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Prayer Guide Tool for the Deaf Using Gyroscope Sensor and HC-12

Muhammad Mahda Winasis[1*)], Hanifah Rahmi Fajrin[2)], and Wisnu Kartika[3)]

[1, 2, 3)] Department of Medical Electronics Technology, Universitas Muhammadiyah Yogyakarta, Indonesia
Corresponding Email: [*)] m.mahda.vok19@mail.umy.ac.id

***Abstract* – Congregational prayer for muslim is a prayer that is done together at least consisting of an Imam (leader of congregation) and Makmum (participants / followers). In carrying out congregational prayers, deaf people frequently struggle to follow the instructions of the Imam's movement. Therefore we need a tool that can help the deaf in performing congregational prayers. In the previous tools, there are still shortcomings in the short data transmission and cannot distinguish the vibrations in each prayer movement. The short data transmission distance causes the deaf to be less than optimal in carrying out congregational prayers because vibration notifications will not be conveyed from Imam to Makmum. In this study, a tool will be designed to guide the deaf when performing congregational prayers. This tool uses the HC-12 wireless module to transmit data from the Imam's device to Makmum's device. Changes in prayer position will be detected by the MPU 6050 gyroscope sensor. The tool will send notifications to the deaf Makmum in the range of separate vibrations for any changes in the Imam's movement. After testing on 30 different people, the accuracy value is 85, 3% and the tool can transmit data at a maximum distance of 30 meters. As a result, the tool can assist the deaf in performing worship services.**

Keywords: Gyroscope, Wireless, Deaf, Congregational prayers.

I. INTRODUCTION

Over 5% of the global population, or 430 million people, require rehabilitation to address their 'disabling' hearing loss. Over 700 million people – or one out of every ten people – are expected to have disabling hearing loss by 2050 [1]. Meanwhile, according to the Directorate General of Population and Civil Registration, Indonesia's population recorded in June 2021 reached 272.23 million, of which 236.53 million were Muslims, including people with disabilities [2], [3]. In addition , there are 13,802 people in Indonesia who are deaf [4].

Deafness is someone who has a hearing loss, either completely or still has residual hearing. The deaf who have difficulty hearing affect the inhibition in speaking, so that the deaf cannot understand verbal language well. As a result, it affects the emergence of other problems in life such as problems in the social aspect. Deaf people also need help from others in their daily lives, including in worship, such as praying in congregation for Muslims. Following the movement of the Imam in congregational prayers, especially in the position of getting up from prostration, is a problem experienced by the deaf [5], [6].

So far, to assist the deaf in carrying out congregational prayers, hearing aids have been used. However, this tool still has drawbacks, such as making a buzzing sound that can interfere with concentration for the deaf [6]–[10]. In the previous research, a tool called the "GGS" [11] was made which is a prayer movement detection tool for the deaf makmum. However, this tool still has shortcomings, one of which is the short transmission distance and the vibration notification is still the same for every prayer movement so that the deaf cannot distinguish the movements of the imam in prayer.

The short data transmission distance causes the deaf to be less than optimal in carrying out congregational prayers because vibration notifications will not be conveyed if congregational prayers are carried out in a mosque that has a large size with a large capacity. In addition, the current Covid-19 condition also requires worshipers to practice physical distancing. Therefore, a prayer guide is needed for the deaf with data transmission of more than 15 meters.

In this study, a tool in the form of a Gyroscope bracelet will be designed that can guide the deaf in carrying out congregational prayers. This tool uses a gyroscope sensor which is used to detect changes in the prayer movement of the imam. The signal transmission technology from the Imam to the Makmum's device uses a wireless module with a communication distance of up to 100 meters [11], this range is much wider than the previous device that used the HC-04 proximity sensor [12].

II. METHODOLOGY

A. Congregational Prayer

Prayer is worship for muslims which consists of several words and deeds that begin with Takbir and end with greetings and fulfill the specified conditions. The Prayer Movement consists of:

1. The Takbiratul Ihram and Holding Arm

Takbir is an expression of intention. So in praying there must be a Takbir movement. When someone is doing Takbiratul Ihram (raising hands), then he is in a standing position by raising both hands parallel to the shoulders or ears perfectly then followed by reciting takbir. After the Takbiratul Ihram movement, the hands should be in Holding Arm position.

2. Ruku'

Ruku' is the position of bending the body in prayer.

3. I'tidal

I'tidal is the movement of getting up from bowing' before doing prostration.

4. Prostration

In the prostration movement, it is to put the head on the prayer mat which is held on the ground where it stands. The prostration is performed by lowering the body, and first the knees are in contact with the ground, then the hands and finally the forehead.

5. Sitting (Iftirasy)

How to do iftirasy sitting is to get up from prostration and then sit by placing your left foot under your buttocks and your right leg folded facing the Qibla.

Congregational prayer is a prayer that is done together at least consisting of an imam (leader of congregation) and makmum (participants / followers). This makmum can consist of anyone, male or female. Makmums are not allowed to stand in front of the imam, so if makmum standain front of the imam, the prayer is invalid. If a woman is present in congregational prayers, she should stand separately behind the men and do not join in the same row with them. Makmum must follow the Imam and it is forbidden to precede him. If the Makmum precedes his movement, then the prayer is invalidated. Makmum must also be able to know with certainty the movement of the Imam by seeing or hearing even with the help of a conveyer (speaker or person). This can happen to people with hearing impairments who need assistive devices to be able to follow the movement of the Imam [13]. The illustration of the prayer movements can be seen in Table 1.

Table 1. Illustration of Prayer Movement [14]

No.	Prayer Movement	Posture
1	Holding Arm	
2	Ruku’	
3	I’tidal	
4	Prostration	
5	Iftirasy	

B. Flowchart

It can be seen in the Figure 1 that when the tool is used, the wireless module between the imam and makmum’s devices will be connected. The gyroscope sensor works to detect changes in the angle experienced by the Imam's device in 3 degrees, namely the x, y, and z axes. After the prayer movement changes, a command signal will be sent from the Imam’s device to makmum’s device using the HC-12 module. The indicator in the form of a vibrator motor will vibrate and the LED will light up when the signal has been received by the makmum’s device.

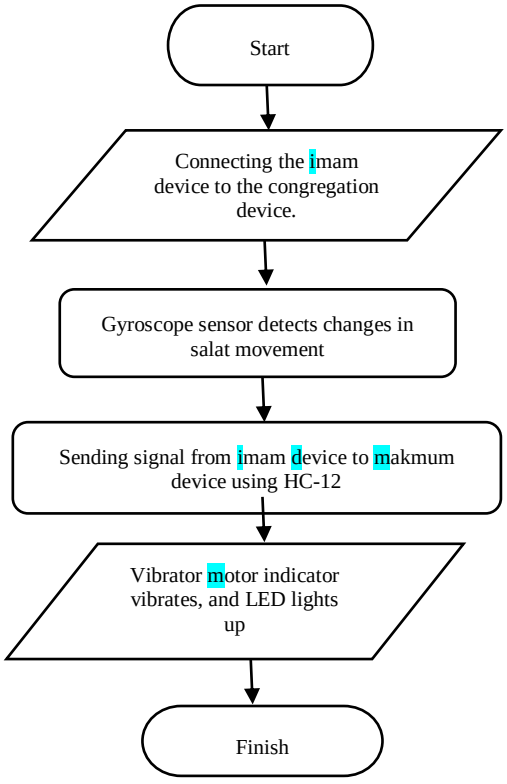

Figure 1. The tool flowchart.

C. Gyroscope Sensor

A gyroscope, often known as a gyro, is a device that uses the principle of continuous angular momentum to

measure or maintain orientation. The mechanism consists of a revolving wheel with a stable disc inside. Gyroscopes are commonly found in robots, aircraft, and other high-tech devices. By resting on a wheel or disc that rotates fast about an axis, the gyroscope can discern the orientation of motion [11], [15], [16].

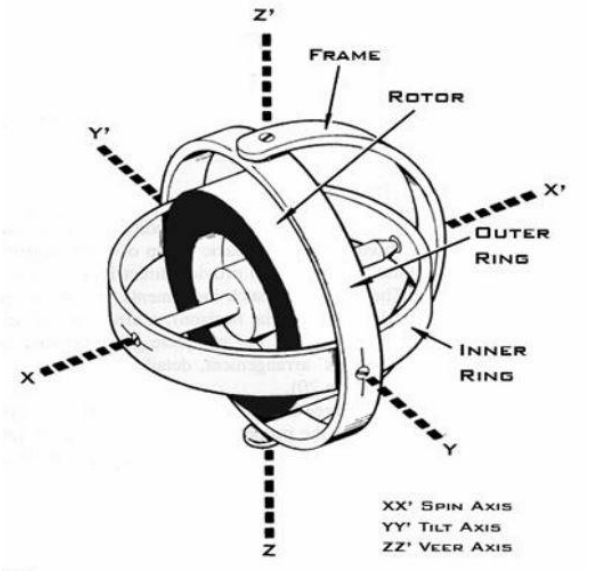

Figure 2. Gyroscope working principle [11].

The gyroscope sensor can detect motion according to gravity, or in other words, detect the user's movement. Before being used, the gyroscope sensor is first calibrated using a pendulum. The calibration process serves to obtain the value of the calibration factor. The gyroscope produces angular velocity along three axes: the x-axis, which become the phi angle (right and left) [16], the y-axis, which will later become the theta angle (top and bottom), and the z-axis, which will later become the psi angle (front and back) [17]–[19].

D. Module Serial HC-12

HC-12 is a radio module used for serial communication which is a new generation of multi-channel data transmission. Frequency on this module works between 433 MHz - 473 MHz. Frequency is set with a location space of 400 KHz so that it can have a transmission power channel. The transmission power of this module is 100 mW (20dBm) [20], [21].

HC-12 has five pins which will be connected to the microcontroller. There are also pins for antenna installation which have two usage options, namely using the available spring antenna or an external antenna that is installed using a coaxial cable [22].

Figure 3. Module HC-12 [22].

E. Tool's Circuit

Figure 4 is a schematic of the Imam's device circuit. In this device there is a sensor that detects changes in angle or motion, namely the Gyroscope MPU 6050. The microcontroller in this tool uses an Arduino Nano, which functions to process changes in the prayer movement instructions. HC-12 is used as a wireless module that sends command signals to Makmum devices.

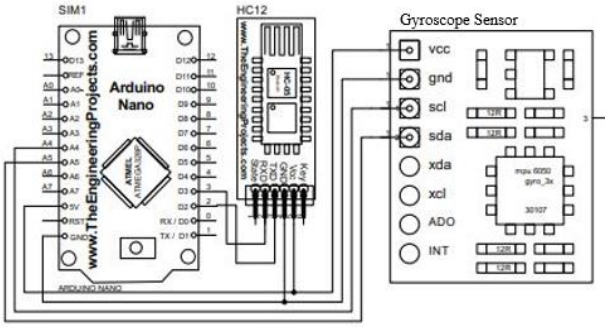

Figure 4. Imam's device circuit.

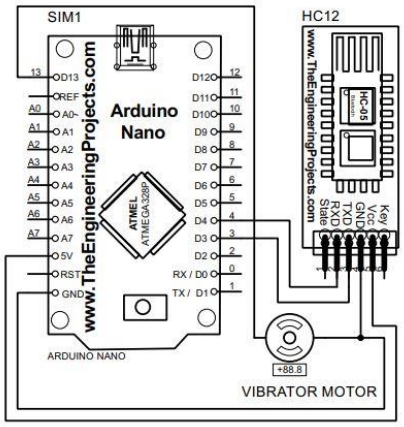

Figure 5. Makmum's device circuit.

Figure 5 is a schematic of the circuit on the Makmum device. The component used is Arduino Nano as a controller [13], [23] for the Makmum's device circuit. Wireless communication from Imam to Makmum devices uses HC-12 as a signal receiver. As an indicator of changes in the motion of the prayer position using a micro vibrator motor [24], [25].

F. Performance Metric

Accuracy is the similarity or closeness in measurement results to actual numbers or data. Accuracy can be expressed as a measure of how close the value of the average measurement results obtained from a number of repeated measurements to the true value. In this research to calculate the success rate of the test, the accuracy formula is used [26].

$$Accuracy = \frac{number\ of\ correct\ predictions}{total\ predictions}\ x\ 100\% \qquad (1)$$

III. RESULTS AND DISCUSSION

To determine the performance of the tool, a test was conducted by measuring the distance of signal transmission from the Imam device to the Makmum device. If the signal transmission is successful, the Makmum device will vibrate. The test is carried out with different signal transmission distances on 30 people who have a height between 155 cm to 170 cm. The rotational motion of an object with an inertial frame reference can be detected using a gyroscope sensor which can be used to measure the orientation of the accelerometer at a time, so that the gyroscope sensor is also influenced by height [5].

This study uses a Gyroscope sensor to detect changes in angles at each position of the prayer movement, Table 2 shows the data.

Table 2. Angle Change Data of the Prayer Movement

Angle	Holding Arms	Ruku'	I'tidal	Prostrations	Iftirasy
X(°)	(-20)-(-5)	30– 55	40- 75	40-65	10-30
Y(°)	(-60)–(-90)	0 - 15	(-5)-75	(-10) - (-30)	(-30) -(-10)
Z(°)	60 - 65	(-6) – (-15)	(-5)-5	(-5)-10	-5 - (-15)

Table 2 contains the angle values used for setting the determination of each prayer movement using the X, Y, Z angles. In the Holding Arms position, the angles used are (-20)°-(-5)°, (-60)°-(- 90)°, 60°-65°. In the Ruku' position, an angle of 30°-55°, 0°-15°, (-6)°-(-15)°, (-6)°-(-15)° is used. In the I'tidal position, the angles used are 40°-75°, (-5)°-75°, (-5)°-5°. In the prostration position, the angles used are 40°-65°, (-10)°-(-30)°, (-5)°-10°. As for the Iftirasy position, an angle of 10°-30°, (-30)°-(-10)°, -5°-(-15)° is used.

After obtaining the angle value as shown in Table 2, then testing the gyroscope sensor, whether the test angle is in accordance with the setting angle (Table 2). If appropriate, then the HC-12 convey a signal in the form of a change of the prayer movement from the Imam's device to the Makmum's device. Testing is performed after the device has successfully sent and received data. The data for testing at a certain distance (5 meters – 35 meters) can be seen in Table 3 - Table 5. This experiment was conducted out on 3 Imams who have different heights. This is a test sample that was available at that time.

Table 3. First Trial Data (155 cm)

Distances (m)	Holding Arms	Ruku'	I'tidal	Prostration	Iftirasy
5	✓	✓	✓	✓	✓
10	✓	✓	✓	✓	✗
15	✓	✓	✓	✓	✓
20	✓	✗	✓	✓	✓
25	✓	✓	✓	✗	✓
30	✓	✓	✓	✓	✗
35	✗	✗	✗	✗	✗

Description : ✓ : the device is connected successfully.

✗ : the device is not connected.

Table 3 is the result of an experiment on Imam who has a height of 155 cm. It can be seen that the test results at a distance of 5 and 15 meters, the tool succeeded in sending a signal from the Imam to the Makmum device, with an indicator in the form of an LED flashing and a vibrator motor vibrating at every prayer movement. Meanwhile, at a distance of 10 and 30 meters, in an Iftirasy position, the device does not detect the signal given by the Imam's device. Likewise, at a distance of 20, 25 and 35 meters, the Makmum's device also cannot pick up the signal given by the Imam's device.

Table 4. Second Trial Data (160 cm)

Distances (m)	Holding Arms	Ruku'	I'tidal	Prostration	Iftirasy
5	✓	✓	✓	✓	✓
10	✓	✓	✓	✓	✓
15	✓	✓	✓	✓	✓
20	✓	✗	✗	✓	✓
25	✓	✓	✓	✓	✗
30	✓	✗	✓	✓	✗
35	✗	✗	✗	✗	✗

Table 4 is an experiment conducted on an Imam with a height of 165 cm. At a distance of 5, 10 and 15 meters, the Imam's device managed to send a signal to the Makmum device. Meanwhile, at a distance of 20 to 35 meters, the Makmum device does not succeed in capturing the signal from the Imam's device in certain prayer

movements.

Table 5. Third Trial Data (170 cm)

Distances (m)	Holding Arms	Ruku'	I'tidal	Prostration	Iftirasy
5	✓	✓	✓	✓	✓
10	✓	✓	✓	✓	✗
15	✓	✓	✗	✓	✓
20	✓	✓	✓	✗	✓
25	✓	✓	✗	✗	✓
30	✓	✗	✗	✓	✗
35	✗	✗	✗	✗	✗

Table 5 is the result of an experiment on Imam who is 170 cm tall. It can be seen that the signal that was successfully sent from the Imam's device to the Makmum's device was only at a distance of 5 meters.

Table 3 to Table 5 show that at a distance of 35 meters the devices can no longer communicate with each other, so the furthest distance used in this study is 30 meters.

After knowing the maximum distance of data transmission between devices as far as 30 meters, then data collection is conducted out to assess the device's performance at that maximum distance. This test was conducted on the deaf community (GERGATIN) branch of Yogyakarta, Indonesia by taking sample data of 3 people 30 times. Figure 6 displays the data.

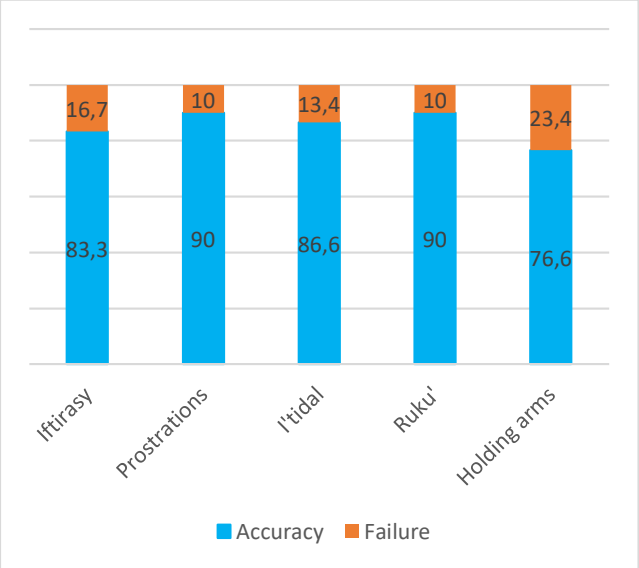

Figure 6. Data collection results.

Figure 6 describes that the accuracy value in the Holding Arms position is 76.6%, at the Ruku' position is 90%, at the I'tidal position is 86.6%, in the prostration position the accuracy is 90%, and at the Iftirasy position it is 83.3 %.

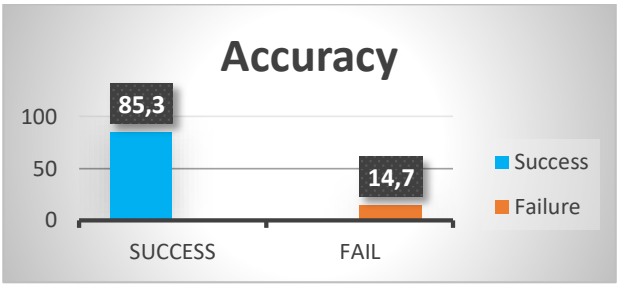

Figure 7. Total accuracy value.

Figure 7 describes the total accuracy value for all Salat movements from 30 trials carried out at a distance of 30 meters as shown in Table 6. It can be seen that the overall accuracy for all Salat movements is 85.3%.

Some of the failures that occur in the experiment can be caused by: the angle range is not in accordance with the set limit, so that changes in angles outside the range will not be read or detected by the Gyroscope, different heights for each person are also differentiating angle ranges, as well as delivery range distances that has exceeded the maximum limit of the device will cause the signal not to be sent.

In this study, the HC-12 wireless module was used which has a longer data transmission distance than the module in the previous study (HC-04), which can only transmit data at a maximum distance of 15 meters [6].

IV. Conclusion

After conducting the experiment, it can be concluded that the tool can be used as a prayer guide for the deaf with an accuracy value of 85.3% at a signal transmission distance of 30 meters. The gyroscope sensor is used to detect changes in the position of the prayer on the Imam which is captured by the Makmum device. Furthermore, the data transmission in this study uses the HC-12 with a longer transmission distance than the HC-04.

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