Automatic Lighting System In Smart Homes For Elderly Based On IOT

Mayla Ayyuni Sonya[1], Kurniawan D. Irianto[2]
[1,2] Department of Informatics, Universitas Islam Indonesia, Yogyakarta, Indonesia
E-mail: [1] 20523241@students.uii.ac.id, [2] k.d.irianto@uii.ac.id

Abstract: The goal of this research is to create and optimise an autonomous lighting system based on the Internet of Things (IoT) in a smart home, with a focus on improving the comfort and safety of the elderly. The system uses LDR and PIR sensors, as well as embedded IoT devices, to automatically modify illumination in response to changes in light intensity and the presence of occupants. The research results suggest that the created autonomous lighting system works well with its components. Testing shows that the LDR and PIR sensors respond quickly to changes in light and motion, with the light reacting according to the local time set by the RTC. When the LED lights are turned on, the brightness may be changed using the dimmer. The system can also be controlled remotely via a mobile application. During the testing phase, black box testing methodologies were used to optimise the system's functional capabilities, guaranteeing that users may easily monitor the automatic lighting via the application interfaces. As a result, the system has demonstrated that both the hardware and the Blynk application are effective in managing the lights, making it simple for people to manage while giving significant benefits.

Keywords: *IoT, ESP32, Blynk, Blackbox Testing.*

INTRODUCTION

As the world's population ages, the number of senior persons grows. Ageing is an unavoidable process that is typically assessed by chronological age, with persons 65 years or more referred to as elderly (Singh et al., 2014). However, ageing differs depending on genetics, lifestyle, and health. The elderly can be grouped by age (65-75, 76-85, >85) to better understand the ageing process (Hochel, 2019). Globally, the number of elderly individuals is growing. According to the World Health Organisation (WHO), the number of individuals aged 60 and up will treble by 2050, while the number of people aged 80 and up will reach 400 million. The senior population is anticipated to reach 1.2 billion by 2025 and two billion by 2050 (Shrivastava et al., 2013). Medical advances, improved access to care, and preventive medications have all contributed to this growth. Indonesia now has a 9.6% aged population, which is close to the 10% level that qualifies it as an ageing country. According to 2019 data, five Indonesian provinces have a percentage of senior persons exceeding 10%: DI Yogyakarta, Central Java, East Java, Bali, and West Sulawesi (Hakim, 2020). The senior population in Indonesia is expected to reach 28.8 million (11.3%) by 2020 (Mahwati, 2014).

The growing geriatric population causes changes in illness patterns, with chronic medical disorders such as multimorbidity becoming more common as people get older. Multimorbidity is defined as the presence of two or more chronic diseases in the same person, and it affects 55% to 98% of the older population (Mahwati, 2014). The decline in physical performance induced by this condition has an impact on a person's functional status, which is measured using five Activities of Daily Living (ADL) such as dressing, bathing, getting in and out of bed, eating, and toileting (Madyaningrum et al., 2018). This makes it difficult for the elderly to carry out home duties, such as managing daily electricity usage.

Today's advancements in smart home technology make it possible to create a more welcoming atmosphere for seniors. Smart houses are residences that use modern technology to give personalised services to their users (Hong et al., 2022). This technology, which includes Internet of Things (IoT) sensors, enables homes to automatically detect and adapt to the demands of their occupants. A prepaid smart power system that can monitor electricity usage via smartphone is one example of smart home deployment (Irianto, 2023). Furthermore, with smart home technology, the elderly can control numerous components of their home, such as lighting, via a smartphone app, allowing them to overcome physical constraints and increase their independence (Liao et al., 2023). Furthermore, the elderly in Indonesia are increasingly using mobile phones and internet access, proving their technological adaption (Basrowi et al., 2021).

Nowadays, technological breakthroughs have created several options to improve the quality of life for the elderly through the use of smart homes. Smart home technology is defined as the integration of services and communication, the use of computing and information technology, environmental intelligence and automatic control, and the ability to monitor and control remotely in order to improve comfort, security, energy efficiency, and meet the needs of its inhabitants (Sovacool, 2020). Pal et al. (2018) define a smart house as a combination of technology and services delivered over a home network with the goal of increasing the residents' quality of life. In the era of smart home networks, Power Line Carrier Systems and X10 technologies are followed by ZigBee and Z-Wave, which provide efficient alternatives for managing household devices using radio waves and mesh network principles (Robles et al., 2010).

Several studies have shown that smart home technology, particularly in lighting control, has a high potential for providing effective solutions to the issues that the elderly encounter. Deepak Kumar Rath's (2016) research in "Arduino Based: Smart Light Control System" emphasises the necessity of an efficient and energy-saving lighting system that incorporates external lighting conditions evaluation and automatic lamp changes. Furthermore, the studies by Siddhart Wadhwani et al. (2018) on "Smart Home Automation and Security System using Arduino and IoT" and Widyaningrum and Pramudita (2018) on "Automatic Lamp and Fan Control Based on Microcontroller" provide an overview of the use of sensors and microcontrollers to automatically control electronic devices in the home, including lighting.

However, there is a gap between the ideal concept and its practical application in the setting of the elderly. Although smart home technology is fast advancing and has the potential to improve the lives of the elderly by providing them more control over their surroundings, there are still barriers to widespread adoption among the older population. Although the amount of elderly persons using mobile phones and accessing the internet has increased, more efforts are needed to ensure that this technology is widely accepted by this demographic. This is in contrast to the reality that potential consumers' impressions of smart home technology design and control are impacted by their desire for comfort, security, energy efficiency, and intuitive ness of use (Wilson et al. 2017). Furthermore, given the Indonesian population's economic situation, the initial cost of adopting IoT systems frequently serves as a barrier for building owners, despite the potential for large long-term savings. Government incentives and support for innovative ventures might help to overcome financial constraints. A lack of awareness and technical capabilities in establishing and administering IoT systems is also an issue that must be addressed (Adhicandra, 2024).

As a result, this study adds considerable additional value by developing an Internet of Things (IoT)-based automatic lighting control system specifically customised to the needs of the elderly. According to the definition, the Internet of Things (IoT) is a network of connected electronic devices that allows data exchange and communication among them via an integrated system (Taiwo et al., 2021); the lighting system will follow these guidelines. This technology not only uses light and motion sensors to automatically modify lighting, but it also takes into account issues such as ease of use and accessibility for the elderly. Furthermore, the mobile application linked to this system will enable users to easily and efficiently adjust the illumination, even from a distance.

Thus, the goal of this research is to create an Internet of Things (IoT)-based automatic lighting control system for smart homes that is specifically tailored to the elderly. This technology will allow the elderly to regulate the timing of turning lights on and off, as well as alter the intensity of lighting both manually and automatically, so overcoming their difficulties in regulating electricity usage at home and increasing their independence and comfort in life.

RESEARCH METHOD

This study takes an experimental approach with a systematic design that merges hardware and software components to create an Internet of Things (IoT)-based autonomous lighting system with the NodeMCU ESP32 as its brain. The NodeMCU ESP32, Light Dependent Resistor (LDR) light sensor, Passive Infrared (PIR) motion sensor, relay, Real Time Clock (RTC), dimmer, Light Emitting Diode (LED) light, and the Blynk application are among the components of the IoT-based autonomous lighting system research.

The method for performing this research is to put the system on a miniature house as a demonstration instrument.

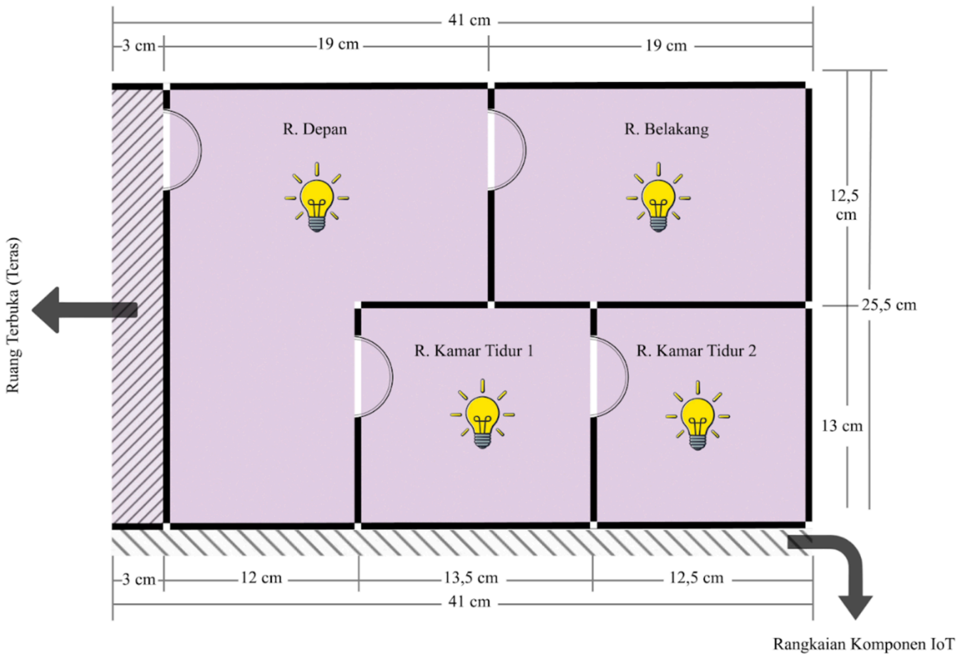

Figure 1. LED Light Installation Layout Design

Testing involved confirming hardware and software functionality and mimicking real-world scenarios such as changes in light intensity, motion detection, morning or afternoon, and midnight.

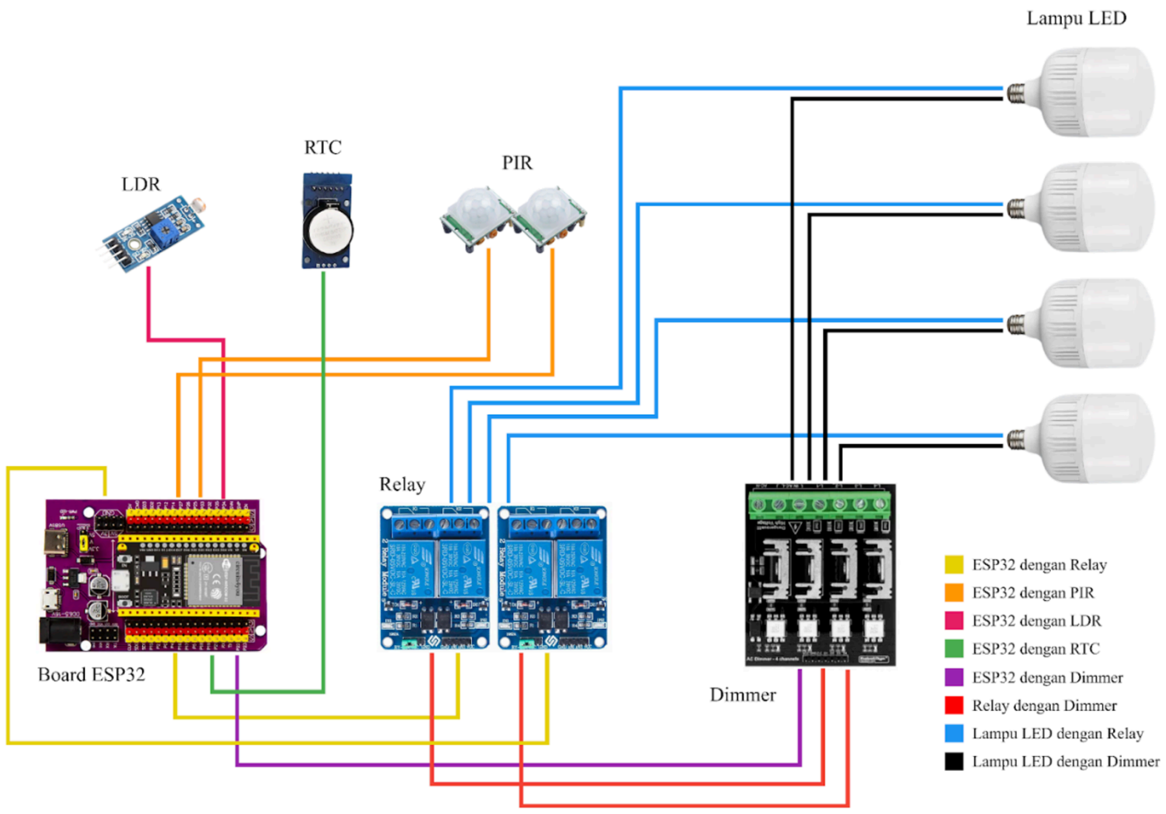

Figure 2. Hardware Design

The Nodemcu ESP32 is necessary for the system integration assembly to function. This microcontroller was chosen as the system's brain because of its ability to connect to the internet using WiFi. The LDR light sensor and PIR motion sensor are used to monitor ambient factors as well as human activities. The lights are controlled by a relay, and the RTC allows the system to record and manage time for automatic scheduling. LED lights and dimmers serve as light sources with adjustable brightness levels. The NodeMCU ESP32 microcontroller is programmed using the Arduino IDE, and the Blynk application serves as the user interface, allowing users to monitor and control the lights wirelessly. Screwdrivers, cutters, rulers, scissors, and glue guns are used to create a house miniature for demonstration purposes. The system components are also physically assembled using jumper wires, black tape, acrylic, styrofoam, and screws.

Data was collected through a series of tests involving the verification of hardware and software functions as well as simulations of real conditions. The tests were conducted using the blackbox testing method to ensure that the system functions according to the specified requirements. Testing with this method aims to assess the performance of each feature in the configured application. This test does not evaluate the program code in depth. Data analysis is conducted by comparing the test results with the expected expectations, and the conformity between the two is evaluated.

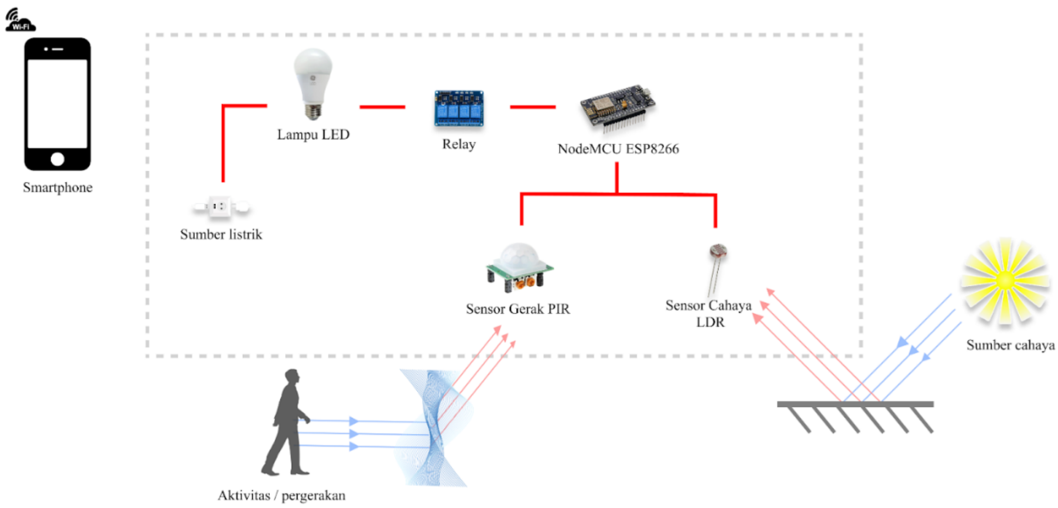

Figure 3. System Topology

Table 1. Component Testing Parameters

No	Component	Testing	Expected Results
1.	Blynk Application	Testing all Blynk interface features in various modes	The LED indicator light turns on and off.
2.	Sensor LDR	Testing the LDR sensor in various lighting conditions	The indicator shows the relay is off and current is flowing.
3.	Sensor PIR	Testing the PIR sensor to detect moving objects	The indicator shows the relay is off and current is flowing.
4.	RTC	Observing time with the RTC scheduling algorithm	The indicator shows the relay is off and current is flowing.
5.	Dimmer	Testing the dimmer in adjusting the brightness of the LED light.	The light of the LED lamp can change: bright, dim, and dark.

The Vivo V19 smartphone, which runs Funtouch OS 10 and Android 10, will serve as the testing platform. The black box testing included testing the manual mode, sensor automated mode, and scheduling mode to see whether the LED light goes on or off under specific conditions or inputs in these three modes.

RESULTS AND DISCUSSION

The research findings include an examination of the functions of each major component, including the LDR light sensor, PIR motion sensor, relay, dimmer, and RTC. Testing was carried out under a variety of scenarios to guarantee that the system performed optimally in detecting light intensity, movement, and time settings. In addition, the findings of user interface testing using the Blynk program will be shared to assess the convenience and efficacy of remote control. Data obtained from real-world simulations and testing of hardware and software operation provide a comprehensive picture of the produced system's reliability and efficiency. The adoption of this hardware leads to the creation of an autonomous lighting system linked to the Internet of Things (IoT). This technique is used on a miniature house with four lights installed in various rooms, including the living area or front room, the back room, and two bedrooms. Figure 4 depicts the placement of the lights and sensors in the miniature house. The LDR light sensor is put in the front room since it has the best access to ambient light, whereas the PIR motion sensor is positioned in the bedroom to detect movement in a low-light environment.

Figure 4. Miniature Top View

A little house is shown above, complete with an LDR sensor, a PIR sensor, and an RTC. The LDR sensor linked to the ESP32 board detects light intensity. The ESP32 digitally processes data from the LDR sensor. If the LDR sensor detects enough light, the ESP32 instructs the relay to turn off the LED lights. If the LDR sensor does not detect light, the ESP32 keeps the relay active, allowing the light to remain on. The PIR sensor detects movement and operates similarly to the LDR sensor, but based on motion. This system functions in the mode set in the Blynk application. The RTC on the tiny controls the automatic scheduling based on time.

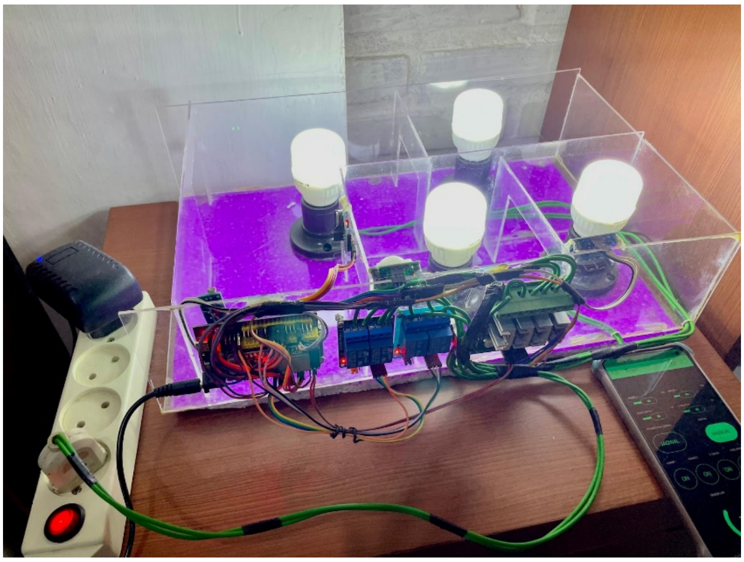

Figure 5. Setting the Automatic Lighting System

Figure 5 depicts the different IoT components that have been implemented, including the ESP32 board as the control core, LDR sensors for measuring light intensity, PIR sensors for motion detection, relays for power switches, and dimmers for controlling the brightness of four LED lights. The power adapter is linked to the ESP32 board and plugged into a power source, as is the socket for the LED light fittings. This system is then tested to ensure that all components operate in accordance with the stated requirements, optimising autonomous lighting control in a variety of environmental and user scenarios.

Software Implementation

The Blynk application for Android devices was chosen for the construction of an IoT-based automatic lighting system due to its functionality and convenience of use in IoT projects. Blynk provides a straightforward interface with a 'drag and drop' idea, making it simple to organise widgets based on project requirements. This application requires an internet connection to function.

The image above depicts the Blynk interface when the ESP32 is linked to the smartphone's hotspot network, allowing users to instantly operate the autonomous lighting system. In "manual" mode, users can turn the lights on and off using the app's four on-off buttons. The "automatic" and "schedule" modes enable the system to run according to pre-defined configurations. The "schedule" mode uses the RTC to set the lights' on and off periods, whereas the "automatic" mode relies on data from the PIR and LDR sensors. The dimmer can be used in any mode as long as the lights are turned on, and the settings can be modified via Blynk.

Figure 6. Blynk Interface

Blackbox Testing Results

In this test, test scenarios covering multiple input situations were constructed to confirm that each component, such as the LDR sensor, PIR sensor, relay, RTC, and dimmer, performs as intended. The test results data demonstrate that the automatic lighting system meets the desired parameters. Each component works together in harmony and responds to the input. The reaction findings are recorded in the table below to guarantee that the automatic lighting system operates effectively and efficiently.

Table 2. Blackbox Testing Results

No	Testing Scenario	Expected Results	Conclusion
1.	Input “on” pada tombol mode	- Label pada *button* mode manual berubah menjadi “manual” - Label pada seluruh *button* lampu berubah menjadi “on” - Lampu indikator *relay* 1 modul 1 menyala - Lampu indikator *relay* 1 modul 2 menyala - Lampu indikator *relay* 2 modul 1 menyala - Lampu indikator *relay* 2 modul 2 menyala - Lampu LED ruang depan menyala - Lampu LED ruang belakang menyala - Lampu LED kamar 1 menyala - Lampu LED kamar 2 menyala - *Dimmer* ruang depan aktif - *Dimmer* ruang belakang aktif - *Dimmer* kamar 1 aktif - *Dimmer* kamar 2 aktif	[✓] Valid [ ] Tidak Valid
2.	Input “off” pada tombol mode “manual”	- Label pada *button* mode manual berubah menjadi “off” - Label pada seluruh *button* lampu berubah menjadi “off” - Lampu indikator *relay* 1 modul 1 padam - Lampu indikator *relay* 1 modul 2 padam - Lampu indikator *relay* 2 modul 1 padam - Lampu indikator *relay* 2 modul 2 padam - Lampu LED ruang depan padam - Lampu LED ruang belakang padam - Lampu LED kamar 1 padam - Lampu LED kamar 2 padam - *Dimmer* ruang depan nonaktif - *Dimmer* ruang belakang nonaktif - *Dimmer* kamar 1 nonaktif - *Dimmer* kamar 2 nonaktif	[✓] Valid [ ] Tidak Valid

3.	Input “on” untuk lampu LED di ruang depan (dalam mode manual)	- Label pada *button* lampu berubah menjadi “on” - Lampu indikator *relay* 1 modul 1 menyala - Hanya Lampu LED ruang depan menyala - *Dimmer* ruang depan aktif	[✓] Valid [ ] Tidak Valid
4.	Input “off” untuk lampu LED di ruang depan (dalam mode manual)	- Label pada *button* lampu berubah menjadi “off” - Lampu indikator *relay* 1 modul 1 padam - Hanya Lampu LED ruang depan padam - *Dimmer* ruang depan nonaktif	[✓] Valid [ ] Tidak Valid
5.	Input “on” untuk lampu LED di ruang belakang (dalam mode manual)	- Label pada *button* lampu berubah menjadi “on” - Lampu indikator *relay* 1 modul 2 menyala - Hanya Lampu LED ruang belakang menyala - *Dimmer* ruang belakang aktif	[✓] Valid [ ] Tidak Valid
6.	Input “off” untuk lampu LED di ruang belakang (dalam mode manual)	- Label pada *button* lampu berubah menjadi “off” - Lampu indikator *relay* 1 modul 2 padam - Hanya Lampu LED ruang depan padam - *Dimmer* ruang belakang nonaktif	[✓] Valid [ ] Tidak Valid
7.	Input “on” untuk lampu LED di kamar 1 (dalam mode manual)	- Label pada *button* lampu berubah menjadi “on” - Lampu indikator *relay* 2 modul 1 menyala - Hanya Lampu LED kamar 1 menyala - *Dimmer* kamar 1 aktif	[✓] Valid [ ] Tidak Valid
8.	Input “off” untuk lampu LED di kamar 1 (dalam mode manual)	- Label pada *button* lampu berubah menjadi “off” - Lampu indikator *relay* 2 modul 1 padam - Hanya Lampu LED kamar 1 padam - *Dimmer* kamar 1 nonaktif	[✓] Valid [ ] Tidak Valid
9.	Input “on” untuk lampu LED di kamar 2 (dalam mode manual)	- Label pada *button* lampu berubah menjadi “off” - Label pada *button* lampu berubah menjadi “on” - Lampu indikator *relay* 2 modul 2 menyala - Hanya Lampu LED kamar 2 menyala - *Dimmer* kamar 2 aktif	[✓] Valid [ ] Tidak Valid
10.	Input “off” untuk lampu LED di kamar 2 (dalam mode manual)	- Label pada *button* lampu berubah menjadi “off” - Lampu indikator *relay* 2 modul 2 padam - Hanya Lampu LED kamar 2 padam - *Dimmer* kamar 2 nonaktif	[✓] Valid [ ] Tidak Valid

11.	Input “otomatis” pada tombol mode “otomatis dan jadwal”, berikan cahaya dari luar jendela ruangan	- Label pada *button* mode manual dan otomatis berubah menjadi “otomatis” - Label pada *button* lampu ruang depan berubah menjadi “on” - Lampu indikator *relay* 1 modul 1 menyala - Lampu LED ruang depan menyala - *Dimmer* ruang depan aktif - Data perubahan nilai intensitas cahaya akan tampil pada *dashboard gauge* sensor LDR.	[✓] Valid [ ] Tidak Valid
12.	Input “otomatis” pada tombol mode “otomatis dan jadwal”, berikan gerakan/ayunan benda disekitar sensor	- Label pada *button* mode manual dan otomatis berubah menjadi “otomatis” - Label pada *button* lampu kamar 1 dan kamar 2 berubah menjadi “on” - Lampu indikator *relay* 2 modul 1 menyala - Lampu indikator *relay* 2 modul 2 menyala - Lampu LED kamar 1 menyala - Lampu LED kamar 2 menyala - *Dimmer* kamar 1 aktif - *Dimmer* kamar 2 aktif	[✓] Valid [ ] Tidak Valid
13.	Input “jadwal” pada tombol mode “otomatis dan jadwal” pada pukul 14:00 (*range* waktu 06:00 - 18:00 opsional)	- Label pada *button* mode manual dan otomatis berubah menjadi “jadwal” - Label pada seluruh *button* lampu berubah menjadi “off” - Lampu indikator *relay* 1 modul 1 padam - Lampu indikator *relay* 1 modul 2 padam - Lampu indikator *relay* 2 modul 1 padam - Lampu indikator *relay* 2 modul 2 padam - Lampu LED ruang depan padam - Lampu LED ruang belakang padam - Lampu LED kamar 1 padam - Lampu LED kamar 2 padam - *Dimmer* ruang depan nonaktif - *Dimmer* ruang belakang nonaktif - *Dimmer* kamar 1 nonaktif - *Dimmer* kamar 2 nonaktif	[✓] Valid [ ] Tidak Valid
14	Input “jadwal” pada tombol mode “otomatis dan jadwal” pada pukul 20:00 (range waktu 06:00 - 18:00 opsional)	- Label pada *button* mode manual dan otomatis berubah menjadi “jadwal” - Label pada seluruh *button* lampu berubah menjadi “on” - Lampu indikator *relay* 1 modul 1 menyala - Lampu indikator *relay* 1 modul 2 menyala - Lampu indikator *relay* 2 modul 1 menyala - Lampu indikator *relay* 2 modul 2	[✓] Valid [ ] Tidak Valid

	menyala - Lampu LED ruang depan menyala - Lampu LED ruang belakang menyala - Lampu LED kamar 1 menyala - Lampu LED kamar 2 menyala - *Dimmer* ruang depan aktif - *Dimmer* ruang belakang aktif - *Dimmer* kamar 1 aktif - *Dimmer* kamar 2 aktif

Discussion

The automatic light system testing was conducted using the results table above to ensure that each mode works as planned. The testing of this system begins with the input "on" being entered on the "manual" mode button. The intended outcome is that the label on the manual mode button is changed to "manual," and the label on all of the light buttons is changed to "on." Additionally, all indication lights on relay modules 1 and 2 are expected to illuminate. The LED lights in the front, back, room 1, and room 2 are also expected to turn on, as will the dimmer in all four rooms. All of the intended events in this scenario have been achieved, hence it is considered genuine.

The "manual" mode button was then turned "off" for testing purposes. In this case, it is intended that the label on the manual mode button switches to "off" and that all lights and dimmers turn off. According to the test findings, all indication lights on relay modules 1 and 2 turned off, as did the LED lights in the front, back, room 1, and room 2, and all dimmers became inactive. These results are consistent with predictions and are considered valid.

Further testing include manually supplying "on" and "off" inputs to each LED light in the front, back, rooms 1, and 2. When the "on" input is applied to the front room LED light, the light button label changes to "on," indicator light 1 on module 1 illuminates, and the front room dimmer is triggered. When the "off" input is entered, the light button label changes to "off," indicator light 1 on module 1 goes out, just the LED light in the front room turns out, and the front room dimmer is off. A same scenario applies to the LED lights in the back room, room 1, and room 2, with the predicted results obtained in each test, resulting in all being pronounced valid. In the "automatic and schedule" mode, testing is carried out by delivering "automatic" input accompanied by changes in light from outside the room window and motion surrounding the sensor. In the first scenario, the expected outcomes include changing the mode button label to "automatic," changing the light button label in the front room to "on," turning on the indicator light of relay 1 on module 1, turning on the LED light in the front room, and activating the front room dimmer. The LDR sensor gauge dashboard will also provide data on light intensity variations. All predicted results in this scenario are attained, hence it is pronounced genuine. In the second scenario, when there is movement around the sensor, the mode button label changes to "automatic," the light button labels in rooms 1 and 2 change to "on," the indicator light of relay 2 on modules 1 and 2 turns on, the LED lights in rooms 1 and 2 turn on, and the dimmers in both rooms activate. The results of this test also satisfy expectations and have been certified legitimate.

Finally, the testing was carried out by entering "schedule" at 14:00 and 20:00. At 14:00, during the time range of 06:00 - 18:00, the predicted consequence was the changing of the mode button label to "schedule," all light button labels to "off," all relay indicator lights on modules 1 and 2 switched off, LED lights throughout the room turned off, and all dimmers became inactive. The test results revealed that all of these prerequisites had been met, hence they were deemed genuine. At 20:00, outside of the time frame of 06:00 - 18:00, the predicted outcome was the changing of the mode button label to "schedule," all light button labels to "on," all relay indicator lights on modules 1 and 2 switched on, LED lights throughout the room turned on, and all dimmers became active. These test findings met expectations and were therefore judged valid.

With accurate findings in all testing scenarios, it is possible to infer that this automatic lighting system is successful and efficient in automating light control based on environmental variables.

The findings of this study will be compared to prior expert studies on automatic lighting systems in smart homes. Rath (2016) investigated the usage of Arduino to control lights by adjusting to external light, which is comparable to the testing done in this work on the automatic lighting system. Similarly, Widyaningrum and Pramudita (2018) built an automatic lighting system utilising the Arduino microcontroller, with a focus on the utilisation of LDR and DHT11 sensors. Furthermore, Nur Aishah Zainuddin et al. (2019) investigate light automation using PIR motion sensors, which is consistent with the automatic mode testing in this work. Wadhwani et al. (2018) discuss the usage of Arduino in smart home control, but they focus more on security. Nonetheless, this study makes a significant addition by thoroughly testing multiple operating modes of the automatic lighting system, including manual, automatic, and scheduled modes, and proving success according to expectations in each test scenario. Thus, the findings of this study demonstrate that the suggested automatic lighting system is effective and efficient at automating light management based on environmental variables.

CONCLUSION

This study intends to create an Internet of Things (IoT)-based automatic lighting control system tailored to the needs of the elderly. The introduction explains how the elderly's difficulties, such as difficulty controlling lights owing to physical limits and multimorbidity, can be solved by implementing smart home technology. The designed system combines light and motion sensors to automatically adjust lighting and includes a mobile app for simple and efficient operation.

The test results reveal that the system meets the intended parameters, as described in the "Results and Discussion" chapter. The blackbox testing approach ensures that each component performs properly, from the sensor to the settings in the Blynk application. This technology not only automates light control effectively and efficiently, but it is also user-friendly and accessible to the elderly.

This research has a wide range of potential directions. Some prospective advances include integration with other smart home devices such as temperature control, home security, and entertainment systems to improve the elderly's overall quality of life. Furthermore, the development of a mobile application interface that is more user-friendly for the elderly with limited technology, the addition of security features such as notifications to family members or carers in case of emergencies, and the adaptation of the system for various health conditions of the elderly, such as visual impairments or mobility limitations, with simpler voice control or remote control features, are important steps for the improvement of this.

The findings of this study pave the way for longitudinal studies that will look into the long-term impact of employing this system on the independence and quality of life of the elderly. Furthermore, implementing and evaluating the system in a variety of settings, such as nursing homes in both urban and rural areas, will aid in determining its usefulness in varied situations. Collaboration with healthcare providers can also be used to link this system with aged care programs, resulting in a more comprehensive solution. The application of concepts such as those found in Germany, namely Ambient Assisted Living (AAL), is the ability to respond quickly to the physical conditions and home environment of the elderly (Zhang et al., 2020), allowing for early detection of emergencies or health changes that require medical attention.

REFERENCE

Albana, I., Asgalani, A., & Rachmadani, M. D. (2021). Esensial Internet Of Things Dalam Konsep Bangunan Cerdas (Studi Kasus: ESP8266 dan Prediksi Energi). *Prosiding Seminar Teknologi Perencanaan, Perancangan, Lingkungan Dan Infrastruktur*, 457–461.

Adhicandra, I. (2024). Studi Kasus Tentang Penggunaan Teknologi Internet of Things (IoT) Dalam Meningkatkan Efisiensi Energi di Bangunan Pintar. *Edusaintek: Jurnal Pendidikan, Sains danTeknologi*. https://doi.org/10.47668/edusaintek.v11i3.1297

Basrowi, R. W., Rahayu, E. M., Khoe, L. C., Wasito, E., & Sundjaya, T. (2021). The Road to Healthy Ageing: What Has Indonesia Achieved So Far?. *Nutrients*, 13(10), 3441. https://doi.org/10.3390/nu13103441

Hong, Y.-K., Wang, Z.-y., & Cho, J. Y. (2022). Global Research Trends on Smart Homes for Older Adults: Bibliometric and Scientometric Analyses. *International Journal of Environmental Research and Public Health*, 19(22), 14821. https://doi.org/10.3390/ijerph192214821

Irianto, K. D. (2023). Pre-SEMMS: A Design of Prepaid Smart Energy Meter Monitoring System for Household Uses Based on Internet of Things. *Journal of Electronics, Electromedical Engineering, and Medical Informatics*, 5(2), 69-74. https://doi.org/10.35882/jeeemi.v5i2.282

Liao, J., Cui, X., & Kim, H. (2023). Mapping a Decade of Smart Homes for The Elderly in Web of Science: A Scientometric Review in CiteSpace. *Buildings*, 13, 1581. https://doi.org/10.3390/buildings13071581

Mahwati, Y. (2014). Determinants of Multimorbidity among The Elderly Population in Indonesia. *Kesmas, Jurnal Kesehatan Masyarakat Nasional*, 9(2), November 2014.

Madyaningrum, E., Chuang, Y.-C., & Chuang, K.-Y. (2018). Factors Associated with The Use of Outpatient Services among The Elderly in Indonesia. *BMC Health Services Research*, 18, 707.

Pal, D., Funilkul, S., Charoenkitkarn, N., & Kanthamanon, P. (2018). Internet-of-Things and Smart Homes for Elderly Healthcare: An End User Perspective. *IEEE Access*. https://doi.org/10.1109/ACCESS.2018.2808472

Patel, J., Thorat, S., & Dusane, S. (2020). Automatic Street Lighting Control System Using Microcontroller and Sensors. *International Journal of Scientific Research in Science, Engineering and Technology*. https://doi.org/10.32628/IJSRSET2072114

Rath, D. K. (2016). Arduino Based: Smart Light Control System. *International Journal of*

Engineering Research and General Science, 4(2), March-April, 2016.

Robles, R. J., & Kim, T.-h. (2010). Applications, Systems and Methods in Smart Home Technology: A Review. *International Journal of Advanced Science and Technology*, 15.

Shrivastava, S. R. B. L., & Shrivastava, P. S. (2013). Health-care of Elderly: Determinants, Needs, and Services. *International Journal of Preventive Medicine (Int J Prev Med)*, 4(10), October 2013.

Sovacool, B. K., & Rio, D. D. F. D. (2020). Smart home technologies in Europa: A Critical Review of Concepts, Benefits, Risks and Policies. *Renewable and Sustainable Energy Reviews*, 148.

Taiwo, O., & Ezugwu, A. E. (2021). Internet on Things-Based Intelligent Smart Home Control System. *Hindawi Security and Communication Networks*.

Trisna, M., et al. (2023). Urgensi Revisi Undang-Undang Tentang Kesejahteraan Lanjut Usia. *Jurnal Masalah-Masalah Sosial*, Volume 11, No. 1 Juni 2020.

Wadhwani, S., Singh, U., Singh, P., & Dwivedi, S. (2018). Smart Home Automation and Security System using Arduino and IOT. *International Research Journal of Engineering and Technology (IRJET)*, 05(02), Feb-2018.

Wilson, C., Hargreaves, T., & Hauxwell-Baldwin, R. (2017). Benefits and Risks of Smart Home Technologies. *Energy Policy*, 103, 72-83.

Widyaningrum, & Pramudita. (2018). Automatic Lamp and Fan Control Based on Microcontroller. *IOP Conf. Series: Journal of Physics: Conf. Series*, 953, 012146.

Zainuddin, N. A., et al. (2019). Automated Light Control for IoT Application. *International Innovation*.