Journal of Applied Informatics and Computing (JAIC)
Vol.9, No.5, October 2025, pp. 2257~2263
e-ISSN: 2548-6861

Multi-Modal Sensor Integration in Smart Rooms to Optimize Internet of Things-Based Monitoring and Security Control of Autistic Child Detection Activities

Muh Arfah Taufiq [1]*, Supriadi Sahibu [2]*, Abdul Jalil [3]**
* Sistem Komputer, Universitas Handayani Makassar
** Teknik Komputer dan Jaringan, Politeknik Negeri Ujung Pandang
arfahtaufiq@gmail.com [1], supriadi@handayani.ac.id [2], abduljalil@poliupg.ac.id [3]

Article Info

Article history:

Received 2025-09-02
Revised 2025-09-15
Accepted 2025-09-19

Keyword:

Multi-Modal Sensor,
Smart Rooms,
Internet of Things,
Autism,
Child.

ABSTRACT

The advancement of Internet of Things (IoT) technology has opened new opportunities for automated monitoring systems, especially for children with Autism Spectrum Disorder (ASD). These children require intensive supervision due to communication limitations and unpredictable behavior. This study aims to design and implement a smart room system integrated with multi-modal sensors to monitor autistic children's activities in real time.Using a Research and Development (R&D) approach with the ADDIE model, the system was developed with an ESP32 microcontroller and sensors including PIR (motion), DHT22 (temperature), microphone (sound), and LDR (light). The Mamdani fuzzy logic algorithm processes sensor data to classify safety levels. Data is visualized and notified via the Blynk platform.Test results show the system effectively detects "safe," "needs attention," and "critical" conditions with high accuracy, providing timely alerts for parents. This solution enhances home-based supervision and offers a practical, IoT-based approach to child safety and care.

I. Introduction

The development of Internet of Things (IoT) technology has brought significant changes in various aspects of life, including in the fields of health and security. One of its increasingly developing applications is in smart room systems that integrate various sensors for monitoring and security control. In this context, monitoring the activities of children, especially toddlers with autism spectrum disorder (ASD), becomes a primary concern because it requires more intensive supervision and rapid response to certain conditions. Toddlers with autism often show different behavioral patterns compared to typical children, such as hyperactivity, repetitive movements, or communication difficulties. Therefore, a monitoring system capable of detecting their activities in real-time is needed to provide early intervention and improve the quality of care. However, conventional monitoring still faces various obstacles, such as limited caregivers, varying levels of alertness, and a lack of automated systems that can accurately and responsively detect activities.

In recent years, the development of Internet of Things (IoT) technology has presented innovative solutions to improve people's quality of life. One of its applications is in smart home systems, which allow remote monitoring and control of various aspects of the household, including security, comfort, and energy efficiency. The Internet of Things (IoT) is a topic that has been widely developed in the last decade. Currently, many technology developers are creating smart devices that can facilitate human work. Smart home systems are one of them. In smart home systems, physical devices can communicate through the internet network or other near-cable networks to exchange information or carry out commands from the residents of the house (Hadi et al., 2022). Children with autism cannot carry out their daily activities independently but need help from those around them. Their needs must be met by those around them due to the inability of autistic children to regulate and make decisions about what they do, such as toilet training, preparing food, learning at school, socializing, and so on. The companionship of those around them plays an important role in determining their future. However, teaching independence requires time, effort, and repetition for the child to develop. Independence for autistic children can be characterized by the individual's ability to care for or help themselves without needing assistance from those around them (Barokah & Sarasati, 2024).

A sensor is a device used to measure a state in the surroundings or environment from a certain energy into electrical energy. The use of sensors as input devices has been widely used in daily life, such as for household appliances, control systems, robotics, the Internet of Things, industry, and home security systems. The development of sensor and instrumentation technology in the industrial revolution 4.0 era has encouraged researchers to develop integrated systems between sensors into a new sensor module or commonly called a multi-modal sensor. A multi-modal sensor is a device or module consisting of several sensors that are integrated into a single unit to become a new sensor module device (Suparno & Jalil, 2021).

In this study, we aim to develop a device that can be used to monitor the activities of children with autism. It is expected that the outcomes of this research will provide valuable benefits to society by offering an idea for monitoring the activities of autistic children, particularly when parents or family members are engaged in activities outside the home.

II. METHOD

A. Research Design

This research uses the Research and Development (R&D) method with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). This model is used to develop a smart room system based on the Internet of Things (IoT) with multi-modal sensor integration for monitoring autistic children. Figure 1 show research design of this study.

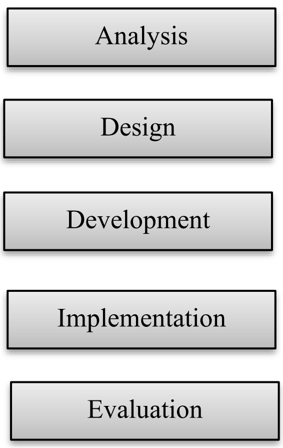

Figure 1 Research Design

Based on information of Figure 1, The analysis stage begins with identifying the monitoring needs of autistic children to ensure that the system provides meaningful assistance and safety. A comprehensive literature review is then conducted, focusing on existing studies related to the Internet of Things (IoT), sensor technologies, and the application of fuzzy logic in monitoring systems. Based on the findings, the hardware and software requirements are determined to support the development of an adaptive and reliable monitoring solution.

In the design phase, the architecture of the smart room system is established to accommodate the integration of multiple components. The hardware design incorporates the ESP32 microcontroller along with various sensors such as PIR, DHT22, LDR, and sound sensors, supported by an actuator in the form of a buzzer. Furthermore, the Mamdani fuzzy algorithm is developed to process sensor inputs and generate intelligent decisions. To complement the hardware and algorithm, the user interface of the system is designed using the Blynk application, enabling real-time monitoring and notification.

The development process involves assembling the hardware components and ensuring proper configuration of the system. Each sensor is integrated with the ESP32 microcontroller to capture environmental data in real time. The fuzzy logic program is then created and embedded into the microcontroller to handle decision-making based on sensor inputs. Finally, the system is connected to the Blynk application, which facilitates communication between the device and the end user through mobile-based monitoring.

During the implementation stage, the smart room system is deployed in the living space of an autistic child to validate its functionality. Both hardware and software components are tested in real operating conditions to ensure seamless operation. Additionally, system notifications are verified through the Blynk platform to confirm that alerts and updates are effectively delivered to caregivers or parents.

The evaluation phase is conducted by testing the system under various environmental conditions, including changes in temperature, light intensity, sound levels, and movement. The performance of the system is then assessed in terms of detection accuracy and response time to different scenarios. Lastly, an analysis of the system's reliability is performed to determine its effectiveness in consistently providing accurate and timely security status information for the monitored environment.

B. Block Diagram

A block diagram is a type of system diagram in which functions are represented by blocks connected by lines, illustrating the relationship and flow between the blocks. In the fields of engineering, hardware design, electronics, software development, and system workflows, block diagrams are widely used. Figure 2 show the block diagram of this study.

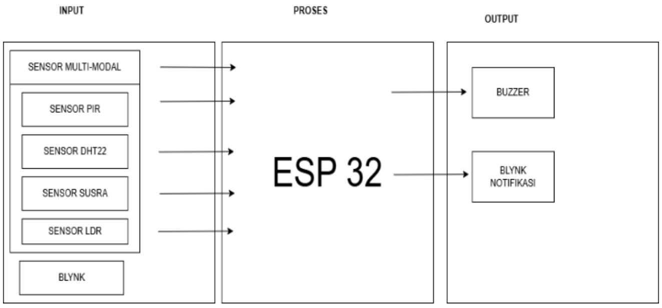

Figure 2. Block Diagram

Based on information of Figure 2, The input stage of the system integrates multiple sensing devices to capture diverse environmental parameters. A multi-modal sensor is employed to combine different modalities such as light, sound, temperature, and motion, thereby enhancing both the accuracy and reliability of monitoring. This type of sensor has been widely adopted in fields including autonomous vehicles, robotics, security, and healthcare applications. Additionally, a Passive Infrared (PIR) sensor is utilized to detect the presence of humans or animals by measuring infrared radiation, which is commonly applied in automatic lighting systems, alarms, and security monitoring. To measure environmental conditions, a DHT22 sensor is integrated, offering high accuracy in both temperature and humidity readings, making it suitable for IoT solutions, smart home applications, and climate control systems. Furthermore, a sound sensor is used to convert sound waves into electrical signals, enabling applications such as voice recognition, voice control, and alarm systems. Light intensity is captured using a Light Dependent Resistor (LDR), which adjusts its resistance value based on illumination levels, a principle widely implemented in automatic lighting and light monitoring systems. Finally, the Blynk platform is incorporated to enable real-time connectivity between microcontrollers and smartphone or web applications, facilitating remote monitoring and control of the system.

The processing unit of the system is built around the ESP32 microcontroller, which features a dual-core processor and integrated Wi-Fi and Bluetooth capabilities. It supports multiple communication protocols such as SPI, I2C, and UART, allowing seamless integration with various sensors and peripherals. Due to its power efficiency and versatility, the ESP32 has become a popular choice for IoT-based projects, smart home solutions, and robotics applications. In this research, the ESP32 serves as the primary controller, managing data acquisition from sensors, executing the fuzzy logic algorithm, and transmitting information to the user interface.

The output components of the system are designed to provide both auditory and digital notifications. A buzzer is employed as an audible indicator to signal specific conditions or warnings, a feature commonly found in alarms, bells, and security alert systems. In addition, the Blynk application is used to deliver real-time notifications directly to the user's mobile device, ensuring that caregivers or parents are immediately informed about environmental changes or critical events detected by the sensors. This dual output mechanism enhances system responsiveness and ensures timely awareness of monitored conditions.

III. Results and Discussion

Multi-Modal Sensors in Smart Rooms for Optimizing Monitoring and Security Control of Autistic Child Detection Activities Based on the Internet of Things designed using ESP32, Buzzer Module, PCB (Prototyping Board), DHT11, Microphone, PIR and LDR have been successfully built with effective integration between hardware and software. ESP32 as the brain of the entire system, a data processing tool from various sensors (temperature, sound, motion, LDR) which will be displayed on mobile devices through the BLYNK application.

Overview of system implementation, this study has produced an Internet of Things-based monitoring and control system for detecting autistic children's activities. This system consists of: Multi-modal sensors (DHT11, LDR, Sound, PIR), ESP32 microcontroller, and Blynk platform. Furthermore, Fuzzy logic algorithms for processing multi-modal sensor data (temperature, sound, motion, and light) so that the system can more flexibly interpret the environmental conditions of autistic children. This system was installed in a smart room simulation. Data acquisition was carried out using simulated objects over several weeks. Figure 3 and 4 show the hardware used in this study.

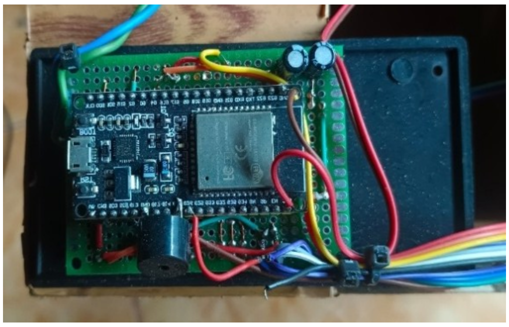
Figure 3. ESP32 Microcontroler to process the data

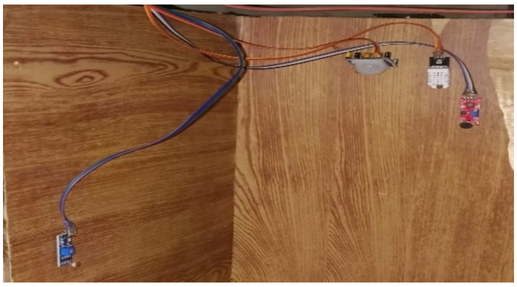
Figure 4. The multi-modal sensors used in this rtudy

The Figure 4 shows sensors installed in the room to detect movement and temperature within the smart room. Signals detected by the sensors are sent to a microcontroller, which displays the data in real time or sends it to an IoT platform for monitoring via a smartphone. This data is useful for parents to monitor the movements of their autistic children

The system was installed in a simulated room with multiple sensor points. Data acquisition was automated over several weeks. Figure 5 show the information of the autistic children when do the activities in the room.

Figure 5. Activity information of the autistic child

Based on the information of Figure 5, the output from an IoT-based monitoring system designed using the Blynk platform. This display shows the results of real-time monitoring of the child's environmental conditions, obtained from a temperature sensor (DHT11), a sound sensor (analog microphone), a motion sensor (PIR), and a light sensor (LDR). This system applies fuzzy logic to classify the child's safety level based on the combined input from these four sensors. The output display consists of two virtual LCDs, each displaying two rows of information:

a) Virtual LCD 1 (Pin V0):
The first row, status: Safe, indicates the child's overall status. In this case, the status "Safe" means that the system does not detect any potential danger based on the sensor input. The second row, temperature: Normal, indicates that the room temperature is within the range considered normal by the fuzzy system, which is between 24°C and 30°C.

b) Virtual LCD 2 (Pin V4):
The first row, sound: Quiet, indicates that the sound intensity in the environment is detected at a low level (analog value <100), which is categorized as "quiet."
Second line Grk : Moving Indicates that the PIR sensor detected movement, which is assumed to be child activity in the monitoring area.

Furthermore, Figure 6 – 9 shows the set of fuzzy temperature, sound, lDR, and PIR implemented in this study to describe concepts that are vague or imprecise.

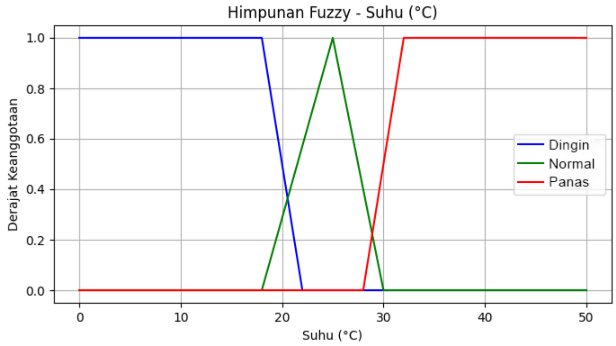

Figure 6. Fuzzy of temperature sensor

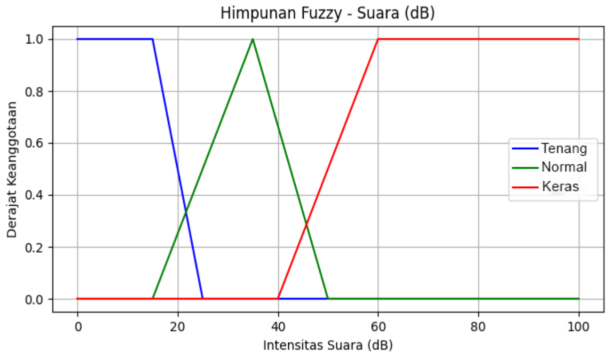

Figure 7. Fuzzy of sound sensor

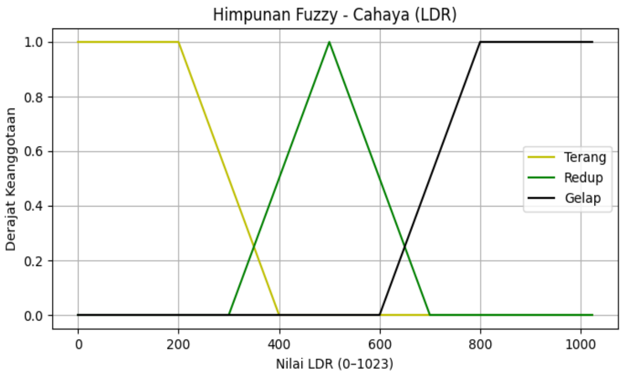

Figure 8. Fuzzy of LDR sensor

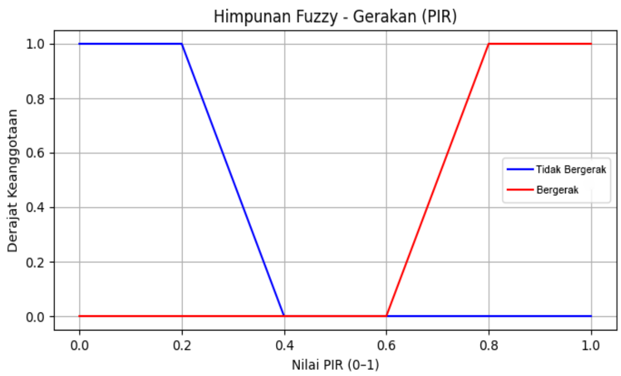

Figure 9. Fuzzy of PIR sensor

Based on the information of Figure 6, the fuzzy membership function for temperature is defined across three categories: cold, normal, and hot. The *cold* set (blue) has a full membership value of 1 up to approximately 18 °C, gradually decreases, and reaches 0 for temperatures above 22 °C. The *normal* set (green) follows a triangular distribution, beginning at 18 °C, reaching its peak membership of 1 at 25 °C, and then declining to 0 at 30 °C. The *hot* set (red) starts with a membership value of 0 below 28 °C, increases between 28 °C and 30 °C, and achieves full membership at temperatures above 32 °C. Based on this representation, temperatures at or below 18 °C are classified as *Low*, 25 °C as *Medium*, and those at or above 32 °C as *High*.

According to the information of Figure 7, the fuzzy membership function for sound levels is defined in three categories: quiet, normal, and loud. The *quiet* set (blue) has a full membership value of $\mu = 1$ up to approximately 15 dB, then gradually decreases until reaching 0 at 25 dB. The *normal* set (green) increases from 15 dB, reaches its peak membership of 1 at 35 dB, and declines to 0 at around 50 dB. The *loud* set (red) begins to rise at 40 dB and achieves full membership ($\mu = 1$) from 60 dB onwards. Based on this definition, sounds at or below 15 dB are categorized as *Quiet*, 35 dB as *Normal*, and 60 dB or above as *Noisy*.

Then follow the information of Figure 8, the fuzzy membership function for light intensity is categorized into three sets: bright, dim, and dark. The *bright* set (yellow) maintains a full membership value below 200, gradually decreasing until it reaches 0 at approximately 400. The *dim* set (green) follows a triangular distribution, beginning to rise at 300, achieving maximum membership at 500, and decreasing back to 0 at 700. Meanwhile, the *dark* set (black) starts increasing at 600, reaches full membership ($\mu = 1$) beyond 800, and remains constant up to the maximum value of 1023.

Furthermore, based on the information of Figure 9, The fuzzy membership function for motion detection using the PIR sensor is defined in two categories: still and moving. The *still* set (blue) has a full membership value ($\mu = 1$) between 0 and 0.2, then gradually decreases until reaching 0 at 0.4. In contrast, the *moving* set (red) begins to rise at 0.6 and achieves full membership ($\mu = 1$) within the range of 0.8 to 1.0. Accordingly, PIR sensor values close to 0 are interpreted as *No Movement*, while values approaching 1 indicate *Movement*.

Input-output variables used in the Mamdani fuzzy logic system Input Variables: Data obtained from sensors. Motion Sensor (PIR): Used to detect movement. Temperature Sensor (DHT22): Used to measure temperature. Sound Sensor (Microphone): Used to detect sound. Light Sensor (LDR): Used to detect light levels. Output Variables: Decisions generated by the system. Security Level: Classification of the child's security level, which can be one of three conditions: “safe,” “needs attention,” or “critical.”

Used in the system to determine the security level based on a combination of sensor readings. This system is designed to detect significant changes such as unusual movement, loud noises, extreme temperatures, or abnormal lighting.

Example Rule 1: IF Temperature is ‘Very Hot’ AND Movement is ‘High’, THEN Security is ‘Critical’. Rule 2: IF Temperature is ‘Normal’ AND Movement is ‘Low’, THEN Security is ‘Safe’. Each rule maps a combination of input conditions to a single output condition, allowing the system to make the right decision even if the data from the sensors does not exactly match the values specified in the rules.

Fuzzy integration with Blynk notifications (real-time decision flow) The system continuously collects data from various sensors installed in the room, namely:

Motion Sensor (PIR): Measures movement, Temperature Sensor (DHT22): Measures room temperature. Sound Sensor (Microphone): Detects noise levels, Light Sensor (LDR): Measures light intensity. This data is raw input that will be processed by the system.

After the sensor data is received, it is processed through three main stages of the Mamdani fuzzy algorithm. Fuzzification: Numerical values from sensors (e.g., temperature 30°C) are converted into fuzzy sets (e.g., ‘hot’ or ‘very hot’). Inference Engine: This engine applies predetermined fuzzy rules (“IF-THEN”) to evaluate all fuzzy inputs simultaneously. For example: IF (temperature is ‘high’) AND (movement is ‘high’) THEN (security is ‘critical’). Defuzzification: The results from the inference engine, which are still fuzzy values, are converted back into clear numerical values. This produces the final security level classification, such as “safe,” “needs attention,” or “critical.” This research makes a significant contribution to the field of assistive technology for children with Autism Spectrum Disorder (ASD), which can be strengthened as follows:

1. Improved Quality of Automatic Monitoring

This research offers a more sophisticated and comprehensive solution compared to conventional monitoring methods. By integrating various sensors (motion, temperature, sound, and light), this system can monitor several aspects of the child's environment simultaneously. This multi-modal approach produces richer and more accurate data, allowing parents or caregivers to obtain a more holistic picture of the child's condition.

2. Intelligent Decision Making with Fuzzy Logic

Another major contribution is the use of fuzzy logic. Children with ASD often exhibit unpredictable and difficult-to-predict behavior. By using fuzzy logic, the system can interpret ambiguous or uncertain sensor data (e.g., “somewhat excessive” movement or “fairly loud” sound) and convert it into clear decisions about safety levels. This is crucial because it allows the system to adapt to the variability of autistic children's behavior, reducing false alarms and providing more relevant alerts.

3. Integrated IoT-Based Solution

This research integrates all components (sensors, data processing, and notifications) into a single functional IoT (Internet of Things) platform. This integration enables:

Remote Monitoring: Parents can monitor their children from anywhere via the Blynk app.

Real-Time Notifications: Instant alerts are sent when potentially dangerous conditions are detected, enabling quick intervention.

This solution functions as a powerful support tool, reducing the workload of caregivers and providing peace of mind thanks to a system that automatically and intelligently monitors the environment of children with ASD.

The advantages of multi-sensor integration over single-sensor integration can be implicitly demonstrated through the principles underlying this research.

1. More Accurate Decision Making

Single-sensor-based systems can only make decisions based on one type of data, which is often insufficient for detecting complex situations. For example: A Motion Sensor (PIR) alone cannot distinguish between a child who is playing quietly and a child who is experiencing agitation.A sound sensor (microphone) alone cannot distinguish between crying due to hunger and crying due to pain, especially if there is no visual context or other data. A temperature sensor (DHT22) alone cannot determine whether the room temperature is rising because a child has a fever or because the weather is hot. Conversely, multi-sensor integration allows fuzzy logic to combine data from all sensors, creating a richer understanding of the environment. For example, if the motion sensor detects “a lot” of movement AND the sound sensor detects ‘loud’ sounds, the system can conclude with greater certainty that there is a “critical” situation that requires attention.

2. Increased Reliability and Reduced False Alarms

Relying on a single sensor increases the risk of false alarms. For example, an alarm based solely on a sound sensor may sound due to loud noises from outside the room, not from the child. With multi-sensors, the system can verify the data. When the sound sensor detects loud noises, the system can check the data from the motion sensor. If there is no movement, it is likely that the noise is coming from outside, thus avoiding false alarms.

3. Ability to Identify Complex Behavior

Children with autism often exhibit complex behaviors. A multi-sensor system can better identify these patterns. For example, a combination of high temperature, minimal movement, and unusual sounds could indicate a health condition, not just play activity. The synergy between this data is crucial for providing more accurate and relevant analysis.

Thus, although the document does not present direct comparative data, the logic of this research shows that multi-sensor integration is fundamentally more reliable and effective due to its ability to collect, process, and conclude information from various sources, resulting in smarter and more accurate decisions compared to systems that rely on only one type of data.

The IoT-based monitoring system has demonstrated effectiveness in accurately detecting the activities of autistic children in real time. Its reliability is further strengthened through the integration of multiple sensors, including temperature, sound, motion, and light, which collectively enhance detection performance. Fuzzy logic plays a significant role in this system by enabling the classification of activity conditions into safe, normal, or at-risk categories.

Unlike conventional binary approaches, fuzzy logic provides greater flexibility in decision-making, allowing the system to adapt more effectively to varying conditions. The results of this study are consistent with previous research on IoT applications in health and safety monitoring, while offering novelty by specifically addressing the monitoring of autistic children within a smart room environment.

Practically, the system can support parents and therapists by enabling supervision without requiring continuous direct observation and holds potential for further integration into mobile applications to improve usability and accessibility. Nonetheless, the research is constrained by its limited testing in small-scale, controlled environments, highlighting the need for validation under more diverse and complex real-world conditions. For future development, the integration of artificial intelligence and machine learning is recommended to enhance predictive capabilities and anomaly detection, while broader trials in household and inclusive educational settings are necessary to ensure system scalability and robustness.

IV. CONCLUSION

This study focuses on the development and evaluation of a smart room system that integrates multi-modal sensors for monitoring and controlling the security of autistic children’s activities, utilizing the Internet of Things (IoT) and fuzzy logic. The system is designed to detect both movement and environmental conditions in real time, while automatically generating decisions regarding the status of the child’s room. The implementation results and sensor data analysis from the simulation indicate several key findings. First, the IoT-based smart room system, developed using ESP32, PIR sensors, DHT22, sound sensors, and light sensors (LDR), has been successfully designed and implemented to monitor autistic children’s environments and classify their conditions as “Safe,” “Attention Required,” or “Critical.” Second, the Mamdani fuzzy logic algorithm proved effective in processing multi-sensor data to evaluate activity safety levels, enabling the detection of unusual movements, loud noises, extreme temperatures, or abnormal lighting as indicators of potential risks. Third, repeated testing over four weeks under varying conditions confirmed the system’s high accuracy in detecting and classifying activity states, as well as its ability to provide rapid notifications through the Blynk application. Finally, the system contributes significantly to enhancing parental supervision and ensuring the safety of autistic children in home environments by delivering real-time information that allows early prevention of potential hazards without complete reliance on manual observation.

ACKNOWLEDGEMENTS

This research was supported by the Research and Community Service Institute of Handayani University Makassar, which provided facilities for the study. The author declares no conflict of interest. This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

REFERENCES

[1] Barokah, A., & Sarasati, B. (2024). Dinamika Peran Orang Tua Menanamkan Kemandirian Anak Autis. 24(2), 171–180.

[2] Dewi, I. P., & Fikri, R. (2023). Optimalisasi Keamanan Rumah dengan Implementasi Sistem Notifikasi Gerbang Cerdas Berbasis Internet of Things (IoT). 4(4), 816–829. https://doi.org/10.47065/josyc.v4i4.4004

[3] Fitriani, T. (2023). Pengaruh Media Lego Terhadap Kemampuan Mengenal Warna Pada Anak Autis Kelas Dasar II di UPT SLB Negeri 1 Bone. http://eprints.unm.ac.id/34306/%0Ahttp://eprints.unm.ac.id/34306/1/JURNAL Fitriani T.pdf

[4] Hadi, S., Dewi, P., Labib, R. P. M. D., & Widayaka, P. D. (2022). Sistem Rumah Pintar Menggunakan Google Assistant dan Blynk Berbasis Internet of Things. MATRIK : Jurnal Manajemen, Teknik Informatika Dan Rekayasa Komputer, 21(3), 667–676. https://doi.org/10.30812/matrik.v21i3.1646

[5] Maulana Malik Ibrahim, F., Dedy Irawan, J., & Primaswara Prasetya, R. (2023). Rancang Bangun Rumah Pintar Dengan Konsep Internet of Things (Iot) Berbasis Web. JATI (Jurnal Mahasiswa Teknik Informatika), 7(1), 812–821. https://doi.org/10.36040/jati.v7i1.6188

[6] Prafanto, A., Budiman, E., Widagdo, P. P., Putra, G. M., & Wardhana, R. (2021). Pendeteksi Kehadiran menggunakan ESP32 untuk Sistem Pengunci Pintu Otomatis. JTT (Jurnal Teknologi Terapan), 7(1), 37. https://doi.org/10.31884/jtt.v7i1.318

[7] Putri, P., & Andraini, L. (2022). Implementasi Iot Untuk Rumah Cerdas Melalui Mikrokontroler Berbasis Wemos. Jurnal Portal Data, 2(6), 1–11. http://portaldata.org/index.php/portaldata/article/view/167

[8] Rahmadhani, V., & Widya Arum. (2022). Literature Review Internet of Think (Iot): Sensor, Konektifitas Dan Qr Code. Jurnal Manajemen Pendidikan Dan Ilmu Sosial, 3(2), 573–582. https://doi.org/10.38035/jmpis.v3i2.1120

[9] Rosaly, R., & Prasetyo, A. (2020). Flowchart Beserta Fungsi dan Simbol-Simbol. Journal of Chemical Information and Modeling, 2(3), 5–7.

[10] Saputro, U. A., & Tuslam, A. (2022). Sistem Deteksi Kebakaran Berbasis Internet Of Things Dengan Pesan Peringatan Menggunakan NodeMCU ESP8266 Dan Platform ThingSpeak. Jurnal Infomedia, 7(1), 24. https://doi.org/10.30811/jim.v7i1.2958

[11] Saskia Eka Cahyani, Tatang Rohana, & Santi Arum Puspita Lestari. (2023). Implementasi fuzzy logic pada sistem pengairan sawah dalam meningkatkan efisiensi penggunaan air berbasis IoT. INFOTECH : Jurnal Informatika & Teknologi, 4(1), 37–46. https://doi.org/10.37373/infotech.v4i1.496

[12] Setyawan Agus, Prabowo Muhammad Nur, & Suseno Jatmiko Endro. (2020). Rancang Bangun Sistem Keamanan Pintar Pada PintuKamar Menggunakan Rfid, Password Dan AndroidBerbasis Arduino Uno. Berkala Fisika, 23(1), 34–39.

[13] Suparno, W., & Jalil, A. (2021). Sensor Multi-Modal Untuk Deteksi Gerak Objek Pada Sistem Keamanan Rumah Berbasis Komunikasi Node Robot Operating System Multi-Modal Sensor for Object Motion Detection on Home Security System Based on Robot Operating System Nodes Communication. Jurnal Elektro Luceat, 7(1), 1–9.

[14] Zaenal Mutaqin, M., M. Edra Favian, & Ade Kurniawan. (2024). Sistem Smart Home Pemantauan dan Pengendalian Suhu Ruangan Menggunakan Arduino ESP32 Berbasis Green Energy. JUPITER : Journal of Computer & Information Technology, 5(2), 101–113. https://doi.org/10.53990/jupiter.v5i2.355

[15] Zalukhu, A., Swingly, P., & Darma, D. (2023). Perangkat Lunak Aplikasi Pembelajaran Flowchart. Jurnal Teknologi, Informasi Dan Industri, 4(1), 61–70. https://ejurnal.istp.ac.id/index.php/jtii/article/view/351