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Non-Invasive Bladder Volume Measurement and Monitoring System Using Raspberry Pi

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Abstract:

Estimating the amount of urine in the bladder is a major challenge for patients, such as those with spinal cord injuries and some elderly people, who lack the ability to feel when their bladders are full or who have difficulty getting to the toilet on time. For those who experience urine incontinence, real-time bladder monitoring can be quite beneficial. The two main types of invasive and non-invasive bladder volume monitoring devices can be separated. For precise urine volume measurement, invasive procedures involve directly inserting a catheter into the urethra. The urinary tract may be harmed, and it is uncomfortable and restricts the user's normal movements. [1]This study will investigate the measurement of bladder volume using non-invasive techniques like ultrasound. Urinary incontinence can consequently greatly benefit from real-time bladder monitoring. A variety of wearable devices with various sensing and communication technologies have recently been developed in an effort to produce both invasive and non-invasive approaches.

Keywords **—**Raspberry pi 3b+, Ultrasonic Sensor, Bluetooth Module(HC-05),bladder monitoring; bladder urine volume; urinary incontinence; wearable devices; ultrasound.

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I. INTRODUCTION

Non-invasiveAccurate bladder function monitoring is now achievable without invasive procedures thanks to non-invasive bladder volume monitoring systems that use ultrasonic technology. Bluetooth modules can be incorporated into the design of these systems to improve accessibility and usability by enabling wireless connections to mobile apps. The mobile app can track bladder volume changes over time, send alarms, and show real-time data regarding the patient's bladder volume. Particularly for patients who need to self-monitor their bladder function at home, this technology has substantially increased the efficiency and accuracy of bladder volume monitoring. Overall, non-invasive bladder volume monitoring systems with Bluetooth integration have the potential to revolutionize the way healthcare providers monitor urinary function, leading to better outcomes for patients with bladder-related conditions.

II. CYSTOMETRY

Cytometry is a test performed to check for issues with the bladder's ability to fill and empty. The quantity of urine in the bladder is determined using cytometry. The pressure in your bladder and how full you believe your bladder to be are compared to that number. Your healthcare professional can learn from the results about the bladder's and urinary tract's muscles, mechanics, and nerve response. [2]

III. SYSTEM COMPONENTS

1.1. Raspberry Pi:

A device the size of a credit card called the Raspberry Pi uses an ARM processor and can run Linux. T Raspberry Pi 3 Model B+ has four USB ports, one GB RAM, dual-band Wi-Fi, Bluetooth 4.2, Bluetooth Lo Energy (BLE), an Ethernet port, HDMI output, auc output, and RCA composite video output (through t 3.5 mm jack). It also has Bluetooth 4.2, Bluetooth Lo Energy (BLE), Bluetooth 4.2, Bluetooth Low Ener (BLE), Bluetooth 4.2, Bluetooth 4.1, dual-band Wi- and four USB ports (GPIO). A microSD card with an operating system on it is necessary for the Raspberry Pi. [3](Figure.1)

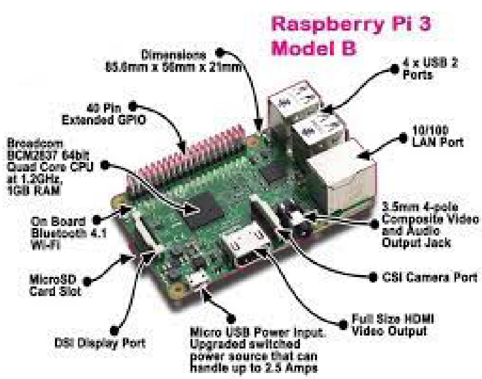


Figure.1 Raspberry pi 3b+

1.2. Specifications[4]

- BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
- 1GB LPDDR2 SDRAM
- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
- Extended 40-pin GPIO headerBroadcom
- Full-size HDMI
- 4 USB 2.0 ports
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- 4-pole stereo output and composite video port
- Micro SD port for loading your operating system and storing data
- 5V/2.5A DC power input
- Power-over-Ethernet (PoE) support (requires separate PoE HAT)

1.3. Thonny

By combining essential tools (such a code editor, compiler, and debugger) into a single software package, an integrated development environment (IDE) makes it easier for programmers to create computer programmes. The environment for the language is already provided by an IDE, so users do not need to install anything on their computers. For those just learning Python, there is a free IDE called Thonny. [5]

1.4. Ultrasonic Sensor HC-SR04

Ultrasonic sensors are electronic devices that measure a target's distance through the emission of ultrasonic sound waves before turning those waves into electrical data. In travelling, ultrasonic waves move more quickly than audible sound does. The two main essential parts are the transmitter and receiver. Using piezoelectric crystals, the transmitter generates sound, which it then transmits to the target before returning to the receiving component. [6]

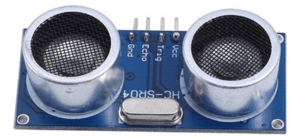


Figure.2 Ultrasonic Sensor

1.5. Bluetooth Module HC-05

For wireless communication, the HC-05 Bluetooth module in figure.3 is designed. Both master and slave configurations are compatible with this module. The HC-05's red LED indicates whether Bluetooth is active and the status of the connection. Before being connected to the HC-05 module, this red LED continuously flashes in a periodic manner. When it connects to any other Bluetooth device, its blinking is reduced to two seconds. For this module, 3.3V is required. [7]

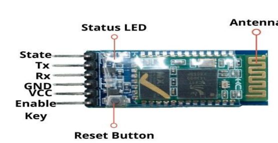
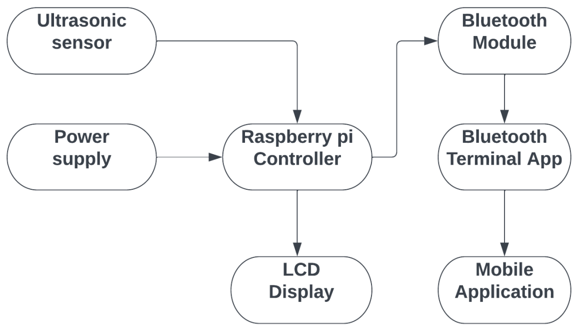


Figure.3 Bluetooth Module

IV. BLOCK DIAGRAM



V. METHODOLOGY

1.1. Preparation of Raspberry Pi OS

The Raspberry Pi needed to have an operating system (OS) installed before anything else. The Raspberry Pi Foundation offers BUSTER, a straightforward OS installer. It may be downloaded and extracted to a blank SD card from the official Raspberry Pi website. When the card containing Buster is put into a Raspberry Pi, it displays a list of available operating systems that can be loaded on the device. The Raspbian desktop version without any additional applications was chosen as the operating system when the Raspberry Pi was powered on in BUSTER. The Raspberry Pi's official Linux-based operating system is Raspbian.Which is shown in the

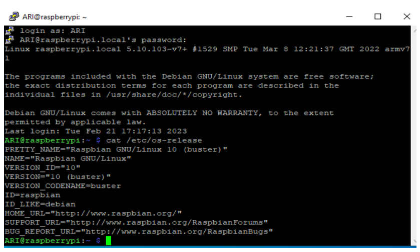


figure.4

Figure.4 Raspberry pi OS

1.2. Preparation of Thonny in Raspberry Pi

A free Python Integrated Development Environment (IDE) called Thonny was created specifically with the novice Pythonista in mind. It contains a built-in debugger that might be useful when you encounter ugly issues and, among other fantastic capabilities, it allows you to perform step through expression evaluation. Thonny is a fantastic, user-friendly IDE that is pre-installed on Raspbian. When you load the software, an interactive environment with a Python emphasis is present. By selecting the Raspberry Pi icon and then Programming > Thonny Python IDE, you may launch Thonny. Write your program in the top pane, click *File* > *Save as...* to save it, and click *Run* > *Run current script* to execute the program. Output will appear in the bottom interpreter pane, which is shown in the figure.5

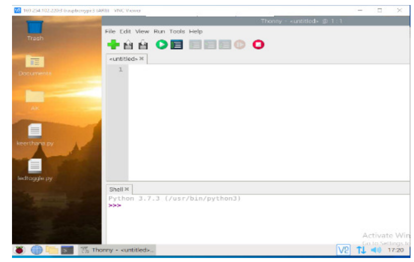


Figure.5 Thonny Software

1.3. Interfacing Ultrasonic Sensor

A wealth of knowledge about voiding dysfunction can be found by using ultrasound technology, which is an imaging tool. It is possible to scan the bladder and figure out its form by attaching an ultrasonic wave transmitter and receiver to the skin above the bladder. The figure illustrates this.

It is based on a combination of four ultrasonic transducers that send ultrasound waves perpendicular to the abdominal wall in the direction of the bladder within a 30-degree field of view. When the bladder is full, the sensor alerts the user to empty it by continuously estimating the BUV condition. More research is needed to improve the system's performance, with a focus on expanding the neural network's size to improve the system's functionality on mobile devices with constrained computational power. Despite these drawbacks, the findings indicate that MoUsE might be a useful tool for ultrasound imaging research and instruction. [8], which is shown in the figure.6

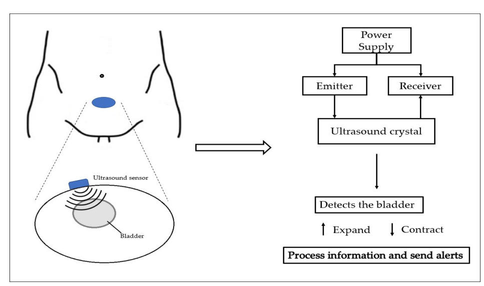


Figure.6 Working of Ultrasonic Sensor

1.2.*Bluetooth Interfacing and Mobile App*

The device to be monitored must be connected to the HC05 Bluetooth module, which must then be configured using the necessary commands to create a Bluetooth connection with the smartphone. Provide software for smartphones that will allow data transfer through Bluetooth connections and provide device status information. Installing the Bluetooth Terminal app service into the software will enable it to send notifications and alerts to the user's smartphone whenever the device state varies from the predetermined range. Create an app for the smartphone that can provide information about the device's status to Bluetooth Terminal App in order to create and deliver notifications to the user's phone.. Shown in figure.7

Figure.7 Bluetooth Terminal App

VI. RESUT AND DISCUSSION

There are a number of encouraging findings and implications from the non-invasive bladder volume measurement and monitoring system using a Raspberry Pi and a Bluetooth terminal software. By properly measuring and monitoring bladder volume without the need for invasive catheterization, the device may lessen the need for dangerous operations. The Bluetooth connectivity enables users to receive messages and updates in real-time, which may give people with bladder issues peace of mind. This non-invasive monitoring technology may help people with bladder problems live better lives and may also be useful in hospitals and other medical facilities.

VII. CONCLUSION

In conclusion, a method for non-invasively measuring and monitoring bladder volume utilizing a Raspberry Pi and Bluetooth shows promise for enhancing the quality of life for people who have bladder difficulties. This device may lessen the need for dangerous operations and give customers peace of mind by eliminating invasive catheterization and giving real-time information and notifications via a mobile app. In healthcare settings, where non-invasive bladder monitoring may be helpful for patient care and monitoring, the initiative also has ramifications. Overall, this experiment shows a promising strategy for non-invasive bladder monitoring, which may enhance patient care and lower medical expenses.

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