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SITCARE: AN IOT-BASED SITTING BEHAVIOR MONITORING SYSTEM USING SENSOR FUSION

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Abstract. *Prolonged sitting and poor sitting posture have become significant occupational health concerns among office workers, contributing to musculoskeletal disorders, fatigue, and reduced work productivity. This study proposes SITCARE, an Internet of Things (IoT) based office sitting behavior monitoring system that integrates an FSR402 pressure sensor, an MPU6050 gyroscope, and an HC-SR04 ultrasonic sensor using a sensor fusion approach. The proposed system continuously monitors sitting duration, chair inclination, and seat height, while transmitting real time sensor data to a Firebase Realtime Database for web-based visualization. In addition, an automated Telegram chatbot provides reminders to encourage regular breaks and adequate hydration. The developed system was evaluated through sensor validation, communication performance testing, system functionality assessment, and user acceptance evaluation. Experimental results demonstrated reliable sensor operation, stable cloud communication with an average round trip latency of 220 ± 50 ms and zero packet loss, as well as successful real time dashboard visualization and notification delivery. Furthermore, user evaluation involving 20 participants achieved an overall satisfaction score of 4.50 out of 5, indicating positive acceptance of the proposed system. These findings demonstrate that SITCARE provides an effective and practical IoT based solution for promoting ergonomic awareness and healthier workplace behavior among office workers.*

1. INTRODUCTION

The rapid advancement of digital technology has significantly transformed modern working environments, resulting in increasingly sedentary lifestyles among office workers [1]–[4]. The widespread adoption of computers and digital devices has encouraged employees to spend prolonged periods in seated positions while performing daily tasks. Although this work pattern has improved efficiency and productivity across various industries, prolonged sitting has become a major occupational health concern. Maintaining a static sitting posture for extended periods has been associated with musculoskeletal disorders, particularly low back pain, neck pain, and shoulder discomfort, while also reducing concentration and overall work performance [5]. Furthermore, sedentary behavior increases the risk of obesity, type 2 diabetes, cardiovascular disease, and other chronic health conditions, making it a significant public health issue [6].

Besides prolonged sitting, inadequate hydration is another common yet frequently neglected issue among office workers. Employees often remain focused on their tasks without consuming sufficient water, leading to dehydration that negatively affects cognitive performance, physical endurance, and overall well being [7]. Healthy sitting behavior is influenced by multiple ergonomic factors, including sitting posture, sitting duration, and adequate hydration.

Recent advances in sensing technologies and the Internet of Things (IoT) have enabled the development of intelligent systems for workplace health monitoring. Several studies have proposed posture monitoring solutions using pressure sensors, inertial measurement units (IMUs), textile sensors, and IoT platforms to improve ergonomic awareness and detect improper sitting behavior [8]–[11]. While these approaches have demonstrated promising results, most of them primarily focus on posture recognition and rarely integrate sitting duration, multi sensor information, and hydration reminders into a single monitoring framework. Moreover, relying on a single sensing modality may reduce system robustness under varying user characteristics and environmental conditions.

To address these limitations, this study proposes **SITCARE: An IoT-Based Sitting Behavior Monitoring System Using Sensor Fusion**, an IoT based monitoring system that combines pressure sensors, a gyroscope, and an ultrasonic sensor through a sensor fusion approach. The integrated sensor data are transmitted to a cloud database and presented through a web based dashboard for real time monitoring. In addition, the system provides automatic reminders for posture correction, scheduled breaks, and hydration based on ergonomic recommendations. By integrating multi sensor monitoring, IoT connectivity, and preventive health notifications into a unified platform, SITCARE aims to improve monitoring reliability, promote healthier workplace behavior, and ultimately enhance both employee productivity and long term occupational well being.

2. LITERATURE REVIEW

This section reviews the theoretical foundations and previous studies relevant to the proposed SITCARE system. It begins by discussing the principles of workplace ergonomics and the importance of maintaining proper sitting posture to prevent occupational fatigue and musculoskeletal disorders. Subsequently, recent developments in smart chair technologies, sensing devices, sensor fusion, and Internet of Things (IoT) based monitoring systems are presented. Finally, previous studies are critically analyzed to identify existing research gaps that motivate the development of the proposed system.

2.1 Ergonomics of Sitting Posture

Workplace ergonomics is a multidisciplinary field that focuses on optimizing the interaction between workers and their working environment to improve safety, comfort, and productivity [12]. Among various ergonomic factors, sitting posture has received considerable attention because office employees spend a substantial portion of their working hours seated while interacting with computers and digital devices [13]. An ergonomically designed workstation, including appropriate chair dimensions, lumbar support, and sitting posture, plays an essential role in minimizing physical stress on the musculoskeletal system.

Conversely, prolonged sitting in inappropriate postures may gradually increase biomechanical loading on the lumbar spine, neck, and shoulder muscles. Such conditions often lead to musculoskeletal disorders, particularly low back pain, neck pain, and shoulder discomfort, which adversely affect work performance and employee well being. Shariat et al. reported that prolonged static sitting is strongly associated with a higher prevalence of musculoskeletal symptoms among office workers [5]. Therefore, maintaining proper sitting posture and encouraging periodic movement are considered essential strategies for promoting healthy sitting behavior and preventing long term health complications.

2.2 Smart Chair Technologies and Sensor Fusion

The increasing availability of low cost sensing devices has accelerated the development of intelligent chair systems capable of monitoring users sitting behavior automatically. These systems commonly employ multiple sensing technologies to capture different aspects of body posture and movement, enabling continuous ergonomic assessment without requiring manual observation.

Pressure sensors, particularly Force Sensitive Resistors (FSRs), are among the most widely adopted sensing devices for smart chair applications. These sensors measure pressure distribution across the seating surface, allowing the identification of user presence and posture variations based on pressure patterns [8]. Their simple implementation and low power consumption make them suitable for long term monitoring. However, pressure sensors alone may have limited capability in distinguishing postures that produce similar pressure distributions.

To complement pressure based measurements, inertial sensors such as gyroscopes and inertial measurement units (IMUs) have been widely employed to estimate body orientation and spinal inclination. These sensors provide dynamic motion information that cannot be directly obtained from pressure sensors, thereby improving posture recognition during body movement [10]. In addition, ultrasonic sensors offer a noncontact solution for measuring distance and relative body position. Due to their low cost and reliable ranging capability, ultrasonic sensors have been utilized in various smart environment applications, including seat occupancy detection and object positioning [14].

Despite the advantages offered by individual sensors, each sensing modality possesses inherent limitations related to measurement uncertainty, environmental interference, and user variability. Consequently, sensor fusion has become an increasingly important approach for integrating complementary information obtained from heterogeneous sensors. Rather than relying on a single measurement source, sensor fusion combines multiple sensor outputs to generate a more reliable representation of user behavior, thereby improving monitoring accuracy and robustness. Furthermore, the integration of Internet of Things (IoT) technology enables sensor data to be transmitted to cloud platforms, supporting real time visualization, remote monitoring, and automated health notifications through web based applications.

2.3 Previous Works And Research Gap

Numerous studies have explored intelligent systems for monitoring sitting posture and promoting occupational ergonomics through various sensing technologies. These studies demonstrate the feasibility of automatic posture assessment and provide valuable contributions toward reducing work related musculoskeletal disorders. Nevertheless, most existing approaches address only specific aspects of ergonomic monitoring rather than providing a comprehensive assessment of office workers' health.

Tsai et al. developed an automated sitting posture recognition system using capacitive pressure sensors integrated into a chair [8]. The proposed system successfully classified multiple sitting postures by analyzing pressure distribution patterns generated on the seating surface. Although the method achieved satisfactory posture recognition performance, its dependence on a single sensing modality may reduce classification reliability when different users exhibit similar pressure characteristics despite adopting different body orientations.

Martínez-Estrada et al. proposed a smart chair utilizing capacitive textile sensors to monitor sitting posture continuously [9]. Their study demonstrated that flexible textile based sensors could provide unobtrusive posture monitoring while maintaining user comfort during prolonged use. However, the developed system primarily focused on posture recognition and did not consider other important aspects of sitting behavior, such as sitting duration, that are essential for comprehensive ergonomic assessment.

A different approach was presented by Pan et al. who employed wearable inertial measurement units to estimate spinal angles with high accuracy during rehabilitation exercises [10]. Their method achieved an average estimation error of only 2.59°, demonstrating the effectiveness of inertial sensing for posture analysis. Nevertheless, wearable systems require sensors to be attached directly to the user's body, potentially reducing comfort and limiting their practicality for continuous monitoring in office environments.

IoT technology has also been incorporated into ergonomic monitoring systems to facilitate real time data acquisition and remote supervision. La Mura et al. introduced an IoT based posture asymmetry detection system capable of continuously transmitting posture information to cloud services for remote observation [11]. In parallel, Kaur and Pal demonstrated the effectiveness of ultrasonic sensing for accurate distance measurement, highlighting its potential for noncontact positioning applications in smart environments [14]. Although these studies illustrate the advantages of IoT connectivity and individual sensing technologies, they generally employ single sensor approaches that may be vulnerable to measurement uncertainty under varying operational conditions [15], [16].

Based on the reviewed literature, three major research gaps can be identified. First, most existing studies primarily concentrate on posture recognition while overlooking sitting duration, which is a critical component of sitting behavior and ergonomic assessment. Second, hydration management has received limited attention despite substantial evidence linking adequate water intake with cognitive performance and physical well being. Third, previous systems generally rely on a single sensing modality, reducing monitoring robustness when sensor measurements are affected by user diversity or environmental disturbances.

3. RESEARCH METHODS

This section describes the proposed SITCARE system, including its overall architecture, hardware implementation, software design, experimental procedures, and performance evaluation methods. The proposed system integrates multiple sensing devices with Internet of Things (IoT) technology to continuously monitor office workers' sitting behavior and provide real time feedback through a cloud based monitoring platform.

3.1 System Architecture

The proposed SITCARE system was designed as an Internet of Things (IoT) based smart monitoring platform for continuously observing office workers' sitting behavior. As illustrated in Fig. 1, the system consists of four functional layers: the sensing layer, processing layer, cloud communication layer, and application layer. This modular architecture enables continuous acquisition, transmission, storage, and visualization of ergonomic data in real time.

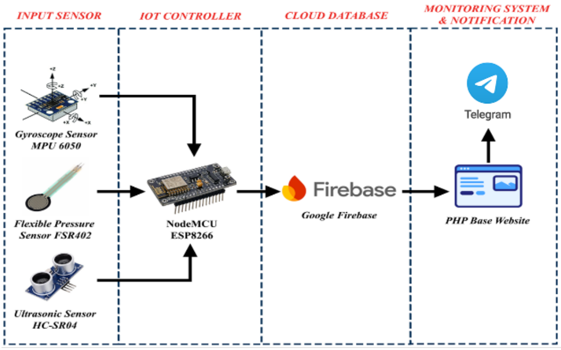

Figure 1. System Architecture

The sensing layer comprises three heterogeneous sensors that monitor different aspects of the user's sitting behavior. An FSR402 pressure sensor is employed to detect user occupancy and sitting duration by measuring pressure applied to the seat cushion. An MPU6050 gyroscope continuously measures the inclination of the chair backrest by estimating pitch and roll angles, allowing changes in sitting posture to be identified. In addition, an HC-SR04 ultrasonic sensor measures the vertical distance between the chair and the floor to estimate the seat height after adjustment.

The acquired sensor data are processed by an ESP32 microcontroller, which serves as the central controller of the system. During each acquisition cycle, the ESP32 collects measurements from all sensors, combines them into a unified data structure, and converts the information into JavaScript Object Notation (JSON) format. The formatted data are subsequently transmitted to a Firebase Realtime Database through a wireless Wi-Fi connection, enabling real time synchronization between the embedded device and the monitoring platform.

At the application layer, the transmitted data are visualized through a web based dashboard that provides continuous monitoring of sitting duration, chair inclination, seat height, and user activity history. Furthermore, when predefined ergonomic conditions are satisfied, such as prolonged sitting duration, the system automatically generates reminder notifications through the messaging platform to encourage users to take short breaks and maintain healthy working habits.

3.2 System Implementation

3.2.1 Sensor Placement

The effectiveness of an ergonomic monitoring system is highly dependent on the appropriate placement of sensing devices. Therefore, each sensor in SITCARE was strategically positioned according to its monitoring objective while minimizing interference with the user's daily activities.

The FSR402 pressure sensor was embedded beneath the seat cushion to continuously detect the presence of a user through pressure variation. This position allows the sensor to accurately distinguish between occupied and unoccupied conditions while remaining completely hidden from the user, thereby preserving seating comfort during prolonged use.

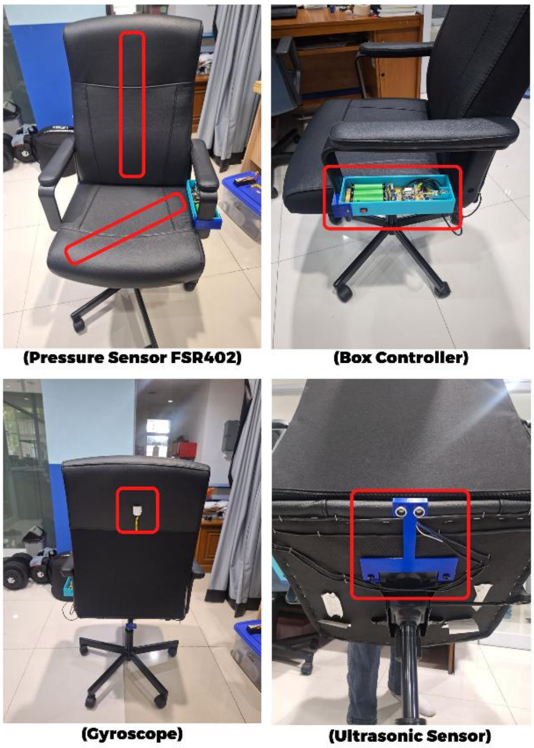

Figure 2. Sensor Placement on the SITCARE

To monitor the inclination of the chair backrest, the MPU6050 gyroscope was installed on the rear side of the backrest. This location enables direct measurement of the backrest orientation without obstructing the user. By continuously calculating the pitch and roll angles, the system can identify changes in sitting posture that may indicate improper ergonomic behavior.

Meanwhile, the HC-SR04 ultrasonic sensor was mounted underneath the chair frame facing the floor. This configuration enables noncontact measurement of the distance between the chair and the floor, allowing the system to estimate the current seat height after manual adjustment. The selected position also protects the sensor from accidental contact during normal operation.

All electronic components, including the ESP32 microcontroller, custom printed circuit board (PCB), power regulation circuit, rechargeable battery pack, and charging module, were integrated into a dedicated controller enclosure mounted beneath the chair, as shown in Fig. 2. This arrangement improves wiring organization, enhances system reliability, and simplifies future maintenance.

3.2.2 Electronic Circuit Design

A custom electronic circuit was developed to integrate all sensing modules into a compact embedded platform. As shown in Fig. 3, the ESP32 serves as the main processing unit responsible for sensor acquisition, local data processing, wireless communication, and cloud synchronization. The pressure sensors were interfaced through LM358 operational amplifier circuits to improve signal conditioning before analog to digital conversion. Meanwhile, the MPU6050 communicates with the ESP32 using the I2C protocol, whereas the HC-SR04 utilizes dedicated digital input/output pins for ultrasonic ranging.

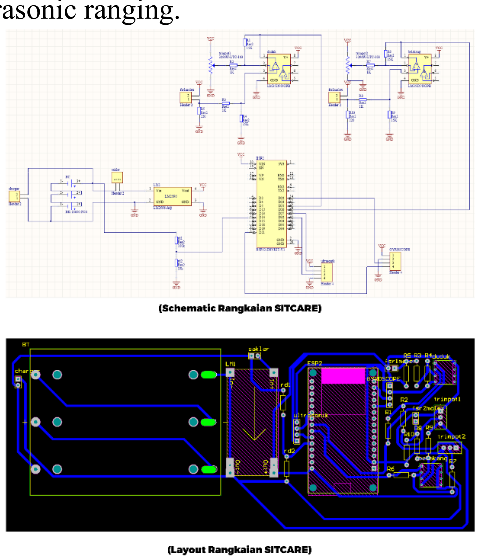

Figure 3. Electronic Schematic and PCB Layout

To improve system stability and reduce wiring complexity, the entire circuit was implemented on a custom designed PCB. The PCB integrates the sensing interfaces, voltage regulation circuitry, battery management components, and communication module into a single compact board. Compared with conventional breadboard based implementations, the custom PCB provides improved electrical reliability, easier installation, and greater robustness for longterm operation.

3.3 Software Design

3.3.1 Embedded Firmware

The embedded firmware was developed using the Arduino framework on the ESP32 microcontroller. As illustrated in Fig. 4, the firmware begins by initializing the communication interfaces, including the I²C bus, analog inputs, digital I/O pins, and Wi-Fi connection. The system continuously attempts to establish a wireless network connection before entering the main operating loop.

During each iteration, the firmware sequentially acquires measurements from the FSR402 pressure sensor, MPU6050 gyroscope, and HC-SR04 ultrasonic sensor. The collected sensor readings are combined into a structured JSON object containing pressure information, chair inclination angles, seat height, and device identification. Before transmission, the firmware verifies the availability of the Wi-Fi connection to ensure reliable communication with the cloud platform.

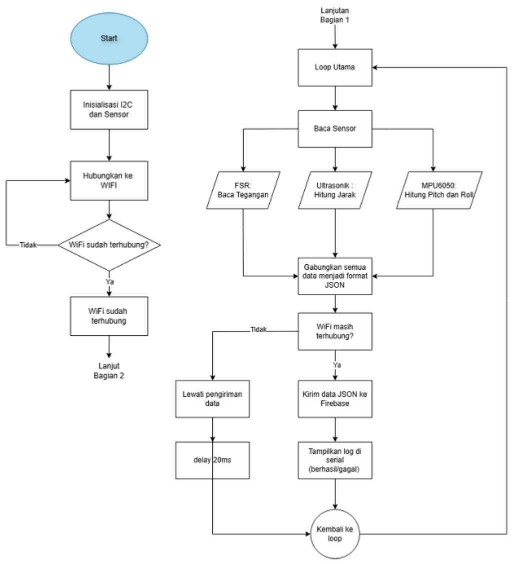

Figure 4. Firmware Flowchart

If the network connection is available, the JSON data are uploaded to the Firebase Realtime Database. Otherwise, the transmission process is temporarily skipped, and the system continues collecting sensor measurements until network connectivity is restored. This approach enables uninterrupted local monitoring while maintaining reliable cloud synchronization whenever communication becomes available.

3.3.2 Web Based Monitoring System

A web based monitoring platform was developed to provide real time visualization and management of the collected sensor data, as shown in Fig. 5. The software architecture consists of a front end interface, a back end application server, a MySQL database, and Firebase Realtime Database.

The front end application provides secure authentication for both administrators and users. Administrators are authorized to manage user accounts, configure chair information, and assign device identifiers, whereas users can monitor their individual sitting behavior through personalized dashboards. The dashboard presents real time information, including sitting duration, chair inclination, seat height, historical activity records, and graphical summaries of daily usage.

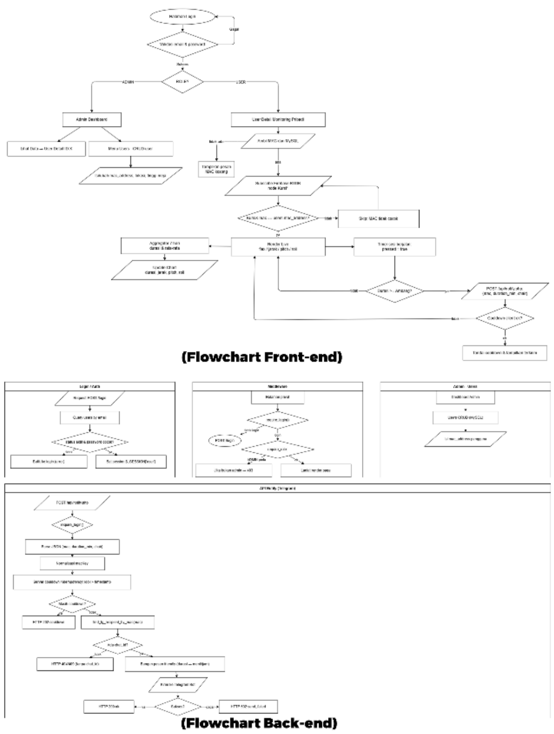

Figure 5. Front end and Back end Workflow

The back end system continuously synchronizes data from Firebase using the registered MAC address associated with each chair. When the accumulated sitting duration exceeds a predefined threshold, the application automatically triggers a notification service that sends reminder messages to the corresponding user. This event driven architecture enables timely ergonomic feedback while minimizing unnecessary communication overhead.

3.4 Performance Evaluation

The performance of the proposed SITCARE system was evaluated through a series of functional and experimental tests involving both hardware and software components. Initially, each sensing module was individually validated to verify its operational accuracy. The FSR402 sensor was evaluated under occupied and unoccupied seating conditions, while the MPU6050 was tested by adjusting the backrest inclination to different angles. The HC-SR04 ultrasonic sensor was validated by comparing the measured seat height with manual measurements obtained using a measuring tape.

Following individual sensor validation, a system integration test was conducted to verify end to end communication among the embedded controller, Firebase Realtime Database, and web based monitoring platform. During this experiment, sensor measurements were continuously transmitted to the cloud while real time visualization and automatic notification functions were simultaneously evaluated. The reliability of wireless communication and database synchronization was also observed throughout the testing process.

Finally, the usability of the proposed system was evaluated through user testing involving office workers. Participants interacted with the SITCARE prototype under typical working conditions and subsequently completed a questionnaire using a five point Likert scale. The evaluation focused on system usability, monitoring effectiveness, user comfort, and overall satisfaction with the proposed monitoring platform.

4. RESULT AND DISCUSSION

This section presents the experimental results obtained from the developed SITCARE prototype. The evaluation focuses on four aspects: (1) sensor and communication performance, (2) system functionality, (3) user interface implementation, and (4) user acceptance.

4.1 Sensor and Communication Performance

The first experiment was conducted to evaluate the performance of each sensing module and the communication reliability of the proposed IoT system. The FSR402 pressure sensor, MPU6050 gyroscope, and HC-SR04 ultrasonic sensor were individually tested under multiple operating conditions before being integrated into the SITCARE platform. In addition, data transmission between the ESP32 microcontroller and the Firebase Realtime Database was evaluated to ensure stable real time communication.

Table 1. Performance Evaluation of SITCARE System.

Test Item	**Test Procedure**	**Measurement Method**	**Result**	
FSR402 Pressure Sensor	5 times sitting/standing cycles	ESP32 ADC input	Sitting	860
				855
				864
				858
				870
			Average	**861**
			Standing	80
				81
				79
				80
				83
			Average	**81**
MPU6050 Gyroscope (Pitch/Roll)	Backrest tilted to 15° (5 repetitions)	Compared with protractor	Angle (degree)	17
				15
				16
				17
				15
			Average	**16**
HC-SR04 Ultrasonic Sensor (Chair Height)	Two chair height levels	Distance measurement	Low Level (cm)	32
				31
				30
				33
				29
			Average	**31**
			High Level (cm)	51
				50
				50
				52
				51
			Average	**51**
Firebase Data Transmission	ESP32 sends data every 200 ms	RTT and packet loss	RTT 220 ± 50 ms, 0% packet loss	
Web Dashboard Update	Dashboard monitoring	Update latency	0.7 ± 0.3 s	
Telegram Hydration Notification	Prolonged sitting simulation	Notification delivery	15 min	Success
			30 min	Success
			45 min	Success
			1 hour	Success
			2 hours	Success
			3 hours	Success

The experimental results indicate that the FSR402 sensor clearly distinguishes between occupied and unoccupied chair conditions. During five repeated measurements, the average ADC value reached 861 when the user was seated, while the average value decreased to 81 when the chair was unoccupied. This large measurement difference provides a reliable indicator for detecting sitting activity without requiring complex signal processing.

The MPU6050 gyroscope also demonstrated stable performance in measuring the inclination of the chair backrest. Calibration experiments using a reference angle of approximately 15° produced an average measured value of 16°, corresponding to an average error of approximately 1°. Such accuracy is sufficient for identifying forward and backward leaning postures during normal office activities.

The HC-SR04 ultrasonic sensor was evaluated for measuring the chair height. The sensor reported an average distance of 31 cm for the low height configuration and 51 cm for the high height configuration, closely matching the predefined experimental settings. These results indicate that the ultrasonic sensor can reliably estimate chair height and support posture related measurements.

Communication performance was evaluated by continuously transmitting sensor data to the Firebase Realtime Database at a sampling interval of 200 ms. The average round trip transmission latency was measured at 220 ± 50 ms, while no packet loss was observed during 200 consecutive transmissions. These results demonstrate that the IoT communication architecture provides reliable real time synchronization between the embedded device and the cloud platform.

Finally, the notification mechanism was validated by simulating prolonged sitting sessions. Telegram notifications were successfully delivered at predefined intervals ranging from 15 minutes to 3 hours, confirming the reliability of the reminder system for encouraging users to take breaks and maintain adequate hydration.

Overall, the experimental results demonstrate that the sensing modules and cloud communication infrastructure operate reliably under normal office conditions. The integration of multiple sensors enables the system to continuously acquire complementary information while maintaining stable real time communication with the monitoring platform.

4.2 System Functionality

Following the validation of the sensing modules and communication infrastructure, the overall functionality of the proposed SITCARE system was evaluated as a complete IoT based monitoring platform. The evaluation focused on verifying the end to end data flow, including user authentication, cloud synchronization, real time visualization, database management, and automated notification services. The objective was to ensure that sensor information collected from the smart chair could be reliably processed and presented to users through an intuitive monitoring interface.

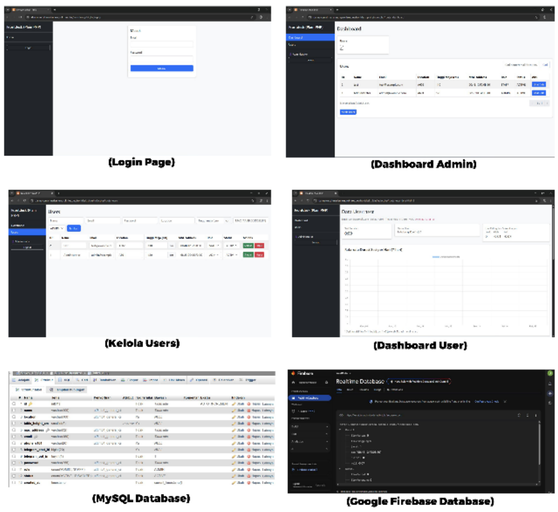

Figure 6. Web based Monitoring Platform of the Proposed SITCARE System

As illustrated in Fig. 6, the developed web application consists of several integrated modules. The login page provides secure user authentication by verifying user credentials before granting access to the monitoring platform. This authentication mechanism ensures that only authorized users and administrators can access the collected sensor data.

The administrator dashboard serves as the central management interface, allowing administrators to monitor registered users, manage user accounts, and configure system parameters such as workstation information and chair identifiers. Through this interface, administrators can efficiently maintain the monitoring environment and associate each smart chair with its corresponding user.

The user management module enables administrators to perform Create, Read, Update, and Delete (CRUD) operations on user records stored in the MySQL database. In addition to user profile information, the database stores chair identifiers, workstation location, desk height, Telegram chat ID, and account status. This information is utilized to establish communication between the embedded device, the cloud database, and individual users.

The user dashboard provides real time visualization of sensor measurements collected from the SITCARE prototype. Sitting duration, chair occupancy status, seat height, backrest inclination, and historical activity are continuously synchronized through the Firebase Realtime Database and displayed using a web based graphical interface. The dashboard allows users to observe their sitting behavior over time and review daily sitting statistics through automatically generated charts.

To support real time communication, SITCARE employs a hybrid database architecture consisting of Firebase Realtime Database and MySQL. Firebase functions as a high speed cloud platform for continuously receiving sensor data transmitted by the ESP32, enabling real time synchronization with the web dashboard. Meanwhile, MySQL stores persistent user information, authentication data, and application configurations that are required for long term system management. The combination of these two databases separates streaming sensor data from user management data, thereby improving system scalability and maintainability.

Besides visualization, SITCARE also incorporates an automated Telegram chatbot as an intelligent reminder service. When the monitored sitting duration exceeds predefined ergonomic thresholds, the backend server automatically generates a personalized notification encouraging users to stand up, stretch, and drink water. The chatbot operates without requiring manual intervention and delivers notifications directly to the registered Telegram account associated with each user.

Figure 7. Telegram Notification

As shown in Fig. 7, the chatbot delivers friendly reminder messages whenever prolonged sitting is detected. By integrating cloud based monitoring with instant messaging services, users receive timely health recommendations regardless of whether the monitoring dashboard is actively open. This notification mechanism enhances user engagement and promotes healthier workplace behavior through continuous ergonomic awareness.

Overall, the experimental evaluation demonstrates that the proposed software platform successfully integrates real time sensing, cloud communication, database management, web visualization, and automated notification within a unified IoT ecosystem. The seamless interaction among these components enables SITCARE to function as a comprehensive office sitting behavior monitoring system rather than simply serving as a sensor equipped chair.

4.3 User Acceptance Evaluation

To evaluate the practical usability of the proposed system, a user acceptance study was conducted involving 20 participants who interacted directly with the SITCARE prototype. As shown in Fig. 8, the evaluation employed a five point Likert scale covering four assessment categories: ease of use, comfort and ergonomics, system performance, and overall satisfaction.

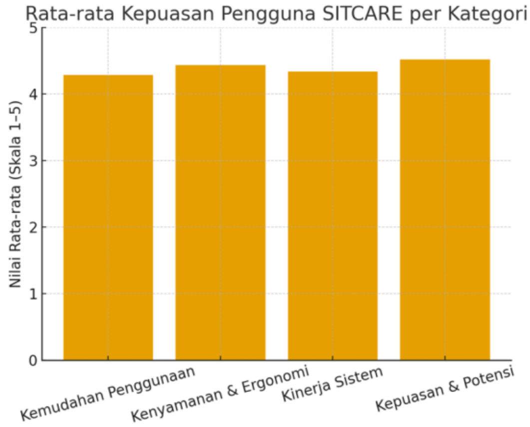

Figure 8. User Satisfaction Score

The overall user satisfaction score reached 4.50 out of 5, indicating a very positive perception of the developed system. Among the evaluated categories, overall satisfaction and future development potential achieved the highest score (4.52), suggesting that participants recognized the practical value of integrating posture monitoring with hydration reminders in everyday office environments.

The ease of use category obtained an average score of 4.28, demonstrating that users considered the dashboard and notification features easy to understand and operate. Comfort and ergonomics received an average score of 4.43, indicating that the embedded sensors did not significantly interfere with normal sitting activities. Furthermore, the system performance category achieved an average score of 4.33, reflecting users' confidence in the responsiveness and stability of the monitoring system during operation.

These findings suggest that the proposed system provides not only reliable technical performance but also satisfactory usability from the end user perspective, which is essential for encouraging long term adoption in workplace environments.

4.4 Discussion

The experimental results demonstrate that integrating multiple sensing modalities through an IoT architecture provides a practical solution for continuous office worker monitoring. Unlike previous studies that mainly focused on posture recognition using a single sensing technology, SITCARE combines pressure sensing, chair inclination measurement, and height detection to obtain complementary information regarding users sitting behavior. This multi sensor configuration improves monitoring robustness by reducing the dependence on a single sensing modality.

In addition to posture monitoring, SITCARE integrates sitting duration tracking and automated hydration reminders into a unified monitoring platform. This functionality extends beyond conventional smart chair systems by monitoring multiple aspects of office workers' sitting behavior rather than focusing solely on posture detection. Furthermore, the integration of Firebase cloud services, a web-based dashboard, and Telegram notifications enables continuous remote monitoring and timely user feedback.

Although the proposed system demonstrates promising performance, several limitations remain. The current implementation has been evaluated primarily in controlled indoor office environments with a limited number of participants. Moreover, posture identification is based on predefined sensor thresholds and does not yet incorporate advanced machine learning techniques capable of recognizing more complex sitting behaviors. Future work will focus on developing SITCARE v2 by integrating machine learning based posture classification, adaptive sensor fusion algorithms, and personalized health recommendations to improve monitoring accuracy and system intelligence.

5. CONCLUSIONS

This paper presented SITCARE, an IoT based sitting behavior monitoring system that integrates an FSR402 pressure sensor, an MPU6050 gyroscope, and an HC-SR04 ultrasonic sensor using a sensor fusion approach. The proposed system continuously monitors sitting posture and sitting duration, synchronizes sensor data with a cloud database, visualizes information through a web based dashboard, and provides automated Telegram notifications to encourage regular breaks and adequate hydration.

Experimental results demonstrated that the proposed system operated reliably, with stable sensor measurements, an average communication latency of 220 ± 50 ms, and no packet loss during data transmission. The user acceptance evaluation also showed positive results, achieving an overall satisfaction score of 4.50 out of 5, indicating that the system is practical and easy to use in office environments. Future work will focus on developing SITCARE v2 by incorporating machine learning based posture recognition, more advanced sensor fusion techniques, and personalized ergonomic recommendations to further improve monitoring accuracy and user experience.

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