Assistive Blood Pressure Monitor for Senile Population

M. Prem Kumar(✉), Reddymalli Narender Reddy, S. Deekshitha, and D. Srinath Reddy

Department of Biomedical Engineering, B V Raju Institute of Technology, Narsapur, TS, India
premkumar.m@bvrit.ac.in

Abstract. Diseases are always challenging for human life and quick diagnosis is the best solution to aftermath treatments. Hypertension needs regular blood pressure measurement. Increase in blood pressure levels may lead to heart and other vascular diseases. Complications of untreated high blood pressure (HBP) may lead to might be a heart attack or kidney damage. HBP is a "silent killer" that damages organs without symptoms or warnings. And Elderly, who depend on others, are the most important group to monitor Blood pressure regularly to prevent diseases ahead in future. With ageing and low vision ability, the burden of checking BP becomes more sophisticated. Digital Blood pressure monitors are currently making life easy with a simple press of a button and the elderly still need an advanced version for their usage. The developed design is aimed at the elderly community. The embedded device provides a simple solution for the elderly with visual representations like smiley, neutral and sad icons on a display. The Illiterate population can also benefit from the design as the Visual representation does not need much education or training.

Keywords: Hypertension · Digital pressure monitor · Embedded Systems

1 Introduction

Blood pressure Monitoring can prevent humans from fatal diseases. Hypertension often referred to as High Blood pressure (HBP) is a crucial element in cardiovascular diseases (CVD) [1]. Heart strokes and kidney malfunctions are usually caused by hypertension. Strenuous exercises also exhibited their impact on blood pressure [2]. Findings on the urban geriatric population more specifically in South India, hypertension was observed to be 46% of individuals who were taking treatment, among the 80% diagnosed [3]. Elevated blood pressure is found in the ageing population and the untreated hypertension group in the urban and rural sections is another daunting challenge for the community. Dementia is also a consequence that is related to blood pressure volatility in the elderly population [4].

Ageing is a barrier to using mobile health technology for the elderly due to their poor vision and cognitive inabilities [5]. Some elders may have physical limitations in mobility or other physical conditions that make it difficult for them to use a traditional

B. Raj et al. (Eds.): ICETE 2023, AER 223, pp. 4–10, 2023.
https://doi.org/10.2991/978-94-6463-252-1_2

blood pressure monitor. It is important for older adults to regularly monitor their blood pressure and work with a healthcare professional to manage it effectively, as uncontrolled hypertension can lead to serious health problems.

Awareness programmes for the early identification of HBP cases are very much in need. Treatment particularly in under-serviced rural India is the most urgent currently [6]. There is always new intervention for the support and care of the elderly community. But the challenges always exist in their own forms.

1.1 Blood Pressure Monitoring Methods

There are several methods for monitoring blood pressure:

1. Auscultatory method: The traditional method of measuring blood pressure, also known as the "sphygmomanometer" method, involves using a stethoscope and a blood pressure cuff to measure the pressure in the brachial artery. The pressure cuff is inflated to a point where the pulse can no longer be heard and then gradually released until the pulse is heard again.
2. Oscillometric method: This method uses an inflatable cuff and an electronic sensor to measure the pressure changes in the artery as the cuff is inflated and deflated. The pressure is determined based on the oscillations in the pressure waveform.
3. Continuous non-invasive blood pressure (CNIBP) monitoring: This method uses a device that is placed on the patient's finger, wrist, or upper arm to continuously measure blood pressure. The device uses a photoplethysmography (PPG) sensor to detect changes in blood volume and an algorithm to calculate blood pressure.
4. Invasive blood pressure monitoring: In this method, a catheter is inserted into an artery to directly measure the pressure. This method is used in critical care settings and during certain procedures such as heart surgery.

All these methods have their own advantages and disadvantages, and the choice of method will depend on the specific needs of the patient and the healthcare provider.

These devices typically consist of a blood pressure cuff as shown in Fig. 1 that connects to a smartphone or tablet via Bluetooth. The device measures blood pressure

Fig. 1. Digital BP Monitor

and the results are displayed on the phone's screen. Elders having poor vision may have difficulty reading the results of a blood pressure monitor, especially if they have poor vision. It is important to note that the accuracy of these devices cannot be as accurate as traditional blood pressure monitors. Recommendation from a healthcare professional is important for using mobile devices for blood pressure monitoring.

The elderly community, depend on others for small work and keeping their health in condition is another challenging task. With less strength and body hindrance, the elderly cannot measure their health and low cognitive ability adds a burden on them. The approach is to provide an accurate stimuli-based device for monitoring the BP regularly. Also, the response rate of visual and auditory stimuli of the elderly varies with the ageing factors. The response rate of audio and visual stimuli can differ greatly depending on the individual and the context in which the stimuli are presented. In general, visual stimuli tend to have a higher response rate compared to audio stimuli, as the human brain processes visual information faster and more efficiently than auditory information.

2 Design

2.1 Development Boards & Sensors

Development boards. Many microcontroller boards are designed for electronic prototyping for domestic applications with nature of industrial grade. They typically include a microcontroller chip, input & output interfaces, power supplies, and other components such as resistors, capacitors, and LEDs. Examples of popular development boards include the Raspberry Pi, Arduino boards, and the Particle Photon. These boards are widely used in electronics projects, and Internet of Things (IoT) applications.

From these boards, Arduino UNO is the most compatible, economic and rugged model in view of its applications compared to other boards available in the market. It is an open-source electronics platform-based on wiring language with easy-to-use hardware and software. Arduino boards are able to read inputs - light from sensors, a finger on a button, or a Twitter message and turn them into an output – turning on LEDs, activating a motor and publishing data online. This simplicity allows for creating interactive objects or environments for the learning community.

Sensor. The Sunrom Blood Pressure Module is used for this design to measure blood pressure, which is based on the oscillometric method. It uses an inflatable cuff and an electronic sensor to measure the pressure changes in the artery as the cuff is inflated and deflated. The module can be used in various applications such as medical equipment, health monitoring devices, and wearable devices. The Sunrom Blood Pressure Module is compatible with various microcontroller platforms such as Arduino, and the device specifications and software libraries are available to assist with the integration of the module into a project.

Sunrom's blood pressure monitoring devices are designed to provide accurate and reliable readings for personal use. They are easy to use, and many models come with features such as automatic inflation and deflation, large displays, and a memory function to store multiple readings.

2.2 Display

There has been extensive research on the visual impact of OLED and LED displays on older adults. One common issue is the decline in visual acuity, colour perception, and contrast sensitivity with age, which can affect the perception of images displayed on these screens. To address these issues, some researchers have recommended the use of larger text sizes, high contrast ratios, and improved colour rendering on displays.

There are several types of displays that can be used with an Arduino board, including:

1. *LED dot matrix displays*: These displays use an array of LEDs to display information and graphics.
2. *Liquid Crystal Displays (LCDs)*: LCDs are widely used for displaying text and graphics.
3. *OLED Displays*: OLED displays are similar to LCDs but use organic materials to produce light, making them thinner and more energy efficient.
4. *TFT Displays*: TFT displays use a thin-film transistor (TFT) screen to display images and graphics. They offer higher resolution and better colour depth compared to LCDs and OLEDs.
5. *E-Ink Displays*: E-Ink displays, also known as electronic paper displays, offer a high contrast and wide viewing angle. They are commonly used in e-readers and offer a paper-like reading experience.

LED dot matrix display. These displays are the best choice for the required stimuli suitable for elderly visualization. They fit the specific requirements such as Size, Color and Cost. The 8×8 LED matrix modules are very affordable and practical displays in electronic device manufacturing shown in Fig. 2. It is designed with 16 pins, allowing for various combinations to turn the LEDs ON and OFF. The common anode configuration of the LED, which emits red light, has an about 3 mm diameter. Due to their high versatility and affordable prices, these displays are high in demand for both industrial projects and the learning community.

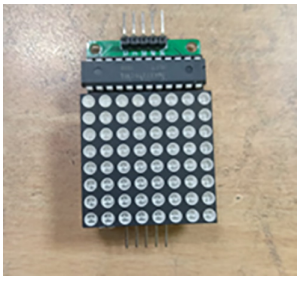

Fig. 2. 8×8 LED matrix modules

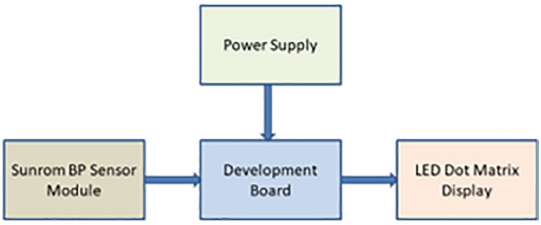

Fig. 3. Block Diagram

3 System Integration

3.1 Block Diagram

The block diagram of the design is shown in Fig. 3. The main components are the Arduino UNO, which is the controller that senses the blood pressure reading from the Sunrom blood pressure sensor, which gives the systolic and diastolic output. The outputs are generally monitored using a serial monitor. And these readings can differentiate normal & abnormal blood pressure values. This controller board is programmed with a threshold value for normal and abnormal blood pressures. Finally, the outputs are converted to display on the LED Dot Matrix Display, which illustrates normal and abnormal values in a graphical illustration instead of numerical values.

4 Results

The device is simple to use with a cuff strap for Wrist usage and a simple button the results are displayed with quick visual emojis of a smiley face for normal BP and a neutral face for abnormal BP. The Threshold is set in the controller for normal BP from 120 mmHg Systolic to 80 mmHg Diastolic which demonstrated a Smiley face as shown in Fig. 4, while any change in the deviation from the normal demonstrated the neural face shown in Fig. 5 on the Matrix Display.

The above Table 1 elucidates the output from the designed device to monitor Blood pressure from 53 subjects of different age groups. Though the focus was on the elderly community for the age group above 50, surprisingly the age group 20 to 50 also felt

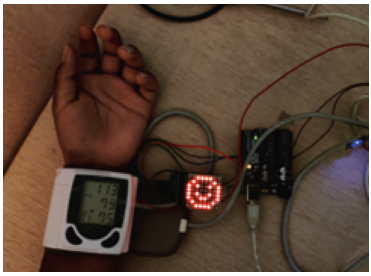

Fig. 4. Smiling Display (Normal)

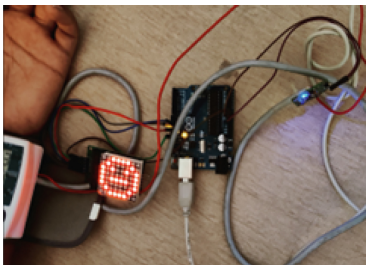

Fig. 5. Neutral Display (Abnormal)

Table 1. Matrix Display Readings for Blood Pressure

S. no	Age Group	Samples	Systolic	Diastolic	Output	Matrix Display
1	20–30	5	125	83	Normal BP	Smile Emoji
		4	90	62	Low BP	Sad Emoji
2	30–45	10	90	60	Low BP	Sad Emoji
		15	150	96	High BP	Angry Emoji
3	45–60	8	80	55	Low BP	Sad Emoji
		11	135	90	High BP	Angry Emoji

the device with a display is easy to use rather than the regular digital BP monitors. Memorizing normal and abnormal values was the grievance for all the groups, while it was a more complex task for elders. The results were satisfactory and validation is out of the scope of the current work.

5 Discussions

The Design was an integration of existing Digital BP devices with Visual Output. It was easy to use a wrist-based Digital BP monitor compared to an arm-based digital BP monitor for the elders with a simple wrap designed with big-size Velcro.

The users needed no training prior to usage and simple instructions could make it a plug-play device. The Emojis or Face display needs no education of their status. The elderly was able to read their normal reading and also enjoyed using the interface of the Matrix display.

Still, certain groups and communities fall short to use technology with a lack of energy or education. From smart wearables to the mobile phones, the technology to monitor health parameters is on par with time.

The general Digital BP monitor has some instructions to monitor the BP of individuals while in sitting and sleeping positions. Wrists-based BP monitor also need proper posture to acquire accurate BP readings. While the posture and other requirements to read BP with the designed device are not discussed with a focus on the visualization

stimuli. The discussion is out of scope regarding the accuracy of the wrist BP Monitors and other wearable devices.

The psychological effect of abnormal BP is also a challenging part for the users. The device is carefully designed with a neutral face for visualization; instead of a sad face for high or low BPs to minimize any anxiety in the users.

References

1. Fuchs, Flávio D., and Paul K. Whelton. "High blood pressure and cardiovascular disease." *Hypertension* 75.2 (2020): 285–292.
2. Fadem, Stephen Z. "Hypertension and Kidney Disease." *Staying Healthy with Kidney Disease: A Complete Guide for Patients*. Cham: Springer International Publishing, 2022. 35–41.
3. Sundarakumar, Jonas S., et al. "Rural-urban and gender differences in metabolic syndrome in the aging population from southern India: Two parallel, prospective cohort studies." *EClinicalMedicine* 47 (2022).
4. van Dalen, Jan Willem, et al. "Association of systolic blood pressure with dementia risk and the role of age, U-shaped associations, and mortality." *JAMA internal medicine* 182.2 (2022): 142–152.
5. Wildenbos, Gaby Anne, Linda Peute, and Monique Jaspers. "Aging barriers influencing mobile health usability for older adults: a literature-based framework (MOLD-US)." *International journal of medical informatics* 114 (2018): 66–75.
6. Boro, Bandita, and Shreya Banerjee. "Decomposing the rural–urban gap in the prevalence of undiagnosed, untreated and under-treated hypertension among older adults in India." *BMC Public Health* 22.1 (2022): 1–16.