IoT-Based Intravenous (IV) Therapy Monitoring System for Elderly Care

Faris R. Firdaus[1], Kurniawan D. Irianto[2]
[1,2]Department of Informatics, Faculty of Industrial Technology, Universitas Islam Indonesia, Indonesia
Email: [1]20523194@students.uii.ac.id, [2]k.d.irianto@uii.ac.id

Abstract

The rapid growth of technology has had a tremendous impact on many parts of life, including medicine. One of its most significant advancements is the Internet of Things (IoT), which allows electrical gadgets to connect more efficiently. In the realm of health, IoT has enabled smart solutions such as intravenous (IV) therapy monitoring systems for elderly patients receiving outpatient care. Elderly patients sometimes require intravenous therapy, which necessitates careful monitoring. However, physical and cognitive limitations make it difficult for individuals to operate intravenous devices on their own. As a result, an IoT-based intravenous monitoring system has been developed to make it easier for the elderly to monitor their intravenous at home. This technology monitors intravenous volume in real time and sends alarms in the event of fluid delivery issues or failures. This technology is projected to improve the quality of life for older people by providing a sense of security and reducing the need for frequent hospital visits.

Keywords: Internet of Things, Blynk, Intravenous (IV), Elderly Care, Monitoring System

Introduction

The fast growth of technology in the modern period has had a substantial impact on many facets of human life. Human inventiveness is currently on the rise, and gadgets are emerging that can help humans perform better at work, making activities more practical and efficient (Ruslan et al., 2016). In addition, technical developments provide other benefits. For example, when technology becomes more advanced, numerous tools are tested and employed to ensure efficiency and efficacy in all tasks. Several experiments have been carried out to attain optimum efficiency with minimal work and energy (Muhammad, 2013).

The Internet of Things (IoT) is one of the most significant technical advances that has altered the way electronic devices are connected and managed. IoT connects diverse gadgets to the internet, allowing for quick and efficient data interchange. It also allows us to control and monitor electrical devices remotely, making it easier to manage our daily life (Seri and Ansarullah, 2021). In addition, technology improvements have offered new opportunities in a variety of industries, including healthcare. The availability of current technology enables us to have a more effective and cheap healthcare system. Telemedicine technology, for example, enables us to conduct remote medical consultations rather than visiting a hospital (Azlina et al., 2024). This is especially important for communities living in rural or difficult-to-reach areas.

The Internet of Things (IoT) technology has facilitated the creation of a variety of smart solutions to various health problems. Intravenous or Infusion systems, which are used to precisely administer medication or other fluids into a patient's body, are an excellent example (Fikri et al., 2023). Monitoring and control have never been easier or more complex than with IoT-connected infusion devices. IoT connectivity enables smart features like real-time medicine dose monitoring, error or failure warnings, and fluid flow modifications based on patient requirements (Sri et al., 2022).

An intravenous (IV) device is a highly important medical tool, especially for the elderly. Elderly individuals, or people of advanced age, frequently have a variety of health conditions that demand infusion therapy (Fikri et al., 2023). This infusion therapy employs infusion devices designed specifically to deliver fluids or medications into the patient's body through blood vessels (Wanti et al., 2016). The safe and precise use of infusion devices is crucial to the health and comfort of the elderly. Although infusion devices are important for the elderly, they typically struggle to understand and use them efficiently. This might happen for a variety of reasons, such as cognitive decline, vision problems, or a misunderstanding of how to use an infusion device (Irfan et al., 2019). As we age, many things must be maintained, including our physical and mental health, a healthy and consistent diet, and the safety and comfort of our home and surroundings (Zakiyatunnisrina and Irianto, 2024). As a result, it is vital to find solutions that will help the elderly manage their infusion devices more effectively and safely.

With the advancement of IoT, numerous research projects have merged IoT technologies, microcontrollers, and the cloud to develop IoT-based infusion monitoring systems. (Irianto, 2023). With the introduction of technologies like this, elderly individuals should find it easier and more comfortable to manage their own infusion systems. This method provides numerous additional benefits, including increased independence and confidence in their ability to control their own care. Patients will feel safer and more comfortable knowing that their infusion therapy is flowing smoothly and successfully, especially because it is taking place in their own environment at home. Even if home care gives comfort, it is still necessary to provide adequate attention and supervision to ensure the quality of care. To overcome this issue, an infusion monitoring system based on Internet of Things (IoT) technology may be a viable option for older people who prefer home care.

In view of ever-changing technological developments and more complex healthcare demands, this final project aims to develop an autonomous infusion monitoring system using the Internet of Things (IoT). This strategy is specifically designed to meet the needs of older individuals receiving outpatient care at home. This technology enables the elderly to monitor their infusions more conveniently and comfortably. They will not need to visit the hospital on a regular basis to monitor their infusion because this gadget will provide accurate information about the infusion volumes they are receiving. This gadget can also deliver notifications if there are any issues or malfunctions throughout the infusion process.

Research Method

A. Requirement Analysis

The needs analysis aims to determine the components and functionalities required to create an IoT-based infusion monitoring system. This system requires hardware such as the ESP32 microcontroller, load cell sensor, and HX711 module to measure and process the infusion fluid's weight data, as well as an OLED display and buzzer to show information and deliver alarms when the infusion is nearly complete. On the software side, the Arduino IDE is required for programming and Blynk for real-time remote monitoring. This analysis guarantees that all required components are available and functioning optimally to accomplish the system's goals.

Table 1. Hardware and software requirements

Category	Component	Description
Hardware	Mikrokontroler ESP32	Microcontroller with Wi-Fi and Bluetooth, functioning as a control center and data processor.
	Load Cell	Sensor to measure the weight of infusion fluid.
	Module HX711	Signal amplifier to read data from the load cell accurately.
	Oled Arduino	Small screen to display information visually.
	Active Buzzer	Sound generator for alerts when the infusion fluid is almost finished.
	Jumper Cable	Cable to connect components in the circuit.
	Micro USB Cable	Cable for supplying power and programming the ESP32.
Software	Arduino IDE	Software for writing and uploading code to ESP32.
	Blynk	IoT application to monitor infusion fluids in real-time.
	Wokwi	Online simulator to test microcontroller code before implementation.

B. System Design

The goal of this study is to create a system that automatically monitors the status of intravenous fluid usage in geriatric outpatients utilising IoT technology.

The design contains the following research steps:

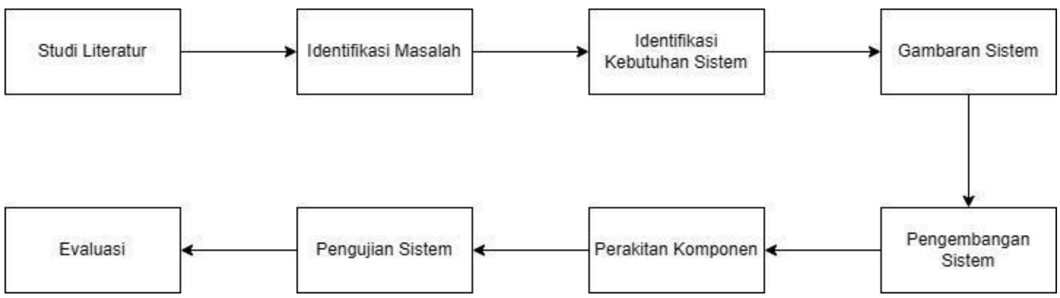

Image 1. Research Steps

1. Problem identification:
   This first stage is analysing the problem at hand, which is the requirement to automatically and in real time monitor the leftover infusion fluid in elderly patients. Elderly patients frequently struggle to report their condition on their own, necessitating the use of an automatic monitoring system that can alert nurses or

family members when the infusion fluid is running low.

2. System requirements identification:
   Several key components are required during the System Requirements Identification stage, including load cell sensors and HX711 to measure the weight of infusion fluids, as well as the ESP32 microcontroller, which interprets data and delivers messages via Wi-Fi. An OLED display displays the fluid content, and a buzzer alerts when the infusion is nearly empty. Nurses and family members can monitor patients remotely in real time with the Blynk app. This system must be precise, generate timely notifications, and be conveniently accessible via an IoT application.
3. System Overview:
   After the requirements have been determined, a general overview of the system is generated. This IoT-based infusion monitoring system is made up of sensors that measure the weight of the infusion fluid and a microcontroller that processes the data and sends it to an OLED display and monitoring apps such as Blynk. When the infusion fluid is nearly done, the system sounds a buzzer and sends notifications to family members or nurses via the application. The system workflow is depicted in Figure 2.
4. System development:
   At this point, software and hardware development is based on the defined requirements. The ESP32 is programmed to read data from the HX711 sensor, compute the remaining volume of infusion fluid, and show the results on an OLED display. The system is also configured to deliver data to the Blynk application in real time. The logic for the buzzer, which sounds at a set volume, is also built.
5. System development:
   At this stage, software and hardware development is carried out in accordance with the defined needs. The ESP32 is set up to read data from the HX711 sensor, compute the remaining volume of infusion fluid, and show the results on an OLED display. The system is also designed to deliver data to the Blynk app in real time. The logic for the buzzer, which sounds at a predetermined volume, is also built.
6. System Testing:
   At this point, the system is rigorously tested to confirm that the measurement of infusion fluid weight is accurate and satisfies the specifications. The system is tested to ensure that alerts are delivered in a timely manner, either via a buzzer or the Blynk application. This testing also includes determining whether data can be accessed in real time from a distance.
7. System evaluation:
   The evaluation is used to determine the system's performance following testing. Failures or difficulties discovered during testing, such as measurement inaccuracies, notification delays, or buzzer malfunctions, will be investigated. Before patients use the system in the real world, improvements are performed to increase its reliability.

This IoT-based infusion monitoring system is designed with numerous critical components to provide accurate and real-time monitoring. A load cell measures infusion fluid by detecting weight variations as the fluid decreases. The weight data is then amplified by the HX711 module and supplied to the ESP32 microprocessor for processing. This microcontroller serves as the processing centre, displaying the remaining infusion volume on the OLED display and activating a buzzer to notify when the fluid is about to run out. In addition, the ESP32 provides data to the Blynk program, allowing for remote monitoring via mobile devices. The graphic below depicts the flow and integration of each component in this system.

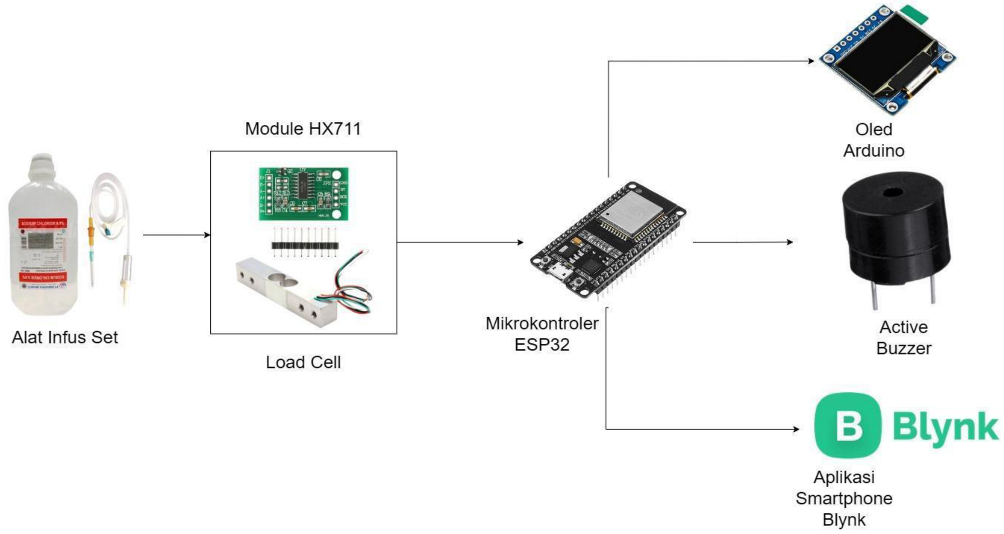

Figure 2. Design System

C. Implementation

Figure 3 depicts the design of the infusion monitoring system. This system is built on the ESP32, a microcontroller that stores program code and interprets data from the HX711 weight sensor, which measures the weight of the infusion. When the infusion weight data is received, the system calculates the remaining fluid volume in the infusion. If the infusion weight indicates that the fluid is nearly empty, the buzzer will sound, and the system will send a notification to the associated Blynk application via the internet. The tool also allows users to track the status of their infusion in real time.

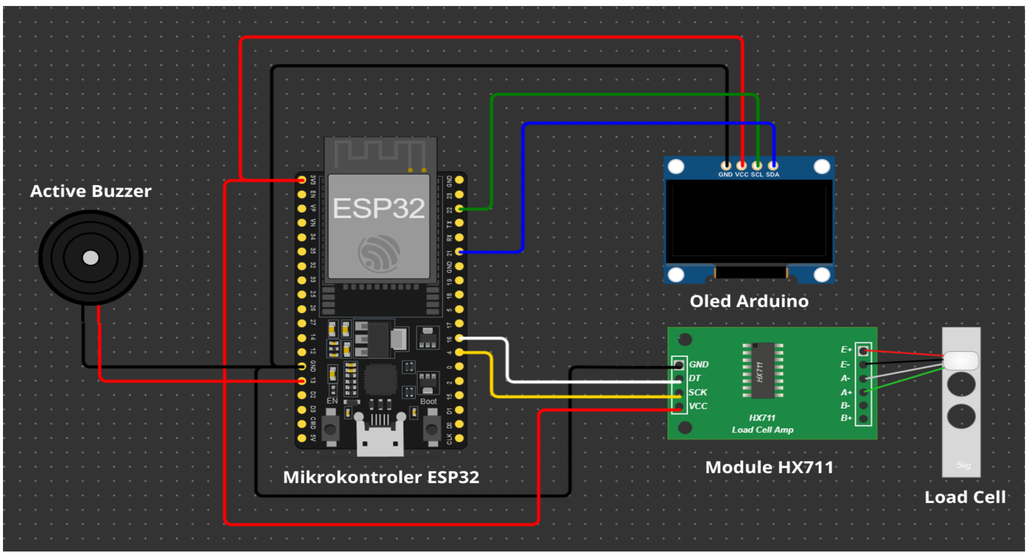

Figure 3. Schematic of the design system

Result

This study develops an autonomous infusion fluid monitoring system for elderly patients utilising IoT technologies. This system's components include the ESP32, HX711 sensor, buzzer module, and OLED display, which were all created with the Arduino IDE platform and Blynk program. This system has undergone black box testing to confirm that all of the features stated in the technical requirements work properly and connect with other systems. (Cipta et al. 2020).

With this advancement, the infusion fluid monitoring device can easily monitor infusion levels in real time, delivering correct information about the remaining fluid volume. Black box testing guarantees that each component meets the specifications (Sasongko et al., 2021), such as infusion weight measurement, refill reminders, and data presentation on the OLED panel. As a result, this technology not only improves the comfort of elderly patients, but it also provides peace of mind to medical professionals and their families. The results of the black box tests are presented below.

A. Arduino IDE Programming

The program for the IoT-based infusion monitoring system is written using the Arduino IDE software. The initial stage involves downloading the essential libraries so that the gadget can function properly. Following that, a program was developed to interface the monitoring system with the Blynk application, allowing for real-time monitoring of infusion fluid volume. This software requires the Auth Token obtained from Blynk, as well as the SSID and WiFi password to be used, to connect the machine to the internet network.

This program sends data from the Load Cell sensor linked to the ESP32 to the Blynk application, allowing users to monitor the infusion volume from any location using their mobile device. Additionally, the monitoring results can be shown immediately on the device's LCD. After completion, the program is uploaded to the ESP32 microcontroller, allowing the monitoring system to function as designed. With this program, the system will function autonomously, offer real-time data, and allow for remote monitoring of patient infusions. Figure 4 depicts a more detailed workflow for this monitoring software.

B. Testing the Accuracy of Infusion Weight Measurement

This test compares the Load Cell sensor's measuring results against a very accurate digital scale. Data is collected whenever there is a 50-gram weight loss in a single infusion. The data is then compared to the measurement results from the digital scale.

Table 2. Comparison of Load Cell Measurements

Scale (gram)	Digital Scale (gram)	Load Cell (gram)	Difference (gram)	Error
500	500,5	496,3	4,2	0,84%
450	450	445,4	4,6	1,02%
400	400	396,1	3,9	0,97%
350	350,6	347,5	3,1	0,88%

300	300,5	298	2,5	0,83%
250	249,4	247,5	1,9	0,76%
200	200,5	198,5	2	1,00%
150	151,5	150,1	1,4	0,92%
100	101,2	100,9	0,3	0,30%
Rata-rata			2,66	0,84%

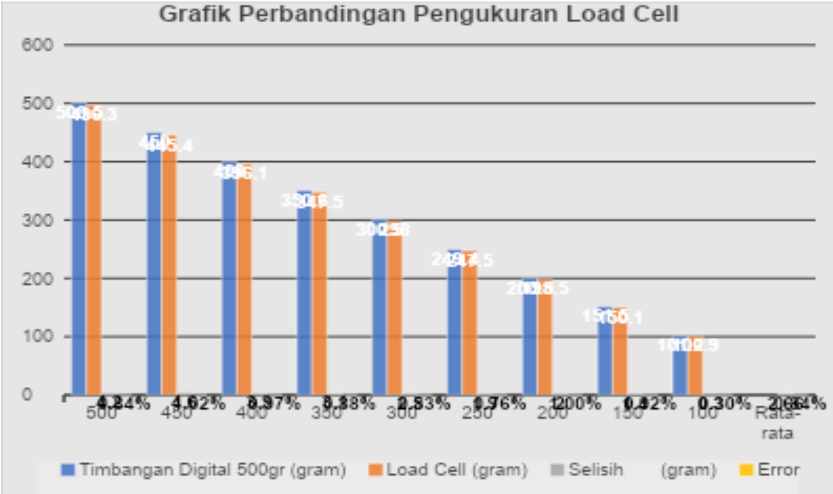

Figure 5. Comparison Graph of Load Cell Measurements

The error figure indicated above was calculated using the method for % error.

$$error=|Y-Z|Z \times 100\%$$

Description:
Y = Load Cell measurement result
Z = Weight measurement scale

Thus, based on the comparison results in Table 1, the Load Cell has an error percentage of 0.84%.

C. Infusion Drop Rate Measurement Testing

After calibrating the Load Cell, testing is performed to determine the weight of the infusion fluid based on differences in drip speed. This test was carried out using a previously created algorithm to track the total volume of infusion fluids. The infusion drip has three speeds: slow, medium, and fast. This test is designed to assess the Load Cell's ability to measure weight as the infusion fluid flows at different speeds. The drip rate is adjusted by a roller clamp on the infusion set. Table 3 shows the weight measurements dependent on the infusion drip rate.

Table 3. Measurement Results Based on Infusion Flow Rate

Flow Rate Measurement		Infusion (gram/minute)	Infusion Average
Low	Experiment 1	5.7	5.53
	Experiment 2	5.6	
	Experiment 3	5.3	
Moderate	Experiment 1	24.9	25.13
	Experiment 2	25.3	
	Experiment 3	25.2	
High	Experiment 1	47.8	45.17
	Experiment 2	45	
	Experiment 3	42.7	

Figure 6. Measurement Graph Based on Infusion Flow Rate

Discussion

A. Blynk Application Design Results

Figure 7 depicts the appearance of the Blynk application after following the previously described methods for constructing it. At the top of the system display, there is a Labelled Value widget that displays the infusion weight digitally. Below it is a Gauge Dashboard widget that transforms weight measurements into volume, allowing nurses and patients to better monitor the remaining volume of the infusion fluid. At the bottom of the display, there is a virtual Push Button that resets the Load Cell sensor measurement to zero in the event of a measurement error or when the nurse wishes to replace the infusion and must reset the sensor reading.

Figure 7. Blynk Application Interface

B. Result of the Electrical Component Circuit Design

Figure 8 depicts the outcomes of the previously mentioned electrical component circuit.

Figure 8. Result of the Electrical Component Circuit

In this system circuit, a perforated PCB serves as a medium for installing and connecting components with solder and tin. The ESP32 microcontroller, HX711 module, active buzzer, and VU and Ground pin connections for the OLED display are all mounted on the PCB using Male and Female Pin Headers. Jumper wires with lengths of 10 cm and 20 cm are used to transfer current from the ESP32 to other components. A ribbon cable with a 4-pin XH connection connects the Load Cell to the HX711 module. This circuit can be powered directly from a power source or via a power bank, allowing the infusion monitoring device to be portable without requiring internal batteries. This allows for greater use without losing the system's key features.

This IoT-based infusion monitoring system is designed using components such as ESP32, HX711 sensor, Zumbador module, and OLED display. All of the components have been assembled and connected to the Blynk platform to allow users to monitor the volume of infusion fluid and receive real-time alerts. The black box test is performed to ensure that the system operates in accordance with the functional specifications without inspecting the source code or internal structure (Abizar et al., 2020).

Initial testing involved calibrating the HX711 sensor to ensure accuracy in detecting the weight of the infusion. This calibration is required so that the sensor can deliver exact readings that are consistent with measurement standards. Following calibration, the sensor measurement data are compared to the reference scale to guarantee accuracy and consistency.

The system testing table shows the results of several settings for monitoring the volume of infusion fluid with the HX711 sensor and the ESP32 microcontroller. This device is intended to monitor the weight loss of infusion fluids and immediately alarm when the fluid volume surpasses a predetermined threshold. When the weight of the infusion fluid approaches zero (0.00 mL), the buzzer will sound continually, indicating that the fluid should be refilled immediately. Additionally, when the fluid volume is between 2 and 10 mL, the buzzer will ring as an early warning.

All of the tests show that this IoT-based infusion fluid monitoring system is capable of offering an effective solution while also making it easy for users to monitor infusions from a distance.

Conclusion

Based on the research findings, the infusion fluid volume monitoring system was successfully created and deployed with Internet of Things (IoT) connectivity capabilities via a smartphone application, enabling for real-time monitoring of infusion volumes. Testing and simulation findings reveal that this system meets the specified standards, providing satisfactory performance and dependability for practical usage. The Load Cell sensor is exceptionally accurate, with a measurement error percentage of only 0.84%. Furthermore, the Active Buzzer has proven useful in providing an auditory warning when the infusion fluid content is between 2 and 10 ml, allowing patients or nurses to be aware that the infusion is nearly empty and must be replaced. The complete system offers a dependable and effective alternative for infusion monitoring.

Reference

Agussalim Ruslan, Adnan, & Niswar Muh. (2016). Monitoring Cairan Infus Berdasarkan Indikator Kondisi Dan Laju Cairan Infus Menggunakan Jaringan Wifi. *ILKOM Jurnal Ilmiah*, *8*(3).

Astuti Sri, Nursaputro Septiantar Tebe, Utomo Ivan Jakeh Dwi Utomo, & Oktaviana Nimas Ayu. (2022). Alat Kendali dan Monitoring Volume Serta Laju Tetes Infus Berbasis Internet of Things. *ORBITH Majalah Ilmiah Pengembangan Rekayasa Dan Sosial*, *18*(3).

Bagus Bayu Sasongko, Fajar Malik, Febry Ardiansyah, Ajeng Fitria Rahmawati, Faisal Dharma Adhinata, & Diovianto Putra Rakhmadani. (2021).) Pengujian Black Box Menggunakan Equivalence Partitions Pada Aplikasi Petgram Mobile. *ICTEE*

Engineering Journals of Information, Control, Telecommunication and Electrical, *2*(1).

Danuari Muhamad. (2013). Perkembangan Dan Transformasi Teknologi Digital. *INFOKAM*, *2*.

Effendy Cut Azlina, Paramarta Vip, & Purwanda Eka. (2024). Peran Teknologi Informasi, Pengelolaan Sumber Daya Manusia, dan Sistem Informasi Rumah Sakit Dalam Meningkatkan Kinerja Rumah Sakit (Kajian Literatur). *Jurnal Review Pendidikan Dan Pengajaran*, *7*(4).

Hadhara Fikri, Munadi Rendy, & Muayyadi Ali. (2023). Alat Monitoring Infus Pasien Berbasis Internet of Things. *E-Proceeding of Engineering*, *10*(5).

Hermawan Lailan Cipta, Mubarok Moh. Rizki, Mairudin Hidayat, Mahdiyan Ahmad, & Yulianti Yulianti. (2020). Pengujian Black Box Pada Aplikasi Verifikasi Data Nasabah Dengan Menggunakan Metode Boundary Value Analysis. *Jurnal Teknologi Sistem Informasi Dan Aplikasi*, *3*(3).

K. D. Irianto, "Pre-SEMMS: A Design of Prepaid Smart Energy Meter Monitoring System for Household Uses Based on Internet of Things", *j.electron.electromedical.eng.med.inform*, vol. 5, no. 2, pp. 69-74, Mar. 2023.

Megawati Seri, & Lawi Ansarullah. (2021). Pengembangan Sistem Teknologi Internet of Things Yang Perlu Dikembangkan Negara Indonesia. *JIEET Journal Information Engineering and Educational Technology*, *05*(01).

Permana Irfan, Rohman Asri Aprilia, & Rohita Tita. (2019). Faktor Faktor Yang Berhubungan Dengan Penurunan Fungsi Kognitif Pada Lansia. *Bina Generasi;Jurnal Kesehatan*, *11*(1).

Rachman Abizar, Arifin Zainal, & Maharani Septya. (2020). Sistem Pengendali Suhu Ruangan Berbasis Internet of Things (IoT) Menggunakan Air Conditioner (AC) Dan NodeMCU V3 ESP82. *Prosiding Seminar Nasional Ilmu Komputer Dan Teknologi Informasi*, *5*(1).

Rihhadatulaisy, Z. H., & Irianto, K. D. (2024). Designing an Automatic Room Temperature Control System for Smart Homes for the Elderly Using IoT. *International Journal Software Engineering and Computer Science (IJSECS)*, *4*(2), 758–766. https://doi.org/10.35870/ijsecs.v4i2.2844.

Seleky Wanti, Kumaat Lucky T, & Mulyadi Ns. (2016). Pengaruh Teknik Penyuntikan Intravena Dengan Cara Mengalirkan Aliran Infus Terhadap Kejadia Flebitis Di Ruang Perawatan Bougenvile RSUD Tobelo. *E-Journal Keperawatan*, *4*(1).