SMART PRAYER MAT: A TEXTILE-BASED PRESSURE SENSOR TO ASSIST ELDERLY WITH COGNITIVE IMPAIRMENT IN PRAYING ACTIVITY

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ABSTRACT. The older adults will eventually experience unavoidable changes in their cognitive, physical and perceptual ability. Several assistive technologies have been used to support the physical, emotional and social needs of the elderly to enable them to perform their daily activities but lack the support for the activities related to their spiritual needs. We present our work where we explore the intersections of technological development and spiritual practices. As we argue that supporting the praying needs will support the spiritual needs of the older adults, we proposed a technological aid for supporting the praying activity among elderly Muslims as a form of mediated practice. We present the description and design of our Smart Prayer Mat, a smart praying mat embedded with a textile-based sensor that prompts audible cues to alert elderly Muslims with cognitive impairment of the completion of ritual cycles (*raka'ahs*) while performing their prayer practices. This novel aid will shed new light upon the convergence of technology and spirituality, techno spiritual space.

Keywords: textile-based pressure sensor, elderly, cognitive impairment, Islam, praying activity

INTRODUCTION

Assistive technologies for the elderly include a wide range of devices and equipment that help the older adult perform a task or prevent injury to support independent living and sustain their quality of life through the improvement of their safety, wellbeing, and social interaction. The use of the assistive technologies for independent living is seen in interventions such as tooth brushing assistance (Peters, Hermann, Wachsmuth, & Hoey, 2014), meal preparation aid (Lussier-desrochers & Lachapelle, 2012) and hand washing assistance (Mihailidis, Boger, Craig, & Hoey, 2008). However, in the current literature innovation of assistive technologies mainly address the physical, emotional and social needs of the older adult and overlook their spiritual needs (Wyche & Grinter, 2009). Although spirituality is not restricted only to religion, studies of spirituality and the older person has highlighted that one aspect of spirituality is on the importance of the continuity of performing worship or prayer (Goldsmith, 2004). In the light of the older adult needs to continue performing prayer despite facing the challenge of cognitive impairment we seek to explore on the use of the smart technology to support the older adult's prayer activity using the Muslim's prayer activity as the context of the study. In a Muslim prayer activity, a prayer mat is used as a cultural practice although it is not manda-

tory according to the Islamic regulation on praying. Guided by the results and findings of our preliminary study (Juhaida, Noor, & Rahim, 2014), we proposed the development of a technological aid that we named as the Smart Prayer Mat. This smart praying mat is embedded with a textile-based pressure sensor that prompts audible cues to alert elderly Muslims of the completion of ritual cycles (*raka'ahs*) while performing their prayer practices.

In this paper we report our research work where we explore the intersections of technological development and spiritual practices through the development of our proposed aid. We begin by reviewing related works; techno-spiritual applications. The following sections provide a more detailed description of our novel design of Smart Prayer Mat.

TECHNO-SPIRITUAL APPLICATIONS

The subject of the convergence of technology, religion and spirituality is discussed in the literature within the context of techno-spiritual applications that support religious activities (Bell, 2006). Despite the emergence of this recent technology space, its use in Islamic religious practice remains overlooked although there is an estimated of 1.2 billion Muslims worldwide (Wyche, Caine, Davison, Arteaga, & Grinter, 2008; Wyche & Grinter, 2009). In the Islamic faith, Muslims uphold five religious activities said to be the pillars of Islam which are the syahadah, ritual prayer (*solat*), fast, haji (pilgrimage) and paying the poor-due *(zakat)*. Among the five pillars, prayer is the most important element in Islamic religious law and is considered as 'the foundation of the religion' (El-sayed, Greenhill, & Westrup, 2008) and reflects a Muslim faith. As an argument to support technology in human activities the use of technology is considered to be a mediated practice (El-sayed et al., 2008). Currently, most of the existing technologies for Muslims are focused on a subset of spiritual activities. The spiritual applications that the Muslims are using support their prayer requirements, of performing their obligatory prayers five times a day at specific times and in specific direction (El-sayed et al., 2008).

In the Muslim practice the identification of the praying time is based on the public call to prayer (*adhan*) from the nearest mosques that alerts people of the obligatory prayer times. Technological support for identifying the prayer time is seen in applications such as the Sun Dial, MobileAzaan, Khashee and Athan Time as these applications were developed to prompt Muslims to their five daily prayer times (Wyche et al., 2009). In addition, Muslims also need to perform their prayer by facing the qibla, or Mecca's direction (Wyche et al., 2008) and to assist the Muslim in determining the qibla, an intelligent prayer rug, Ozenc's illuminated prayer rug has been developed for this purpose. This prayer rug will display an image of a mosque glows brightly, an indicator that the rug faces Mecca and it is the correct prayer direction (El-sayed et al., 2008).

DIFFICULTIES OF ELDERLY MUSLIMS DURING PRAYER

With age, elderly are prone to experience a natural cognitive decline, their attention levels are diminished with limited capabilities in functioning such as perception, reasoning and remembering (Peters et al., 2014). Thus, they faced challenges in performing both simple and complex activities of daily living (Bouma, 1996; Das, Cook, Schmitter-Edgecombe, & Seelye, 2011). Occasionally, they struggle to complete their activities as they tend to forget or omit the steps that are required to complete an activity, having trouble in remembering the activity they are trying to do (Lapointe, Bouchard, Verreault, Potvin, & Bouchard, 2013).In the context of the Muslim prayer activity, besides performing prayer at specific times and in a specific direction, Muslims are also required to fulfill the specific number of ritual cycles for each prayer. For instance, *Fajr* (dawn) prayer with two ritual cycles, *Zuhr* (noon), *Asr* (afternoon) and *Isya'* (evening) prayer fixed with four cycles each and *Maghrib* (sunset) prayer with three cycles. Incomplete cycles are not acceptable in Muslim's prayer practices. Cogni-

tive impairment reduces an elder's ability to perform their daily prayers because of related difficulties in remembering the number of ritual cycles (*raka'ahs*) that need to be completed, or they lose track of the ritual cycle that they have already completed. The need for immediate ways to address the above issue motivates us to propose an aid that puts elderly back on track to correctly complete their ritual cycles while praying. The Smart Prayer Mat provides assistance in the execution of Muslim's praying activity by providing audible cues to the elderly with cognitive deficits, who tend to omit steps and ritual cycles during prayer.

DEVELOPING THE SMART PRAYER MAT

The Smart Prayer Mat that we have developed is embedded with a sensor technology (pressure sensor) as shown in Figure 1 that prompts audible cues to alert a person praying on the mat after completing each ritual cycle.
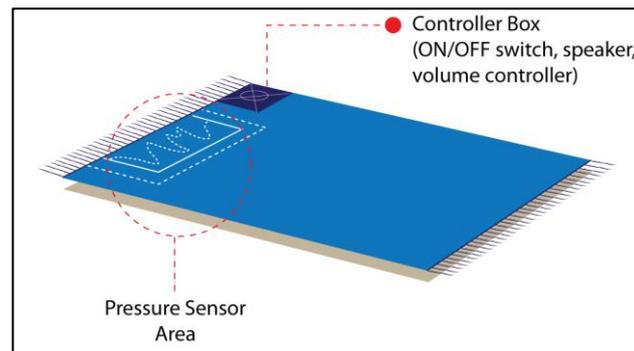

Figure 1. Smart Prayer Mat Equipped with Pressure Sensor

For the Muslims prayer practices, a basic ritual cycle (*raka'ah*) is made up of these six possible positions in a fixed manner (*tertib*) as illustrated in Figure 2 from the person standing still, bowing (*rukuk*), standing again (*I'tidal*) and stopping, forehead touching to the ground (prostration), sitting and second prostration.
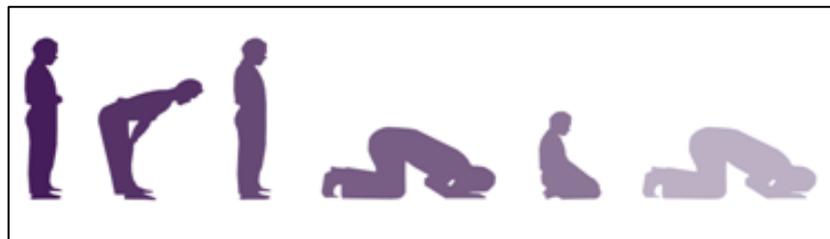

Figure 2. A Sequence of Muslims Prayer Positions

The sensor is located under the forehead area on the mat. The pressure sensor will only sense the touch of the forehead during prostration in a prayer. Thus, pressure sensor readings do not change when the person is not prostrating. Contrarily, values change during prostration only. The sensor will only instruct the audio module to provide the audible cue during second prostration for every cycle (*raka'ah*). For example, if a person is performing his four-cycle prayer, although it involves eight prostration postures, the sensor will provide cues for four times, during the second prostration of every cycle.

Functional Components of Smart Prayer Mat

The Smart Prayer Mat comprises of two input systems, two output systems and a processing system as shown in Figure 3.
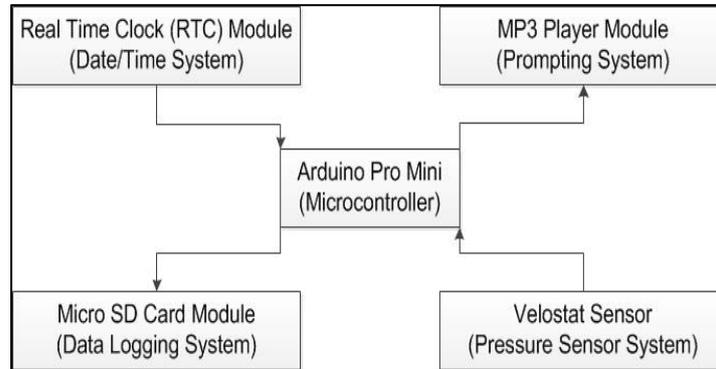

Figure 3. Functional Overview of Smart Prayer Mat

Input System. The Smart Prayer Mat comprises of two input systems: (i) date/time and (ii) pressure sensor system. Real Time Clock (RTC) is the module that will keep track of the accurate date and time of the smart praying mat system. The primary input of the smart praying mat system would be the force of the forehead. The pressure sensor system will sense the touch of a person's forehead (prostration) at the sensor area located on the praying mat. The value will be gathered from the pressure sensor during praying position (No.4) and (No.6) as illustrated in Figure 4.
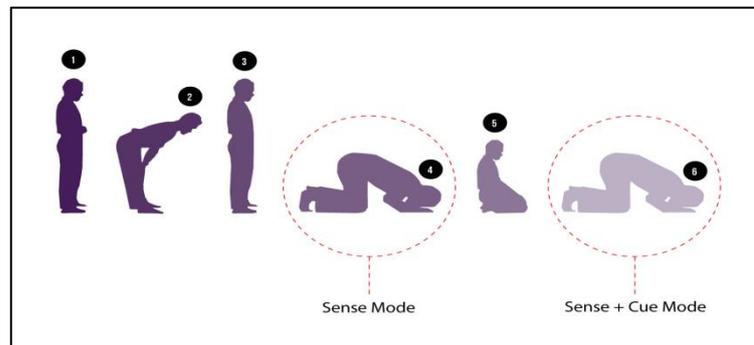

Figure 4. Sensor Activities at No.4 and No.6

Output System. The Smart Prayer Mat system consists of two output systems: (i) prompting and (ii) data logging system. The prompting system uses the Mini MP3 Player module which supports MP3 audio format. All pre-recorded automated cues and startup sounds are stored in micro SD card in the Mini MP3 Player module. This module provides audible cues to prompt the user for each ritual cycle. In order to provide effective cues to users with cognitive limitations, we use audible cues in terms of verbal commands which were pre-recorded. We presented cues with short, specific cues (e.g. "One.") after the first cycle of praying activity performed. The cues will be given after prostration, praying position (No.6) as shown in Figure 4. We chose an audio modality due to two reasons: first, users are familiar with audio prompts since caregivers mainly use verbal instructions. Second, prompting using audible cue rather than the visual cue provides a more direct augmentation of executive function" due to a

close relationship between language and executive function in the human brain (Peters et al., 2014).

Once a person touches his forehead on the sensor area, this system will log the data in the form of *current date and time*, *type of prayer* (based on the predefined time range), *number of ritual cycle* and *duration of every cycle* (in minutes) as shown in Figure 5.

Figure 5. Example of Pressure Sensor Data

Processing Unit. This Smart Prayer Mat system employs Arduino Pro Mini, a microcontroller board based on the ATmega168 (datasheet). This microcontroller acts as the processing unit for input, output and data of this Smart Prayer Mat system. First, once sensor senses the pressure from the forehead of a person, the microcontroller will increment one number to the current number of ritual cycle performed. Next, once one ritual cycle added or the number of ritual cycle is even, the microcontroller will instruct the MP3 player to prompt the audible cues that is in the form of number (represent the number of ritual cycle performed). Finally, there is the possibility for pattern monitoring, where microcontroller will record the log data in the micro SD card. Logs from this system can be used to infer how much time the elderly with cognitive impairment spent for praying activity and the duration of each ritual cycle.

CONCLUSION

This article has presented the description and novel design idea of the Smart Prayer Mat. Our Smart Prayer Mat provides assistance in the execution of Muslim's praying activity by providing audible cues to the elderly with cognitive deficits, who tend to omit steps and ritual cycles during prayer. As of the submission of this paper, we have moved to our actual study as we plan to conduct the experiments in two alternating conditions :(1) baseline without the Smart Prayer Mat and (2) intervention with Smart Prayer Mat. The results of the study will shed new light to the intersection of technological development and spiritual practices, techno-spiritual space.

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