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Implementation of a Responsive Web Interface for IoT-Based Scoliosis Monitoring Visualization

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Abstract

The rapid advancement of digital health technology has increased the demand for real-time and continuous patient monitoring systems, particularly for conditions such as scoliosis that require routine postural assessment. Conventional monitoring approaches often lack effective data visualization and multi-device accessibility, limiting their practical use in healthcare environments. This study aims to design and implement a responsive web interface for real-time visualization of data generated by an Internet of Things (IoT)-based scoliosis monitoring system. The Research and Development (R&D) approach was applied through four stages: system requirement identification, interface design, system implementation, and system evaluation. Data were collected from IoT sensors measuring the Angle of Trunk Rotation (ATR) and transmitted continuously to a web-based dashboard. Evaluation results demonstrated that the system successfully performed stable real-time data transmission, maintained proper synchronization between the IoT device and the server, and displayed monitoring information through responsive graphical and indicator-based visualizations on both desktop and mobile devices. The proposed interface improves data accessibility, supports early detection of scoliosis, and facilitates faster interpretation of patient condition data, contributing to more effective digital healthcare monitoring.

***Keywords**: Internet of Things, Scoliosis Monitoring, Responsive Web Interface, Real-Time Visualization, Digital Healthcare*

1. Introduction

The rapid advancement of digital healthcare technology has significantly transformed healthcare services, particularly in patient monitoring systems. One of the most influential innovations in this field is the Internet of Things (IoT), which enables real-time data collection, transmission, and analysis through interconnected devices. By utilizing IoT technology, healthcare providers can continuously monitor patient conditions regardless of time and location, thereby improving the overall quality and efficiency of healthcare services [1]. In recent years, the demand for healthcare monitoring systems has increased due to the growing number of chronic diseases and the limitations of direct patient observation in healthcare facilities. IoT-based telemonitoring systems have demonstrated the ability to measure and transmit patient health parameters accurately and continuously, enabling healthcare professionals to make timely and data-driven decisions [2]. One medical condition that requires continuous monitoring is scoliosis, a spinal deformity characterized by an abnormal lateral curvature of the spine. Regular posture assessment is essential to support early detection, diagnosis, and appropriate treatment, particularly among children and adolescents [3]. Poor sitting posture over extended periods may worsen musculoskeletal disorders, including scoliosis, back pain, and other posture-related complications [4]. Consequently, numerous studies have focused on developing IoT-integrated monitoring systems capable of detecting and analyzing posture abnormalities in real time [5]. Furthermore, wearable technologies have emerged as promising non-invasive solutions for scoliosis management, supporting long-term monitoring and therapeutic interventions [6]. The integration of artificial intelligence with wearable sensors has also contributed to improving the accuracy and effectiveness of digital healthcare monitoring systems [7]. In addition, wearable medical technologies have shown significant potential in enhancing telehealth-based spinal care and continuous patient monitoring [3]. Besides sensor technologies, web-based platforms play an important role in managing and visualizing healthcare data. Interactive dashboards enable healthcare professionals and users to interpret monitoring results more efficiently and support faster decision-making processes [8]. Similar approaches have been applied in various real-time monitoring systems, including pandemic monitoring platforms and remote patient supervision systems [9], [10]. Effective data visualization is therefore essential to ensure that healthcare information can be easily accessed and understood by users.

Although IoT-based monitoring systems have demonstrated substantial potential in improving healthcare services, several challenges remain, particularly regarding reliable network infrastructure and effective data presentation. Most existing studies focus on sensor development, wearable technologies, or monitoring mechanisms, while limited attention has been given to the development of responsive web interfaces specifically designed for real-time visualization of scoliosis monitoring data generated by IoT devices [1], [5]. As a result, accessibility and usability issues may arise when monitoring information is accessed through different types of devices. The novelty of this study lies in the development and implementation of a responsive web-based interface for real-time visualization of scoliosis monitoring data obtained from IoT devices. Unlike previous studies that primarily focus on sensing technologies and monitoring mechanisms, this research emphasizes the integration of IoT data acquisition with a responsive dashboard capable of providing adaptive visualization across multiple platforms. Therefore, this study aims to design and implement a responsive web interface that enhances accessibility, improves data visualization, and supports more effective scoliosis monitoring in digital healthcare environments.

2. Research Methodology

This study employed the Research and Development (R&D) approach to design, develop, and evaluate a responsive web interface for an IoT-based scoliosis monitoring system. The R&D method was selected because it focuses not only on analyzing a problem but also on producing and validating a functional product that can be utilized in real-world applications. This approach has been widely adopted in the development of information systems and healthcare monitoring technologies due to its systematic process of planning, implementation, testing, and evaluation [11]. The development process consisted of several stages, including system requirement identification, system design, implementation, integration with IoT devices, and system evaluation. The proposed system was designed to collect measurement data from IoT devices and present the information through a responsive web dashboard capable of providing real-time visualization on various devices.

2.1. System Development Framework

The development of the proposed system followed an iterative framework to ensure that both functional and user requirements were adequately addressed. The framework consisted of several stages, including requirement analysis, interface design, IoT integration, data transmission, dashboard visualization, and system testing. Each stage contributed to the refinement and validation of the developed monitoring system.

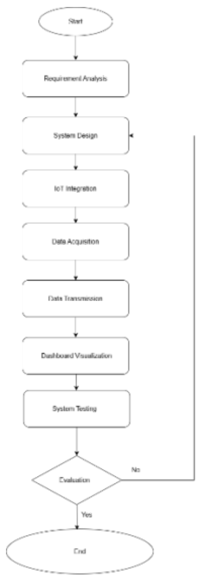

Fig. 1: System development framework of the proposed IoT-based scoliosis monitoring system.

The process began with identifying user requirements and monitoring objectives. Subsequently, a responsive web interface was designed and integrated with the IoT monitoring device. The collected data were transmitted to the server and visualized through a web dashboard. Finally, system testing was conducted to evaluate functionality, responsiveness, and real-time data transmission performance.

2.2. Research Object and Setting

The research object is an IoT-based scoliosis monitoring system designed to measure and display trunk rotation angle data in real time on a web dashboard. The system focuses on measuring the Angle of Trunk Rotation (ATR) in users, which is then rendered as an interactive dashboard. System implementation was conducted in collaboration with a hardware development team, and testing was performed with elementary school-aged subjects using simulated real-time IoT data transmission.

2.3. Data Collection Techniques

Data collection in this study comprised three methods: (1) Literature Study — reviewing journals and research related to IoT-based monitoring systems, web dashboards, and data visualization to establish a theoretical basis; (2) Sensor Data Collection — data were gathered from sensors connected to the IoT device and transmitted to the server via the internet; and (3) System Observation — monitoring system performance, data display behavior, and user interaction with the interface.

2.4. Operational Definition of Variables

The variables in this study are defined as follows. The independent variables are the IoT-based monitoring system and the responsive web interface design. The dependent variables are data visualization quality, ease of use, and display responsiveness. The control variables include the type of device used, internet connection quality, and the type of sensor data employed.

2.5. Data Analysis Technique

Data analysis was conducted using descriptive and evaluative approaches, covering: (1) System Performance Analysis — measuring the system's ability to display data in real time and stably; (2) Interface Display Analysis — evaluating responsiveness, ease of use, and clarity of data visualization; and (3) System Functionality Analysis — testing each feature of the system, including the dashboard, data integration, and notification components. This evaluation ensured that sensor data transmitted from the IoT device was accurately and consistently displayed through the web interface in real time.

3. Results and Discussion

3.1. System Implementation

The proposed responsive web interface was successfully implemented and integrated with the IoT-based scoliosis monitoring system. The web application was developed to receive, process, and visualize measurement data transmitted from the monitoring device. The dashboard serves as the primary interface for displaying patient monitoring information, measurement records, and visualization components in real time.The implemented interface provides users with convenient access to monitoring information through a centralized dashboard. The system supports both desktop and mobile platforms, ensuring accessibility across different screen sizes while maintaining consistent functionality and usability.

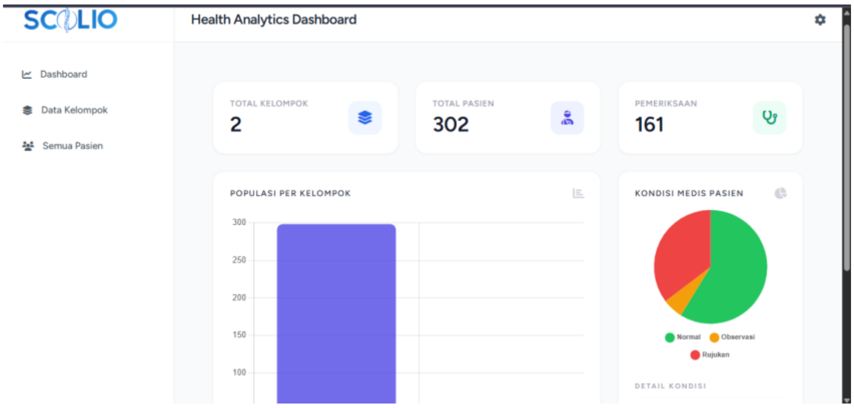

Fig. 2: Main dashboard interface of the developed monitoring system.

3.2. System Evaluation

System evaluation was conducted to verify the functionality and performance of the developed web interface. Several testing scenarios were performed, including data transmission, dashboard visualization, interface responsiveness, and synchronization between the IoT device and the server.The evaluation results indicated that the system successfully received measurement data from the IoT device and displayed the information correctly on the dashboard. Data synchronization between the monitoring device, server, and web application was performed without significant delays, demonstrating the reliability of the implemented communication mechanism. Table 1 presents a summary of the system evaluation results across five testing aspects.

Table 1: System Monitoring Evaluation Results

No.	Testing Aspect	Result	Description
1	Data transmission	Successful (real-time)	Stable
2	Dashboard display	Responsive	Optimal
3	Data visualization	Graphs and indicators displayed	Clear
4	Multi-device access	Functional on mobile and desktop	Good
5	IoT integration	Synchronized with server	Successful

3.3. Responsive Interface Evaluation

The responsiveness of the developed web interface was evaluated by accessing the monitoring dashboard through mobile devices with different screen sizes. The evaluation focused on verifying whether the dashboard layout, navigation elements, and monitoring visualizations remained accessible and functional on smaller displays.

The testing results showed that the dashboard successfully adapted to mobile screen dimensions without affecting usability or readability. Interface components were automatically reorganized into a compact layout, allowing users to access monitoring information efficiently while maintaining clear visualization of measurement results. Navigation menus, monitoring indicators, and graphical elements remained functional and easy to access during testing.
The implementation of responsive design principles ensured that the monitoring dashboard could provide a consistent user experience on mobile devices. These results indicate that the developed web interface is capable of supporting scoliosis monitoring activities through portable and widely accessible platforms.

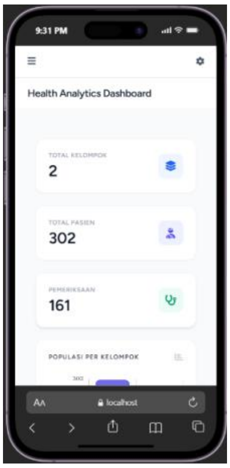

Fig. 3: Mobile view of the responsive scoliosis monitoring dashboard.

3.4. Discussion

The implementation results demonstrate that the developed web interface is capable of supporting real-time scoliosis monitoring through effective visualization and responsive design. The successful integration between the IoT device and the web platform enables continuous access to monitoring information, thereby improving data accessibility and usability.
Compared with conventional monitoring approaches that rely on manual recording and observation, the proposed system provides a more efficient method for presenting ATR measurement results through graphical and indicator-based visualizations. This finding aligns with previous studies showing that web-based dashboard visualization enhances a user's ability to recognize data patterns quickly and supports more efficient clinical decision-making [8]. Furthermore, the responsive interface ensures that monitoring information can be accessed consistently across different devices, supporting greater flexibility for both healthcare professionals and users [9].
From a technical standpoint, the IoT-web integration functioned well, with data transmitted and displayed as expected. The system also demonstrated potential for early detection of postural changes, which is critical in managing scoliosis in children and adolescents [3]. However, several limitations were identified. The system remains dependent on a stable internet connection; when the network is unstable, data transmission experiences delays, causing slower dashboard updates. Local data storage has not yet been implemented, meaning that data is unavailable offline. Additionally, the system has not been evaluated with end users to formally measure usability or user experience. Future work should address these limitations by integrating local storage as a fallback, implementing automatic notifications when ATR measurements exceed threshold values, and conducting formal usability testing to further validate the interface.

4. Conclusion

This study successfully designed and implemented a responsive web interface for real-time visualization of data generated by an IoT-based scoliosis monitoring system. The developed dashboard was able to receive, process, and display Angle of Trunk Rotation (ATR) measurement data in real time through graphical and indicator-based visualizations, thereby improving data accessibility and readability for users across multiple devices.
The evaluation results confirmed that the system achieved stable real-time data transmission, proper synchronization between the IoT device and the server, clear graphical and indicator-based visualizations, and consistent responsiveness across desktop and mobile platforms. The integration between the web application and the IoT device also enabled the storage and display of patient measurement history, facilitating more efficient monitoring compared to manual recording methods.
Overall, the proposed web interface supports more effective scoliosis monitoring by providing real-time access to patient ATR data and facilitating faster interpretation of monitoring results. The responsive web technology also contributes to improved usability and flexibility within digital healthcare environments. Nevertheless, the system's dependence on internet connectivity remains a limitation that needs to be addressed in future development. Future work is recommended to incorporate local data storage for offline functionality, develop automated threshold-based notifications, integrate a dedicated mobile application, and conduct formal usability testing to validate the user experience of the developed interface.

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References

[1] P. Somani, "IoT-enabled smart healthcare monitoring system using real-time data," The Chitransh Academic & Research, vol. 1, no. 4, pp. 346–367, 2025.
[2] L. Kamajaya, A. Pracoyo, L. N. Palupi, and A. R. Hidayat, "Sistem telemonitoring kesehatan berbasis IoT," Jurnal Elkolind, vol. 10, no. 2, pp. 137–145, 2023.
[3] R. Haddas, M. Lawlor, E. Moghadam, A. Fields, and A. Wood, "Spine patient care with wearable medical technology: State-of-the-art, opportunities, and challenges: A systematic review," Spine Journal, vol. 23, no. 7, pp. 929–944, 2023.
[4] D. F. Odesola, J. Kulon, S. Verghese, A. Partlow, and C. Gibson, "A smart system for continuous sitting posture monitoring, assessment, and personalized feedback," Sensors, vol. 25, no. 18, 2025.
[5] M. La Mura, M. De Gregorio, P. Lamberti, and V. Tucci, "IoT system for real-time posture asymmetry detection," Sensors, vol. 23, no. 10, 2023.
[6] S. Fazeli Veisari, S. Bidari, K. Barati, R. Atlasi, and A. Komeili, "Wearable devices in scoliosis treatment: A scoping review of innovations and challenges," Bioengineering, vol. 12, no. 7, 2025.
[7] S. Shajari, K. Kuruvinashetti, A. Komeili, and U. Sundararaj, "The emergence of AI-based wearable sensors for digital health technology: A review," Sensors, vol. 23, no. 23, 2023.
[8] S. Arun, E. R. Sykes, and S. Tanbeer, "RemoteHealthConnect: Innovating patient monitoring with wearable technology and custom visualization," Digital Health, vol. 10, 2024.
[9] D. Gorden and J. M. Oluwaseun, "A web-based real-time pandemic monitoring system," Journal of Metabolic and Diabetes Research, vol. 2, no. 2, pp. 1–17, 2025.
[10] R. Sari, M. K. D. Yanti, D. Y. Liliana, and I. E. Ismail, "Pembuatan aplikasi monitoring karantina mandiri orang dalam pengawasan (ODP) COVID-19 di Kota Depok," ABDIMAS: Jurnal Pengabdian Masyarakat Universitas Merdeka Malang, vol. 6, no. 2, pp. 143–152, 2021.
[11] W. R. Borg and M. D. Gall, Educational Research: An Introduction, 8th ed. Boston: Pearson Education, 2007.