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Assistive Prayer Technology: Developing a Raka'at Tracking System for Elderly Muslims with Physical Limitations

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ABSTRACT

Elderly Muslims who experience memory decline and physical limitations often struggle to accurately track raka'at during prayer. This study proposes the design and development of a portable raka'at monitoring system intended for elderly users. The system integrates pressure sensors to detect prayer movements and a Bluetooth module to facilitate data communication between the microcontroller, sensor, and mobile application. This study explores the integration of an STM32 microcontroller into the system to ensure its feasibility. It also incorporates Shariah compliance through consultations with fiqh Islamic scholars to ensure the device aligns with religious law. The prototype involves two phases of development and requires validation of both its mechanical design and usability. This study contributes to assistive religious technology by enabling elderly Muslims to practice their religious activity with greater confidence.

Keywords: Raka'at Monitoring, STM32 Microcontroller, Bluetooth Communication, Assistive Technology

1. Introduction

Salah (prayer) is a mandatory practice in Islam and one of the five fundamental pillars of the faith. It is a duty that applies to all Muslims, regardless of age. This form of worship must be performed five times daily, with each prayer aligned to specific times based on the local time zone. For elderly Muslims, especially those facing cognitive impairments or physical challenges, maintaining focus and accurately counting the units of prayer (rakʿāt) can be particularly difficult. Although Islamic jurisprudence permits concessions (rukhsah) [1], such as performing prayers while seated, many older individuals continue to experience difficulties in recalling the correct sequence of movements and recitations. This may result in omissions or unintended repetitions during prayer.

Previous research has shown that elderly Muslims often struggle to remember the number of rakaʿāt (units of prayer), which is essential for proper observance of Salah. Although memory lapses can affect individuals of various ages, studies indicate that adults aged 60 and above are particularly prone to memory decline, especially in relation to social engagement. The research also highlights notable differences in memory performance between elderly individuals residing in urban and rural areas, suggesting that participation in social activities positively influences memory retention [2] Furthermore, survey findings reveal that many elderly residents in nursing homes [3] prioritize their religious needs, indicating the importance of providing appropriate tools or support systems to help them maintain and monitor their religious practices effectively.

Existing assistive technologies, such as smart prayer mats [4], are primarily designed for users who pray while standing and are not optimized for portability or seated prayer. Moreover, few existing devices successfully integrate religious compliance, ergonomic design, and usability for elderly Muslims. To address this gap, this study presents a portable raka'at monitoring system tailored for seated prayer. The system uses a tactile pressure sensor to detect physical movement, a Bluetooth module for wireless communication, and an STM32 microcontroller for efficient processing. The proposed solution is guided by Shariah principles through consultation with fiqh scholars to ensure religious

permissibility. This proposed work contributes to the growing field of assistive religious technology by offering a practical and user-friendly device that supports independent worship among elderly Muslims.

In summary, this study seeks to develop and refine a portable rakaʿat monitoring system using tactile sensors and Bluetooth technology, with the goal of supporting elderly Muslims in accurately tracking their prayer units. To achieve this aim, the research focuses on three main objectives: (1) consulting with fiqh experts to ensure a Sharia-compliant design; (2) designing a practical and user-friendly monitoring system that meets the specific needs of elderly users; and (3) conducting data validation to assess the system's accuracy, reliability, and overall effectiveness.

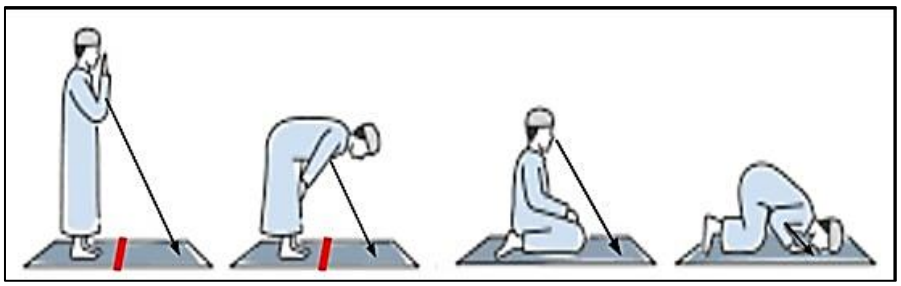

Figure 1. Four physical movements to be sensed [4].

2. Literature Review

Elderly Muslims living with dementia encounter specific challenges in fulfilling their religious obligations such as prayer, which requires both physical coordination and cognitive awareness. Dementia, a cognitive disorder marked by memory loss, significantly impairs the ability of older adults to adhere to routine religious practices like Salah. These individuals may forget how many rakaʿāt they have completed or struggle to remain standing throughout the prayer [5]. Islamic teachings, however, offer accommodations for such individuals, permitting prayers to be performed while sitting or lying down when necessary [6]. Findings from a pilot study involving 36 participants with a mean age of 71.9 years revealed that 20 had cognitive impairments, and 17 of these were diagnosed with dementia [7]. The study further noted that participants with early-stage dementia (Clinical Dementia Rating, CDR = 1) frequently repeated the same prayers and rituals. Those with moderate dementia (CDR = 2) faced difficulties with both physical movements and the recitation of prayer verses, while participants with severe dementia (CDR = 3) were often unable to perform prayers, even with assistance from caregivers [7].

Advancements in embedded-systems and sensor technologies have facilitated the creation of intelligent prayer assistance tools, specifically designed to support elderly Muslims facing cognitive decline or physical challenges. Several studies have introduced solutions such as smart-prayer mats and adaptive chairs equipped with microcontrollers, sensors, and other components to help monitor rakaʿat during prayer.

One smart-prayer system, leveraging the Internet of Things (IoT) technology, utilized a combination of Force-Sensitive Resistor (FSR) sensors, ultrasonic sensors, and an ESP32 microcontroller to detect physical prayer movements. This system was further enhanced with real-time database integration and a mobile application that provided prayer-time reminders and user-monitoring capabilities [4]. In another project, a smart-prayer mat was developed with five strategically placed sensors corresponding to specific body-contact points. This setup was combined with GPS and a digital compass to assist in Qibla-direction alignment. By detecting voltage fluctuations, the system was able to accurately differentiate between prayer postures, thereby improving the precision of rakaʿat counting [8]. For individuals who perform prayer in a seated position, a specialized Salah-chair was developed featuring ultrasonic and infrared (IR) sensors to monitor rakaʿat and assist with recitations via a DF Player audio module. Although effective, the chair's large and non-portable design limited its practicality [9]. Additionally, certain issues may arise due to the design of the Salah-chair.

The challenges associated with using conventional chairs for seated Salah are the potential misalignment within the prayer row [10]. According to [10], the authors emphasize the importance of ergonomic chair design as a scientific approach to minimizing discomfort and physical strain, particularly for elderly users. Notably, the inclusion of armrests was identified as beneficial in alleviating knee fatigue when transitioning from sitting to standing. The study followed a three-phase investigation process: identifying common causes and usage patterns related to prayer chairs, establishing appropriate design criteria, and developing a prototype. Among 124 participants, the most frequently reported causes for chair use during prayer included knee problems (50.8%), aging (42.7%), and back pain (35.5%), with additional factors such as pregnancy (5.6%), foot issues (4.8%), disability (4%), excess weight (3.2%), and others (12.1%). Observations of user patterns revealed that the most common prayer posture was sitting, followed by prostration, and then a combination of bowing, prostration, and seated postures of varying durations [10].

In summary, Table 1 presents a comparative overview of several existing electronic prayer assistance projects, each employing different sensor technologies and targeting specific user needs. Most of the systems reviewed are designed for users who can perform prayers in a standing position. For instance, the Smart Prayer System for elderly Muslims with IoT [4] utilizes an infrared receiver combined with IoT features for counting rakaʿat and issuing prayer reminders; however, it is limited to elderly users who are still able to stand during prayer. Similarly, the Smart Praying Mat with Qibla Tracing [8] employs five sensors using voltage level variations to distinguish rakaʿat, but is also tailored for standing users. The Development of a Salah Chair [11] introduces a seated prayer aid using ultrasonic sensors, but suffers from bulkiness and a lack of portability, reducing its practicality. Additionally, both the Smart Prayer Mat for Elderly using Pressure Sensor [12] and the Smart Prayer Mat using a Piezoelectric Sensor [13] focus on detecting forehead contact during sujood to count rakaʿat, with the latter being slightly more inclusive for general users. Overall, the comparison highlights a gap in solutions that cater to elderly users who pray while seated, particularly those needing a portable and user-friendly design.

Table 1. Comparison of existing electronic prayer project.

Title	Technique	Limitation
Smart Prayer System for Elderly Muslim with IoT [4]	A prayer mat that has IR receiver to count embedded with IoT for notification and reminder.	The designated model is for elder Muslim that can stand when praying.
Smart Praying Mat with Qibla tracing [8]	A prayer mat that has five sensors that differentiate by level voltages used to count raka'at.	The designated model is for stand praying. Ordinary Muslim can use it.
The Development of Salah Chair using Ultrasonic Sensor [11]	A prayer chair that is embedded with ultrasonic sensor to count raka'at.	The designated chair is too bulky and not portable and it is intended solely for Muslims with physical disabilities that prevent them from standing during prayer.
Smart prayer mat for elderly using pressure sensor [12]	A prayer mat that used FSR sensor to receive input from user's forehead and count raka'at.	The designated model is for elder Muslim that can stand while praying.
Smart prayer mat using piezoelectric sensor [13]	A prayer mat that used piezoelectric sensor to receive input from user's forehead and count raka'at.	The designated model is for assisting Muslims. Ordinary people can use it.

In conclusion, while Islamic jurisprudence endorses the use of technological aids in worship, provided they uphold the core principles of prayer, there remains a critical need for solutions that balance Shariah compliance with practical usability. Expert insights confirm that assistive devices, such as rakaʿat counters, are permissible when designed to minimize disruption and address genuine user needs [14] [15]. Despite the progress of existing systems, significant challenges persist, particularly in creating portable, user-friendly devices tailored to elderly users that fully align with Islamic guidelines. Addressing these gaps is essential for developing effective and widely acceptable prayer assistance technologies.

3. Methodology

This study focuses on developing a system for a portable monitor for raka'at counting and aims to improve its usability for user. This phase consists of interviews with fiqh experts, the development of a portable monitor, and the validation of user testing.

3.1 Interview Session - Fiqh Expertise

To ensure that the development of the portable raka'at monitoring system aligns with Islamic principles, interviews were conducted with lecturers from the Faculty of Shariah and Law, Universiti Sains Islam Malaysia, specializing in Fiqh. The objective was to gather expert insights on the concept of *rukhsah* (religious leniency) in prayer, particularly for elderly Muslims who pray while seated. Discussions focused on the permissibility of integrating technology into acts

of worship, physical movement limitations during prayer, and appropriate sensor placement that does not interfere with the core structure of salah. The feedback served as a critical foundation for designing a Shariah-compliant device that does not disrupt the prayer experience.

Based on the interviews conducted, several important considerations emerged regarding the integration of technology into prayer practices. These key points are summarized as follows:

i) The use of assistive technology in prayer is generally permissible for those with genuine needs, such as elderly individuals with memory loss or physical limitations.
ii) The use of technology in prayer is permissible as long as it does not contradict Islamic teachings.
iii) Technological aids should be intended only for specific groups who need them and must avoid causing excessive physical movements, as this would violate the Shafi'i guideline prohibiting more than three major movements during prayer.
iv) Sensor placement should be minimal and non-intrusive, with seat-mounted sensors preferred over those worn on the wrist to reduce interference.
v) The technology must be user-friendly and simple to operate, avoiding cumbersome wiring, and designed to support spiritual focus rather than distract from it.
vi) It is essential to determine the correct sequence for accurately measuring rakaʿat.

These insights will guide the design phase to ensure the portable rakaʿat monitoring system complies with Islamic principles while effectively assisting users.

3.2 Development of portable monitor

The development of a portable raka'at monitoring system involves both electronic and mechanical design processes. The aim to create a compact, user-friendly and Shariah-compliant device that can detect and display the number of raka'at performed during seated prayer.

a) Electronic design

Power System

The power system refers to the management of the power supply for the microcontroller (MCU). The selection of the STM32F103C8T6 has been made as the main microcontroller. This MCU can be activated with a 5V power supply [16].

Sensor connection

The connection of the sensor needs to be studied, as previous research has tested s voltage divider circuit for the FSR sensor [17]. Additionally, another method used a capacitor with the textile sensor to exploit the capacitance theory [18]. The selection of the sensor can be moderately difficult because the piezoelectric sensor tends to produce an output value in a small value range, which is in millivolt. However, the FSR sensor can be useful because it has been used in mass production, and it is easy to comprehend for pressure sensing. For the tactile sensor, it is a main topic before categorizing the sensor into several types such as resistance, capacitance, inductive, textile, piezoelectric, and pyroelectric [19].

Bluetooth and IoT

The Bluetooth connection requires attaching an external HC-05 Bluetooth module to the sensor. This method allows the sensor to be detached from the monitor and placed on the backseat of a chair. IoT connection can be executed with ESP32 module which is a microcontroller embedded with a Wi-Fi module.

4. Expected Result

Before proceeding to the mechanical design phase, the electronic design of the project must be thoroughly tested. An initial visualization of the system is essential for determining the appropriate placement and integration of the required components. Figure 2 illustrates the connectivity between the DF Player, the LCD display, the Bluetooth module, the sensor, and control buttons. Each component serves a specific function: the LCD display presents the rakaʿat count to the user and also includes a zikr counter as an additional feature. The DF Player module stores Quran recitations and can be controlled via the microcontroller (MCU). The control buttons are used to manage playback, reset the rakaʿat counter,

and operate the zikr counter. The sensor is connected to the Bluetooth module to transmit input data. Since the sensor outputs analog signals, the system must be evaluated for its capability to transmit analog data reliably over Bluetooth.

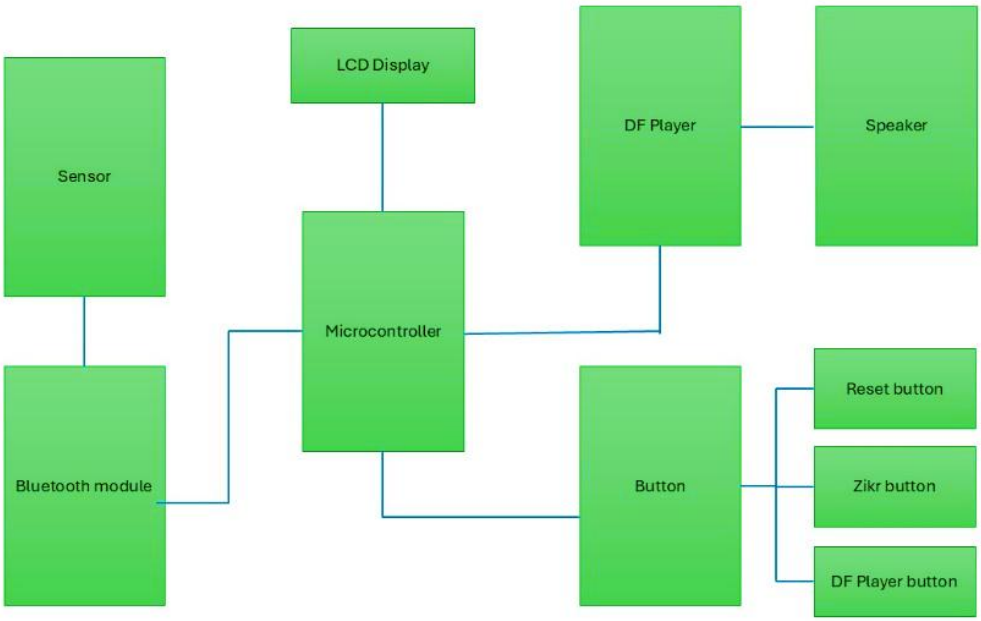

Figure 2. Block diagram

The mechanical design phase begins after the completion of the electronic circuit design. This phase involves developing a 3D model of the system's hardware to facilitate both visualization and expert consultation. The 3D design will serve as the basis for a physical prototype, which will be tested in real-world conditions.

As shown in Figure 3, the sensor is intended to be mounted on the chair to effectively capture user input. Additionally, Figure 2 highlights the armrest as the designated location for attaching the portable monitor. The left side of the armrest has been specifically selected to ensure better visibility of the LCD display, allowing users to easily monitor the rakaʿat count during prayer. The validation phase of this project focuses on evaluating the practicality and functional performance of the proposed rakaʿat monitoring system. It aims to assess the system's effectiveness in real-world settings and gather user feedback regarding usability and acceptance. This phase is essential for identifying potential usability challenges, verifying the system's reliability during actual prayer conditions, and ensuring that the device fulfills its intended purpose in a Shariah-compliant and user-friendly manner.

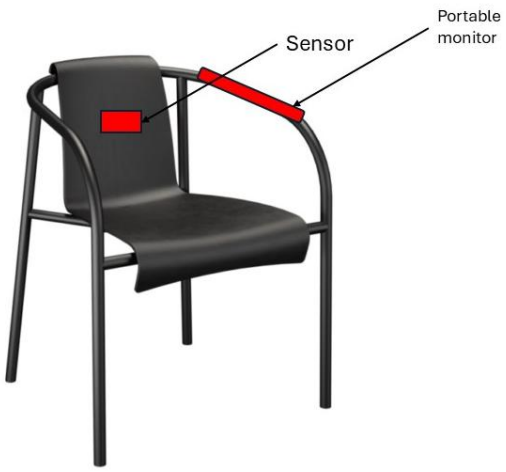

Figure 3. Diagram of an expected outcome.

5. Conclusion

This study presents the development of a Shariah-compliant, portable rakaʿat tracking system designed to support elderly Muslims who perform prayer in a seated position. Grounded in expert insights from Fiqh scholars, the project ensures religious permissibility while addressing the cognitive and physical challenges faced by the elderly during Salah. The design process has focused on integrating microcontroller platforms, pressure sensors, and intuitive user interfaces to create a solution that is both functional and user-friendly. Although the final system is still undergoing refinement, initial testing and expert feedback have played a critical role in guiding ergonomic and technical decisions. The proposed device holds promise in promoting greater prayer accuracy, independence, and spiritual confidence for elderly users. Future work will focus on comprehensive real-world validation and continuous improvement to ensure long-term reliability and widespread adoption.

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