Jurnal Mandiri IT
Vol. 13 No. 1, July (2024), pp. 99-105

ISSN 2301-8984 (Print), 2809-1884 (Online)
Published by Institute of Computer Science

Development of mobile applications for IoT-based room temperature monitoring and control

Aang Alim Murtopo[1], Mukhamad Zulfa Bakhtiar Amalani[2], Syefudin Syefudin[3], Gunawan Gunawan[4]

[1,2,3,4]Informatics Engineering, STMIK YMI Tegal, Tegal, City, Central java, Indonesia

A R T I C L E I N F O

Article history:

Received Jun 6, 2024
Revised Jun 7, 2024
Accepted Jun 15, 2024

Keywords:

Internet of Things (IoT);
Microcontroller ESP8266;
Mobile App;
Sensor DHT22;
Temperature Control.

ABSTRACT

The Internet of Things (IoT) has become one of the most significant technologies, offering a wide range of innovative solutions to improve efficiency and convenience in various aspects of life. One important application of IoT is in environmental management and control, especially room temperature. This research aims to develop a mobile application capable of monitoring and controlling room temperature with an easy-to-understand user interface and the ability to forecast future temperature needs. Research methods used include experimental approaches, data analysis, and model validation to ensure applications function optimally in real-world conditions. The results showed that the application developed was effective in monitoring room temperature conditions in real-time and was able to adjust the temperature quickly and accurately. The implication of this research is the improvement of user convenience and energy efficiency through the use of IoT technology in everyday life.

Corresponding Author:

Mukhamad Zulfa Bakhtiar Amalani,
Informatics Engineering,
STMIK YMI TEGAL,
#1 Pendidikan Street, Tegal City, Central Java 52142, Indonesia.
Email: zulfabakhtiar0107@gmail.com

1. INTRODUCTION

Internet of Things (IoT) technologies have radically changed various sectors, including indoor environmental management and monitoring (Nižetić et al., 2020). The application of IoT in temperature monitoring has improved convenience, energy efficiency, and safety (Valinejadshoubi et al., 2021). However, although significant progress has been made, there are still various challenges that need to be addressed. These challenges must be overcome to fully harness the potential of this technology (Allioui & Mourdi, 2023). Further research and development is needed to overcome these barriers and increase IoT adoption in this context (Brous et al., 2020).

One of the main issues in the study was the development of an efficient mobile application to monitor and control room temperature. The accuracy of the data and the technology's ability to precisely measure and respond to temperature fluctuations are critical (García et al., 2020). Therefore, further research is needed to develop applications that are not only technically advanced but also practical in everyday life, with a fast and accurate response to temperature changes (Karie et al., 2021).

This research aims to develop a mobile application that is able to monitor and control room temperature with an easy-to-understand user interface and the ability to forecast future temperature needs (Subramaniam et al., 2022). This study seeks to fill gaps in previous research by proposing methods that are more flexible and responsive to changing environmental conditions. This application is expected to provide an effective and efficient solution in room temperature management, as well as ensure better comfort and energy efficiency for its users (Metallidou et al., 2020).

This research is important because the mobile applications developed are able to respond to environmental dynamics in real-time and provide accurate decisions and actions based on the data collected (Sinha & Dhanalakshmi, 2022). Therefore, this research contributes significantly to the development of IoT applications that are integrated in everyday life, improving the quality of life and efficiency of energy use. The successful implementation of this application will demonstrate significant advances in environmental monitoring and control technology (Tyagi et al., 2020).

The development of these applications uses an iterative software development approach, ensuring the application can adapt to user needs and change environmental conditions (Oppong-Tawiah et al., 2020). This approach allows continuous iteration to optimize the functionality of the application (Strieth-Kalthoff et al., 2020). Proposed innovations include the integration of machine learning algorithms for prediction and adaptation to temperature change patterns. In addition, the user interface is designed to increase ease and effectiveness of use (Hernández-Morales et al., 2022). This research is expected to produce more accurate and efficient solutions in monitoring and controlling room temperature (Rehman et al., 2022).

The main challenges in developing mobile applications for room temperature monitoring and control include temperature measurement accuracy, effective device integration, data security, and an intuitive user interface. Accurate, easy-to-use, and secure applications are essential for convenience and energy efficiency, as well as to drive widespread adoption of IoT technology. These challenges are influencing the adoption of IoT technology as inaccurate, difficult-to-use, or insecure applications will hinder adoption in the market. Therefore, it is important to have an application that is not only technically advanced but also practical and easy to use in everyday life. This research is expected to make an important contribution to the development of IoT applications for environmental management, with solutions that are easier to use, accurate, and efficient in monitoring and controlling room temperature (Aliero et al., 2021; Bwambale et al., 2022; Hajjaji et al., 2021). The app aims to increase users' control over their environment, thereby increasing the comfort and efficiency of energy use.

In today's digital era, Internet of Things (IoT) technology has made significant contributions in various sectors, including temperature monitoring and energy management. Previous research. integrating IoT and blockchain for temperature monitoring and prevention of counterfeit drugs, emphasizing the benefits of strong data security and transparency in the pharmaceutical supply chain (Singh et al., 2020). Previous research explored optimal temperature control for fuel cells in vehicle applications, emphasizing energy savings and improved operational efficiency (Hu et al., 2021). This research provides a thorough overview of the latest developments in IoT technology, covering applications in various sectors and challenges that must be overcome to increase IoT adoption (Laghari et al., 2021). Previous research has focused on the role of IoT in improving energy efficiency in the energy sector, including the application of IoT in smart power grids and the integration of renewable energy (Hossein Motlagh et al., 2020). Recent research shows how IoT can improve energy efficiency, security, and management in a variety of practical applications, and provides insight into the advancements and challenges that exist in the application of IoT technologies (Ma et al., 2022).

The uniqueness of the application developed in this study lies in the integration of machine learning algorithms for prediction and adaptation to temperature change patterns, as well as a user interface designed to improve ease and effectiveness of use (Hong et al., 2020). The app not only monitors room temperature in real-time, but also provides predictions of future temperature needs for more efficient energy management (Bedi et al., 2020). This study identifies gaps in the literature regarding room temperature monitoring applications that often do not emphasize aspects of friendly user interfaces and quick response to temperature changes (Chojer et al., 2020). To overcome this, this study developed a mobile app that continuously monitors the temperature and allows users to set the temperature according to their wishes (Irfan et al., 2021). Although some researchers focus on developing mobile applications for real-time monitoring and control of room temperature, this study aims to fill in the gaps by emphasizing user-friendly interfaces and fast and accurate responses to temperature changes.

2. RESEARCH METHOD

Research Design

This research involves several key components that are integrated to provide an efficient and responsive solution. Here is a breakdown of the system architecture that uses DHT22 sensors, infrared transmitters, ESP8266 microcontrollers, and jumper cables.

Figure 1. Sensor DHT22

Figure 1. It is the determination of the DHT22 sensor as the main component based on several considerations. First, DHT22 is known for its high accuracy in measuring temperature and humidity, Secondly, it offers easy integration with various microcontrollers, including ESP8266, which facilitates the process of system development and implementation. Third, DHT22 has a wide and stable measurement range, making it ideal for indoor applications where fluctuations in temperature and humidity can have a significant impact on comfort and energy efficiency.

Figure 2. Infrared transmitter

Figure 2. The infrared transmitter selection can simulate existing remote control functions without the need for physical intervention in the AC system itself, facilitating seamless integration with various AC models and brands without the need for hardware modifications. Reduces the need for installation of additional components such as relay modules that may require more complex and invasive electrical installations. Using an infrared transmitter can control the air conditioner remotely via a mobile app, offering an intuitive and flexible user experience, where users can set the temperature, mode, and other settings easily from their smartphone.

Figure 3. ESP8266

Figure 3. The choice of ESP8266 microcontroller as the main component is a strategic decision. The main reason for choosing ESP8266 is its outstanding capabilities in integrated Wi-Fi connectivity, which allows devices to connect directly to the internet without the need for external modules. This is especially important for IoT applications that require devices to constantly send and receive data from the cloud. In addition, ESP8266 has a large developer community and extensive documentation resources, which makes it easy to develop and troubleshoot.

Figure 4. Cable Jumper

Figure 4. Jumper cable determination is used in the prototyping phase to connect temperature sensor components, infrared transmitter sensors, and microcontrollers, Jumper cables are very important in the experimental phase because they provide a flexible and reversible way to make connections between components without permanent solring, can adjust and iterate quickly based on test results. The use of jumper cables makes it easy to replace damaged components, add new sensors, or reconfigure systems without permanent commitment.

Application Development

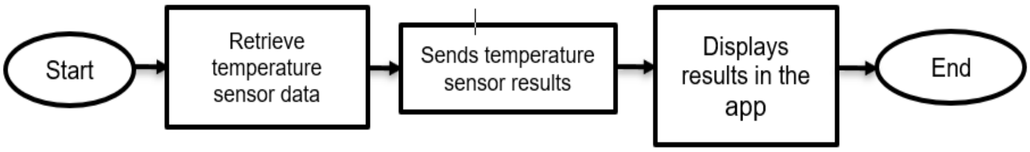

Figure 5. Application flow

The research flow in figure 5. Describes the process of developing an extended application by taking the results of the temperature sensor, At this stage the system reads the room temperature data using a temperature sensor connected to a microcontrller. The next stage sends the results of the temperature sensor, after the temperature data is successfully taken by the sensor, then the microcontroller sends the data to the server via the internet network (WiFi). The next stage displays the temperature result in the app, the temperature data that has been sent to the app is now displayed in the user interface of the mobile app,

Data Collection

Data collection is carried out through the DHT22 sensor, which continuously measures room temperature and humidity. These sensors are connected to ESP8266 microcontroller, which acts as the heart of the data collection system. This microcontroller reads values from the DHT22 sensor at set intervals, to ensure the data received reflects room conditions in real-time. The collected data is then sent automatically to the cloud server via a Wi-Fi connection that has been integrated in the ESP8266. This cloud server stores the data in a database that can be accessed by a mobile application, so users can monitor room temperature conditions from time to time.

Implementation

Application implementation is done using mobile application development platforms such as Android Studio or Flutter. The first phase of implementation involves the design of an intuitive and responsive user interface, which allows users to easily view temperature and humidity data in real-time as well as access historical data. This interface also provides a function to set the target temperature, which is then sent as a control command to the system. Furthermore, the application is developed to communicate with the cloud through a secure API, where the application sends and receives data from a cloud server that has stored input from the DHT22 sensor. In this case, the application acts as a link between the user and the hardware, allowing the user to monitor and control the room temperature remotely.

3. RESULTS AND DISCUSSION

The development of mobile applications for IoT-based room temperature monitoring and control presents various features that make it easier for users to monitor environmental conditions

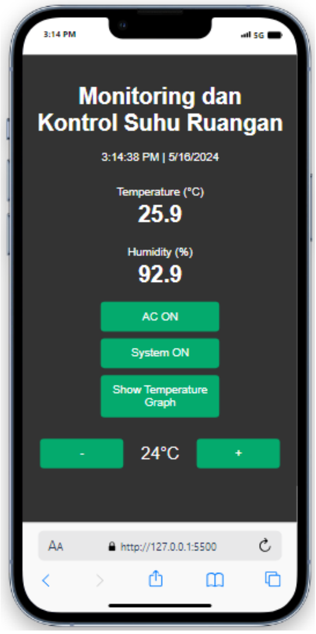

Figure 6. Application view

Figure 6. Displays the current time and date at the top, informing users of the last time the data was updated. In the main view, the current room temperature is displayed as 25.9°C and humidity is 92.9%, allowing users to monitor room conditions in real-time. There are several interactive control buttons provided. The green "AC ON" button indicates that the air conditioner is active, can turn the air conditioner on or off with one touch. Meanwhile, the "System ON" button is also green, indicating that the overall temperature control system is active and can be set through this app. The "Show Temperature Graph" button is provided to display a round-the-clock temperature graph, providing a more detailed and informative visualization of temperature trends.

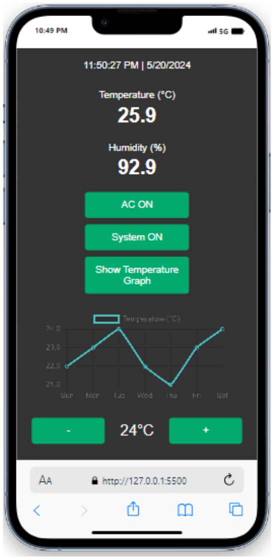

Figure 7. Graph of room temperature monitoring results

Figure 7. Illustrates a graph of the rise and fall of indoor temperatures during one week, from Sunday to Saturday. This graph uses a horizontal axis to display the days of the week and a

vertical axis to display temperatures in degrees Celsius, ranging from about 21°C to 24°C. At the start of the week, temperatures started at around 23.5°C on Sunday, rose slightly on Monday, then dropped sharply to around 22°C on Tuesday. Temperatures then recovered back almost to baseline levels on Wednesday, before dropping again to similar levels on Thursday. Towards the end of the week, temperatures increased significantly on Friday, peaking at around 23.8°C, and stabilized on Saturday.

These temperature fluctuations are influenced by various factors such as changes in indoor activity, the use of heating or cooling systems, or changes in external weather conditions that affect indoor temperature. The data from this graph is very useful for energy efficiency analysis, ensuring comfort for residents,

Table 1. Results of temperature monitoring in the last week

Day	Temperature (°Celsius)
Monday	23,6
Tuesday	22
Wednesday	23,2
Thursday	22,8
Friday	23,8
Saturday	23,9
Sunday	23,5

Table 1. Shows data from temperature monitoring for one week, from Monday to Sunday. Each column in this table lists daily temperatures in degrees Celsius (°C). On Monday, the temperature was recorded at 23.6°C, while Tuesday showed a drop to 22°C. Wednesday saw temperatures rise to 23.2°C, but Thursday dropped back to 22.8°C. The temperature rose again on Friday to 23.8°C and continued to rise until Saturday with 23.9°C. On Sunday, the temperature dropped slightly to 23.5°C. This data shows relatively stable daily temperature variations with some small fluctuations throughout the week.

4. CONCLUSION

This research contributes to the development of IoT applications for room temperature monitoring, improving energy efficiency and user comfort by utilizing machine learning algorithms for future temperature prediction. The developed app offers an easy-to-use interface, allowing users to control the temperature in real-time with fast and accurate responses. It is hoped that this application will reduce energy costs and improve the quality of life by ensuring optimal temperature conditions according to the needs of users in daily life.

REFERENCES

Aliero, M. S., Qureshi, K. N., Pasha, M. F., & Jeon, G. (2021). Smart Home Energy Management Systems in Internet of Things networks for green cities demands and services. *Environmental Technology & Innovation*, *22*, 101443. https://doi.org/10.1016/j.eti.2021.101443

Allioui, H., & Mourdi, Y. (2023). Exploring the full potentials of IoT for better financial growth and stability: A comprehensive survey. *Sensors*, *23*(19), 8015.

Bedi, G., Venayagamoorthy, G. K., & Singh, R. (2020). Development of an IoT-driven building environment for prediction of electric energy consumption. *IEEE Internet of Things Journal*, *7*(6), 4912–4921. https://doi.org/10.1109/JIOT.2020.2975847

Brous, P., Janssen, M., & Herder, P. (2020). The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations. *International Journal of Information Management*, *51*, 101952.

Bwambale, E., Abagale, F. K., & Anornu, G. K. (2022). Smart irrigation monitoring and control strategies for improving water use efficiency in precision agriculture: A review. *Agricultural Water Management*, *260*, 107324. https://doi.org/10.1016/j.agwat.2021.107324

Chojer, H., Branco, P., Martins, F. G., Alvim-Ferraz, M. C. M., & Sousa, S. I. V. (2020). Development of low-cost indoor air quality monitoring devices: Recent advancements. *Science of The Total Environment*, *727*, 138385. https://doi.org/10.1016/j.scitotenv.2020.138385

García, L., Parra, L., Jimenez, J. M., Lloret, J., & Lorenz, P. (2020). IoT-based smart irrigation systems: An overview on the recent trends on sensors and iot systems for irrigation in precision agriculture. *Sensors (Switzerland)*, *20*(4). https://doi.org/10.3390/s20041042

Hajjaji, Y., Boulila, W., Farah, I. R., Romdhani, I., & Hussain, A. (2021). Big data and IoT-based applications in smart environments: A systematic review. *Computer Science Review*, *39*, 100318. https://doi.org/10.1016/j.cosrev.2020.100318

Hernández-Morales, C. A., Luna-Rivera, J. M., & Perez-Jimenez, R. (2022). Design and deployment of a practical IoT-based monitoring system for protected cultivations. *Computer Communications*, *186*, 51–64. https://doi.org/10.1016/j.comcom.2022.01.009
Hong, T., Wang, Z., Luo, X., & Zhang, W. (2020). State-of-the-art on research and applications of machine learning in the building life cycle. *Energy and Buildings*, *212*, 109831. https://doi.org/10.1016/j.enbuild.2020.109831
Hossein Motlagh, N., Mohammadrezaei, M., Hunt, J., & Zakeri, B. (2020). Internet of Things (IoT) and the energy sector. *Energies*, *13*(2), 494.
Hu, D., Wang, Y., Li, J., Yang, Q., & Wang, J. (2021). Investigation of optimal operating temperature for the PEMFC and its tracking control for energy saving in vehicle applications. *Energy Conversion and Management*, *249*, 114842.
Irfan, M., Jawad, H., Felix, B. B., Abbasi, S. F., Nawaz, A., Akbarzadeh, S., Awais, M., Chen, L., Westerlund, T., & Chen, W. (2021). Non-wearable IoT-based smart ambient behavior observation system. *IEEE Sensors Journal*, *21*(18), 20857–20869. https://doi.org/10.1109/JSEN.2021.3097392
Karie, N. M., Sahri, N. M., Yang, W., Valli, C., & Kebande, V. R. (2021). A Review of Security Standards and Frameworks for IoT-Based Smart Environments. *IEEE Access*, *9*, 121975–121995. https://doi.org/10.1109/ACCESS.2021.3109886
Laghari, A. A., Wu, K., Laghari, R. A., Ali, M., & Khan, A. A. (2021). A review and state of art of Internet of Things (IoT). *Archives of Computational Methods in Engineering*, 1–19.
Ma, S., Xu, Y., Pang, Y., Zhao, X., Li, Y., Qin, Z., Liu, Z., Lu, P., & Bao, X. (2022). Optical fiber sensors for high-temperature monitoring: a review. *Sensors*, *22*(15), 5722.
Metallidou, C. K., Psannis, K. E., & Egyptiadou, E. A. (2020). Energy efficiency in smart buildings: IoT approaches. *IEEE Access*, *8*, 63679–63699.
Nižetić, S., Šolić, P., Gonzalez-De, D. L.-I., & Patrono, L. (2020). Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future. *Journal of Cleaner Production*, *274*, 122877.
Oppong-Tawiah, D., Webster, J., Staples, S., Cameron, A.-F., de Guinea, A. O., & Hung, T. Y. (2020). Developing a gamified mobile application to encourage sustainable energy use in the office. *Journal of Business Research*, *106*, 388–405. https://doi.org/10.1016/j.jbusres.2018.10.051
Rehman, A., Saba, T., Kashif, M., Fati, S. M., Bahaj, S. A., & Chaudhry, H. (2022). A revisit of internet of things technologies for monitoring and control strategies in smart agriculture. *Agronomy*, *12*(1), 127.
Singh, R., Dwivedi, A. D., & Srivastava, G. (2020). Internet of things based blockchain for temperature monitoring and counterfeit pharmaceutical prevention. *Sensors*, *20*(14), 3951.
Sinha, B. B., & Dhanalakshmi, R. (2022). Recent advancements and challenges of Internet of Things in smart agriculture: A survey. *Future Generation Computer Systems*, *126*, 169–184. https://doi.org/10.1016/j.future.2021.08.006
Strieth-Kalthoff, F., Sandfort, F., Segler, M. H. S., & Glorius, F. (2020). Machine learning the ropes: principles, applications and directions in synthetic chemistry. *Chemical Society Reviews*, *49*(17), 6154–6168. https://doi.org/10.1039/C9CS00786E
Subramaniam, S., Majumder, S., Faisal, A. I., & Deen, M. J. (2022). Insole-based systems for health monitoring: Current solutions and research challenges. *Sensors*, *22*(2), 438. https://doi.org/10.3390/s22020438
Tyagi, D., Wang, H., Huang, W., Hu, L., Tang, Y., Guo, Z., Ouyang, Z., & Zhang, H. (2020). Recent advances in two-dimensional-material-based sensing technology toward health and environmental monitoring applications. *Nanoscale*, *12*(6), 3535–3559. https://doi.org/10.1039/C9NR10178K
Valinejadshoubi, M., Moselhi, O., Bagchi, A., & Salem, A. (2021). Development of an IoT and BIM-based automated alert system for thermal comfort monitoring in buildings. *Sustainable Cities and Society*, *66*, 102602.