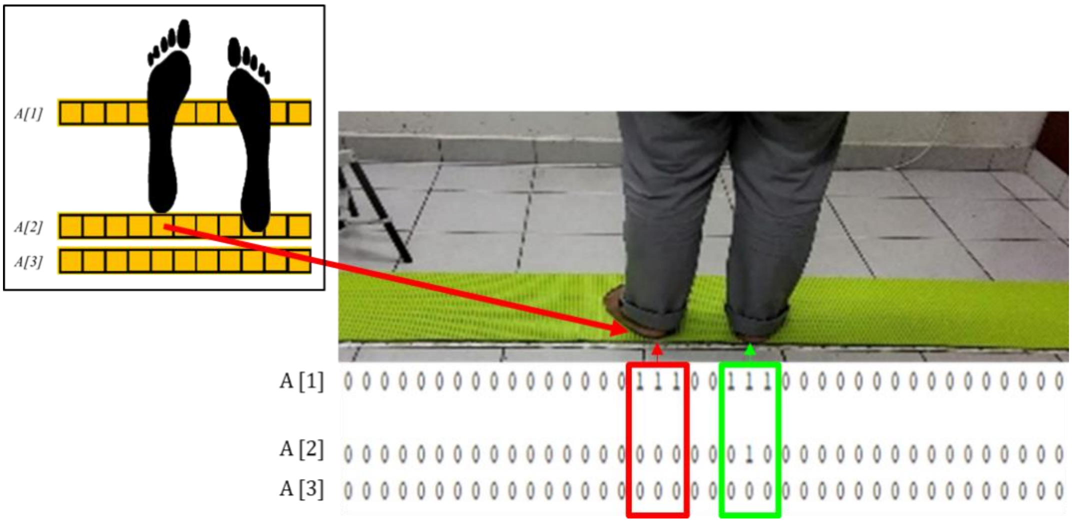

Figure 11. Single Person Raw Data.

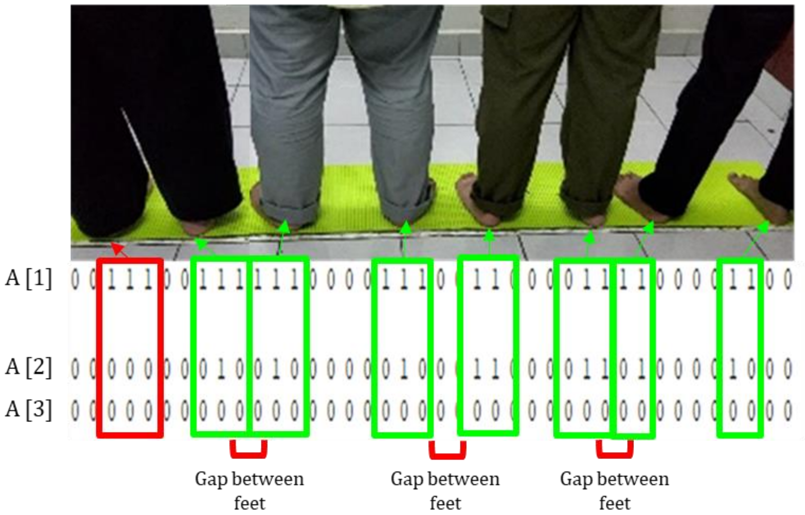

Figure 12. Four Person Raw Data.

Figures 11 and 12 show the raw data for different situations and feet placement. Each foot was placed randomly. Data array of the figures show that the FSR will result in different reading patterns based on the different feet placements on the saf detection mat. The reading of the FSR is taken continuously to enable the detection in real time. This allows the system to detect any feet movements during salah. Hence the system will be able to function throughout the salah.

The pattern of the FSR readings will be interpreted as the placement of the congregations' feet on the prayer mat of mosque. This is achieved by applying a pattern of sensor activation to recognize the feet placement. The accuracy of the feet placement recognition based on the pattern is discussed feet placement testing result.

Proper Saf Alignment Detection based on Feet Placement Test

Based on the recorded raw data, the foot placement pattern is recognized. The condition algorithm is then applied to evaluate the feet placement. The raw result is converted into the simplest form by checking each column for the condition based on the pattern required. The foot placement pattern output represents the raw data for each column. It is arranged as a string and represents three conditions; PASS, NOT PASS, and IDLE. The foot placement pattern is set based on the condition on all three row and continuously check for each column. The condition shown in Table 4 below.

Table 4 Condition based on feet placement pattern for each column

Row1	Row2	Row3	Status	Simplified Output
HIGH	LOW	LOW	Feet Aligned	PASS
LOW	LOW	LOW	No Foot Detected	IDLE
HIGH	HIGH	HIGH	Foot Too Backward	NOT PASS
HIGH	LOW	LOW	Foot Too Forward	NOT PASS
ELSE			Not Align/Not Closed	NOT PASS

Figure 13. Saf status data result for one person feet placement.

Figure 14. Saf status data result for four person feet placement.

Based on Figure 13 and 14 above, the reading from the microcontroller successfully shows the simplest data reading by checking each row based on condition set in Table 4. Then the same reading for each row was transferred through serial communication to ESP01Wi-Fi module to transmit the data using Wi-Fi connection to database.

SafAr Apps Display Testing Result

The system displays the saf condition using a combination of SafAr app (based on Android TV Apps), LCD display, Red and Green LEDs. These three indicators are used and play different roles. The SafAr app has been designed specifically to display the saf status. This apps first shows the introductory page for three seconds then displays the saf status as well as the guidelines for the congregation. The SafAr app is as shown in Figures 15 below.

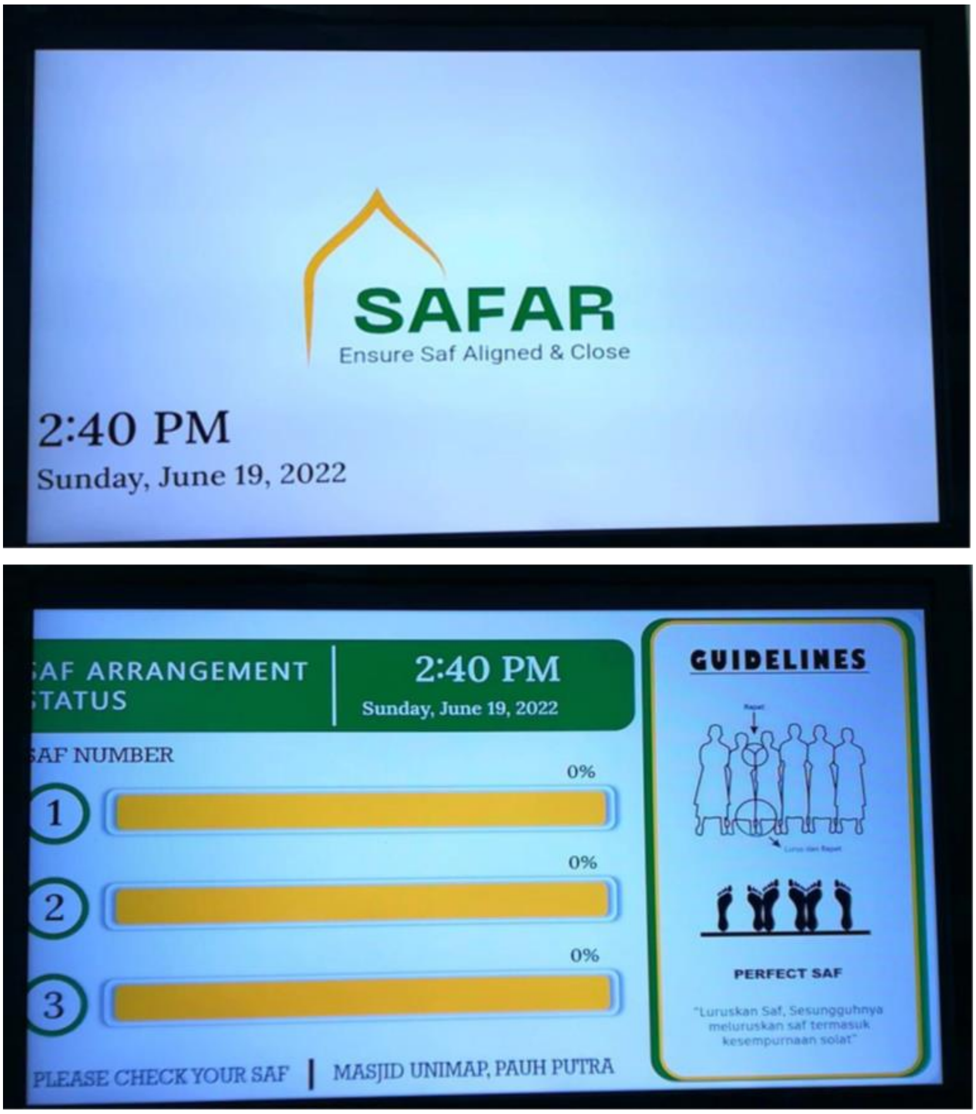

Figure 15. First Screen (Top) and Second Screen (Bottom) of SafAr Android TV Apps.

Figure 15 above shows the page run as a splash screen, with main logo, time, date and day. The transition to second page of the apps is after three seconds. The second page show the various information such as date, time, and day, some instruction for correct saf arrangement on the right side, and in the middle show the status for three saf with pass percentage, and name of the mosque on the bottom side of the page.

The result for the display was shown in Figure 16 and 17 below. This is shown in a graphical format in three colors:

- Green for PASS
- Red for NOT PASS
- Yellow for IDLE

The results obtained are based on same situation from raw data result, the status is display based on retrieve data from database.

Figure 17. Display result for single person feet placement on FSR sensor.

Referring to Figure 17, the indication for the single person shows a green indicator in the middle and a red part on the side. By referring to the image of the single person position, it shows the left foot of the single person is too forward and does not step on the FSR for the second row, resulting in the red indication for the left foot.

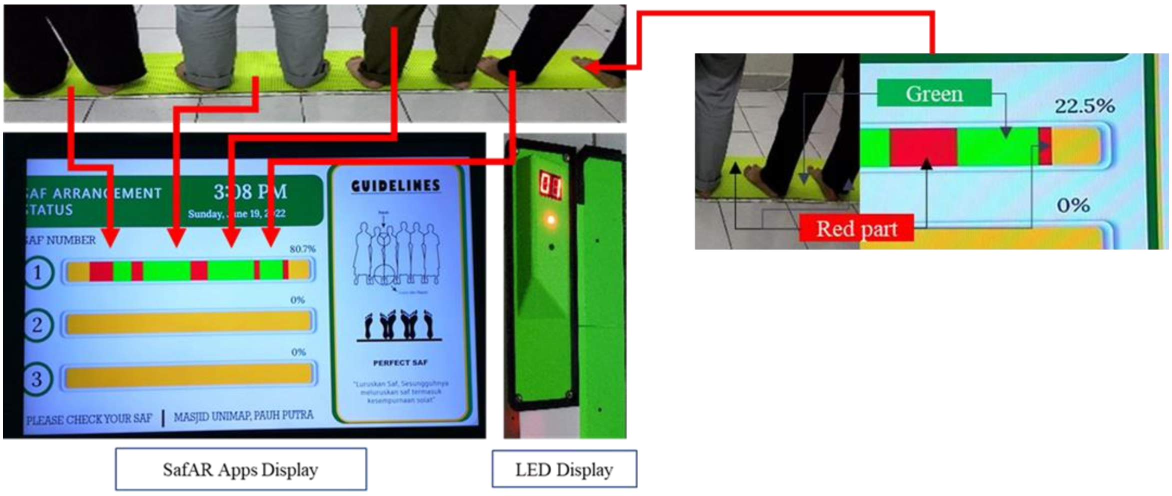

Figure 18. Display result for four people feet placement on FSR sensor.

Figure 18 shows the result display, the fourth person from left resulting two red colour column between the green columns. This indicates the fourth feet from left are aligned with the saf, but due to the feet shape being "V" shape, the FSR sensor between feet is detecting only on the first row. This condition indicates the NOT PASS condition. This problem can be solved if the congregations on the saf is filling the gap between them with a gap less than 2cm, the indication will convert to a green colour indication.

Figure 17 and 18 show that the system for saf detection is able to detect the congregation foot placement and displays it on the LCD panel of the SafAr app successful. Each graphic indicator in the Android application represents the row of the FSR sensor array. Based on the shown indication result for all people's position, the reading is synchronous between the database and the apps showing the indication system are accurate.

The LED result display is based on the condition for overall status inside the saf. If all PASS without any NOT PASS status, it will convert to a green colour indication. This indication is not affected by the Wi-Fi latency and delay, only depends on the processing performance of the microcontroller.

Figures 19 and 20 show the comparison between green LED indication and red LED indication result.

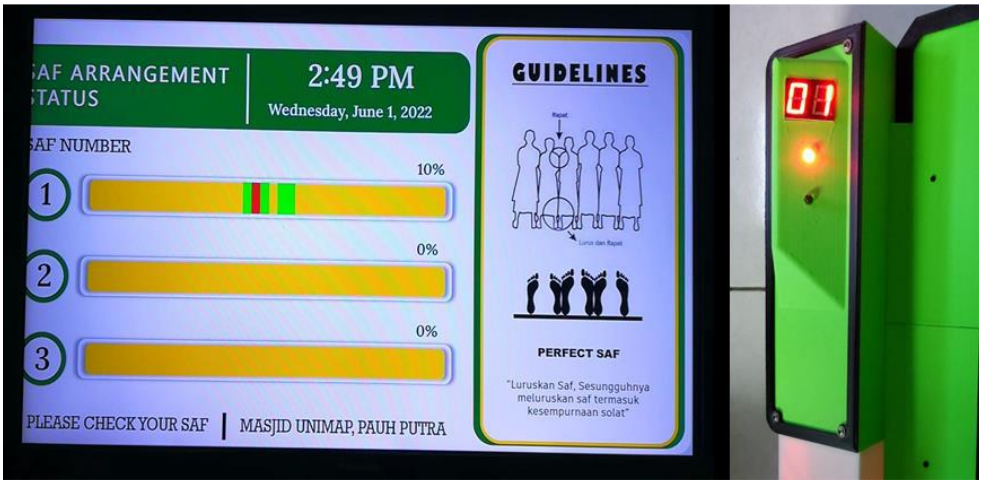

Figure 19. Red LED indication result if there is NOT PASS condition in saf.

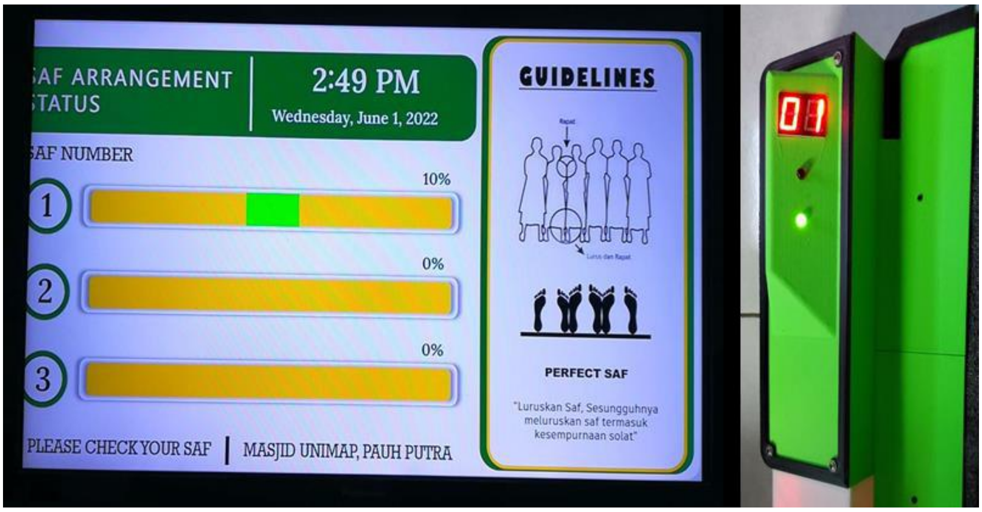

Figure 20. Green LED indication result if there is only PASS condition in saf.

System Performance Evaluation

The performance of the saf detection system is evaluated in three categories. These are the main functionalities and components that can affect the performance of the whole system. These are:

- Sensor placement strategy
- Sensing detection and transferred data latency
- Display effectiveness

The first category is the sensor placement strategy effectiveness. The detection approach used in this system is an array of FSR sensors. The testing result for this configuration shows the arrangement can detect both alignment and distance between congregations in the single saf with accurate detection.

There are expected miss-reading (mismatch of the sensor activation and the actual foot placement) output problems when a person with "V" shape feet steps on the FSR sensor array. This problem was solved if the congregations on the single saf has a gap of less than 2cm between another. When the gap is minimized, two feet will step on the same sensor column and change the condition into PASS.

The second category is the sensing detection and transferred data latency. The main factor to ensure the data transferring process at optimum performance is the latency of the internet connection of the device, and the android TV. If the latency is high, the time taken for data transmitting is long and can cause delays to Android TV Apps.

The last category is the display effectiveness. According to the testing result, all three indication element performances were flawless and delivered the information. The first indication element is two digits 7 segments displayed the saf number clearly for congregation reference. SafAr Android TV Apps. This app displays various information and guidance for congregation reference to correct the saf. The status of saf for each congregation was displayed clearly and synced with the data in the Firebase.

Overall, based on the performance of the three categories, the system's performance is evaluated as functioning as designed. Meanwhile, two main problems need to be given more attention to improving the system. The first one is the miss-reading problem when the various shapes of feet step on the FSR sensor array. The second problem is the latency between the device and the main indicator, it is important to ensure the latency is as low as possible to ensure the delay of the data transferring process between the device and main indicator was at a minimum.

CONCLUSION

This paper has presented the new approach on saf arrangement monitoring system. The method used is FSR sensor array as detection element, Wi-Fi connection as data transferring method, and Android TV Apps as main display. The results showed that each it of sensor read successfully and was converted to simplest form to transmit to Firebase. Android TV Apps as main indicator was effectively showing the guideline for perfect saf and saf status as feedback for Imam and Congregations. This can conclude the objective has been achieved. However, there is some consideration in order to apply the system in real application such as the latency and the risk for sensor to miss-reading. There is recommendation for further works. Improve sensor arrangement configuration to increase the flexibility in detecting various feet shape and implementation of Artificial Intelligence to make the system be able to study the pattern of feet shape and increase the accuracy.

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