International Journal on Advanced Science Engineering Information Technology

Vol.14 (2024) No. 3
ISSN: 2088-5334

IoT-based Flex Sensor Gloves for Immobility Patients: A Prototype

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Abstract—**Immobility patients often experience difficulties in daily interactions, especially communicating with nurses or carers. This study designed a glove prototype installed with a tension sensor as a communication tool to help patients. The designed prototype, a cutting-edge innovation, is paired with five flexible sensors to make it easier for nurses to read the five-finger movement signals. This prototype is not just a tool but a lifeline, equipped with temperature and pulse sensors that provide real-time monitoring of the patient's physical condition, enhancing patient safety. Testing of the flex sensor glove prototype is carried out by processing flex-sensor input data temperature sensors, and Pulse Oximeter sensors so that they can be displayed on the Blynk application. Every movement conveys the patient's emotions and is implemented with Arduino UNO; a wireless serial interface is used for data transmission between transmitter and receiver. In an emergency, communications will be transmitted using a GSM module. The flex sensor indentation is processed by Arduino-Nano and sent to the Blynk application. Every movement conveys the patient's emotions and is implemented with Arduino UNO; a wireless serial interface is used for data transmission between transmitter and receiver. In an emergency, communications will be transmitted using a GSM module. The results of the flex sensor test show that the prototype will send notifications in the form of requests to the Blynk application.**

Keywords— **Blynk; flex sensor; immobility patients; gloves.**

Manuscript received 14 Sep. 2023; revised 19 Jan. 2024; accepted 20 May 2024. Date of publication 30 Jun. 2024.

I. INTRODUCTION

In recent years, numerous papers have presented the design of a medical device prototype, including electronic devices used as mittens. Physiological parameters include temperature, flexible angle, heart rate, and oxygen saturation. Multiple sensors may be used by a system consisting of electronic devices worn as gloves by geriatric or at-risk individuals [1]. The emergence of numerous medical devices that serve as auxiliary facilities and technological advancements currently have a positive impact on enhancing public health [2]. To address the issue of individuals with disabilities so that others can comprehend the motion dialect. Consequently, it has been proposed that any recorded motion-based communication be identified about it. The display design is based on four concepts: the detection unit, the preparation unit, the voice stockpiling unit, and the remote correspondence unit. Combining the flexible sensor and the APR9600 with the LM386 accomplishes this. Flexible sensors embedded within mittens that respond to signals. This instrument is highly dependable and quick to respond [3].

Modifying the code on the microcontroller provides the ability to read a variety of dialects [4]. One of these medical devices is the Arduino controller, which monitors patients' medical data, such as body temperature and pulse rate per minute, to ensure that they are in optimal health [5]. Finger testing was used to ascertain patients' heart rates, yielding an average RSD value of 1.48%, with 2.86% and 5.02% on the respondent's right and left fingers, respectively [6]. This research describes the problems related to the need for technology tools to assist stroke patients in interacting and communicating with their attendants using a flex sensor comprising temperature and pulse sensors. Adjust the output via DFPlayer Mini and display it on an LCD device. This research seeks to develop a prototype of a communication device that can measure the body temperature and heart rate of patients with limited mobility who have suffered a stroke. Isyanto and Jaenudin [5] devised medical devices to address the rising demand for health sector infrastructure. Arduino is one of these medical devices that monitors patient medical data, such as body temperature and pulse rate. The heart, the body's most vital blood-pumping organ, tends to malfunction in patients with stroke or other underlying diseases [7].

Consequently, we will design a prototype heart rate detector using an ATmega328 microcontroller and a pulse sensor to measure and detect heart rate [8]. The Arduino-pro-mini ATmega328 microcontroller processes the incoming signal and displays the heart rate data per minute on an Arthana OLED display [9]. Compared to the Elitech Mobile Fox 1 Pulse Oxi meter, tests on ten participants using an engineered cardiac detector yielded an average relative error of 0.32% [10], [11]. On average, the respondents' right and left digits had RSD values of 2.86 and 5.02 percentage points on the finger test [12].

In addition to integrating visual signals based on motion recognition, outdoor localization, and short distance based on Ultra-Wideband and physiological parameter monitoring modules, the design and implementation of the developed system aim to combine these modules. Together, these modules contribute to creating a network used to monitor the location of fellow soldiers and send alert messages based on their movement and health parameters. The motion recognition module consists of a glove with flexible sensors, IMU, ECG, temperature, and PPG health monitoring devices, as well as UWB-based communication [13]. Communication between normal individuals and those with vocal and hearing impairments is challenging. People who cannot be understood by the public use sign language, producing communication barriers. Paralyzed people also require regular assistance; therefore, it is necessary to implement intelligent assistance mittens for disabled people [14], [15].

With the aid of flexible sensors, the finger movements of the wearer are detected, and the corresponding instructions are displayed on the Android and audibly output. Messages of caution transmitted via the GSM module during emergencies [16]. Iqbal [17] designed a communication aid for post-stroke patients that uses five flex sensors embedded in the glove to detect finger-bending movements. Attached to the fingers, a flex sensor provides information on the various finger movements, which is processed or translated by an LCD, and valuable information produced from speakers via the DFPlayer Mini media player [18].

Several varieties of devices have been created, but they are costly and cumbersome. They have developed a device that can be used to educate the patient's movements. The IoT-based device used for *Plegia* patients is a pair of mittens with an accelerometer sensor that is designed very simply [19]. Every movement conveys the patient's emotions and is implemented with Arduino UNO; a wireless serial interface is used for data transmission between transmitter and receiver. In the event of an emergency, communications will be transmitted using a GSM module [20], [21]. The wearable soft robotic glove (MR-Glove) consists of two components, namely, a set of soft pneumatic actuators and gloves [22].

Wireless smart gloves are based on multi-channel capacitive pressure sensors that can recognize 10 Sign Language movements, consisting of 16 capacitive sensors. Sensor data is captured by a capacitance-to-digital converter [23]. A Weft Knit Data Glove is made by knitting multifilament conductive yarn and elastomer yarn using Whole Garment technology to help stroke patients [24]. Sensor-based instrumented gloves to measure the range of motion of ten finger joints. The use of the glove in real-world applications has been demonstrated by demonstrating a Virtual Reality (VR) platform using a Raspberry Pi-based module [25]. Vibration-suppressing gloves can be worn to suppress vibrations simultaneously but independently. This prototype was tested for Parkinson's tremor patient [26]. The Brazilian Sign Language recognition system consists of an instrumented glove and an acquisition system. The instrumented glove has five sensors, an inertial sensor, and two contact sensors and is designed with silver-coated fabric. Alpha-sign is intended to recognize the 26 letters of the alphabet [27].

Patients with a stroke can communicate using mittens equipped with flexible sensors. Five flexible sensors on the glove detect finger movements and provide real-time data on heart rate, temperature, and commands. An Arduino-nano microcontroller converts the input signal data into commands that are output via the LCD and the speaker. This prototype is simple for stroke patients to use and makes it simpler for nurses to understand what patients want [28]. This research developed a communication aid in the form of a glove that uses a flex sensor as its primary sensor to convert finger curvature into a request. Arduino Nano processes this flex sensor indentation data, which is then sent to the Blynk application. This prototype includes a temperature sensor for measuring body temperature and an oximeter sensor for measuring pulse. When the finger containing the flex sensor is bowed, it will send a request to the Blynk application as a notification.

II. Materials and Method

A. Impaired Physical Mobility

Long-term impairment of physical mobility can impede psychosocial functions such as anxiety, mood disturbances, and verbal or nonverbal communication. Immobility disorders can hurt self-esteem and social interactions [29]. Patients with speech disorders or aphasia may have difficulty communicating. Aphasia is frequently diagnosed in stroke, stuttering, and total laryngectomy patients [30]. As the number of patients increases, so does the prevalence of communication disorders in geriatric populations. Several studies have demonstrated that hospitalized patients with communication disorders are more likely to develop complications [31].

Additionally, communication disorders in patients are linked to limited access to care. Language disorders are characterized by impaired spoken and written language comprehension and use. Aphasia is the most prevalent form of language-based communication disorder. Aphasia is a communication disorder caused by traumatic brain injury. The primary cause of aphasia is a ruptured cerebral blood vessel. Additionally, aphasia impairs a person's ability to comprehend and express language. Additionally, it can affect nervous system regions involved in information processing, memory, thinking, and other higher-order language functions such as problem-solving and abstract reasoning. Aphasia is common among stroke and brain injury patients. Adults who fail to develop normal language due to hearing loss or developmental disorders may also exhibit language disorders. Neurological disorders such as stroke, neuromuscular disease, and impaired nerve cell development can cause speech disorders. Speech disorders can affect the precision of articulation, the voice, the fluency, and the resonance. Depending on its severity, speech impairment can significantly impact the patient's ability to communicate with the rest of the medical personnel. These conditions, including Parkinson's, Huntington's, and amyotrophic lateral sclerosis, can impair communication [32].

According to The American Speech-Language-Hearing Association (ASHA), cognitive-communication disorders are characterized by communication difficulties caused by cognitive impairment. Attention, memory, organization, problem-solving and deductive reasoning, and executive function are examples of cognitive processes. This condition can affect verbal and non-verbal communication, including speaking, listening, reading, writing, and pragmatic skills [33]. In addition to the condition of the hearing aid, environmental factors such as environmental noise, other sound sources, and room acoustics can affect hearing loss. Visual information from the speaker's face, situational terminology, and linguistic context can facilitate communication when a person with normal hearing engages in a conversation in a quiet environment with adequate illumination.

Conversing and exchanging information may be more challenging in noisy environments with poor illumination and limited visual cues. In this condition, a person with hearing loss will have difficulty communicating [34]. Language barriers have a significant impact on healthcare quality. This issue typically arises when health professionals and patients do not share the same mother dialect. Despite the language barrier, all patients must be provided with high-quality care that adheres to human rights and equality principles. Patients who do not communicate in the local language have less access to health services than local patients. Similarly, multiple studies have demonstrated that patients with language barriers have poorer health than those who speak the local language [35].

B. Flex Sensor and Arduino

A finger will be connected to the Arduino Nano microcontroller via a voltage divider circuit to detect movement. When this sensor is bent by the bend of the user's finger, there is a change in resistance, which will later be processed by the Arduino-Nano microcontroller and added to a follow-up command. The Flex sensor is sent to the Arduino-Nano via a voltage divider circuit, where the input leg of the flex sensor is connected to the Vcc pin on the Arduino Nano, and the output leg of the flex sensor is given a resistor of 10K Ω then connected to the GND pin on the Arduino-Nano. The voltage divider circuit functions convert the change in the resistance value on the flex sensor into a change in the voltage value, making it easier to program the design because it can use ADC values. The output and 10KΩ resistors on each leg of the flex sensor output will be connected to the pins on the Arduino, A0, A1, A2, and A3. Fig 1 shows the shape of the connecting circuit between the flex sensor and the Arduino Nano microcontroller. The Flex sensor is connected to the analog pins A0, A2, A4, and A6 on the Arduino Nano, each with a 10KΩ resistor as a voltage divider resistor.

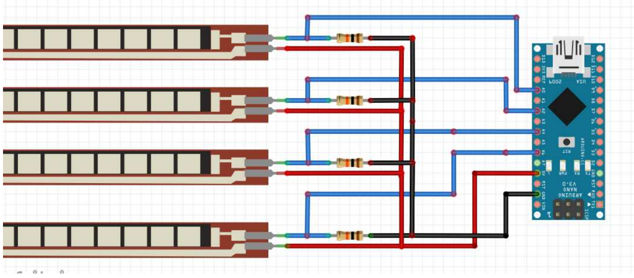


Fig. 1 Arduino-Nano with Flex Sensor

C. Temperature Sensor with Arduino

This prototype detects changes in user temperature in real time and will be connected to the Node MCU microcontroller via digital pins. If this sensor reads temperature changes, the Node MCU will immediately process the digital data displayed in the Blynk application. Digital data from this temperature sensor is entered via pin D5 on the Node MCU, the input pin for digital values from the Node MCU. The power supply for this sensor is obtained from the Vin pin on the NodeMCU board, and for the ground, it will be connected to the GND pin on the NodeMCU board. Fig 1 shows the digital data output of the DS18B20 temperature sensor connected to digital pin D5 of the MCU Node and a voltage source connected to the Vin pin and the GND pin on the MCU Node.

The DS18B20 digital sensor has a 9-to-12-bit ADC (Analog to Digital Converter) that operates in temperatures ranging from -10ºC to 85ºC with an accuracy of approximately -0.5ºC. On the DS18B20 sensor, the conversion of the ADC value itself is carried out directly in the sensor. Hence, the data that enters the microcontroller is already in the form of digital data. The manufacturer of this tool, Maxim Integrated, does not include the temperature change resolution on the output digital value. The digital value is directly converted into a temperature quantity so we cannot calculate the digital value for temperature for this temperature sensor. The data is validated by comparing the measured values read by the temperature sensor with those of a digital thermometer.

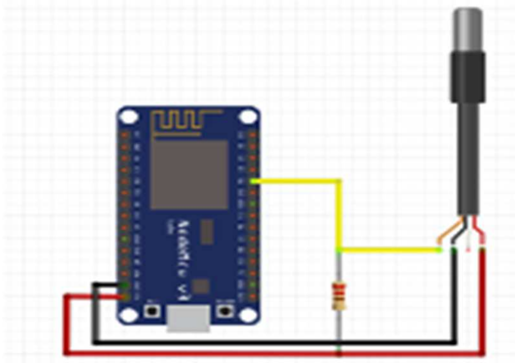


Fig. 2 Arduino-Nano Connected to Temperature Sensor

D. Arduino-Nano with Modul WIFI ESP-01

This prototype is an additional tool that will function to transmit input data from sensors that have previously been processed by the Arduino Nano microprocessor. This data will be sent using an internet network based on IoT (Internet of Things) to the Blynk application. This WIFI module has several legs, including VCC connected to pin 3.3 V, TX connected to pin D6, RX connected to pin D5, and GND pin connected to GND pin on Arduino Nano.

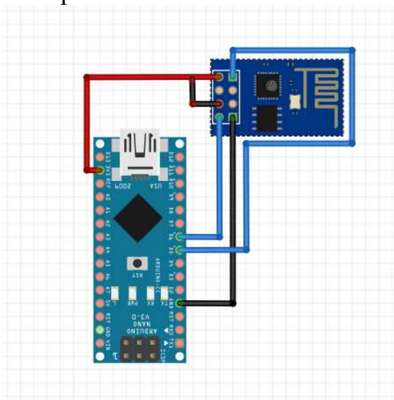


Fig. 3 Arduino-Nano with Modul WIFI ESP-01

E. *Pulse Sensor and Arduino-Nano*

By connecting the Arduino-Nano microcontroller's analog pins, variations in the heart rate of stroke patients can be detected in real time. When the sensor detects variations in heart rate, the corresponding data is immediately processed and displayed on the LCD layer. This pulse sensor sends analog data to pin A7 on the nano board, which supplies 5Vdc to the grounded GND pin.

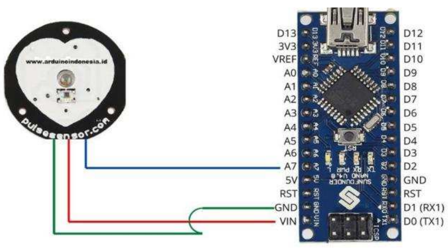


Fig. 4 Arduino-Nano Circuit Connected to Pulse Sensor

The temperature sensors aid in the design of the communication device for stroke patients. Its purpose is to provide excellent systematic convenience for the prototype development procedure. The sensor's output is a resistance between 25 K and 40 K under normal and maximal bending conditions, respectively. Changes in resistance from the flex sensor to the voltage divider circuit are converted into voltage data, which is transmitted to the Arduino nano analog ports A0 to A7. Arduino-Nano provides power to this device when a +7-12V DC power supply is connected to the VIN pin. For sensors connected to the 5Vdc port and supplying power to the LCD and mini DFPlayer, the output is +5Vdc. Arduino-Nano processing data will be displayed on the LCD, which is connected via the Serial Data and Serial Clock pins to send data to communication support and activate Inter-Integrated Circuit I2C communication.

The overall design is a series of several components forming a system with input circuits, process circuits, and output circuits. Fig 5 is the overall circuit schematic that will be made where each flex sensor as input is connected to pins A0, A2, A4, and A6 to send analog signals to the Arduino Nano, then digital data from the Max30102 sensor will enter pins D1, D2 respectively are the SCL and SDA pins on the Node MCU. In addition, there is also a DS18B20 temperature sensor, which is connected to the MCU Node via pin D4 on the MCU Node as a data pin, which has digital data from the temperature sensor. The GND and VCC legs of the temperature sensor are connected to the GND and Vin pins on the MCU Node. Four Flex sensors are used with a voltage divider circuit using a 10 KΩ visor as the reference resistance in the voltage divider circuit used and installed on the DS18B20 temperature sensor, which uses a 4.7 KΩ visor. An ESP-01 WIFI module also sends data processed on the Arduino Nano to the Blynk application. Then, the data that has been processed by NodeMCU, such as body temperature, oxygen saturation, and heart rate, will also be sent to the Blynk application using the WIFI connection that has been installed on the NodeMCU ESP8266 board.

III. Results and Discussion

Several steps must be carried out, including searching for and inserting the library of components used into the Arduino IDE software. The library function is to be able to access and use a collection of functions and definitions that have been created by the component developer. Including the library in the Arduino IDE software will make the program creation process more accessible. As explained in the planning block diagram section, this research uses two microcontrollers, Arduino Nano and Node MCU. The electronic circuit of the Node MCU is the DS1B820 sensor and the Max30102 sensor. The MCU Node's electronic circuit reads and sends data from the DS18B20 sensor in the form of the glove user's body temperature and the Max30102 sensor in the form of the glove user's heart rate and oxygen saturation to the Blynk. The MCU node no longer needs to use a WIFI module to connect to the internet because it is equipped with WIFI on this board.

Several stages must be carried out to make the program according to what is desired, including finding and inserting a library of components used into the Arduino IDE software. The function of including this library is to access and use a collection of functions and definitions created by the component developer. Including the library in the Arduino IDE software will make the program creation process more accessible. The program functions to read input data from the flex sensor. A logic program is also created, which will later read two conditions from the flex sensor: normal or no bending and full bending conditions.

Apart from conditioning the conditions on the flex sensor, this program also applies to the ESP-01 Wi-Fi module, which will connect to the WIFI network. After the microcontroller program has been created and successfully inserted into each microcontroller, the next stage is to install the Blynk application. The Blynk application displays input data such as oxygen saturation levels, glove user's body temperature, and heart rate, and also displays request notifications if the prototype user moves one of his fingers. The appearance design that has been created in the Blynk application. The display in this design has two boxes or menus, each with names such as "ESP" and "Nano". The names of this menu are the initialization of the two microcontrollers used, namely, Node MCU ESP and Arduino Nano. Each of these menus has its function, such as the ESP menu and the ESP menu functions to display data from the temperature and heart rate sensors. Meanwhile, the nano menu displays the ADC value of the flex sensor and provides a notification when one of the flex sensors is bent.

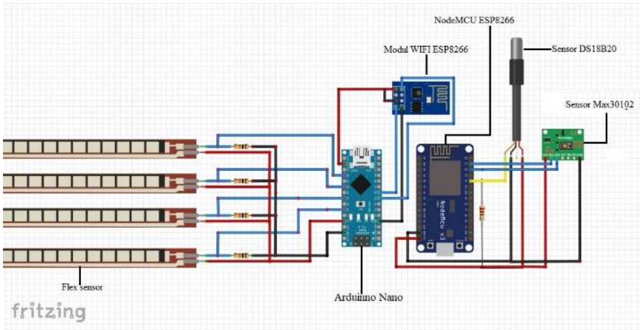


Fig. 5 The prototype overall series

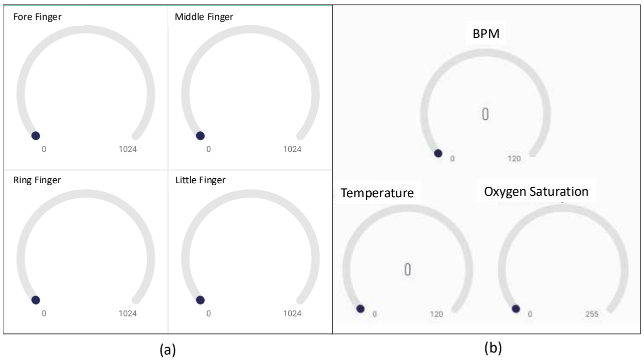


Fig. 6 The display design of the Blynk Application

Fig 6 displays the contents of the "ESP" and "nano" menus when opened. In Fig 6, part (a) is the display that appears when the "nano" menu is opened, with four boxes, each with its name, such as the middle finger, index finger, little finger, and ring finger. Each of these boxes has a value range of 0-1024, which is the ADC value of the flex sensor, which is read by the Arduino Nano microcontroller and will change according to the conditions of the flex sensor with a maximum value limit of 1024. Fig 6 (a) and Fig 6 (b) three boxes have different names, such as Bpm or heart rate, body temperature, and oxygen saturation.

The 0-value contained in the Blink application display is because the built tool has not been connected to the internet, and no data is sent to the Blynk application, making the value 0. Flex sensors are resistance-type sensors used to detect resistance changes on the sensor itself. The change in question is a change in length influenced by the curve of the user's finger. The larger the indentation given to the sensor, the higher the resistance provided. This change is obtained from the basic resistance formula, multiplying the length by the specific resistance divided by the cross-sectional area.

In this test, the flex sensor serves as input for reading the indentation of the finger from the glove user, which is then read by the Arduino nano microcontroller and processed according to the magnitude of the indentation angle of the glove user's finger. After compiling the program on the Arduino IDE, the next step is to test the flex sensor on the knuckle holder to see whether it is as expected. The flex sensor is set in two conditions: the normal condition or no bending and the fully bent condition.

Fig 7 shows a test of the flex sensor on the user's hand under normal finger conditions or when the finger is not bent. The output value of the Analog Digital Converter (ADC) is calculated by reading the analog flex sensor data under normal conditions or without any indentation displayed on the Arduino IDE serial monitor. After testing, each finger gives a different ADC output value. This is due to the difference in bending on a small scale on each finger.

Fig. 7 Flex sensor test

Table 1 presents the ADC value data from the flex sensor, which is as many as 10 data points. This data is generated from flex sensor testing, carried out by looking at the ADC value read on the Arduino IDE serial monitor for 10 seconds. The data listed in Table 2 shows that the ADC value on the flex sensor installed on each finger changes every second. The flex sensor installed on the little finger has varying ADC values; the highest is 860, and the lowest is 837. Then, the flex sensor on the ring finger has the highest ADC value of 773 and the lowest ADC value of 760. Likewise, with the flex sensor installed on the middle finger and index finger, respectively, the highest ADC values are 761 and 795, and the lowest ADC values are 753 and 777.

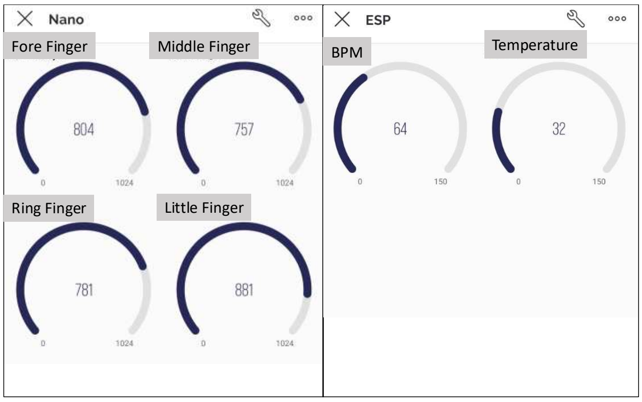
TABLE I
THE ADC VALUE OF THE FLEX SENSOR TEST RESULTS IN THE UNBENT CONDITION

Test	**Flex Sensor**			
	Little Finger	Ring Finger	Middle Finger	Fore Finger
1	860	772	757	791
2	858	768	756	795
3	859	772	757	785
4	858	775	755	778
5	852	770	755	777
6	837	771	757	786
7	858	760	759	784
8	856	773	761	783
9	858	771	757	784
10	858	760	753	785

The highest and lowest values are because when the patient's hand is in a normal condition or not bent, a slight bend occurs accidentally on the patient's finger. These small indentations on the fingers are felt by the flex sensor, which makes the ADC value of the flex sensor constantly change even when the hand is not bent. Table 3 presents the ADC value data from the flex sensor testing results when fully bent, as shown on the Arduino IDE serial monitor, with as much as 10 data. Data collection was carried out when the sensor was not bent. Data collection was also done when the sensor was fully bent by looking at the ADC value read on the Arduino IDE serial monitor for 10 seconds—changes in ADC values read by the microcontroller. On the index finger, for example, before it was bent, the ADC value seen on the serial monitor was 791, but when it was fully bent, the ADC value changed to 820. The other fingers also experienced changes in the

ADC value when the flex sensor was fully bent. The ADC value is the maximum ADC value that can be read by the Arduino nano microcontroller from each flex sensor when the flex sensor is fully bent. After knowing the ADC value of the flex sensor in normal conditions and fully bent conditions, a program can be created to adjust to the value read to create an if or else command in the Arduino IDE. During testing under normal conditions, the ADC value of the little finger was found to be in the range of 837-860. This range of lowest and highest values is the ADC value read when there is no significant bending on the sensor. This range of lowest and highest values is due to the unconscious bending of the glove user's fingers.

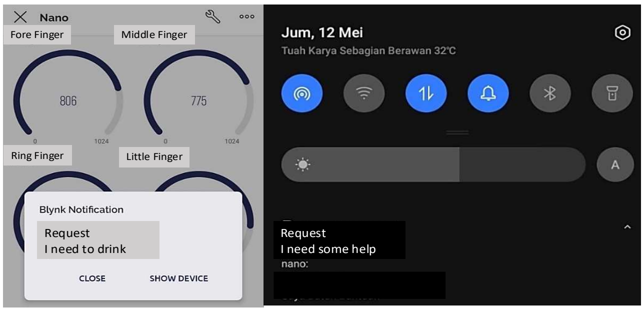
Meanwhile, after being fully bent, the ADC value on the little finger that is read is 923. The value 923 is the maximum ADC value that can be read by the Arduino nano microcontroller when the flex sensor is fully bent. The ADC value is between the unbent and fully bent conditions to create accurate programs on the Arduino IDE. This minimizes the accidental bending of the glove user's fingers and facilitates the flex sensor's bending process. The appearance of the Blynk application on Android displays when the device is not connected to the internet and when it is connected. It also shows the words ESP and Nano, which are the names of the microcontrollers used in the Node MCU ESP8266 and Arduino Nano.



(a) (b)

Fig. 8 The Display on Each Microcontroller

Fig 8 is a display of data from each microcontroller that has been sent to the Blynk application. In Fig 8 (a), there is a Nano display menu. The data displayed is the ADC value from the flex sensor, which will change at any time following the curve of the prototype user's finger. This change in the ADC value of the flex sensor will later be read and processed on the Arduino Nano so that when the ADC value has passed the minimum bending limit, the Arduino Nano will send a notification displayed in the Blynk application. Then, in Fig 8 (b), there is also a display menu that says ESP; the data displayed is the value of the heart rate and body temperature of the glove user. This data is real-time condition data for the glove user in the form of heart rate and body temperature. When the prototype user bends his finger according to his wishes, a notification will appear in the Blynk application. Figure 8 shows the display when a notification comes into the Blynk application. Fig 8 (a) is a notification that appears when the Blynk application is open, while Fig 8 (b) is a notification display that appears on the smartphone when the Blynk application is not open.



(a) (b)

Fig. 9 Notification display on a smartphone

Apart from using a smartphone, Blynk can also be accessed via a nurse's laptop or computer connected to an internet connection. The trick is to open one of the browsers on your laptop or computer, then after the browser is open, go to the www.blynk.cloud site and log in using the email that has been registered with Blynk. The initial display will appear after successfully logging in to the Blynk site.

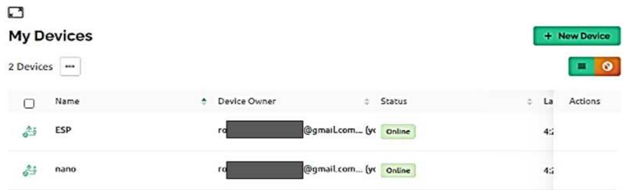


Fig. 10 Blynk's initial appearance on the nurse station monitor screen

Fig 10 shows an initial view of the Blynk that was opened using a nurse's station computer. In this initial display are two device names, ESP and Nano, which initialize two microcontrollers (NodeMCU and Arduino Nano). The data is sent to Blynk; the user clicks on one of the microcontroller initialization names contained in the initial appearance of this Blynk according to what the user wants.

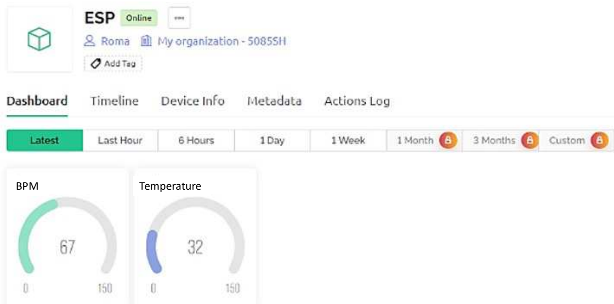


Fig. 11 Display from the NodeMCU microcontroller

Fig 11 shows the ESP display on the "my device" display. After clicking, a different display will appear. This menu display contains data or sensor values from the glove user's heart rate and body temperature. In designing this tool, it only sends notifications from the Arduino nano microcontroller, so the Node MCU only sends real-time data in the form of the glove user's body temperature and heart rate. Testing aims to test whether the tool has been made to function according to the initial design. This test is carried out to prove whether the data that has been processed by the microcontroller can be sent and displayed to the Blynk application or not. The following are the results of testing the flex sensor on the Blynk application, which was obtained with the help of 10 people as subjects in the prototype trial of this tool.

Fig 12 is the data from the flex sensor test results on the Blynk application, which was tested with the help of 10 volunteers. Flex sensor 1, a flex sensor attached to the index finger, shows that the value of the change in resistance when the flex sensor is bent can be read on the Arduino Nano as ADC data. This ADC data is also successfully sent to the Blynk application and then successfully sends a notification containing a request "I want to eat" that appears on the Blynk app. Likewise, with flex sensor 2, flex sensor 3, and flex sensor 4, each of which is a flex sensor attached to the middle finger, ring finger, and little finger on the glove, it can also be read on Arduino nano. It can send notifications in the form of requests to Blynk applications. From testing these 10 people, the result was that all flex sensors could be read in the Blynk application, and all flex sensors could send notifications to Blynk in the form of requests without any significant problems.

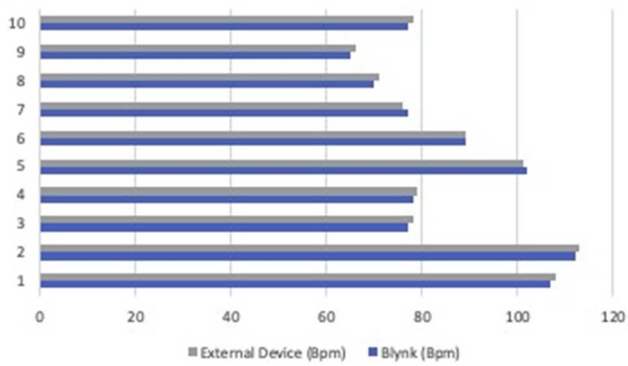


Fig. 12 Sensor Test Data on Blynk

Fig 13 presents the results of the heart rate readings of the 10 subjects who are measured. The measured values vary widely and are not always the same; this is because, at the time of measurement, the conditions of the subjects were different; some were relaxed, and some had just done activities that moved their limbs a lot. After comparing the measurement results using the Max30102 sensor and a digital heart rate measuring instrument, a calculation is performed to find the relative error value. The relative error value is the difference or deviation between the value measured by the sensor and the actual value or expected value. The smaller the relative error value obtained, the more accurate the sensor used. After calculating, the relative error value was obtained from the most minor, 0.89%, and the highest, 1.54%.

Fig 13 presents the results of temperature sensor testing on the 10 subjects that have been measured. In testing, the DS18B20 temperature sensor showed a low level of sensitivity due to the area that can detect temperature. The digital thermometer used as a comparison has a relatively slow response to changes in temperature, so it takes a while to get accurate results. In this Blynk application, the displayed value is an integer instead of a decimal number, as indicated by a digital thermometer, making the measurement inaccurate. The test results show a range of relative error values, with the smallest value being 2.85% and the highest value reaching 5.88%.

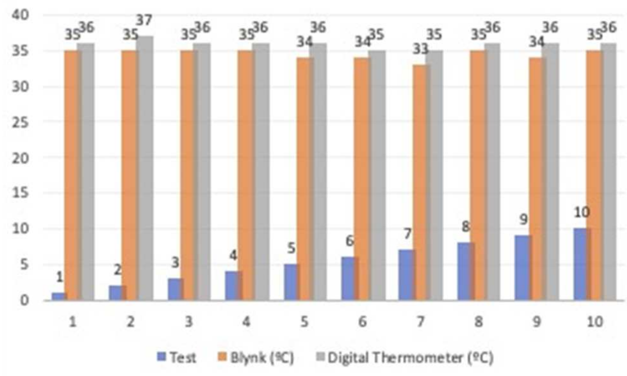


Fig. 13 Temperature Sensor Test Results on Blynk

IV. CONCLUSION

In developing a communication aid for stroke patients using a temperature sensor mounted on a glove, testing this tool shows that each part and function can work properly. The flex sensor detects the bend angle of the finger, which acts as an analog value, which is converted into digital data, which is processed by the Arduino-Nano and produces an output in the form of a command displayed via Blynk. The flex sensor can read the finger grooves of the glove user well. The Arduino Nano microcontroller can process input values from the flex sensor as ADC values into request data sent to the Blynk application. The DS18B20 sensor works well as a sensor that reads the body temperature of the prototype user. The Max30102 sensor functions well, but in this research, this sensor can only read the user's heart rate, not the oxygen saturation of the glove user. Data processed on the Arduino Nano microcontroller and NodeMCU has been successfully sent and displayed on the Blynk application. The Blynk application can send notifications when the flex sensor is bent in the form of a request. This prototype allows nurses to hear requests from immobility patients. It displays the data processing results in text output and measures heart rate and body temperature in real-time.

ACKNOWLEDGMENT

The authors thank the Universitas Riau of the Institute for Research and Community Service for funding this research, Contract Number: 8312/UN19.5.1.3/AI.04/2023.

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