Design of voice enabled fall detection on Raspberry pi 3B+

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Abstract— **Visually impaired people, face many issues in their day to day life such as difficulty in road crossing, occasional body imbalance resulting in injuries, difficulty in cash counting, doing simple arithmetic calculations etc. In this paper we propose a solution to minimize the above issues which implements a voice enabled feature to help the users in a better way. The design uses COTS (Commercially Off-The-Shelf) components that include Raspberry pi 3b+, an accelerometer, a humidity sensor and a key pad. It aims to enhance the lifestyle of both visually impaired and also the elderly people.**

Keywords—fall detection, helpline center.

I. INTRODUCTION

The proposed design aims to implement i) a voice enabled Smart Fall Detection Monitor System (SFDM) ii) a Calculator Functionality with Speech (CFS) output. SFDM detects the sudden fall of the user and sends an immediate message to the Help Line Center. It includes a Smart Fall Detection algorithm. CFS aids both the Visually Impaired People (VIP) and elderly people in need.

India has around 8 million blind and 62 million visually impaired people. India is the first country which started Blindness Control Programs to reduce the Prevalence of Blindness [1].

Globally India has the second largest geriatric population. There are about 103.2 million elderly people whose age is 60 years and above. Body imbalance is often observed and a major concern in elderly people and also among VIP. 20%-30% of the injuries among the elderly people is caused due to sudden falls. 50% of the elderly people of age 65 years and above get hospitalized due to these falls [2]. Conventionally smart phones are being used to overcome this issue faced by them but they are expensive and difficult to use.

Special devices and assistive technologies such as Screen readers, Descriptive Video Services, Optical character recognition assist VIP. The awareness of these technologies to the users is very minimal in India.

A survey is conducted on 180 blind people, 75% of them wanted an electronic calculator which can perform at least four arithmetic operations (add, subtract, multiplication, division) with immediate confirmation of keyboard entry, speech output for the result [3].

The proposed design meets the requirements like road crossing, sudden fall for visually impaired people and elderly people. It also implements a user friendly calculator for performing simple arithmetic calculations.

Section II describes the system level block diagram. Section III describes the detailed block diagram. Section IV describes the hardware setup and results. Section V describes the future scope. Section VI describes the conclusion.

II. SYSTEM LEVEL BLOCK DIAGRAM

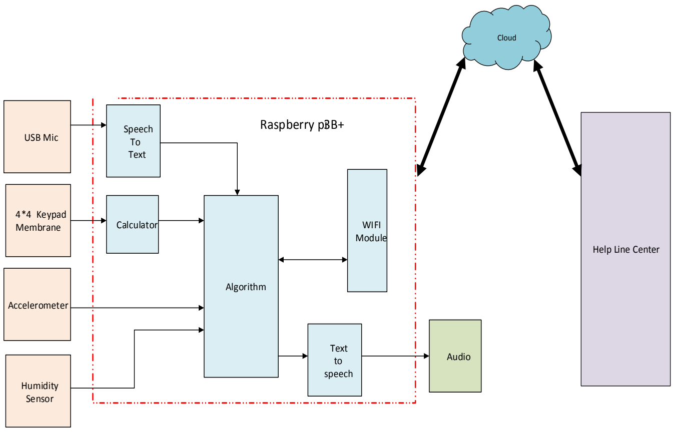

Fig. 1. System level block diagram

The block diagram consists of raspberry pi 3b+, an accelerometer ADXL 345, a humidity sensor DHT11 and a 4*4 matrix membrane keypad, an USB Mic. Raspberry pi sends the emergency message to the help line center via cloud.

A. Raspberrypi 3 b+:

It is a small sized computer with quad core processor running at 1.4 GHz. It has a built in Wi-Fi and Bluetooth stack. The board consists of 4x USB ports, 1x Ethernet port, 1GB RAM, micro SD card slot, 28x GPIO pins. It uses Raspbian OS (downloadable from Raspberry Pi official site). The OS to be flashed on 8GB Micro SD card.

B. Accelerometer (ADXL 345): A thin, ultralow power, 3-axis digital accelerometer.

C. Humidity Sensor (DTH11): Detect atmospheric humidity and temperature.

D. 4*4 Matrix Membrane Key pad: Sends numbers and arithmetic operators to Raspberry pi.

E. USB Mic: It is USB 2.0 Compatable Mic

F. Help Line Center: A special phone service to which the people can call and ask for the help.

III. DETAILED EXPLANATION OF BLOCK DIAGRAM

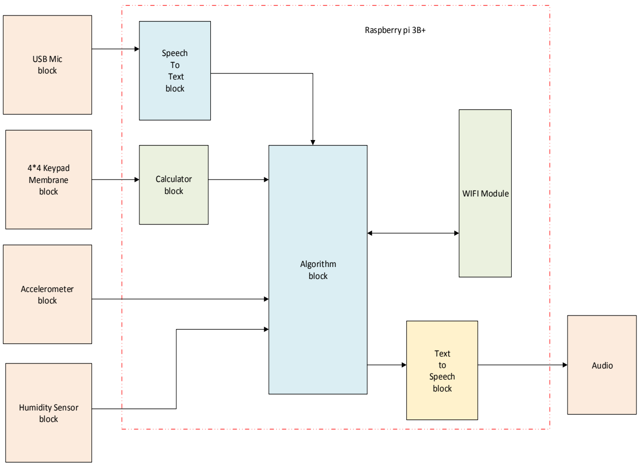

Fig. 2. Detailed block diagram

A. Accelerometer block: Communicates with external IC and send to the Fall detection block.

Attitude angles calculations (Accelerometer) are given below

- angle around x axis = arctan $(g_y / \sqrt{g_x^2+g_z^2})$
- angle around y axis = arctan $(g_x / \sqrt{g_y^2+g_z^2})$
- angle around z axis = arctan $(g_z / \sqrt{g_x^2+g_z^2})$

Where g_x, g_y, g_z are the acceleration in x, y, z axis. Based on the attitude angles, the accelerations along the three-axes the accelerometer IC gives the 16 bit two's compliment digital output via I2C interface at 100 Hz frequency [4].

B. Humidity sensor block: Communicates with humidity sensor over GPIO pins and it sends the digital output to the processor at every 500ms interval. It sends humidity as high when the humidity is greater than 80%.

C. USB Mic block: Sends voice signals to Raspberry pi. It Interfaces between Mic and speech to text block

D. Keypad interface: Recognizes the key press, and sends the value to processor to perform for calculator functions (+, -, *, / and numbers).

E. Text to speech block: It communicates with keypad interface and speaker and it converts the calculator text output to Speech and sends to speaker.

F. Speech to text: Mic output converted to text using the Speech Recognition package in raspberry pi. It uses Google Speech API, it has a training model in which various referneces of phrases, words, phones are stored and also a recognition model to compare input speech with the set of refernces.[6]

G. Algorithm block:

It is responsible for the detection of a sudden fall of the user (VIP and elderly people) and sending the message is desired. This block detects the fall of the user, whether in high humidity bathroom area or any other less humidity area. It communicates the message information to the help line center with internet (online – Telegram bot), without internet (offline – Twilio).

i) Fall Detection Algorithm:

To detect the sudden fall the threshold values for the change in acceleration in x, y, z axes is calculated using the following formula

$P = \text{sqrt}\,(a_x^2+a_y^2+a_z^2)$,

a_x, a_y, a_z are the accelerations in the x, y, z axes acquired every 500ms.

From the result of our continuous test the lower and upper threshold values for the accelerometer as set as greater than 380.

Sudden fall (p_{sf}) → $p>380$ m/sec^2.

Normal (p_{nml}) → 80 m/sec$^2<p<380$ m/sec^2

(P is normal when user performs activities such as walking, sitting, lying down etc.)

Fall detection method:

The speech captured from the USB Mic gets converted to text using the Speech Recognition package in raspberry pi. Google Speech API uses a language model to convert the sounds into letters and recognition model for the mapping. The design is trained with words such as abba, amma, shit, oh my god, help etc.

The event of fall is detected (p_{sf} is true) and the user utters any of the above trained words via USB mic within 25 sec after the fall. Also humidity sensor output (>75% humidity) is considered for detecting if the fall is in bathroom.

An SMS message is sent when fall is detected to the helpline center for assistance.

Calculator functionality:

It is an added feature for making basic arithmetic operations. The data is input from keypad and the result is in speech form to an external speaker. This process uses Google text to speech API.

Multi-threading mechanism is used to run both the fall detection system and the calculator.

Figure.3.1, Fig 3.2 shows the flowchart for smart fall detection and the Calculator.

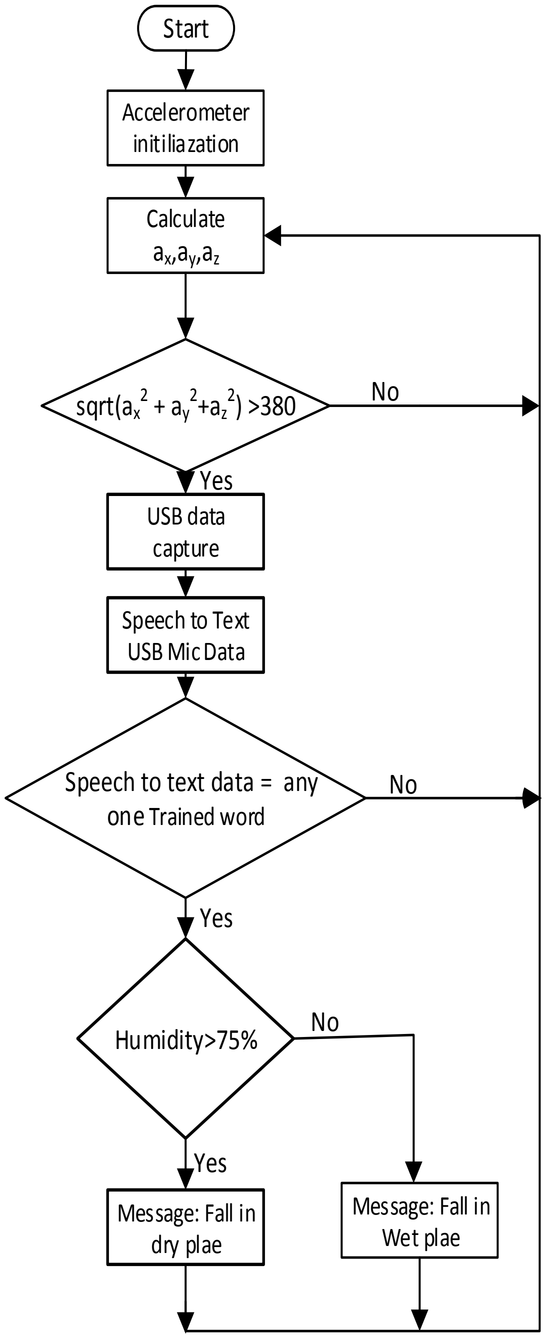

Fig. 3.1. Flowchart for SFM

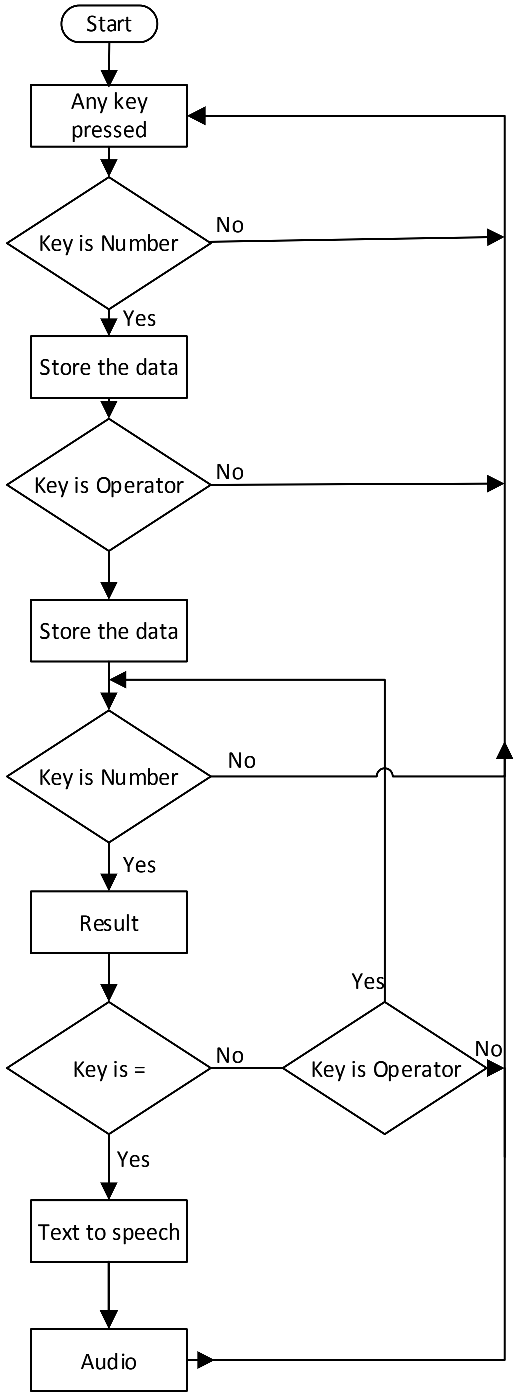

Fig. 3.2. Flowchart for CFS

IV. HARDWARE SETUP AND RESULTS

The hardware setup for the proposed model is as shown in the fig. 4.

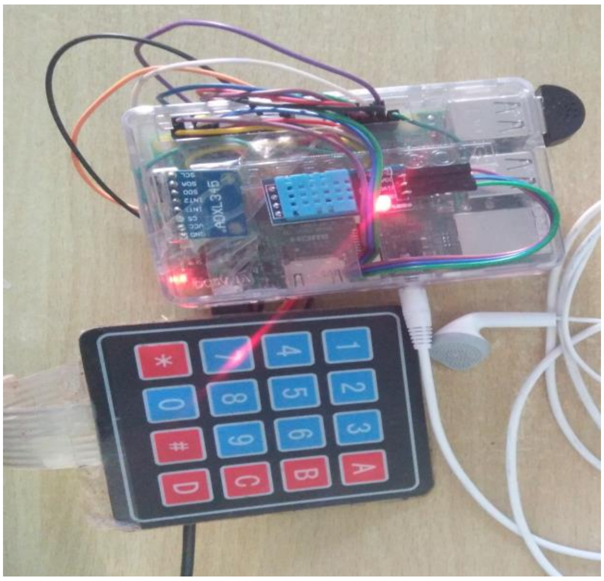

Fig. 4. Hardware setup

From the experimentation results the values a_x, a_y, a_z, p values are noted and fig.5 indicate the detection of sudden fall when $p_{sf} > 380$.

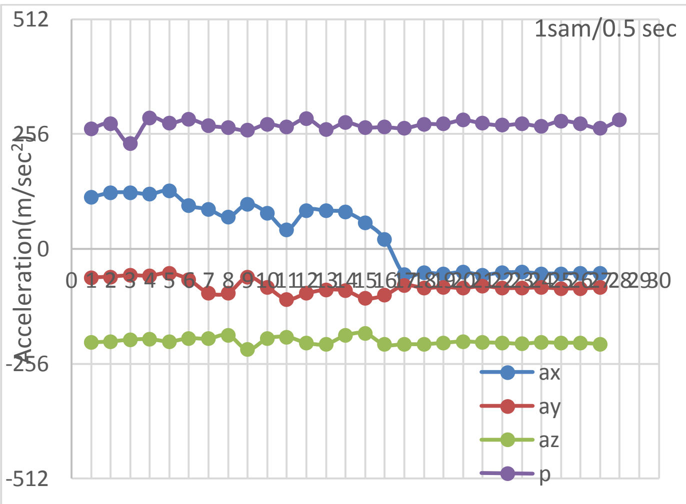

Fig. 5.1. User in resting position

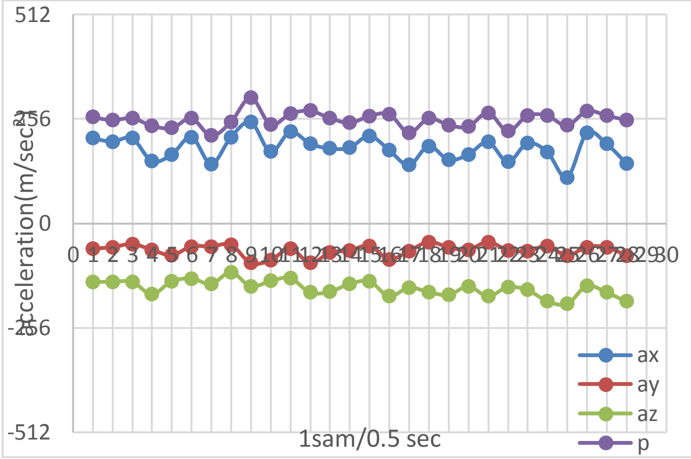

Fig. 5.2. User is walking

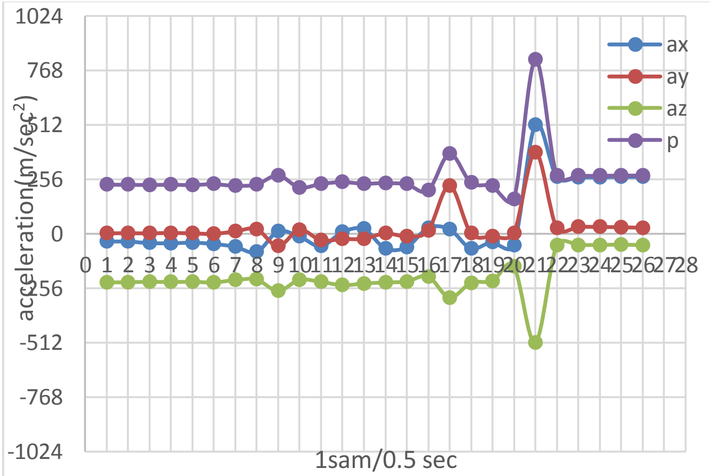

Fig. 5.3. Fall in front direction

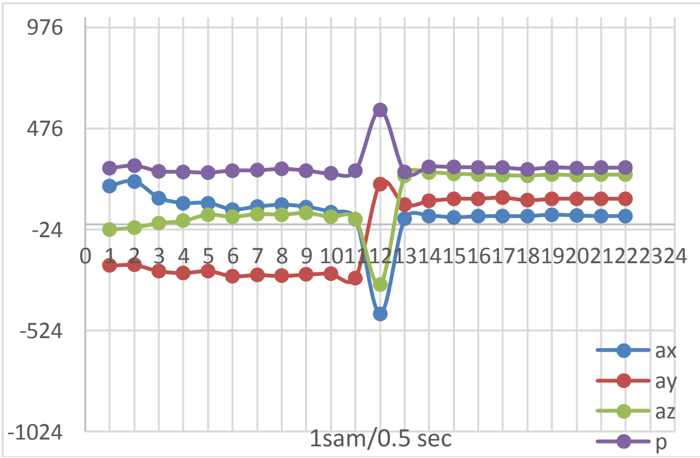

Fig. 5.4. Fall in left direction

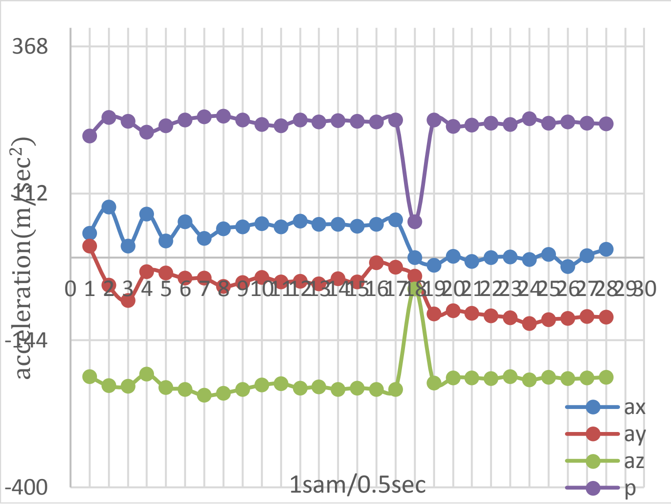

Fig. 5.5. Fall in back side

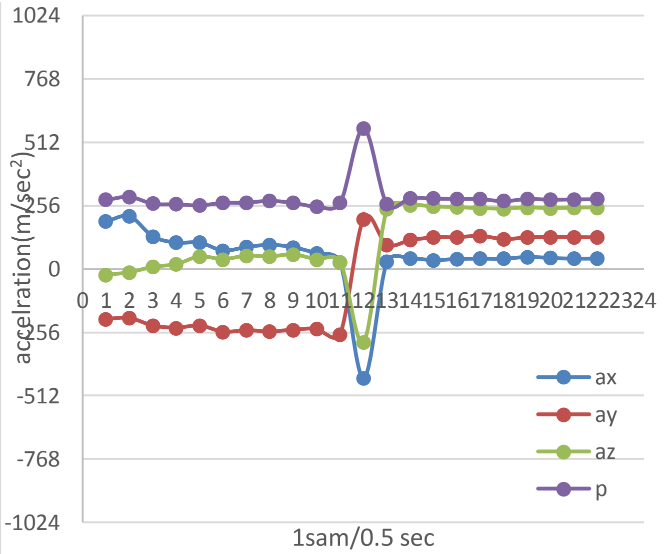

Fig. 5.6. Fall in y

Fig 5.1 and Fig 5.2 shows the acceleration values for every 0.5 sec in x, y, z axes when the user is in resting position and walking state respectively which indicates normal condition. Fig 5.3 shows the sudden change in acceleration at 21st second as p = 818 > 380 for the front side fall. Fig 5.4 shows the change in acceleration at 12th second as the p value exceeds the threshold value that is 568 for left side fall. Fig 5.5 shows the change in acceleration when the user experiences back side fall at 18th second as p = 62 < 80. Fig 5.6 shows the change in accelerations for a right side fall as p = 568 at 12th second.

The images of the normal and telegram emergency messages can be seen in the figures 5.7 and 5.8 respectively. The user can not only send the emergency messages but also the voice texts to their kith and kin.

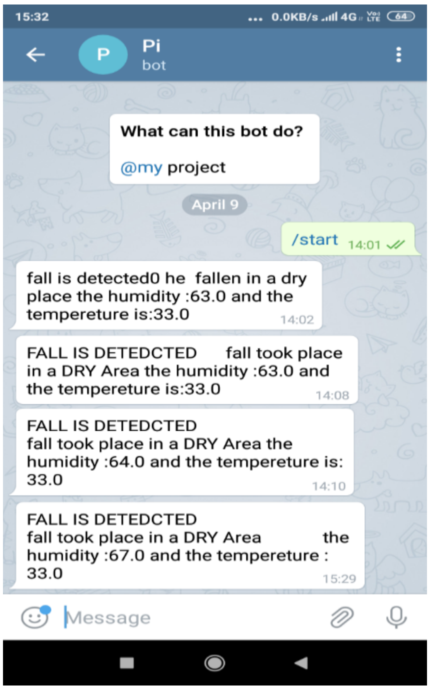

Fig. 5.7. Emergency message sent to telegram API

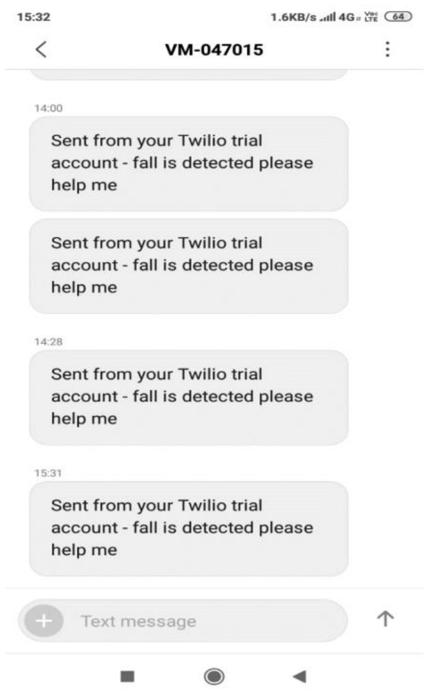

Fig 5.8. Shows the normal and telegram emergency message

After the fall is detected at the immediate 5th sec, a telegram message was sent and the 6th sec, a text message was sent on the phone

V. FUTURE SCOPE

Offline emergency messages can be sent by interfacing raspberry pi with GSM module. The information about the latitudes and the longitudes where the fall took place can be found by interfacing GPRS with raspberry pi. The keypad can be made a braille scripted one by using 3D printing so that VIP can use the calculator effortlessly.

VI. CONCLUSION

In this paper, we proposed a voice enabled Smart Fall Detection Monitor System (SFDM) and Calculator Functionality with Speech (CFS) output is detailed. An Algorithm features to send an emergency message when the fall took place and calculator whose output can be heard in the speech format is explained. The results and the validation setup on Raspberry pi 3b+ is discussed.

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