

Performance Evaluation of i-Sajadah: A Smart Prayer Rug with Raka'ah Notification System

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Abstract

Perform five times of solah per day is an obligation for all Muslims. Each of the five solah has a different raka'ah. While performing the solah, there is a possibility to forget how many raka'ah have been completed especially in performing four raka'ah solah which are Zuhr, Asr and Isya'. This difficulty of remembering the raka'ah sequences could happen to inexperienced children, the elderly and those having cognitive and memory weakness. This situation may affect concentration while performing solah. Therefore i-Sajadah is proposed as a smart device to notify the user on exact raka'ah that has been completed. This device consists of a sensory component, processor and indicator system. As a result, the innovation of i-Sajadah presents high potential solution as a user-friendly device to help Muslims to mastery the daily raka'ah sequences thus improves the concentration and quality of solah.

Keywords: Solah, Raka'ah, i-Sajadah, Smart Device, Notification

Introduction

Performing solah five times a day is the second pillar of Islam, compulsory to all Muslims. Every routine in a solah should be implemented so that the solah performed perfectly and regarding Islamic principles. However, when performing solah it is possible for the Muslim to lose focus, and this has been proven through Electroencephalography studies (Brookmeyer et al., 2007). During performing solah, there is a possibility to doubt the number of raka'ah that already completed, especially during the four raka'ah prayers.

The difficulty for a person to remember which raka'ah is being performed mostly occurs to the elderly, especially those who are diagnosed with mild cognitive impairment and memory weakness diseases, such as low-stage dementia, mild amnesia, and level 1 Alzheimer. This difficulty may also occur to children who have just started to learn performing solah.

Moreover, since the person must repeat the raka'ah a plurality of times and sometimes recite long verse *surahs* from the Quran at first two raka'ah, it sometimes becomes a shortcoming for the person to remember which raka'ah is being performed. Under these circumstances, once forgotten, the person must go back and perform additional raka'ah to ensure that at least the exact number of raka'ah has been performed in a solah.

A few systems have previously been proposed to overcome the problem of remembering the number of raka'ah already performed in a solah. In considering the design evolution of the prayer rug to support the solah, an electronic user interface must first detect the different body postures performed. Most body-posture tracking work has been performed using vision systems or with special sensors. Researchers have used optical, acoustic or magnetic techniques (Durlach & Mavor, 1995). Typically, the user must wear markers that are detected by special high-resolution cameras. Three-dimensional analysis software is then used to interpret and modify the existing 3D virtual model of the user to determine the current posture when performing solah.

These systems have the disadvantages that the size of the captured room is limited in space, that they are often installed in a fixed place, and that the user must wear special markers. This is not a limitation when capturing one time or special events, for example gait analysis. However, for finding inappropriate movements within daily activities, such as a solah, motion tracking systems would not be practical since the camera's view of user's body could be obstructed by common house objects, the user might feel uncomfortable due to mounted markers worn during performing solah or might forget to wear them.

De Rossi et al. (2000) considered integrated sensors directly into clothing to support solah. Having the sensors in a garment has the advantage that the sensors do not disturb users during performing solah. However, these systems are still experimental, and the user might feel uncomfortable because the garment is often more rigid compared to commercial cloth and he/she must wear the same garment for every five times of daily prayer occasionally. Hansson et al. (2001) developed body mounted transducer accelerometers. However, these sensors are several centimeters in size and therefore not practical. As an alternative, Tollmar et al. (2003) used stereo cameras and a 3D virtual model of the solah performer to detect a limited set of body gestures. However, such computer vision-based techniques require the user to wear cloth that is color contrasted with the background for the image segmentation to work, which makes them again impractical. Another method is an ultrasonic distance measurement directly on the skin (SonoSense, 2008). This product has been commercialized and is used to measure the posture of the back but is only applicable for restricted movements.

After considering each of the existing methods for posture detection in solah, augmenting the traditional prayer rug with digital sensors seemed the least intrusive and most versatile approach. Users expect the prayer rug to be light, portable and usable everywhere regardless of the light conditions or background colors. Requiring the users to wear special cloth or mount markers on their body when performing solah is impracticable as well.

A decision was made to augment the traditional rug with a screen for displaying scriptures to the user during solah and digital sensors for detecting body positions. A prayer rug is often used by Muslims during their prayers. Hence, no learning is required to understand how to

use a prayer rug; the user will only be required to replace an existing tool with a similar but digital one. A popular physical tool often has qualities which enable the user to perform the salah, for which the tool was designed effectively (Norman, 1988). Embedding electronics into prayer rugs, while preserving their original functionalities, has repeatedly been shown through several works through selection of interaction techniques.

Hassan Faouaz (2004) designed a Muslim Prayer Counter, which can be used for displaying the number of times prayers through the number of times a switch is contacted by a user's head. Later, Raed (2009) invented an interactive and portable electronic prayer counter that indicates a current or completed raka'ah of a salah performed by a user that includes a display for indicating a prayer or raka'ah count. However, both devices, may create confusion to users, especially between the second and third raka'ah of salah. In this case, when a person completed the second *Sudjood*, the counter already displays "3" indicates third raka'ah, though the second raka'ah is still not completed since the person does not perform the *Tashahhud Awal* yet. As a result, the person has to perform the *Sahwi Sudjood* after *Tashahhud Akhir* to complete the salah's routine. Nevertheless, there is a possibility the person forgets to perform the *Sahwi Sudjood* as to complete the salah.

An Islamic prayer and pedometer watch was proposed by Sanaa Marhaben (2013) to aid Muslims in becoming or staying physically fit and in performing the five daily prayers, especially notifying an individual in advance of the time to pray, the direction of Qibla, and the correct Raka'ah number. Most of the previous designs have disadvantages, such as Hassan Faouaz (2004) Muslim prayer counter is unwieldy and difficult to carry when travelling from one place to another, especially when the user must perform salah at different places during the day, such as at home, work, school, and so on.

The Muslim prayer counter may be distracting to a user since focus must be diverted from the salah being performed to the particular placement of the forehead on the prayer rug. Interactive electronic prayer counter is inconvenient to use since the device functionally worked only if the position of the user's forehead is precisely placed on the switch in order to advance the raka'ah count. Thus, the objective of this project is to build a system that eliminates the weaknesses of previous work.

Research Motivation

Performing five daily salah (prayers) is obligatory for Muslims, each consisting of a different number of raka'ah (prayer cycles). However, many individuals, including inexperienced children, elderly worshippers, and those with cognitive or memory impairments—often face difficulties in accurately tracking the raka'ah count during prayers, particularly in four-raka'ah salah such as Zuhr, Asr, and Isya'. This confusion can negatively impact concentration and the overall quality of worship. Motivated by this issue, the i-Sajadah device has been proposed as an innovative, user-friendly solution designed to accurately notify users of completed raka'ah, thus enhancing their prayer experience and enabling better focus and mastery in performing salah.

Methodology

i-Sajadah with PIC algorithm has been designed to cater for the elderly, inexperienced children who are just starting to learn praying and those having cognitive and memory

weaknesses, such as Level-1 Alzheimer, dementia and mild amnesia patients who might forget how many raka'ah have been performed. The invention of I-Sajadah incorporates the effectiveness of the counter to notify the number of raka'ah, as well as the necessity to consider the position of each electronics component, convenient to cater all types of prayer rugs and users of different age and height.

Another unique feature of the smart raka'ah notification device of i-Sajadah is the raka'ah alert device in the form of a bracelet to be worn for Muslims who are vision impaired or blind. The blind user who performed solah will sense a vibration on his/her wrist from the raka'ah alert device, according to the number of forgotten raka'ah in his/her prayer performed.

Technical Specification

The actual size of the i-Sajadah is shown in Figure 1. The size of the i-Sajadah is 116 cm x 68 cm. This size combines the size of the frame and the standard sajadah (prayer rug) in the market. The light grey area is based on the size of actual sajadah which is 106 cm x 58 cm. This area will be a guideline for the users when they want to perform a solah. The users can choose either to pray directly using the i-Sajadah or they can place a prayer rug on top of it.

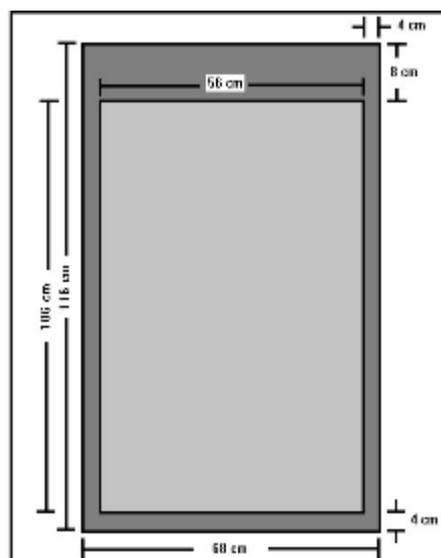


Figure 1: Design of i-Sajadah

The sensor for head, knee and foot regions of the i-Sajadah is only covered in this area to provide a maximum performance of the product. The dark grey area is the frame for the i-Sajadah. This frame provides added value in offering a nice and attractive design for the product. A 7-segment LED display will be placed at the top center of the i-Sajadah at the frame area. The main controller is placed at the right side of the frame, parallel with the head region area.

Design of Sensor – Pixel Dots Pressure Sensor

The position of the sensors is shown in Figure 2. The light grey area is divided into nine equal parts. Each of the sensors has an area of 12 inch x 8 inch respectively. The area for numbers 5, 6 and 7 are for the foot region. Whereas, numbers 2, 3 and 4 are for the knee region and for the head, only one area is used (number 1) since the users usually tend to put their head

at the middle of the i-Sajadah. Overall, in total, there a seven sensors' placement on the i-Sajadah.

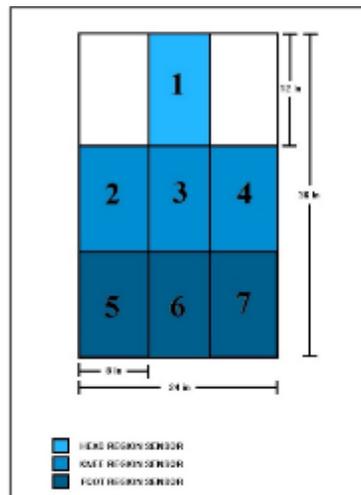


Figure 2: Sensors placement on i-Sajadah

The sensors for the i-Sajadah are called the Pixel Dots Pressure Sensors. This sensor is made from silicon rubber or known as elastomeric, the same material used to make a keypad. This is to provide maximum comfort for the user while using this i-Sajadah.

Each of the sensors consists of many silicon rubber keys at it. This silicon rubber key consists of conductive carbon contact pill that work as switches. Each of the keys will react to the pressure applied by the users' feet, knee and forehead which then activates each region according to the area that has been pressured. Hence, the more silicon rubber keys exposed to the pressure, the more effective the sensor becomes. Table 1 below shows the general specifications for silicon rubber keypad.

Table 1

Specification for Silicon Rubber Keypad

Button travel	0.8-1.5 mm
Force	60-300 grams
Dielectric Strength	>1 min @ 500 VRMS
Contact Resistance	< 200 Ohms
Life Cycles	1,000,000

Figure 3 illustrates the design of silicon rubber keys installed at pixel dots pressure sensors of the i-Sajadah.

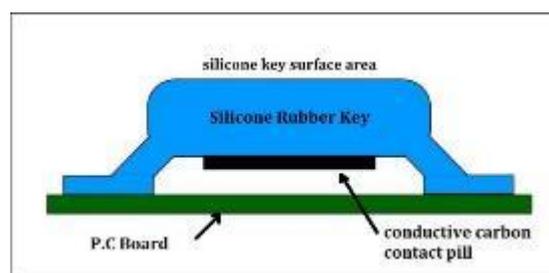


Figure 3: Silicon rubber keys design

Result and Analysis

The i-Sajadah was successfully simulated and analysed to evaluate its functionality and performance. Results obtained from the simulations, device configuration, operational flow and user-survey analysis are discussed in the following sections.

Simulation Results

The simulation of the interface circuit for connecting with the Seven Segment Display is important to test the functionality of the circuit before the hardware part is constructed. As shown in Figure 4, the i-Sajadah controller circuit is constructed using Proteus. The circuit designed is programmed using C Language which has been stored in flash memory for the PIC16F877A microcontroller.

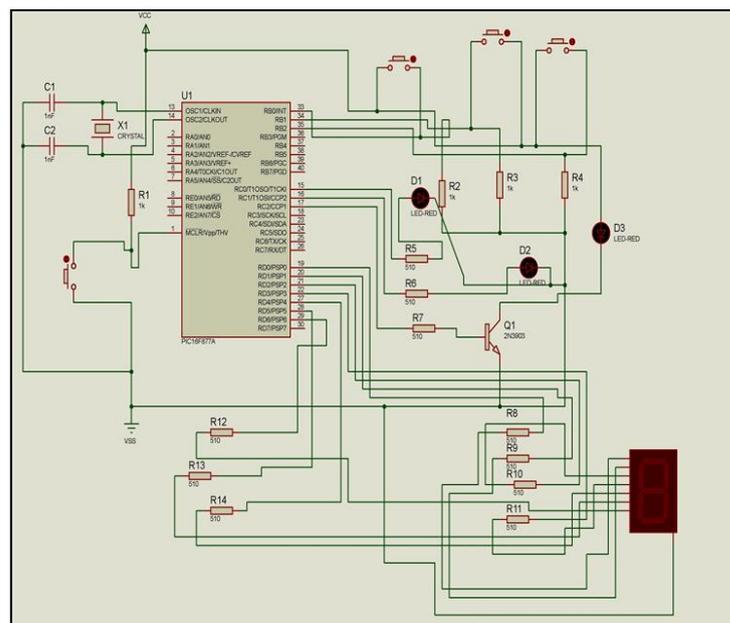


Figure 4: Simulation of the i-Sajadah controller circuit constructed in Proteus

When the circuit is simulated, the microprocessor will collect the number of raka'ah done after certain chains of sensors are triggered. Each raka'ah is considered to be complete when the entire sensor at foot region, knee region, and head region are triggered according to the sequences. The counter will only count until 4 since the maximum number of raka'ah in daily prayer is only up to 4.

LED 1 will light up when sensor at head region triggered once (at first *Sudjood*) and LED 2 will light up when sensor at head region triggered for the second time (at second *Sudjood*).

Next, both LEDs will turn off when the sensor at the head region and knee region are not triggered. The 7-segment LED display will only show the number of raka'ah done for 2 seconds when the right foot sensor does not detect any weight for a moment on the prayer rug.

When a user starts to perform his/her 4 raka'ah solah, the feet are positioned on the i-Sajadah's foot region, where the person stands in an upright position facing the Kiblah, known as *Iqama*. The feet that touch the sensor on the foot region triggers the 7-Segment LED Display to show "1", the first raka'ah. This is shown on Figure 5 from the Proteus simulation graph with associated number of raka'ah shown at the 7-Segment LED Display.

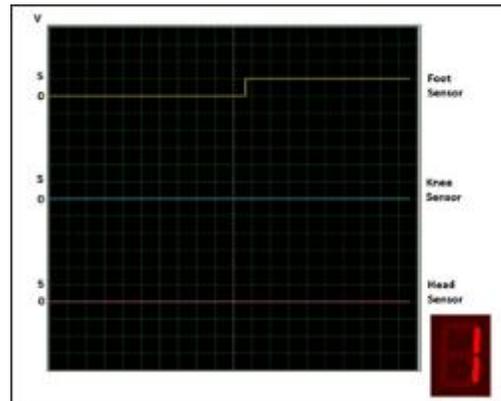


Figure 5: Simulation of the i-Sajadah at the first *Iqama* in the solah performed

When the person is performing his/her first prostrate or *Sudjood*, with the feet, knees, palms of both hands, forehead and tip of nose touching the clean ground, both sensors located at the i-Sajadah's knee and head region triggers. The 7-segment LED display will depict "2" if the person again be in the *Iqama* position to begin a new cycle or raka'ah. Figure 6 illustrates the simulation graph if a complete cycle or ra'kaah is performed, where each raka'ah, there will be two times of *Sudjood*. This can be seen as two peaks from the graph of head sensor section.

Device Configuration and Flow of Operation

The i-Sajadah is designed as a smart raka'ah notification device to be used at any prayer rug, to cater Muslims who are healthy but have short-term memory loss or weakness, such those who have mild amnesia, dementia and Level-1 Alzheimer's disease to perform solah accordingly to the correct number of raka'ah. The 7-segment LED display will only show the number of raka'ah already performed if and only if the person forgets under the following two conditions:

- i. In case the person is standing in an upright position or *Iqama*, he/she should uplift his/her right feet a little bit in order for the raka'ah to be displayed.
- ii. In case the person rises to a sitting position with head bowed or *Qu'ud* from the first *Sudjood*, he/she should uplift his/her left knee a little bit in order for the raka'ah to be displayed.

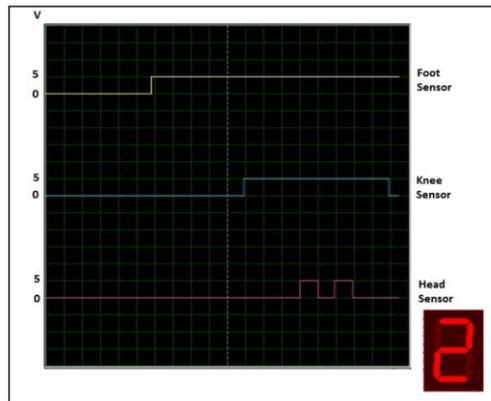


Figure 6: Simulation of the i-Sajadah at the first completed cycle or raka'ah in the salah performed

The 7-segment LED display on the i-Sajadah will not display any number, as long as the person confidently knows how many raka'ah he/she already performed in the salah. This feature is incorporated for the i-Sajadah design, in order to maintain the concentration (*khusyuk*) and quality of the solat being performed. Figure 7 shows the location of the sensors and 7-segment LED display placed on the i-Sajadah.



Figure 7: Position of sensors in i-Sajadah

The product of the i-Sajadah is depicted at Figure 8 below. It consists of the prayer mat of the i-Sajadah, the main switch box and the raka'ah alert device bracelet, used by vision impaired or blind users.



Figure 8: Product of i-Sajadah

The block diagram of the i-Sajadah is portrayed at Figure 9. It consists of the sensors placed on the foot, knee and head regions and 7-segment LED display on the i-Sajadah mat, the main power switch that include the PIC16F877A microcontroller circuit, ON/OFF and RESET button, battery compartment and two *Light Emitting Diodes* (LEDs). The raka'ah alert device bracelet is an additional accessory designed with the i-Sajadah to cater for vision impaired and blind Muslims to perform solah on the i-Sajadah.

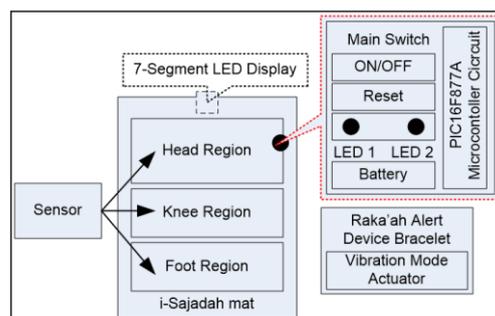


Figure 9: Block diagram configuration for i-Sajadah

Survey Analysis on the Usage of i-Sajadah

After the i-Sajadah prototype device is completed, a survey to gain feedback on the device is conducted. This survey has been done by using online survey forms and questionnaire handout given to the experts. This survey has more than 120 respondents than have been distributed through online social media.

Most of them agree and are satisfied with this product. The i-Sajadah survey is conducted based on satisfaction and acceptance towards the product. It is measured using the scale range from 1 to 5 where 1 represents "*Strongly Disagree*" until 5 which notified as "*Strongly Agree*".

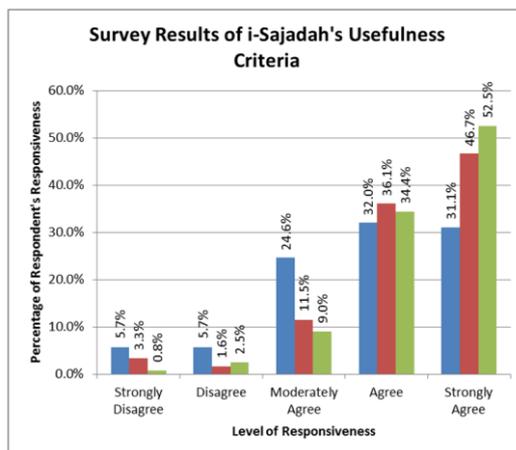


Figure 10: First section on i-Sajadah survey respond regarding its usefulness feature

The i-Sajadah survey is divided into several sections. The first section covers the usefulness of the product. From the graph of Figure 10, most of the respondents strongly agree (scale 5) and agree (scale 4) that i-Sajadah can improve the confidence level and the concentration (khusyuk) of solah (referring to the graph's blue bars). They also strongly agree that the product can train children to master their solah (graph's red bars). Moreover, this product can help Muslim patients that have level 1 Alzheimer, low-scale dementia, mild amnesia, short term memory weakness, as well as the vision impaired and blind community to remember the exact number raka'ah in a solah accordingly (graph's green bars).

The second criterion covers the usability of i-Sajadah. From the graph of Figure 11, most respondents agree that this product is user friendly or easy to use (referring to the graph's yellow bars), flexible and portable to be used (graph's red bars) as well as convenient to be used anytime and anywhere to be used without reading its user's manual (referring to the graph's blue bars).

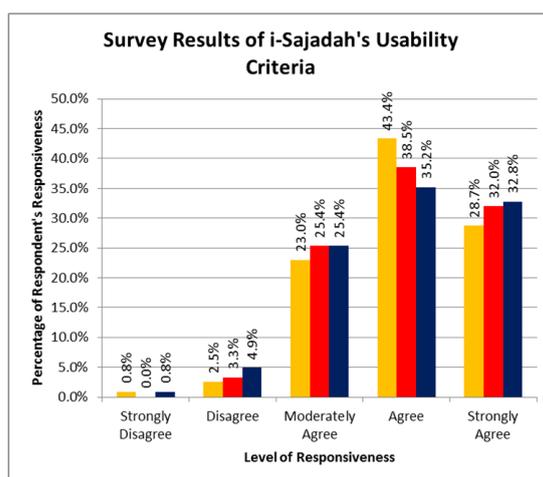


Figure 11: Second section on i-Sajadah survey result regarding its usability feature

The third section focuses on the user satisfaction of i-Sajadah. From the graph illustrated in Figure 12, most of the respondents agree that they can learn fast on the step-by-step procedure in using the i-Sajadah (referring to the graph's purple bars). They also agreed that they were satisfied with using the i-Sajadah and pleased with its functionality (graph's green

bars) and they agreed to willingly offer and introduce this product to other users (referring to the graph's blue bars).

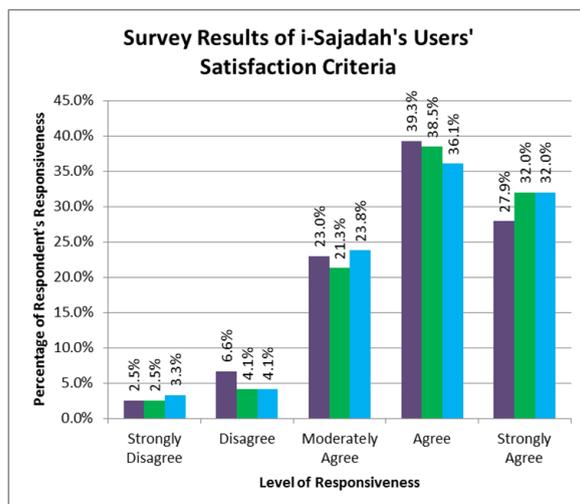


Figure 12: Third section on i-Sajadah survey result regarding to user satisfaction

The four criterion covers the confirmation of experts about i-Sajadah. From the graph depicted in Figure 13, most of the experts especially from *Jabatan Mufti Negeri Melaka, Majlis Agama Islam Melaka (MAIM)* agreed that the size of the i-Sajadah's raka'ah indicator is suitable and its feature helps to improve the quality of solah (referring to graph's red bars). Furthermore, the experts agreed that the design of this product can attract Muslims to use it on a daily routine (graph's yellow bars). I-Sajadah is easy to fold and portable, suitable for any kind of physical background, height and age, as well as the system fulfills the perception and satisfaction by Muslims (referring to graph's blue bars).

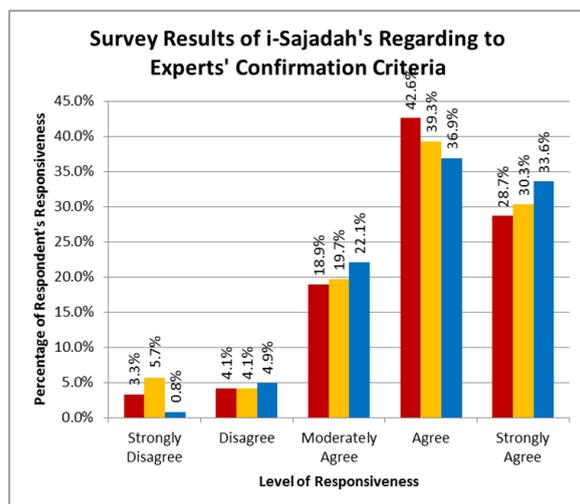


Figure 13: Third section on i-Sajadah survey result regarding to user satisfaction

Overall, the simulation results, supported by the survey analysis, demonstrate that the i-Sajadah prototype effectively addresses the intended objective, providing a reliable raka'ah counting mechanism and improving the concentration and quality of prayers for users, particularly those experiencing memory challenges.

Conclusion

The i-Sajadah unique feature is focusing on the raka'ah notification for the Muslim who performs the solah but forgetting the number of raka'ah he/she already completed. However, the number of raka'ah can only be displayed from the 7-segement LED display to the person only when he/she intends to know. The benefit of implying this feature into the i-Sajadah design is to preserve the quality of the solat performed in term of the purity and perfection to God, as well as to maintain the concentration (*khusyuk*) of the Muslim to perform the *ibadah* to Allah S.W.T. impeccably.

Although this device focuses its usage for Muslims who experiencing cognitive and memory weakness diseases such as mild amnesia, dementia and level-1 Alzheimer patients but then capable and legitimate to perform the five daily prayers, it can also be applied as a learning instrument for children who start to learn how to perform solah, with the guidance from their parent or guardian.

The i-Sajadah also come with the raka'ah alert device bracelet so that the scope of usage can be broaden to Muslims who are vision impaired or blind. The number of raka'ah can be notified by them in terms of the number of vibrations sensed from the bracelet worn at the user's wrist. From the feedback obtained from the survey conducted, the i-Sajadah presents a suitable alternative for the Muslim community in performing a perfect *ibadah* to Allah S.W.T. especially the five times daily prayer that constituted as one of the main pillars of Islam.

The invention of I-Sajadah incorporates the effectiveness of the counter to notify the number of raka'ah, as well as the necessity to consider the position of each electronics component, convenient to cater all types of prayer rugs and users of different age and height.

This research makes a significant contribution to assistive religious technology by enhancing both theoretical and contextual understanding. It supports human-centered design through cognitive load reduction in ritual practices, introducing a new approach to improving religious experiences via unobtrusive assistive tools. The i-Sajadah addresses challenges faced by Muslims with cognitive impairments, the elderly, children, and the visually impaired by offering an accessible and culturally appropriate solution. It advances Islamic technology innovation by showing how embedded sensors and interactive feedback can aid religious practices without disturbing spiritual focus. Overall, the study bridges practical gaps and enriches multiple disciplines, including engineering, Islamic studies, gerontology, and human-computer interaction.

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