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Development of an IoT-Based MAX30102 Optical Sensor Device to Analyze Oxygen Saturation and Heart Rate During Qur'an Recitation

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ABSTRACT

Reading the Qur'an as an active spiritual vocalization activity can influence physiological responses, particularly oxygen saturation (SpO_2) and heart rate. This study aims to design and evaluate a detection device to measure the effect of active Qur'an recitation on SpO_2 and heart rate using a MAX30102 optical sensor integrated with an Internet of Things (IoT) system. The system consists of a MAX9814 sound sensor, ATmega328 microcontroller, RTC DS3231 module, microSD storage, LCD display, and real-time monitoring via the Blynk application. The experiment involved five healthy students (3 males and 2 females, aged 20–22 years) from the Diploma Program in Physics, Universitas Sumatera Utara. Measurements were conducted for five minutes under three conditions: before, during, and after Qur'an recitation. The results show a significant decrease in heart rate by 6.21% ($p < 0.05$) and a significant increase in oxygen saturation by 1.48% ($p < 0.001$) after recitation. The system achieved accuracy levels with 7.06% error for heart rate and 0.67% for SpO_2. This study demonstrates the novelty of integrating optical sensing and IoT-based real-time monitoring to analyze physiological responses to active Qur'anic recitation.

Keywords: Heart rate; Internet of Things (IoT); MAX30102; Qur'an recitation; Oxygen saturation.

ABSTRAK

Membaca Al-Qur'an sebagai aktivitas vokalisasi spiritual yang aktif dapat memengaruhi respons fisiologis, khususnya saturasi oksigen (SpO_2) dan denyut jantung. Penelitian ini bertujuan untuk merancang dan mengevaluasi sebuah perangkat deteksi guna mengukur pengaruh pembacaan Al-Qur'an secara aktif terhadap SpO_2 dan denyut jantung menggunakan sensor optik MAX30102 yang terintegrasi dengan sistem Internet of Things (IoT). Sistem ini terdiri dari sensor suara MAX9814, mikrokontroler ATmega328, modul RTC DS3231, penyimpanan microSD, layar LCD, serta pemantauan waktu nyata melalui aplikasi Blynk. Eksperimen ini melibatkan lima mahasiswa kondisi sehat (3 laki-laki dan 2 perempuan, berusia 20–22 tahun) dari program Diploma Fisika, Universitas Sumatera Utara. Pengukuran dilakukan selama lima menit dalam tiga kondisi: sebelum, selama, dan setelah membaca Al-Qur'an. Hasil menunjukkan penurunan signifikan pada denyut jantung sebesar 6,21% ($p < 0,05$) dan peningkatan signifikan pada saturasi oksigen sebesar 1,48% ($p < 0,001$) setelah pembacaan. Sistem ini mencapai tingkat akurasi dengan kesalahan 7,06% untuk denyut jantung dan 0,67% untuk SpO_2. Penelitian ini menunjukkan kebaruan dalam integrasi sensor optik dan pemantauan waktu nyata berbasis IoT untuk menganalisis respons fisiologis terhadap pembacaan Al-Qur'an secara aktif.

Kata kunci: Denyut nadi; Internet of Things (IoT); MAX30102; Membaca Al-Qur'an; Saturasi oksigen

1. Introduction

The activity of reciting the Holy Qur'an in a tartil manner constitutes a structured vocalization process that involves the simultaneous coordination of the respiratory system, phonation mechanisms, and neurocognitive regulation [1]. The activity of reciting the Holy Qur'an in a tartil manner involves coordinated respiratory control and neurophysiological regulation. The recitation pattern governed by the rules of tajwid requires stable breathing control, appropriate regulation of the length of pronunciation, and a consistent articulation rhythm [2]. From a physiological perspective, this slow and controlled breathing pattern can activate the parasympathetic nervous system by increasing vagal nerve tone, subsequently reducing heart rate, increasing heart rate variability (HRV), and stabilizing the cardiovascular system. Slow breathing patterns can activate the parasympathetic nervous system, reducing heart rate and improving oxygenation [3]. Several studies demonstrate that slow breathing techniques improve the efficiency of alveolar ventilation and gas exchange, thereby potentially increasing peripheral oxygen saturation (SpO_2) and reducing cardiovascular stress responses [13].

The measurement of physiological parameters such as oxygen saturation and heart rate is commonly performed non-invasively using the photoplethysmography (PPG) method [4], [5]. Photoplethysmography (PPG) is widely used for non-invasive measurement of heart rate and SpO_2 using optical sensors such as MAX30102 [6], [7], [8]. This technique operates based on the interaction between light and biological tissues in accordance with the modified Beer–Lambert law, where changes in arterial blood volume during the cardiac cycle generate pulsatile signals that can be used to calculate heart rate and SpO_2 [11], [12]. The MAX30102 sensor is an integrated PPG module that combines red and infrared LEDs, a photodetector, and signal-conditioning circuits within a single low-power chip, which makes it widely used in portable health monitoring systems [14]. Numerous studies indicate that PPG sensors and wearable devices provide good accuracy in measuring heart rate and SpO_2 and can be integrated with Internet of Things (IoT) systems to enable real-time transmission of physiological data [15], [16].

Several studies also report that Qur'anic recitation can influence human physiological responses. Doufesh et al. reported that listening to Qur'anic recitation (murottal) can reduce heart rate and enhance relaxation states based on EEG and cardiovascular parameters [9]. Another study indicates that murottal therapy is associated with increased oxygen saturation and reduced anxiety levels in certain respondents [10]. Previous studies show that Qur'anic recitation affects physiological responses such as relaxation and oxygenation. However, most previous studies focus on passive listening (murottal) and rely on conventional clinical instruments. Research investigating active Qur'an recitation using integrated optical sensors and IoT-based real-time monitoring systems remains limited. However, a clear research gap remains, as studies focusing on instrumentation that specifically investigate the effects of active Qur'anic recitation on SpO_2 and heart rate using optical sensors integrated with Internet of Things (IoT) systems are still very limited.

Therefore, this study aims to design and implement a detection device based on the MAX30102 sensor integrated with IoT technology to monitor changes in oxygen saturation and heart rate before, during, and after Qur'an recitation. This research is expected to contribute to the development of optical sensor based biomedical instrumentation and to provide additional empirical evidence regarding physiological responses to religious vocalization activities**.** To the best of our knowledge, this study is among the first to integrate active Qur'anic recitation analysis with an IoT-based MAX30102 optical sensor system for real-time physiological monitoring.

2. Methods

2.1. Participants and Experimental Conditions

This study involved five healthy Muslim students Diploma Program in Physics (3 males and 2 females, aged 20–22 years) (Table 1). All participants had no history of cardiovascular or respiratory diseases. The experiment was conducted under controlled conditions:

a. Room temperature: 25–27°C
b. Resting condition before measurement
c. No caffeine intake
d. Quiet environment

The independent variable is Qur'an recitation activity, while the dependent variables are heart rate and SpO_2. Controlled variables include posture, duration, and sensor placement.

Table 1. Participant Characteristics

Sample	Age	Gender	Health Status
S1	21	Male	Healthy
S2	22	Female	Healthy
S3	20	Male	Healthy
S4	21	Female	Healthy
S5	22	Male	Healthy

2.2. Tools and Components

The tools and components used in this research include supporting assembly equipment as well as the main electronic components of the instrumentation system. The equipment used consists of a 12-volt power adapter, connecting cables, a mini USB cable, a screwdriver, a PCB board, header pins, a soldering iron, a switch, and solder wire. All of these devices are used in the processes of system design, assembly, and testing to ensure that the circuit can be properly integrated.

The electronic components used in this research include an ATmega328 microcontroller, diodes, an LM7805 voltage regulator IC, capacitors, a 16×2 LCD display, LEDs, a MAX30102 sensor, a MAX9814 sensor, an I2C module, a MicroSD module, an RTC DS3231 module, resistors, transistors, and a Wemos D1 Mini ESP8266 module. All of these components are assembled into an integrated detection system that performs data acquisition, processing, storage, and transmission of the measurement results.

2.3. Research Block Diagram

This research employs an experimental approach that aims to design, implement, and evaluate the performance of a detection device for analyzing the effect of reciting the Holy Qur'an on oxygen saturation (SpO_2) and heart rate using an Internet of Things (IoT) based MAX30102 optical sensor. The system block diagram (Figure 1) illustrates the integrated operational workflow of the device, starting from signal acquisition to data transmission. A 5-volt power supply initiates the system and provides electrical power to the entire circuit. This power source activates the ATmega328 microcontroller, which functions as the central unit for system control and data processing.

During the acquisition stage, the MAX30102 sensor measures oxygen saturation (SpO_2) and heart rate (BPM) based on the principle of photoplethysmography (PPG), while the MAX9814 sound sensor detects the recitation frequency when the subject reads the Qur'an. The ATmega328 microcontroller processes the signals from both sensors to generate physiological parameters that have been converted into digital form.

Subsequently, the RTC DS3231 module provides real-time clock information so that each recorded dataset contains a precise timestamp. The system stores the data on an SD card through the microSD module, which functions as a data logger. In addition to local storage, the system transmits the data through the Wemos D1 Mini ESP8266 WiFi module to an IoT platform (the Blynk application), which allows SpO_2 and BPM values to be monitored in real time via a smartphone.

Meanwhile, the 16×2 LCD displays the sensor readings and time information directly on the device. Therefore, the block diagram demonstrates the integration of optical signal acquisition, microcontroller-based data processing, time-based data logging, and IoT-based transmission within a single instrumentation system that operates simultaneously and in real time.

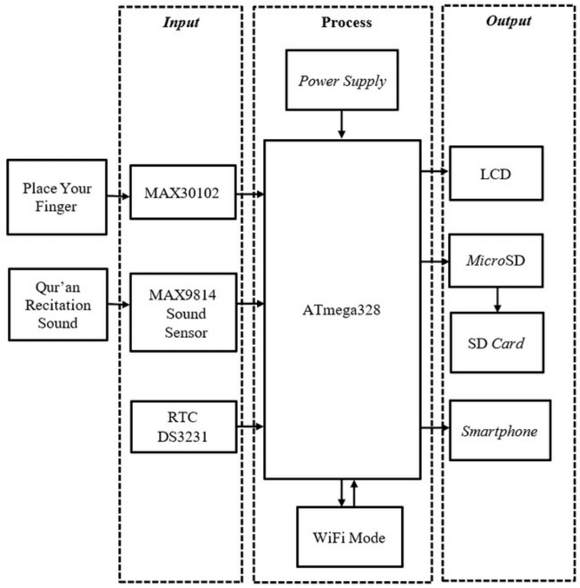

Figure 1. Block diagram of the detection device for analyzing the effects of reciting the Holy Qur'an on oxygen saturation and heart rate using an Internet of Things (IoT) based MAX30102 sensor.

2.4. Software Development

The software development stage aims to build a communication and monitoring system based on the Internet of Things (IoT) (Figure 2). The process begins with writing and uploading the source code using the Arduino IDE application, which functions as the programming environment for the microcontroller. The developed program includes the initialization of the MAX30102 and MAX9814 sensors, the processing of sensor readings, the transmission of data through the Wemos D1 Mini ESP8266 WiFi module, and the synchronization of communication with the IoT platform. The program code enables the system to read sensor data periodically, process the readings into SpO_2 values, BPM, and sound frequency, and transmit the results to an Android application in real time.

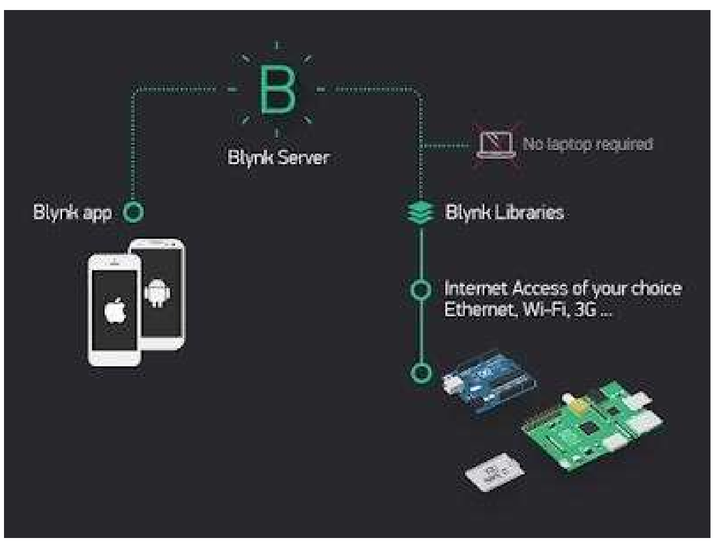

Figure 2. The diagram illustrates the workflow of the Internet of Things (IoT) system.

The hardware system is subsequently connected to the Blynk application on a smartphone through a WiFi network using the ESP8266 module. This stage requires an authentication token that the user obtains during the account registration process in the Blynk application. The token serves as a unique device identifier that enables secure and verified data communication between the device and the application. The first step in establishing communication with the Blynk application is installing the Blynk application from the Play Store or from another platform that provides the installation service. After the installation is successfully completed, the next step requires the user to create an account in the Blynk application by entering a valid email address and a preferred password. Figure 3 shows the interface for entering the email address and password.

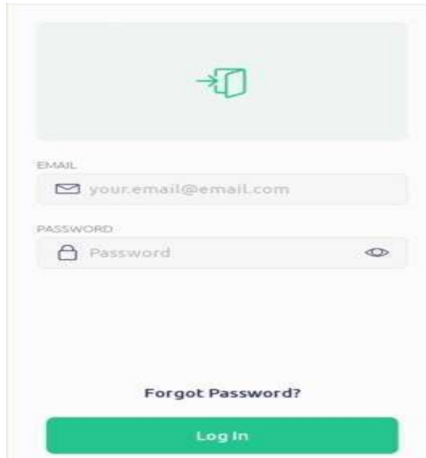

Figure 3. Login interface for entering the email address and password

After the user successfully logs into the Blynk application, the next step involves configuring the network connection by entering the WiFi SSID and password that have been previously defined for the ESP8266 module in the microcontroller program. The SSID and password entered in the application must correspond to the WiFi network connected to the device to ensure proper data communication. Once the configuration process is completed and the device is connected to the Blynk server, the sensor readings from the MAX30102 and MAX9814 modules are automatically transmitted and displayed within the application. Figure 4 presents the results of the transmitted data.

Figure 4. Results of Data Transmission to the Blynk Application

After the connection is successfully established, the microcontroller automatically transmits the sensor readings to the Blynk server through the internet network and displays them on the application interface in the form of numerical values and monitoring graphs. The developed software system therefore enables the monitoring of physiological parameters to occur in real time, in an integrated manner, and through access via a smartphone as long as the device remains connected to a WiFi network.

3. Results and Discussions

3.1. Heart Rate Data

This study conducted heart rate measurements on five Muslim students from the Diploma Program in Physics, Faculty of Vocational Studies, Universitas Sumatera Utara, cohort 2019. The system collected the data in real time using the MAX30102 sensor with a recording interval of every 2 seconds for a duration of 5 minutes under three measurement conditions: before reciting the Qur’an, during Qur’an recitation, and after reciting the Qur'an. The system automatically recorded the measurement results and stored them in Microsoft Excel format for further analysis by calculating the average heart rate value (bpm) under each condition. Table 2 presents the results.

Table 2. Results of Heart Rate Measurement

Sample Testing (S)	**Heart Rate (bpm)**			**Percentage Decrease (%)**
	Before Reciting the Qur'an	**During Qur'an Recitation**	**After Reciting the Qur'an**	
S1	81.23	88.64	78.35	3.55
S2	83.72	81.64	79.03	5.60
S3	79.89	87.47	74.43	6.83
S4	78.68	92.07	76.57	2.68
S5	83.68	65.03	73.32	12.38
Average				**6.21**

Based on Table 2, heart rate values vary across subjects and conditions. In general, several samples show a temporary increase during recitation, which may be associated with vocalization activity and breathing regulation. However, heart rate values tend to decrease after recitation compared to the pre-recitation condition, indicating a physiological shift toward relaxation. To quantify this change, the percentage decrease in heart rate was calculated using Equation (1).

$$\%\ Decrease = \left|\frac{Final\ BPM\ Value - Initial\ BPM\ Value}{Initial\ BPM\ Value}\right| x\ 100\% \tag{1}$$

The results show an average decrease of 6.21%, indicating a tendency toward improved physiological stability after recitation. To statistically validate this observation, a paired sample t-test was conducted comparing heart rate values before and after Qur'an recitation. The analysis yielded a statistically significant decrease in heart rate ($p < 0.05$), indicating that the observed change is unlikely to occur by chance. Furthermore, the 95% confidence interval (CI) for the mean difference confirms that the post-recitation heart rate is consistently lower than the pre-recitation condition.

This decrease in heart rate reflects activation of the parasympathetic nervous system, likely due to controlled breathing patterns and a calmer psychological state during recitation. Figure 5 illustrates the comparison across conditions.

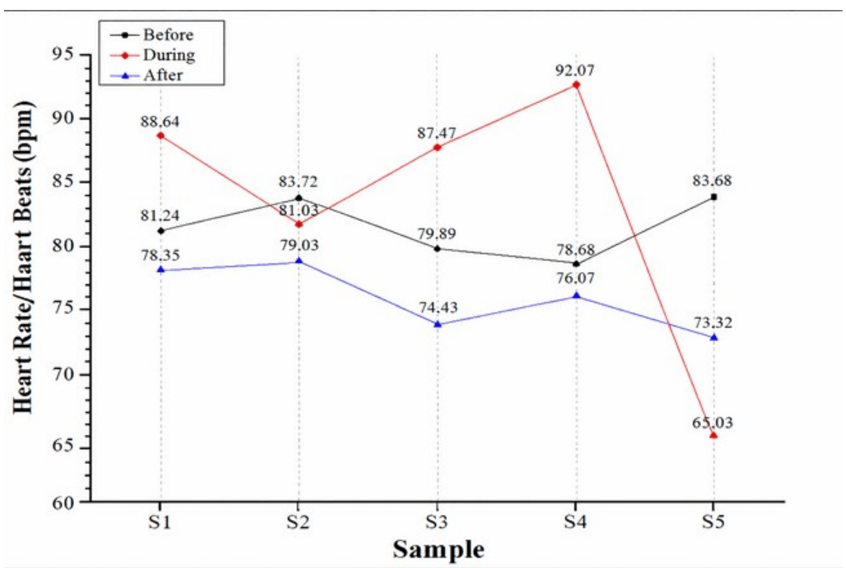

Figure 5. Graph of the Average Heart Rate of the Test Samples

The graphical trend also shows a transition toward a more stable waveform after recitation, suggesting improved physiological regulation.

3.2. Oxygen Saturation Data

The study measured oxygen saturation (SpO_2) using the MAX30102 sensor for 5 minutes under three conditions: before, during, and after reciting the Qur'an. The system recorded the data in real time and calculated the average value for each sample. The percentage increase was calculated using Equation (2).

$$\%\,Increase = \left|\frac{Final\ SpO_2\ - Initial\ SpO_2}{Initial\ SpO_2}\right|\ x\ 100\% \tag{2}$$

Table 3. Results of Oxygen Saturation Measurement

Sample Testing (S)	Oxygen Saturation (%)			Percentage Increase (%)
	Before Reciting the Qur'an	During Qur'an Recitation	After Reciting the Qur'an	
S1	96.51	97.11	98.10	1.65
S2	96.37	96.87	97.77	1.45
S3	96.34	96.99	97.75	1.46
S4	96.50	97.22	98.00	1.55
S5	96.49	96.98	97.73	1.29
Average				**1.48**

Based on Table 3, oxygen saturation values show a consistent increase during and after recitation compared to the baseline condition. The average increase of 1.48% indicates a positive physiological response associated with improved oxygenation.

To further validate these findings, a paired sample t-test was performed comparing SpO_2 values before and after recitation. The results show a highly significant increase in oxygen saturation ($p < 0.001$). In addition, the 95% confidence interval (CI) indicates that the increase in SpO_2 is consistently positive across all samples. This increase suggests improved gas exchange efficiency, likely influenced by controlled breathing patterns during recitation. Figure 6 presents the visualization of SpO_2 changes.

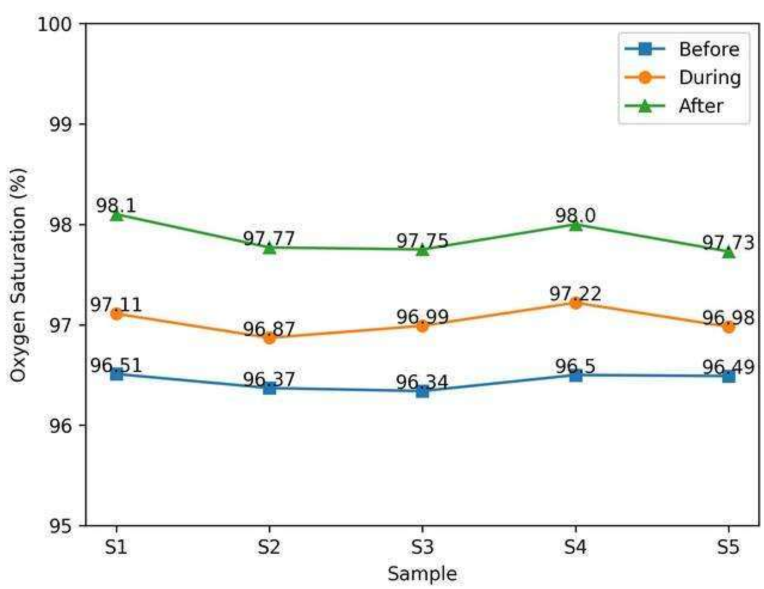

Figure 6. Graph of the Average Oxygen Saturation of the Test Samples

The graphical trend demonstrates reduced fluctuation and improved stability after recitation, indicating a more regulated physiological condition.

3.3. Measurement Error Percentage of the Sensor

The study uses the percentage error to determine the accuracy level of the MAX30102 sensor by comparing its measurement results with those obtained from a standard device, namely a pulse oximeter. The calculation determines the percentage error using the Equation 3.

$$\% \, Error = \left| \frac{MAX30102 \, Sensor \, Value - Standard \, Pulse \, Oximeter \, Value}{Standard \, Pulse \, Oximeter \, Value} \right| x \, 100\% \tag{3}$$

The study performs this calculation for both the heart rate (bpm) and oxygen saturation (SpO_2) parameters while the respondents recite the Qur'an.

3.3.1. Percentage Error of Heart Rate Measurement

The study evaluates the accuracy of the heart rate measurement by comparing the readings obtained from the MAX30102 sensor with those obtained from a pulse oximeter across five respondent samples. Table 4 presents the measurement results from both devices along with the calculated percentage error values.

Table 4. Comparison of heart rate measurements obtained from the MAX30102 sensor and the pulse oximeter, along with the percentage error for each sample during Qur'an recitation.

Sample Testing (S)	**During Qur'an Recitation**		**Difference**	**Error (%)**
	MAX30102 (bpm)	***Pulse Oximetry* (bpm)**	$\lvert \mathbf{MAX30102} - \boldsymbol{Pulse\ Oximetry} \rvert$	
S1	88.64	89.00	0.36	0.41
S2	81.64	84.00	2.36	2.81
S3	87.47	91.71	4.24	4.62
S4	92.07	91.60	0.47	0.51
S5	65.03	89.00	23.97	26.93
Average			**6.28**	**7.06**

The analysis results indicate that the average percentage error is 7.06%. This value demonstrates that the MAX30102 sensor provides a relatively good level of accuracy in measuring heart rate within the developed system.

3.3.2 Percentage Error of Oxygen Saturation Measurement

The study evaluates the accuracy of oxygen saturation measurements using the same method, which compares the readings obtained from the MAX30102 sensor with those obtained from a pulse oximeter while the respondents recite the Qur'an. Table 5 presents the measurement results from both devices along with the calculated percentage error values.

Table 5. Results of oxygen saturation measurements obtained using the MAX30102 sensor and the pulse oximeter, along with the percentage error for each sample.

Sample Testing (S)	**During Qur'an Recitation**		**Difference**	**Error (%)**
	MAX30102 (bpm)	***Pulse Oximetry* (bpm)**	$\lvert \boldsymbol{Pulse\ Oximetry} - \mathbf{MAX30102} \rvert$	
S1	97.11	98.00	0.89	0.91
S2	96.87	96.57	0.30	0.31
S3	96.99	97.86	0.87	0.89
S4	97.22	98.00	0.78	0.80
S5	96.98	97.40	0.42	0.43
Average			**0.65**	**0.67**

The calculation results show that the average percentage error is 0.67%. This value indicates that the MAX30102 sensor provides a very high level of precision in measuring oxygen saturation. Overall, the accuracy testing results demonstrate that the developed system is capable of measuring heart rate and oxygen saturation with adequate accuracy, which enables the system to detect changes in physiological parameters that occur during the activity of reciting the Qur'an.

4. Conclusion

This study reports key quantitative findings, including a 6.21% decrease in heart rate, a 1.48% increase in oxygen saturation, and sensor error rates of 7.06% for heart rate and 0.67% for SpO_2. The results confirm that the developed IoT-based system using the MAX30102 optical sensor is capable of effectively measuring physiological responses during Qur'anic recitation in real time. The observed changes indicate a shift toward a more stable and relaxed physiological condition after recitation. Statistical analysis further demonstrates that these changes are significant and consistent across participants, supporting the reliability of the findings. In terms of practical application, the system shows potential as a biofeedback tool in spiritual contexts, a supportive therapeutic device, and a complementary instrument for clinical monitoring. Additionally, its IoT integration enables future development into wearable health technologies for continuous physiological monitoring. Overall, the proposed system provides a reliable and efficient approach for real-time monitoring of physiological parameters and offers promising contributions to IoT-based biomedical instrumentation.

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References

[1] S. Laborde, E. Mosley, and J. F. Thayer, "Heart rate variability and cardiac vagal tone in psychophysiological research – Recommendations for experiment planning, data analysis, and data reporting," *Frontiers in Psychology*, vol. 9, 2018.
[2] A. Zaccaro, A. Piarulli, M. Laurino, et al., "How breath-control can change your life: A systematic review on psychophysiological correlates of slow breathing," *Frontiers in Human Neuroscience*, vol. 12, 2018.
[3] F. Shaffer and J. P. Ginsberg, "An overview of heart rate variability metrics and norms," *Frontiers in Public Health*, vol. 5, 2017.
[4] T. Tamura, Y. Maeda, M. Sekine, and M. Yoshida, "Wearable photoplethysmographic sensors Past and present," *Electronics*, vol. 7, no. 12, 2018.
[5] M. Elgendi, R. Fletcher, Y. Liang, et al., "The use of photoplethysmography for assessing cardiovascular function," *Scientific Reports*, vol. 9, 2019.
[6] T. Pereira, N. Tran, K. Gadhoumi, et al., "Photoplethysmography based monitoring in healthcare: A review," *npj Digital Medicine*, vol. 3, 2020.
[7] S. M. R. Islam, D. Kwak, M. H. Kabir, M. Hossain, and K. S. Kwak, "The Internet of Things for health care: A comprehensive survey," *IEEE Access*, vol. 6, pp. 678–708, 2018.
[8] P. P. Ray, "A survey on Internet of Things architectures and applications for healthcare," *Journal of King Saud University – Computer and Information Sciences*, vol. 30, no. 3, pp. 291–319, 2018.
[9] H. Doufesh, F. Ibrahim, N. A. Ismail, and W. A. Wan Ahmad, "Effect of Quran recitation on the human brain: A systematic review," *Journal of Religion and Health*, vol. 58, 2018.
[10] A. Kurniawan, A. Widodo, and L. Suryani, "The effect of murottal Al-Qur'an therapy on physiological responses and anxiety level," C*omplementary Therapies in Clinical Practice*, vol. 39, 2020.
[11] P. H. Charlton, V. Marozas, L. N. Y. Wong, et al., "Wearable photoplethysmography for cardiovascular monitoring," *Physiological Measurement*, vol. 40, no. 6, 2019.
[12] B. Bent, B. A. Goldstein, W. A. Kibbe, and J. P. Dunn, "Investigating sources of inaccuracy in wearable optical heart rate sensors," *npj Digital Medicine*, vol. 3, 2020.
[13] N. Selvaraj, A. Jaryal, S. Santhosh, et al., "Slow breathing practice improves cardiac autonomic function," *International Journal of Psychophysiology*, vol. 137, 2019.
[14] D. Castaneda, A. Esparza, M. Ghamari, C. Soltanpur, and H. Nazeran, "A review on wearable photoplethysmography sensors and their potential future applications," *Biosensors*, vol. 8, no. 3, 2018.

[15] A. Reiss, I. Indlekofer, P. Schmidt, and K. Van Laerhoven, "Deep PPG: Large-scale heart rate estimation with photoplethysmography signals," *IEEE Journal of Biomedical and Health Informatics*, vol. 23, no. 1, 2019.
[16] Y. Yang, W. Gao, et al., "Wearable sensors for real-time physiological monitoring," *Advanced Healthcare Materials*, vol. 10, 2021.