Internet of Things for Surgery Process Using Raspberry Pi

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Abstract—The development of the internet of things makes all objects interconnected, making it the next technical revolution. It has been applied extensively in various sectors, including agriculture, smart parking, and industrial places, and most importantly, in the health monitoring process.[1] To monitor or its application in surgery procedure is one of its uses in healthcare. This project proposes a system aimed to solve sudden occurrences and emergencies during the operation process. The system's objective is to minimize deaths and other possible effects of the phenomena by connecting the surgeon with an online specialist all over the world. The proposed system architecture is based on medical sensors measuring the patient's physical parameters utilizing wireless sensor networks. The sensors send the parameters to the Raspberry Pi, which converts them to digital data. The digital data is transferred over the wireless network to the server, which is then sent to the cloud environment using the internet of things. Additionally, In case of any problem, the system works by sending the surgeon a voice signal to open the system and record the message and send it with the video that was recorded by the Raspberry pi cameras through the server to all the surgeons involved in the system through the Internet of things all over the world. Then the surgeons from across the globe communicate according to his specialty of assistant surgeon to communicate with the surgeon inside the operating room through headset and microphone.

Keywords—Raspberry Pi, Internet of Things (IoT), ECG sensor, Frequency Heart Rate Variability EMG Signals, Wi-Fi, Frequency Heart Rate Variability, Blood Pressure, Sensor Element Respiration, Body Temperature Sensor, Accelerometer Sensor.

1 Introduction

The Internet of Things (IoT) topic in recent years has been on the high rise especially in economic, social, and technical importance. Internet of Things using processors, microcontrollers, and sensors with accessories used for communication via the internet and has turned to be the constitutive part of the internet. IoT is developed with a protocol that aids communicating as well as interacting with each other and the user respectively [2][3]. The communication through the internet helps to identify a lot of applications which are built grounded on the Internet of Things technology where every physical object such as sensor devices is linked to the internet.

One of the industries that play a vital role in the Internet of things is the healthcare sector. The adaptation of this technology in different systems of healthcare has helped to minimize the difficulty experienced by the physicians or the doctors including other health professionals and the clients, who are the patients — starting from providing homecare replacing the expensive clinical care as well as prevention a substitute which is efficient in delivering healthcare service. One of the benefits related to the use of the internet of things is an increase in supporting the patient quality life, cost, and ensuring the life span of patients with appropriate medication. Additionally, in conventional health care, the undetected health problems can be determined and resolved via the use of IoT technology ensuring healthcare services through digital identity maintenance for every patient complication to be significantly reduced.[3]

The constant communication between the health sensors device and the smartphone or computer having the default capability to communicate with the server makes the entire system reduce the cost and the complexity of the system. Given that the internet of things is termed as the physical system's network it allows parameters to be sensed or else be controlled remotely across network infrastructure, therefore, creating chances for more physical world integration to computer-based systems. This integration results in enhanced accuracy, efficiency, and economic advantages also reduced human intervention. On the other hand, in healthcare or medical systems both software and hardware devices need some investigations when it comes to the internet of things concept.

2 Problem Statement and Objectives

In recent years multiple incidents and cases of malfunction during the surgery and the emergence of sudden circumstances have been reported. Most of these emergencies are not within the expectations and the procedures of the operation in parts of the body of the patients. The inability of the doctors to performing or conduct the procedure to save the patient on her/his own without resorting to a specialist doctor online has been one of the causes of the worse, which is the death of the patient. The inability to leave the patient and out of the operating room to seek the help of the specialist doctor has been quoted as a trending issue that needs to be resolved. This is a critical issue around the world and must be addressed immediately. Internet of Things can offer the required solution to this problem; the wireless sensor technology gives information on the different wireless sensor by giving the adjustment in diversity sensor technology.

The wireless sensor technology can be used to receive information concerning the patient body temperature, heartbeat, blood pressure, and other significant parameters during operation exercise. This is attainable through the internet of things platform via the internet. This paper offers the health monitoring system during the operation procedure that determines critical human conditions for instance heart rate, blood pressure, sugar, oxygen, and other parameters. Apart from these parameters, the electronic system will record the patient's initial details before the operation of the X-rays. In case of any emergency, the system will send warning signals in the form of a message or call to the surgeon.

"The utilization of both the internet of things and Raspberry Pi has to gain satisfactory comments in health supervision, and this project gives the concept of the two platforms and its application in surgery operation. A popular platform Raspberry Pi provides the full Linux server on the small platform with the internet of things at a fordable amount. Raspberry enables interface services as well as mechanisms through the general-purpose I/O interface. Using both concepts makes an adequate system infrastructure. Therefore, this project aims to fashion a prototype to monitor the patient in the operation room condition. Also, Raspberry Pi is the processor of the system".[4]

Raspberry functions perfectly as a multi-processor. The device comprises a graphics card, RAM, a volatile memory, device interfaces, including other external wireless device interfaces. In terms of power-consuming Raspberry Pi consumes minimal power making it a cheap and powerful device. To provide commands it needs keyboard, power supply as well as a display unit as a standard PC.

3 Related Works

The aim of the proposed system in this project is the transfer information or message in case of malfunction or a sudden occurrence in the operation or surgery process in real-time. The link between the different elements is described with the following system structure. The proposed system design comprises two parts that are hardware and software parts. The hardware unit part includes receivers and transmitters while on the software unit contains software languages, for instance, MATLAB, Python, and their interfaces. Before discussing the proposed system, it is crucial to review the Architectural design of already existing systems in healthcare. In most of the IoT applications, various steps are observed during its operation, which includes a collection of the data, processing the data, storage of the data, and transfer of the data.

3.1 IoT & Embedded system

We confer the low cost and the small system of the RFID-Raspberry Pi system provides a potent new use to field biologists. it's an obsequious, versatile, and relatively inexpensive system for automated data-logging and audio or video playback and recording. The RFID technology already fare manner in ecology and evolution, when conjugate with the RPi or other single accost cheat computers, presents many interesting opportunities for experimental and observational field investigation Low-cost audiovisual playback and recording triggered second-hand Raspberry Pi. [5]

[6] The Author focuses on IoT middleware as many systems are built from existing middleware and these inherit the implicit ease properties of the middleware framework. In the first part, we created a matrix of security challenges that attach the existing CIA+ plan to three plain areas: decision, fret, and damage. Assistance part, they used a structured seek an approach to identity 54 precise IOT middleware frameworks and we analyzed the security pattern of each of those. While there are existing surveys of IoT middleware, none of them focused on a detailed analysis of the carelessness of the sweep systems and therefore this has a clear contribution to the literature.

Every application has the processing of the initial and the last step, but in specific applications, storage does not apply, especially when it comes to real-time communication. Fig.1 presented by [7], below shows a general architecture of the Internet of things. The figure shows that IoT entails many components, which include radio transceivers, wireless connectivity RF component, low power multi-radio chips, and other essential components.[8]

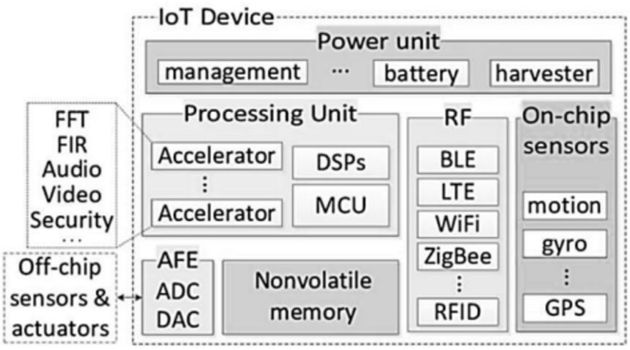


Fig. 1. IOT general architecture

Recent advances in technologies have conceded the plan of slender-size low-power and moo-cost devices that can be joined to the Internet, enabling the emerging paradigm of Internet-of-things (IoT). In this invited paper, we discuss and resume the IoT example with a special center on Life consumption and methodologies for its minimization. In this papery, we have sum up the generalities helter-skelter potency minimization for IoT devices, and we have ventilated several techniques that can be used for such a purpose.[9]

3.2 IoT & Healthcare system

[10] Authors said point Patients' health is affected by changeable sensors and then the data which is stored by the Internet of Things is displayed through the website that supports admission the remote track. Thus, with the interest of sensors, we can diminish humanistic errors as well as the employed path in the room is also shorten due to the

dimension of the system. Necessary actions can be taken during semi-major ailment and the health of the patient can be tracked at home as well as by the doctor

According to [11] general system using IOT and raspberry pi tools is primarily focused on determining the health condition of the patient entailing the health parameter, and obtaining perfect outcomes. This system has been helpful for health facilities since the values of the parameters are all in real-time. Via the system, the physician can be calibrated the body temperature, ECG, heart rate parameter of the patient proficiently, also, the Raspberry device can store information momentarily. The heart rate is received in pulses; body temperature in the form Celsius, ECG received in percentage and is shown on a distinct website or health care device.

Considering the general architecture design with raspberry pi to monitor patient it comprises sensors connected to the skin of the patient and at the other end connected to the raspberry pi projected based on Fig. 2 below. [10]

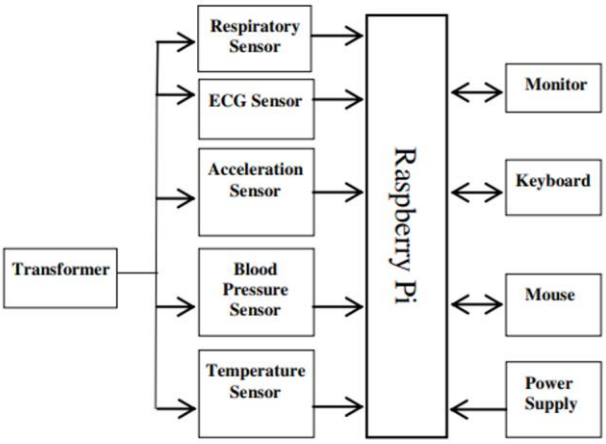


Fig. 2. Architectural design diagram comprising raspberry pi

Each sensor value is stored in the server, simultaneously, displaying the very new values. This enables all the stakeholders linked to the patient including the doctor to see the patient's information data together with the corresponding login data. With the system above, the doctor can access the history records of the patient and suggest changes in medication and prescription in regular monitoring. The benefit of adopting the Raspberry tool in the application is because of its multi-capacity efficiency of low power consumption, as already explained in the introduction part. Furthermore, the system installation at the end part is secure and can also be obtained from a database and as a result, gives valuable information [12][13].

[14] We discourse extended monitoring of the forbearing mode and store the magnanimous data in the server using the IoT conception. At the same opportunity, we can also use a touch sensor which is a habit to get a complaint from the patient when he is in a panic. The trackpad is useful in such a distance that the patient can touch the pad to inform others about his needs in the form of audio.

According to Heartbeat and Temp Measuring Sys, [15] they said the shift uses the optical technology to detect the flood of manslaughter through the finger and offers the profit of portability over the cut and dried recording systems. This paper personates these challenges as well as solutions to these problems by proposing a construction which like a Reticulum to be formed between the patient and doctor to endow abstracted supervise of a patient by analyzing the data of the patient. The optical pulse sensory counts the heartbeat per minute and the constitution sensory appraises the temperature from the body and both the uniform data are sent to a receiving issue utilizing wireless technology where the data is expanded in a phone for further progress and subject care. The optical pulse sensor reckons the heartbeat per temperature sensory moderation the moderation from the strength and both the measured data are sent to an embrace death utilizing wireless technology where the data is unfolded in a cell phone for further protuberance and persevering care. LM35 is used as a temperature sensor in this device which appraises the temperature of the thickness and the measured data is fed to the transmitter model. [24]The GSM module requires an SMS to be sent to a mobile shift which may require gainful for SMS to the mobile operator unless the authority takes an initiative to cause the service free of charge which would increase the reliability of the device.

In the up-to-date oversight surrounding, the custom of IoT technologies brings the convenience of physicians and patients, since they are appropriate to changeable in different areas (such as real-time supervise, patient complaint management, and healthcare control). The person's sensory network (BSN) technology is one of the core technologies of IoT developments in the healthcare system, where a patient can be monitored worn an assembly of puny sway and lightweight wireless sensory nodes. This system instant the architecture of IoT and workmanship of Smart health monitoring using IoT [16].

According to Ashlesha A. Patil,[17] said a sensor node has attached on the forbearing body to aggregate all the extraordinary from the wireless sensors and sends them to the BSN care swelling. The attached sensors on the patient's body form a wireless body sensor network (WBSN) and they are competent to sense the heart scold, Temperature of the surrounding. The principal advantage of this system in comparison to previous systems is to reduce the energy diminution to hold the network day, swiftness up and prolong the news coverage to increase patient peculiarity of biography.

4 The Proposed Architectural Method

The projected system to be used in helping the surgeon while conducting the operation to minimize deaths and other operations contain connected sensors in their separate ways. The objective of the sensors is to send data to the device, which is integrated with the board. In this project proposed system the main tool is the Raspberry Pi which is connected to all the sensors. Primarily the Raspberry Pi operates at 5 volts Direct Current power supply. On the other hand, the sensors are connected to different power supply since they work at different power, and in the system, the transformer is used in handling the sensors. “The sensors used in the system detect different biological functions in the human body and are part of the hardware part of the system Fig. 3 shows the Block Diagram of the system. The hardware elements are then integrated with the software system which acts as the controller of the hardware and generation of the report" [18][19]. Apart from the sensors, the system will be fitted with microphones and cameras to record any problem during the operation procedure where it will send to the board then to the wireless system via the internet of things system all over the world.

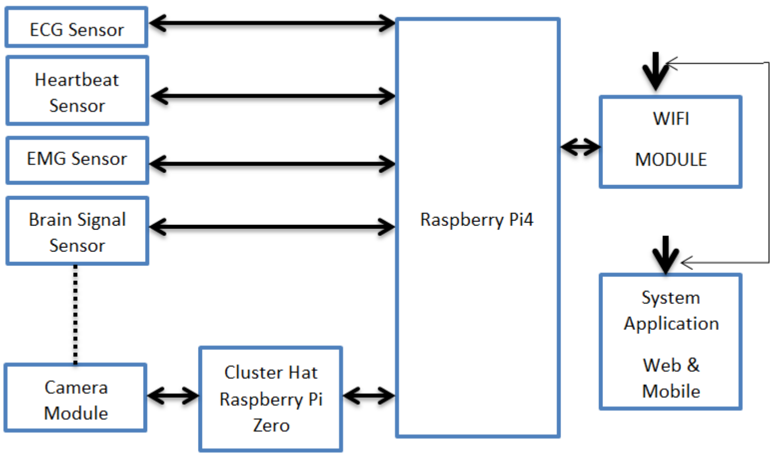


Fig. 3. System Block Diagram

The sensors included in the system include a respiratory sensor, ECG sensor, Blood pressure sensor, heart rate sensor, acceleration sensor, glucose sensors, airflow sensor, brain signal sensor, and body position sensor. "Given that the Raspberry Pi lacks an inbuilt analog to digital converter. The information or data from the sensors is collected with the PIC microcontroller then the digital data is transferred to the Raspberry Pi which has an inbuilt Wi-Fi therefore after processing and displaying the sensor information and other recorded information on LCD it as well enables the storage of the data on the cloud via wireless network or Wi-Fi where the online specialist can access the data on their computers and smartphones".[8] [14]The different components of the proposed system and their effectiveness are described below. **Fig. 4** below shows the project Fritzing Circuit Diagram showing sensors included in the system. **Fig. 5** shows the representation of the proposed system architecture.

From the proposed system architecture, the raspberry pi is connected with the sensors which are connected to the patient in the operation room. The raspberry pi at the other end is connected with the software system using a Wi-Fi connection. Sensor senses data of malfunction in the patient body sending it to the server where it is compared with the standard values which are stored in the system. This comparison checks the abnormal and healthy conditions of the patient. In the case of abnormalities, a message is sent to the doctor or online specialist to avoid critical situations. "Apart from the sensor the Raspberry Pi Zero with camera module records the video data which is then transferred to the processor for processing. Additionally, the surgeon uses headphones fitted with a wireless microphone to communicate externally where the speech is recognized and sent to the webserver as digital data where is sent to the internet of things and received by the online specialist as notifications text or voice message on the monitoring and smart devices"[20]. The headphones are also used to receive the response and guidance from the specialists outside the operating room.

The system is controlled by the administrator where the new patient's entries, as well as the surgeon or doctor, are made. After getting the information from the sensors and stored in the database the display is done on a separate UI page, which is loaded periodically and collects data from the database. The sensor time interval ranges from 5-10 seconds. In case of sudden occurrence, the message is sent to the specialist in real-time. For the projected system, the system and hardware device are connected centrally. Therefore, two servers are used one for system deployment and the other server for a database to store data. All data originating from the operation room is in the digital format to give the advantage of the speed of operation as well as digital processing to be more efficient than an analog signal.[21]

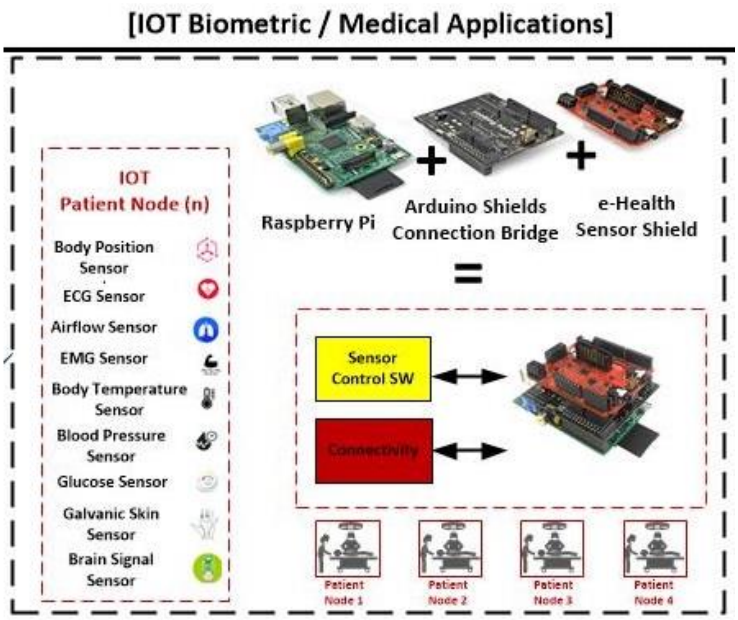


Fig. 4. Project Fritzing Circuit Diagram

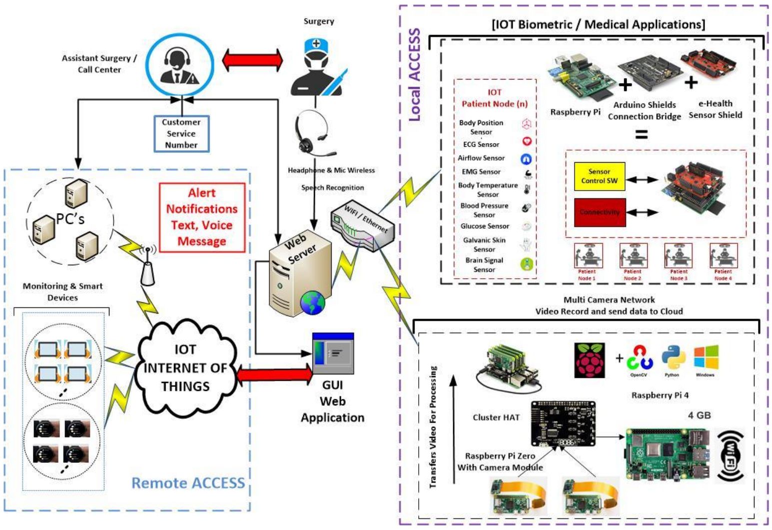


Fig. 5. Proposed System Architecture

4.1 Proposed system hardware module to be used

Raspberry pi: As already mentioned, Fig. 6 shows raspberry pi is one of the essential hardware used in the proposed system. The main objective of the hardware is to get the physical parameters from the sensors and convert them into digital data. The characterization of the raspberry pi is that it supports plugging using USB ports. Additionally, it has fourteen more GPIO pins. 64bit ARMv8 Broadcom BCM2711 Quad-Core Computer running at 1.5GHz. 4 poles Stereo output and Composite video port. CSI camera port for connecting the Raspberry Pi camera. DSI display port for connecting the Raspberry Pi touch screen display. Full-size HDMI. 1GB RAM. Theses specifications enhance the efficiency of the hardware in converting the physical parameters into digital data.[17] [14] Table [1].

Table 1. Raspberry Pi Model B Specifications

Item	Description
Size (mm)*	85.6 x 53.98 x 17
Weight (g)*	45
Processor	Quad-core Cortex-A72 (ARM v8) 64-bit, BCM2711
RAM	1GB, 2GB or 4GB LPDDR4-3200 SDRAM
Power	5V DC via USB-C connector & GPIO header (minimum 3A*)
Pins Connector I/O	40 pin GPIO headers
Communication	2.4 GHz & 5.0 GHz IEEE 802. 11ac wireless Bluetooth 5.0, BLE Gigabit Ethernet
Graphic & Video Encoding	H.265 (4kp60 decode) H264 (1080p60 decode, 1080p30 encode) OpenGL ES 3.0 graphics
Ports I/O	2 USB 3.0 ports 2 USB 2.0 ports. 2 × micro-HDMI ports (up to 4kp60 supported) 2-lane MIPI DSI display port 2-lane MIPI CSI camera port 4-pole stereo audio and composite video port
Programming language	C, C++, Java, Phyton
Operating System	Raspbian, Ubuntu, Android, ArchLinux, FreeBSD, Fedora, RISC OS

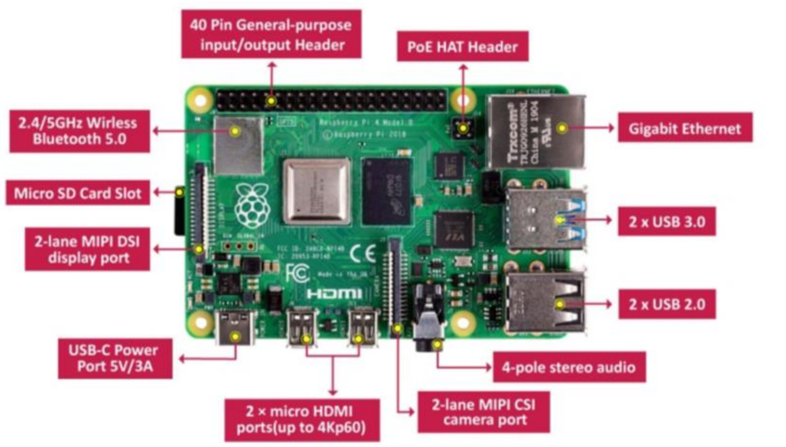


Fig. 6. Raspberry Pi 4 Computer Model B 4GB

Sensors: Since the system comprises various sensors that are body position sensor, ECG sensor, airflow sensor, EMG sensor, Body temperature sensor, blood pressure sensor, glucose sensor, galvanic skin sensor, brain signal sensor, and heartbeat sensor. Emphasize is done on a heartbeat sensor, which is critical during an operation procedure.[18][19].

In surgery, the heart rate of a patient is essential since it determines the flow of blood in the patient body. Therefore, it must be watched closely while conducting the procedure. Hence for the proposed project, it is one of the hardware. It operates by combining simple optical heart rate sensor Fig. 7 shown below; it amplifies the pulse and cancels the noise in the circuitry making it easier and faster to attain reliable pulse readings from fingertip or earlobe. The sensor contains a super bright red LED as well as a light detector. The reason the light is super bright is that it passes via the finger, and it is detected at the other end. The sensor works based on the light modulation principle by the flow of blood through the finger at every pulse. The variations of the detected pulse are converted to an electrical pulse where the signals are amplified and triggered by an amplifier giving an output signal as a blinking light at every heartbeat. This is analog output, which is connected to the controller directly which measures the beats per minute rate.[17] [16]

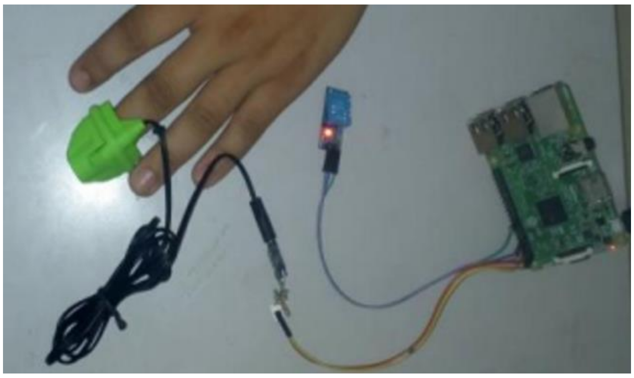


Fig. 7. heart rate sensor attached to the patient body

The data from the sensor is transferred to the Raspberry pi board and is converted to the digital data, which is then sent to the webserver using the wireless network. To keep the surgeon, update the information is updated into the UI periodically. Simultaneously the digital data is transferred to the GUI Web Application which then transfers the information to the Internet of Things sending alert notifications to the monitoring and smart devices of the specialists outside the operation room. After receiving the alert, the specialist response is transferred through the same infrastructure until it now reaches the surgeon.

4.2 Software description

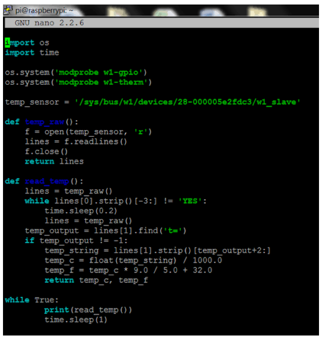
For this project system, Raspbian, a Debian-based computer operating system, was utilized. Various Raspbian versions exist, including Raspbian Jessie and Raspbian Sketch. For Raspberry pi grounded microprocessor Raspbian is highly optimized. Raspbian utilizes PIXEL, and Pi enhanced lightweight X-Window setting as its crucial desktop.

Additionally, it is made of a modified LXDE desktop environment as well as the Open box stacking window manager containing a fresh theme and little extra modifications. Raspbian also is an open operating system centered on Debian elevated for the

Raspberry Pi hardware. Moreover, it contains more than 35,000 packages, pre-compiled software shoved in a pleasant format for informal connection on Raspberry Pi.

To preinstall, the Raspbian OS 2 GB SD card is required, although a 4 GB SD card or even more than this is extremely suggested for prospect addition of packages commended [22]. Fig. 8 below explains the project code used in the Raspbian OS. The sensor data reading code is burned in the microcontroller and interfaced with the Raspberry Pi using the I2C bus interface. For further stages, the code is written in Python in the Raspbian OS Nano text editor. The piece of the software code is written to read the value of the sensor in the text editor. A fresh file is built first using the Nano editor with the command $Nano sensor.py in the Raspbian OS terminal window. Then in sensor.py, the code below is written. [14]

```
import RPi.GPIO as GPIO
import time
pin = 24
GPIO.setmode(GPIO.BCM)
GPIO.setup(pin, GPIO.IN)
while 1:
sensorValue = GPIO.input(pin)
print sensorValue
time.sleep(0.1)
```



```
pi@raspberrypi: ~
GNU nano 2.2.6

import os
import time

os.system('modprobe w1-gpio')
os.system('modprobe w1-therm')

temp_sensor = '/sys/bus/w1/devices/28-000005e2fdc3/w1_slave'

def temp_raw():
    f = open(temp_sensor, 'r')
    lines = f.readlines()
    f.close()
    return lines

def read_temp():
    lines = temp_raw()
    while lines[0].strip()[-3:] != 'YES':
        time.sleep(0.2)
        lines = temp_raw()
    temp_output = lines[1].find('t=')
    if temp_output != -1:
        temp_string = lines[1].strip()[temp_output+2:]
        temp_c = float(temp_string) / 1000.0
        temp_f = temp_c * 9.0 / 5.0 + 32.0
        return temp_c, temp_f

while True:
        print(read_temp())
        time.sleep(1)
```

Fig. 8. system software in OS & Code used in the Raspbian OS

Then Nano is saved by clicking ‘Ctrl+o’ the saved by clicking ‘return,’ then ‘Ctrl+x.’ And the program can be viewed in the OS.

4.3 Sample system implementation

Step1: The simulation diagram of IOT Surgery Operation using Single-Board Computer (SBC-PT) (Raspberry PI) [23] connected with microcontroller MCU-PT through switching by UTP direct connection shown in Fig. 9, in this system was built as a simulator of a real system using Cisco Packet Tracer to support surgery operation on distance in an emergency case, the Sound sensor senses voice and gives a signal to raspberry pi then camera, the system uses image processing to detect an exact area of the affected part and highlights it accordingly. The system now transmits the patient information (body temperature, heart signal, etc.) and images of the occurrence over IOT to be viewed by the user online.

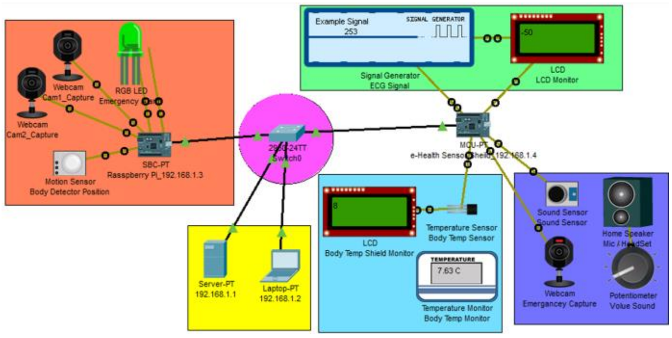


Fig. 9. Simulation of IOT Surgery Operation with Sample Sensor

Step2: Sensor calibrations: In this work, we tried have tested to advance the precision of the measurements through actual-time software calibration, The calibration can be added on appear-up tables that decide aim parameter values can be stored with the Raspberry PI Software in the SD-card or can be transferred to the server.

To begin sensory measure, it needs to measure the actual resistance worth (R_a, R_b, R_c) of the Wheatstone span calibration project. Its be conduct out with an Avometer that is also used to verify the real worth of a reference voltage V_r = 3V. The temperature sensory calibration is utility as a sample on how to moderate the default calibration based on the e-Health kit manufacturer. First, the parameters A_{ux} and R_{aux} are estimated as equation (1), (2), [25]

$$A_{ux} = \frac{V_t}{V_r} + \frac{R_b}{R_a + R_b}, \quad (1)$$

$$R_{aux} = \frac{R_c \, . \, Aux}{1 - Aux}, \quad (2)$$

The estimated R_{aux} is exponentially related to the temperature as follows equation (3):

$$R_{aux}(T) = f \quad . \quad p^T \Rightarrow \quad T \quad = \frac{\log(R_{aux}(T) \;\; / \;\; f)}{\log(p)} \qquad (3)$$

- *f* and *p*: values depend on the measured temperature
- R_{aux} : measured resistance

Step3: The simulated system was coded throw python, JavaScript and finally build by blocky programming Fig. 10 language (Drag & Drop) included parameters and system function, added connection to the server to send mail included patient info after connected all device by port connection analog, digital, Ethernet ports and IP number Table 2.

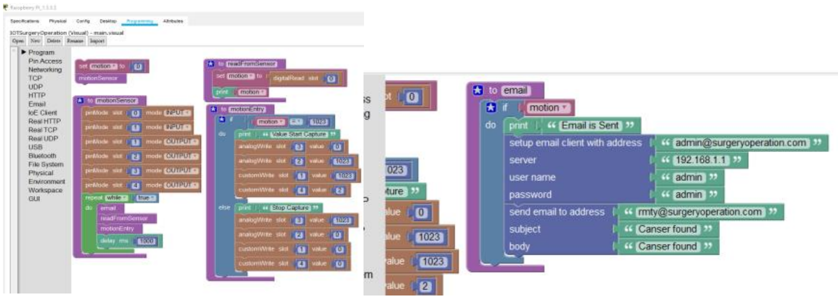


Fig. 10. Blocky Programming - IoT Surgery Operation

Table 2. System Port Connections

#	Type Connection	Origination Port	Destination Port
1	Custom IO-Link	Raspberry Pi_192.168.1.3: D4	Cam2_Capture: D0
2	Custom IO-Link	Raspberry Pi_192.168.1.3: D1	Cam1_Capture: D0
3	Custom IO-Link	Raspberry Pi_192.168.1.3: D2	Emergency Alarm: A0
4	Custom IO-Link	Raspberry Pi_192.168.1.3: D3	Emergency Alarm: A1
5	Custom IO-Link	Raspberry Pi_192.168.1.3: D0	Body Detector Position: D0
6	Custom IO-Link	Body Temp Sensor: D0	e-Health Sensor Sheild_192.168.1.4: D3
7	Custom IO-Link	Body Temp Sensor: A0	Body Temp Shield Monitor: A0
8	Copper Straight-Through	Switch0: FastEthernet0/2	192.168.1.1: FastEthernet0
9	Copper Straight-Through	Switch0: FastEthernet0/1	192.168.1.2: FastEthernet0
10	Custom IO-Link	e-Health Sensor Sheild_192.168.1.4: D1	ECG Signal: D0
11	Custom IO-Link	ECG Signal: A0	LCD Monitor: A0
12	Custom IO-Link	LCD Monitor: D0	e-Health Sensor Sheild_192.168.1.4: D2
13	Custom IO-Link	e-Health Sensor Sheild_192.168.1.4: D0	Emergency Capture: D0
14	Custom IO-Link	Volume Sound: A0	Mic / HeadSet: A0
15	Custom IO-Link	Sound Sensor: A0	e-Health Sensor Sheild_192.168.1.4: A0
16	Copper Straight-Through	Switch0: FastEthernet0/4	e-Health Sensor Sheild_192.168.1.4: FastEthernet0
17	Copper Straight-Through	Raspberry Pi_192.168.1.3: FastEthernet0	Switch0: FastEthernet0/3

5 Procedures of the Project Execution and Analysis Results

This section presents the experimental results regarding the various sensors of the IoT surgery operation Fig. 11. The tested samples of sensors mainly include the body position, ECG sensor, and body temperature. It should be mentioned that the e-Health kit which has been used to development of the IoT SO, supports kinds of measurement of the digital sensor. However, they could not be directly connected to Wi-Fi its required the Arduino shield connection bridge to be connected to the raspberry pi through the same physical resource: the serial port, and additional cluster hat to connect the camera module as shown in the diagram above in Fig.5. This should be done at the preparation phase before the operation procedures start. All the hardware linkage should be verified first before starting the operation. If the Wi-Fi is okay and the online specialist monitoring device is also connected to the internet. Place the patient heartbeat sensor, and this should be done to all the sensors; additionally, the surgeon should be on his/her headphones fitted with microphone and camera and should be linked to the assist and surgeon. The assistant surgery can send the information of an occurrence to the monitoring devices or the server directly as per the surgeon guidelines. Moreover, the doctor can send the information to the webserver directly. The two do not require a raspberry pi board in this case.

The heartbeat, as well as other physical parameters, will be read and displayed on monitor show Fig. 12 if the parameters are abnormal compared to the regular rates it will also be displayed. This information in real-time will be sent to the server then to the internet of things where the online specialist will follow up the process. For our case, the status of the patient will be viewed on the GUI web application. Fig. 13

Fig. 11.: Sensors connected Raspberry Pi

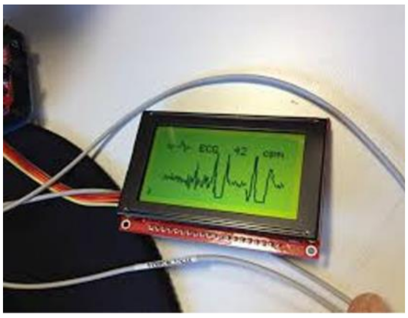


Fig. 12.: Sensors parameters displayed on an LCD

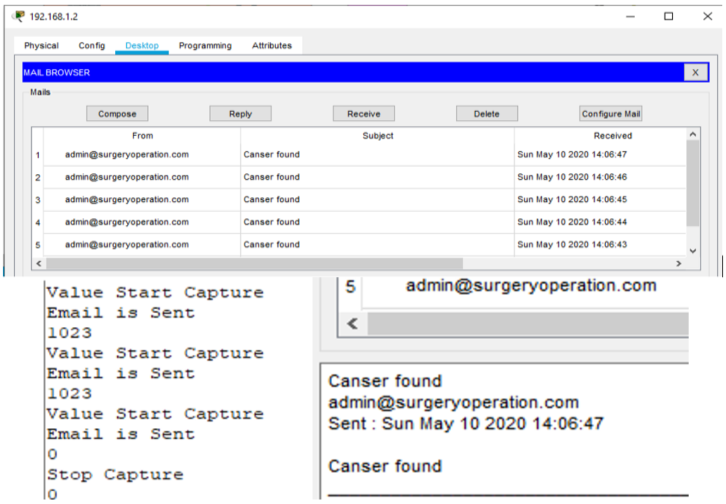


Fig. 13. Patient information was sent by mail

6 Conclusion and Future Work

This project is designed or developed as a prototype to observe and report sudden and emergence in the operation room during the surgery using Raspberry Pi and the Internet of Things. The proposed system is designed to ensure the safety of the patient during the surgery. Continuous monitoring of a patient during surgery is essential. The surgeon can send audio and video via the server and IOT while the sensors like heartbeat and temperature sensors, which are interfaced by Raspberry through the microcontroller, can send the physical parameters in real-time to the online specialist. The digital data in the cloud web server can be accessed by specialists from anywhere around the globe in smartphones and other monitoring devices. Additionally, this intelligence can as well be embedded using LINUX programming language. The interface can be perfected in the future for other healthcare-based sensors that are not included in this system.

7 Abbreviations

- ECG Sensor - Electrocardiogram: records the pathway of electrical impulses through the heart muscle.
- EMG Sensor- Electromyography.
- Fritzing - Is an open-source initiative to develop amateur or hobby CAD software for the design of electronics hardware, to support designers to move from experimenting with a prototype to building a more permanent circuit.
- CSI- Camera Serial Port: is a specification of the Mobile Industry Processor Interface (MIPI) Alliance.

- DSI- Display Serial Interface is a specification by the Mobile Industry Processor Interface.
- GPIO- General-purpose input/output is an uncommitted digital signal pin on an integrated circuit.
- LCD- Liquid Crystal Display
- LXDE- Lightweight X11 Desktop Environment
- USB- Universal Serial Bus

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