Blood Pressure Monitoring System: An Approach for Elderly Care Using IoT

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Abstract

The expanding elderly population demands special attention, including health monitoring. Blood pressure is an important health indicator for the elderly and should be checked on a regular basis to avoid complications. According to the World Health Organization (WHO), around 1.13 billion people worldwide were diagnosed with hypertension in 2015, which equates to one in every three people. Because of the difficulties in getting to hospitals, the elderly do not constantly monitor their blood pressure. Even while measuring at home, people may neglect to document the results. This paper presents the development of an IoT-based blood pressure monitoring system for the elderly that utilizes the MPX5700AP sensor and can display and store measurements via Blynk and Telegram. Data and information collection, requirement identification, system design, device assembly, implementation, system testing, and assessment are all part of the approach. The test results indicate that the system can precisely detect blood pressure. Thus, this technology can assist the elderly by automatically capturing blood pressure measurements.

Keywords: IoT, Blood Pressure Monitoring, MPX5700AP, Elderly Care, Blynk, Telegram.

Introduction

Elderly people are people over the age of 60. The global population aged 60 and more is anticipated to grow from 1.4 billion in 2020 to 2.1 billion in 2050. Since 2021, Indonesia has transitioned to an old demographic structure, with around one in every ten individuals becoming elderly. In Indonesia, the old population is listed as 15.6 million individuals, or around 5.8% of the overall population of 267.6 million (Ainurohmah & Irianto, 2024). Examination of vital signs is one technique to discover if there is a disturbance in the fundamental functions of the body (Cahyana et al., 2023). The elderly become more vulnerable to disease as they age, particularly from high blood pressure. As a result, it is critical to pay more attention to numerous aspects of well-being, such as physical and mental health, maintaining a regular and balanced diet, and guaranteeing safety and comfort at home (Rihhadatulaisy & Irianto, 2024).

Blood pressure is one of the most significant aspects in maintaining life. Not all blood pressure is within normal ranges, creating blood pressure disorders such as hypertension (high blood pressure) and hypotension (low blood pressure) (Fitriani & Nilamsari, 2017). Blood pressure can be measured using two methods: direct and indirect. The invasive method involves putting a needle into the artery, whereas the non-invasive method involves using a tensiometer to take measures on a daily basis (Sulista et al., 2021). High blood pressure is a major risk factor for heart attacks, heart failure, strokes, arterial aneurysms, and chronic heart failure (Nur Fariz & Jamaaluddin, 2021). According to World Health Organization (WHO) figures from 2015, around 1.13 billion individuals worldwide have hypertension, which equates to one in every three persons.

The number of people with hypertension grows year after year; it is anticipated that 1.5 billion people will have hypertension by 2025, and 9.4 million people will die each year as a result of hypertension and its complications. Hypertension affects 34.1% of the population aged 18 and above, with South Kalimantan having the greatest prevalence (44.1%) and Papua having the lowest (22.2%). Hypertension affects people aged 31-44 (31.6%), 45-54 (45.3%), and 55-64 (55.2%) (K. K. RI, 2019). According to these figures, the 55-64 age group has the highest prevalence of hypertension, accounting for 55.2% or more than half of the entire population. This demonstrates that health services are an important consideration for the elderly.

There are several ways to preserve body health, such as consuming nutritious food, exercising regularly, and having regular medical check-ups, especially for the elderly (Syani et al., 2023). The elderly must be able to keep their blood pressure within safe levels (Talahatu et al., 2024). Limited resources and people, along with an increasing demand for geriatric health care, particularly frequent blood pressure measurement and monitoring, have overburdened hospitals. Not to mention the long distance between house and hospital, which makes it difficult for the elderly to go to check on their health. So a remedy is required by developing a system that can assist health services, particularly in monitoring blood pressure in the elderly.

The internet has permeated every element of human life in the fourth industrial revolution (Prayoga, 2020). The Internet of Things (IoT) is one of the most commonly discussed technology breakthroughs nowadays. The Internet of Things is a communication network in which gadgets and sensors are connected to one other or to a larger system (Ratna et al., 2020). The Internet of Things has the potential to solve the difficulties described above. As a result, researchers hope to develop an Internet of Things-based system that will make it easier for the elderly to monitor their blood pressure on a regular basis. The system uses the MPX5700AP pressure sensor to detect systolic and diastolic values. Systolic pressure is the highest pressure that happens when blood is ejected, whereas diastolic pressure is the lowest pressure that occurs when the ventricles relax and blood remains in the arteries (Isyanto et al., 2022). The MPX5700AP sensor generates an analogue signal, which is converted to a digital signal by the microcontroller, resulting in a calibrated ADC value that improves measurement accuracy. The measurement results are relayed to Blynk and Telegram, which have been set up so that users can view their blood pressure measurement results. The Blynk protocol allows for the sending of raw and processed data from any sensor or actuator connected to the ESP32 to the Blynk cloud database via a data stream. The developed system allows the elderly to monitor their blood pressure regularly without having to write it down in a book or other notes. This makes it easier for medical workers to conduct examinations (Irianto, 2023). This technique is intended to help the elderly avoid problems caused by both high and low blood pressure.

Methodology

The initial procedure involves gathering data and information. During this procedure, researchers collect data and information to use as a reference while developing an elderly blood pressure monitoring system based on the Internet of Things. This intends to aid in the system design process. The next stage is to determine needs. During this phase, researchers determine what requirements exist for developing a system, such as the components that will be employed in system design. In this study, numerous components are required to build the tool. The required components include:

a. ESP32

   ESP32 is a microcontroller with Wi-Fi and Bluetooth capabilities, making it ideal for Internet of Things (IoT) applications. This microcontroller is used to run programs that manage the entire system, communicate with sensors, and transmit data.

b. MPX5700AP pressure sensor
This sensor measures blood pressure in the system, detects cuff pressure during inflation and deflation, and calculates systolic and diastolic pressure values.

c. Solenoid
In this design, the solenoid serves as an escape point for air from the cuff during blood pressure measurement.

d. Motor Driver L298N
This driver controls the DC motor pump and solenoid that govern the inflation and deflation of the cuff during blood pressure monitoring.

e. DC Motor Pump
This DC motor pump pumps air into the cuff.

f. Cuff
The cuff is a physical component that is placed on the user's arm to measure blood pressure. The cuff will grow and press against the user's arm, briefly restricting blood flow.

g. Breadboard
This utility employs a breadboard to connect VCC and GND to the ESP32 and other components.

h. Power Supply
A power source that delivers voltage and electric current to the complete electronic system. This tool runs on a battery.

i. Jumper cable
Jumper cables are used for connecting system components.

j. I2C 16x2 LCD
LCDs are used to display data such as blood pressure measurement results.

Figure 1. Diagram of Research Methods

Then there is system design, which involves the researcher creating a system workflow in the form of a flowchart that represents a stage of blood pressure measurement. Flowchart Design for Internet of Things Implementation attempts to assist program development while minimizing errors during the programming process (Fadjar Bastari et al., 2023). Following that, the procedure is continued by generating a schematic to serve as a guide for assembling the tool. Flowcharts are used to represent the steps that occur when the system is operational.

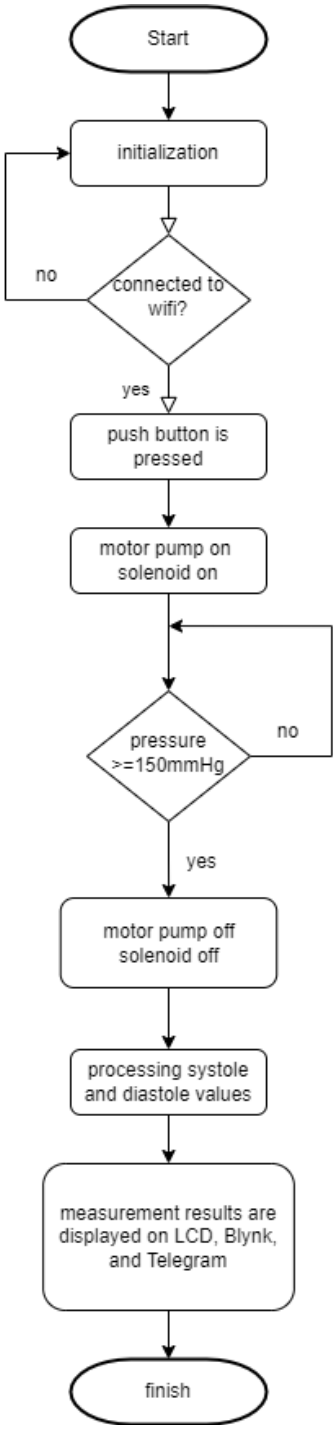

Figure 2. Flowchart of the System Design

Figure 2 depicts the procedure, which begins with the ESP32's initialization and checks to see if the device is connected to the WIFI network. If the connection is successful, the gadget can be activated by pressing the push button, and the DC motor pump will begin measuring blood pressure. When pressure hits 150 mmHg or above, the DC motor pump stops and the solenoid opens to release air from the cuff. The sensor detects systolic and diastolic readings. Blood pressure measurement data, including systolic and diastolic, will be displayed on the LCD and accessible via the Blynk and Telegram apps.

After generating a flowchart, the researcher created a schematic to assist the assembly of the tool's components. The components were linked one by one with jumper connections. Figure 3 shows the schematic of the tool.

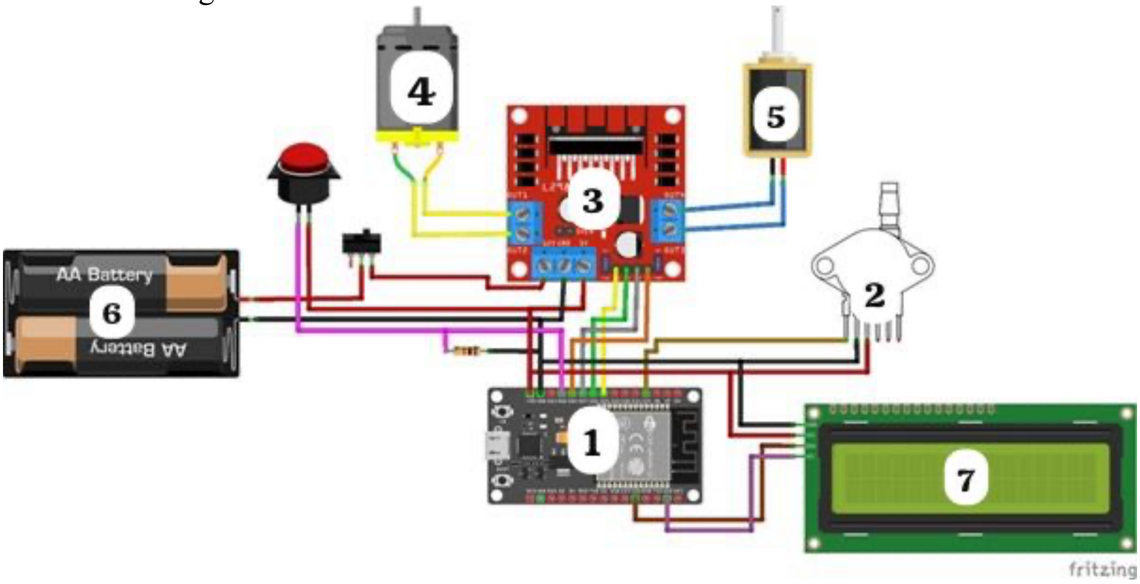

Figure 3. Schematic of the System Design

Descriptions :
1. ESP32
2. MPX5700AP
3. Motor Driver L298N
4. Motor Pump DC
5. Solenoid
6. Battery
7. LCD

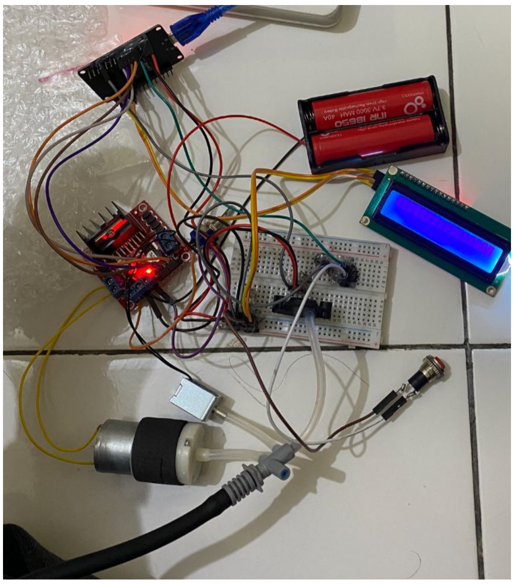

Figure 4. Component Assembly Process

The procedure continues with tool assembly, in which the researcher links numerous components required to create the designed tool so that it can be programmed and run as expected. Figure 4 shows the tool assembling method.

Once the tool has been successfully built, the final version will be created by adding a cover. Next, the tool and system are tested. During this procedure, researchers test the system that has been constructed to ensure that the tool works as planned. Following testing, all findings will be evaluated to determine the system's advantages and downsides.

Figure 5a. Prototype of the System Design

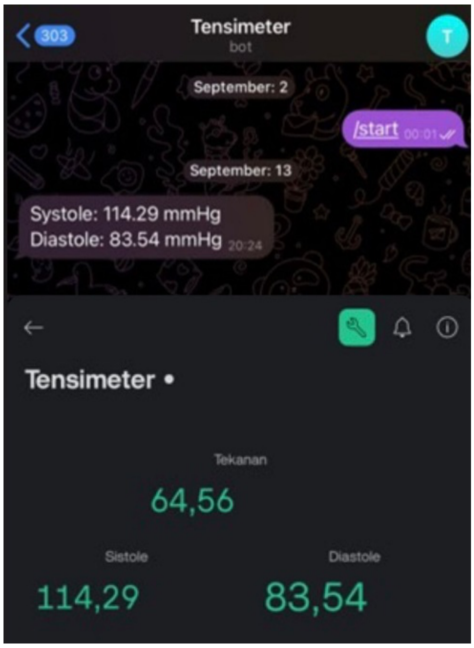

Figure 5b. Sending Notifications to Telegram and Blynk Apps

Results

Figure 5a exhibits the tool's final shape, while Figure 5b depicts Telegram and Blynk presentations with measurement data. The study continued by evaluating the tool created using the MPX5700AP sensor to determine the system's ability to identify systolic and diastolic blood pressure values. Additionally, the sensor's accuracy was evaluated. The test results will be examined to ensure that the proposed system runs smoothly and meets user expectations. The following are the test results.

1. Sensor Calibration

Table 1. Sensor Calibration

mmHg	ADC Value
0	875
20	903
40	923

60	944
80	966
100	990
120	1003
140	1037
160	1055

After modifying the mmHg and ADC (Analogue Digital Converter) values, a formula is obtained using the linear regression equation, which will be utilized in the software to convert the ADC value read from the sensor to mmHg value. The y variable represents the ADC value, whereas x represents the pressure in mmHg. The number of 1.1067 is the gradient or slope of the line, indicating how much the ADC value varies for each 1 mmHg change. The intercept, with a value of 877.69, represents the change in the y variable when the x variable is 0. The linear model's R^2 value of 0.9967 indicates its accuracy based on sensor data. The graphic below shows a linear calibration graph.

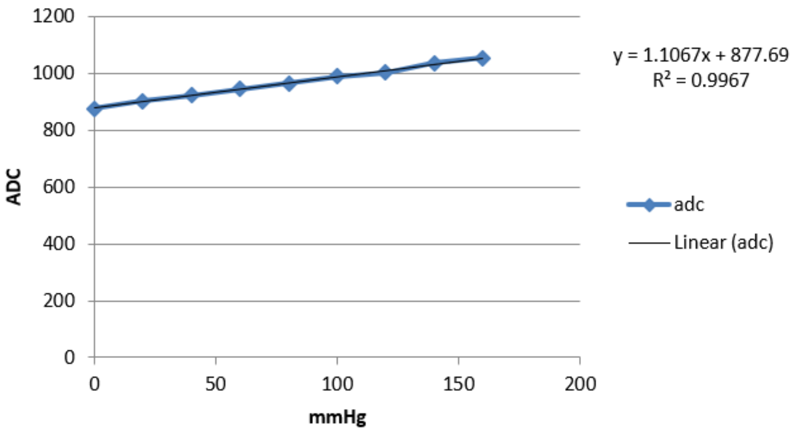

Figure 7. Graph of Tool Calibrations

2. Accuracy Level

Table 2. Result Comparisons

Test	**MPX5700AP(mmHg)**		**Digital Tensimeter (mmHg)**		**Error(%)**	
	systole	**diastole**	**systole**	**diastole**	**systole**	**diastole**
1	136	91	135	83	0,74	9,63
2	134	88	131	82	2,29	7,31

3	126	80	126	79	0	1,26
Average					1,01	6,06

Figure 8. Result Comparisons between the System and Omicron Blood Pressure Tool

The test compared systolic and diastolic data from the MPX5700AP sensor with a digital tensiometer. The results revealed an average inaccuracy of 1.01% for the systolic value and 6.06% for the diastolic value.

Discussion

According to the testing results, the developed IoT-based blood pressure monitoring device can function normally and produce positive results. This device measures blood pressure accurately, especially after the calibration process. The device offers a high level of accuracy, with an average inaccuracy of 1.01% in systolic measurements and 6.06% in diastolic values, compared to commercial tensiometers on the market. Although there is a tiny difference, these findings suggest that the device may be depended on for blood pressure monitoring, particularly by the elderly.

However, measurement results and accuracy are influenced by a variety of external circumstances, such as the user's physical activity before to the test, thus the findings may fluctuate somewhat from ideal results. Furthermore, the interval between measurements is important for guaranteeing accuracy because blood pressure can naturally change in a short period of time.

One of the biggest drawbacks of this device is its reliance on an internet connection. Because this gadget sends data to the Blynk and Telegram platforms via an internet network, it will not function properly if the internet connection is unstable.

Overall, this device is a good tool for monitoring blood pressure, particularly for the elderly who require frequent monitoring. Although there are significant downsides, particularly the need on an internet connection, test results demonstrate that this device may nevertheless offer accurate and dependable data after the calibration process is completed correctly.

Conclusion

The study concludes that an Internet of Things (IoT)-based blood pressure monitoring system based on the MPX5700AP sensor was successfully created and implemented to assist the elderly in regularly monitoring their blood pressure. The test findings indicate that the system accurately detects blood pressure measurements and allows users to monitor them without manually recording results. This technology is designed to assist medical workers in conducting more effective examinations as well as the elderly in maintaining their health by reducing the danger of hypertension and hypotension. However, further development is required to increase measurement precision and gadget endurance over time.

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