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Smart Polyvalent Tracking Device for Data Accumulation and Exhibition

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Abstract **– The proposed device is a refined handheld solution to monitoring the weather conditions and other stats of a particular region and making this data available to the user at all time and places. The main driving principle/technology that supports this project is Internet of Things (IoT) which enables the user to connect and store the entire data in a server. This is made possible by integrating development board Raspberry Pi 0w with various sensors using Raspbian IDE software. Using Web Application programming, the data collected from SQLite database is sent to a Website from which the data is made accessible to the user with any browser supported device. The focus of the proposed model is directed to building a prototype product connect to a server which allows the user to continuously collect real time data like temperature, humidity, pulse rate and atmospheric pressure levels etc. and allow them to be viewed anytime. The design is aimed such that the user can equip it on the get-go and start data monitoring. The project comprises of both hardware and software parts; with hardware part being sensor integration onto the development board and software being written Python Program code which is uploaded into the board from the user. All the objectives of this project are met, planned and derived and the product is considered successful and ready to be launched and implemented in real life application levels.**

Keywords— Internet of Things (IoT), Raspberry Pi 0w, Web Application Programming.

I. INTRODUCTION

The need for data monitoring is an aspect of continuous development and upgradation both in terms of accuracy as well as longevity. The proposed model is aimed at designing a multifunctional sensory device which can be added to trekking personnel, enabling the user to keep track of multiple real-time data like temperature, pressure, humidity, altitude, bpm etc..[1] As entities such as the atmosphere are fitted with sensors, microcontrollers, and various software applications, they become self-protecting and self-monitoring entities, also known as smart entities. All projects calculate air temperature, ambient humidity and atmospheric pressure but individually. The proposed model is designed optimally to ensure easy and reliable access to the user at utmost weather conditions with maximised accuracy. Through web-based monitoring system, the user can monitor data from anywhere, on any device which greatly serves in cutting expense costs. This collected data is stored into a database from which can be accessed by the user accordingly. [2] The weather information is gathered by sensors which intern connected to the Raspberry pi-module serially. It will process and submit the monitored information to SQL database for analysis and management. Data can be monitored and securely processed data is made available to the end user. This way, Trekkers can easily resort to quick access of important data like blood pressure or altitude and can take action accordingly. Parameters like temperature, pressure, altitude, pulse rate levels are very important for a trekker climbing high range mountains. Simultaneous monitoring of these parameters is essential to predict how far the user will be able to tread in such expeditions. In recent years, there have been many developments in this sector, with various non. The main focus here is to design a handheld patent that can assist hikers and improve their way of life.

II. LITERATURE REVIEW

The innovation used in this paper is related to and analyzed through a variety of existing literature reviews. At the bottom of this paper, a reference is applied. Present day models provide information on data such as temperature, pressure, oxygen levels etc. but not to an extent of required precision or accuracy. People cannot always depend on mobile phones for these purposes because the lithium-ion batteries are not designed to withstand harsh cold weather and high altitudes rendering them unreliable. They also do not include the level of multifunctionality as mentioned in the proposed model as most are isolated to either one or the other of these functions. [3] When it comes to accurate measurement of temperature, pressure and altitude, range and accuracy plays a vital role. Sensors discussed in referenced paper for altitude measurement came up inaccurate by a marginal error due to inconsistency in range measurement. However, with the usage of BME280 can now monitor this parameter more accurately

The stunted cost of electronic components (programmable components and sensors) has resulted in the success of a number of low-cost architectures for measuring weather parameters [4]. The authors of the following studies [5] and [6] looked at a smart weather station built on a Raspberry Pi and a smartphone app. The ARM11 processor serves the purpose as the primary core in the proposed system architecture. In this machine single core 32-bit ARM11 processor is used. The authors have included the older BMP-180 with less accurate output for temperature and pressure measurement.

In the case of pulse rate and oximeter advancements,[7] Cell phone manufacturers have recently included an onboard pulse oximeter on the back of smartphones to improve developments in smart health monitoring sectors. [8] In order

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to attain a SpO2 reading, the user must press a fingertip against the sensor. Multiple techniques have been derived to make certain that a human's pulse rate is kept under control [7-11]. Kramer created a modern pulse oximeter that can be used to measure heart rate, blood oxygen saturation and general ventilation levels in other radical anatomical locations at [10]. In his experiment cycle, he compared the blood oxygen saturation levels to baseline SaO2 which was obtained from arterial blood. The research was omitted from the estimation of heart rate precision because there was no suitable ground truth for heart rate. [11] Nilsson found that the ventilation signal could be pin pointed and successfully drawn out at every tested measurement which location include the individual's finger, hand and forearm, shoulder etc. However, these strategies suffer from the same problem of inaccuracy.

Eventhough there has rising evidence for the usefulness of pulse oximetry at high altitude, controversy still exists [12,13]. This is primarily due to variations in individual preconditions, different assessment objectives, different measuring methods, failure to understand system limitations in specific situations, the use of several instruments, and a lack of ability to accurately interpret data [14]. In congruence to the levels of arterial oxygen saturation (SaO2) which is obtained from arterial blood gas (ABG) study, medical pulse oximeters must comply with the international standard for pulse oximeter manufacture ISO 80601-2-61 by default and must maintain high accuracy (average root mean square error Arms 4%) in blood oxygen saturation level readings within the range of 70–100%. [15].

The oximeters used in these instruments are fundamentally the same as those used in hospitals as well as industrial fingertip SpO2 monitors, but using wrist-worn sensor to measure the oxygen saturation levels is inefficient due to proneness to error and unreliability. Non-medical devices that do not comply with this ISO requirement which have higher divergence in SpO2 values. A wide variety of studies have been done to compare reasonably priced commercially available portable devices to medical-standard devices [16]. Poorly fitted instruments, wrist/arm movement, low blood perfusion, and interference are the main causes for its inefficiency. According to these reports, "low-cost" portable devices have sufficiently accurate SpO2 values comprised between 90–100% as compared to medical devices; however, non-medical devices lose accuracy below 90% [17,18].

In the case of higher altitudes, because of the declining barometric pressure and associated partial pressure of oxygen, the human body is subjected to decreased oxygen supply (hypoxia) while rapidly ascending to high altitude (pO2). As a result, multiple physiological responses will be actuated in order to combat hypoxia and the associated risk of becoming ill. [19,20,21]. In the time period of the high altitude stay, changes in resting heart rate are mentioned in 10 out of the entire 20 studies. At moderate altitude, a study introducing regular hiking activities found an initial increase in HR of 8 bpm, with only slight changes during acclimatisation (1 bpm) [22]. The initial drop in SpO2 was stated to range from 5% to 19% in studies conducted at altitudes ranging from 3400m to 4350m.SpO2 increased by 3% [23,24] during acclimatisation in studies with a short period of exposure (5 days) and by 5%–8% in studies with a longer duration.

The rise in SpO2 over time ranged from 1% to 3% when exercise was done consistently in the entire time period of study at these altitudes [25]. A research that looked at SpO2 data right before an exercise test concluded the absence of acclimatisation effect on SpO2 [26]. The saturation levels initially dropped by a margin of 8% to 20% at altitudes greater than 5000 m. The changes in SpO2 during acclimatisation varied between 6–8%. Higher up, the spO2 levels saturate even further becoming inaccurate to some extent.

These findings demonstrate that, considering the wide range of results, finger pulse oximetry in high range/altitudes is an invaluable method for determining the individual course of acclimatisation to high altitude. However, there is a shortfall of data on pulse oximeter measurement accuracy tested at high elevations.[27] researched and studied this effect, using a device to monitor loss of sleep and hypoxia which affected the user's health at different altitude ranges. It also derived that other technical characteristics of the system, such as maximum operating altitude, minimum operating temperature, or the ability to detect low perfusion, should be considered, particularly when treading through higher elevations. Medical pulse oximeters often seem to have higher sensitivity and lower deviations in SpO2 readings below 90% as compared to "low-cost" handheld devices. In addition to the technological factors, as height increases, the measuring process itself becomes more error-prone [28].

The distribution of aquatic species, physicochemical water properties, and rates of ecological processes comprising biochemical cycling are all influenced by water temperature [29]. In aquaculture, water quality control is critical for ensuring long-term water quality. Temperature is one of the important water parameters in several studies on the production of water quality monitoring systems [30]. [31] Furthermore, water temperature is a significant water quality variable since it affects all further parameters like dissolved oxygen concentrations. Water quality control measures the suitability of a given water body for a given reason. Water quality assessments provide insight into the quality and usability of the water system. This is where the concept IoT is introduced into the picture. The main challenge for this technology is to design a device that collects and controls real-time water temperature of a water source.

The primary goal of this paper is to initiate and to implement an effectual monitoring system, where necessary parameters are controlled remotely through database and data is collected and displayed.

III. METHODOLOGY

The proposed model comprises of 2 parts; hardware as well as software with the hardware part being sensor integration onto the development board and software being written Python Program code which is uploaded into the board from the user along with the code and mechanism update this data onto a web application. Figure 1. shows the procedural Flowchart.

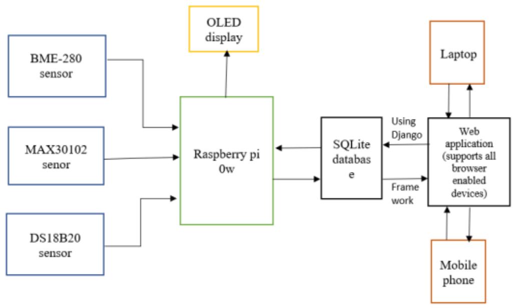

Figure 1 - Block Diagram of entire project

Component List and Specifications:

1) Raspberry pi 0w**:**

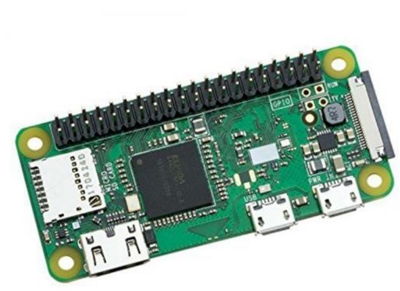

Figure 2- Raspberry pi 0W

- 65mm x 30mm x 5mm Dimensions
- Broadcom BCM2835 SoC
- CPU: 1GHz ARM11 processor
- Includes 512mb of RAM
- Wireless hub included: 802.11n wireless LAN at 2.4GHz
- Two variations of Bluetooth included; Bluetooth Classic 4.1 and Bluetooth LE.
- Power is supplied via a micro-USB connector at a voltage of 5 volts.
- 1080p HD video and stereo audio are available via a mini-HDMI connector.
- MicroSD card for storage
- Micro USB output
- GPIO: 40-pin unpopulated GPIO

2) BME-280 sensor:

Figure 3 - BME-280 sensor

The BME280 is a mechanical barometric pressure sensor that is significantly more advanced than the BMP180. This is available on a small module that uses the 12C serial communication protocol to link with the sensor. This makes it simple to bind it to the Raspberry pi 0w and read data with Python. Temperature, pressure, and humidity are all given by the BME280. The temperature sensor built into the device has been designed for low noise and high resolution.

The 12C serial communication interface on the Raspberry Pi 0w development board must be enabled in order to use this module, as it is not enabled by default. Also make sure BME280 libraries are pre-installed.

- Supply voltage: 3.3 V
- Size: 15 x 10 mm
- Weight: 1 g
- Diameter of mounting holes: 3 mm
- Predictable Temperature: -40 to +85 deg. Celsius (with accuracy ranging between 0 and +65 deg. C)
- Predictable Pressure: ranges from 30,000 to 110,000 Pa, including comparative accuracy of 12 Pa and absolute accuracy being 100 Pa
- Humidity Range: can measure relative humidity in the range (0-100) % with inaccuracy of -3 percent from 20 to 80%.
- Predictable Altitude: 0 to 30,000 feet (9.2 kilometres), with a comparitive precision of 3.3 feet (1 metre) at sea level and 6.6 feet (2 metres) at 30,000 feet.
- Peak Current: 1.12mA Accuracy between 700 to 900hPa and 25 to 40 deg. C: ±0.12hPa and ±1.0m
- Average current consumption (1Hz data refresh rate):
  1.8 µA @ 1 Hz (H, T), 2.8 µA @ 1 Hz (P, T), 3.6 µA @ 1 Hz (H, P, T)

✓ Connect the 3.3V power pin of the Raspberry Pi to Vin terminal.
✓ Connect the GND pin of the Raspberry Pi board to GND terminal.

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- ✓ Connect the BME280 SDI to the Pi SDA pin.
- ✓ Connect the Pi SCL to the SCK pin on the BME280.

3) MAX30102 sensor:

Figure 4 - MAX30102 sensor

MAX30102 is a sensor that combines pulse oximetry and a heart rate monitor. It detects heart rate signals and oxygen saturation levels using two LEDs (IR and Red), a photodetector (visible + IR), optimised optics, and low-noise analogue signal processing. Two LEDs one infrared (having wavelength peaked at 880 nm) and the other red (having wavelength peaked at 660 nm), are included in the MAX30102 sensor, also including a photodiode that traces signals with wavelengths between 600-900nm. The converted electrical (digital) output is then stored in a 32-deep FIFO within the computer, and it is completely configurable via software registers.

Make sure sensor libraries are installed prior to further programming. A couple non-standard Python libraries are required for its integration:

`smbus` and `numpy`

-
- In LED Reflective Solution, Heart-Rate Monitor and Pulse Oximeter Biosensor.
- Operating Voltage: 3.3V power supply complete pulse oximeter and heartrate sensor solution,
- Dimensions are (5.6 x 3.3 x1.55) mm
- Mobile Devices with Ultra-Low Power Consumption
- Power Savings is highly optimized. Also sample rate along with LED current is programmable
- Low-power heart rate monitor (less than 1 milliwatt)
- Shutdown Current (0.7A, typical) is extremely low
- Ability to produce data output quickly
- High SNR, less noise hence

4) DS18B20 sensor:

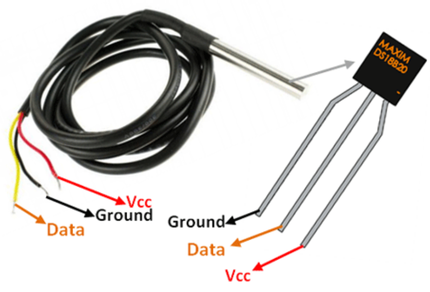

Figure 5 - DS18B20 sensor

Maxim Integrated’s DS18B20 is a 1-wire programmable Temperature sensor. The DS18B20 sensor measures temperatures from 9 to 12 bits in Celsius and also includes an alarm system feature where the user can program its upper bound as well as lower trigger points. Each pin uses a heat-shrinkable pipeline to prevent short circuit, internal sealing glue. Body is made up of Stainless-steel moisture and waterproofed encapsulated tube proof prevents rust. The mentioned sensor has three pins in its TO-92 package: GND, DQ (Data), and VDD. The body is a tube 6mm diameter by 30mm long and is made of stainless steel.

Install the required library ‘w1thermsensor’ for interfacing. Configure pi for 1 wire serial interface.

- Supply voltage (V): 3.0 – 5.5V
- Range of Temperature: -55 ~ +125 Â°C
- Probe diameter: 6mm
- Probe length: 50mm
- Resolution: 9 ~ 12 bit
- Query time: 750 msec
- Available as To-92, SOP and even as a waterproof sensor
- Accuracy: ±0.5

- ✓ Connect the Raspberry Pi 0W3.3V power pin to DS18B20VDD pin.
- ✓ Connect the Raspberry Pi 0W GND pin to DS18B20 GND pin.
- ✓ Connect the Raspberry Pi 0WGPi04 terminal to the DS18B20 DQ pin.

5) OLED screen:

Figure 6 - OLED Display

1.3-inch 128x64 OLED display screen module. Uses SPI serial interface

Install Adafruit python library for OLED interfacing,

- It has a described 128 x 64 resolution.
- IC: SH1106
- PCB Size: 35.4 x 33.5 mm
- Interface Type: SPI / I2C (Address: 0x02)
- Display Colour: Blue or White (Optional)
- Voltage for Operation: 3.3V - 5.0V
- Logic Voltage: 3.3V
- Pixel Pitch: 0.23 x 0.23 (mm)
- Pixel Size: 0.21 x 0.21 (mm)
- Required Current: 20ma
- Functionable Temperature: -40~70°C
- Dimensions: 35.4 X 33.5mm

6) Battery:

3.7V 1000mAH Lithium Polymer (Lipo Rechargeable Battery)

The components are then connected to the pi board following the circuit diagram depicted in Figure 7.

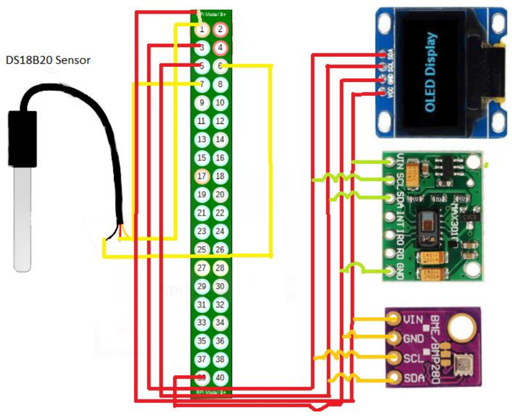

Figure 7 - Circuit diagram of the entire model

The flow of data in the initial phase of the functioning is depicted in Figure 8.

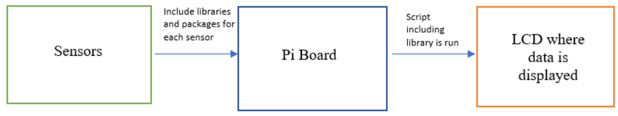

Figure 8 - Block diagram of the initial half of the project

Working:

The above-mentioned sensors (i2c interfaced) are connected to the pi board along with the OLED screen. From this point, once all the required libraries are installed, we can include them in the python script on the Raspbian Software. Once the module is run, the following data of each sensor is displayed on the OLED screen.

Now, sensor parameters can be switched by clicking the button on the pi board. From this point data is proceeded to be stored in SQLite database form. SQLite database is a small and in-process library that reads and writes data to disc files without requiring a separate server

This is done via. the following steps.

1. Make sure i2c communication protocol is enabled.

2. Import MySQLdB libraries for database connection and data collection.

3. Write backend program which will read data from sensors and save in database. This is done by taking sensor address in the 'read address function' in the python script.

4. Now that the data is collected, to send the data into the database we use
[x.execute(INSERT INTO *database name*(*database variables*)]

With this, the database is formed with all the values taken from the individual sensors. The data displayed can be further modified using other library functions. Thus, the recorded data is stored in a tabular form inside the memory of the Pi Board.

From this point comes the process of transferring this data to web application via Django framework. (flowchart depicted in Figure 9.)

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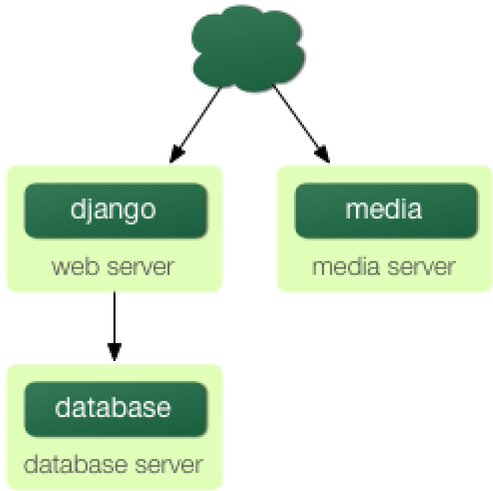

Figure 9 - Django framework flowchart

Django is an open-source backend web application platform built on Python, one of the most common web development languages. Simplicity, versatility, reliability, and scalability are the key objectives. Django places a high value on security. It comes with one of the best out-of-the-box security systems available, and it assists developers in avoiding common security issues, such as
Clickjacking, Cross-site scripting, and SQL injection are all examples of cyber threats. This framework is generally praised for its protection policies against such issues compared to its counterparts.

- Cross Site Request Forgery (CSRF) protection

  CSRF attacks enable a malicious user to carry out activities using another user's credentials without the latter's knowledge or consent. Django comes with built-in security against most forms of CSRF attacks, as long as you allow it and use it appropriately. However, there are drawbacks to any mitigation strategy.

- SQL injection protection

  SQL injection is a type of attack in which a malicious user may use a database to execute arbitrary SQL code. This may lead to the deletion of documents or data leakage. Since Django's queries are built using database parameterization, they are shielded from SQL injection.

- Clickjacking Protection
  Clickjacking is a form of attack in which a malicious site uses a frame to enclose another site. An unwitting user can be fooled into performing unintentional acts on the target site as a result of this assault. Django includes clickjacking security in the form of the X-Frame-Options middleware, which can prevent a site from being made within a frame in a supporting browser.

This makes Django framework ideal for implementation of the proposed model.

Steps to install:

1. Install pip via standalone pip installer and make sure it is updated to the latest version
2. Make sure to look at venv which is a tool that provides python environments. It allows package instalment without administrator privileges.
3. After the creation and activation of virtual environment, input the following command.

   '$ python -m pip install Djang'

The data can now be accessed via any device that can connect to a browser. The most practical device for this would be mobile phones. We can easily access this data through the following steps.

1. Connect the mobile Wi-Fi to the raspberry pi hotspot.
2. Once connected, When the server button is pressed, a weblink is created displayed on the OLED screen.
3. Type this link in the mobile browser and the user will be directed to a login page where he has to type in his login credentials.
4. Once logged in, all the current and previous data that has been monitored will be made available to the user.

IV. RESULT

Figures 10. –16. Include the entire data documentation of proposed model.

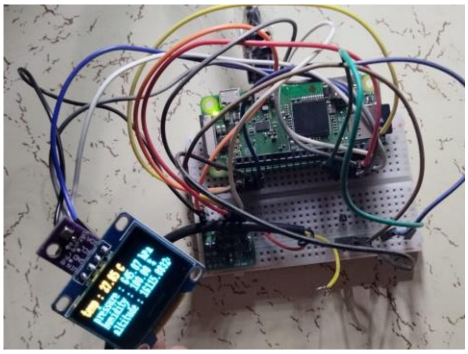

Figure 10 - Hardware Interfacing

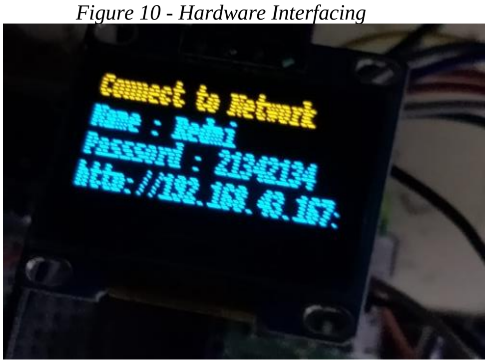

Figure 11 - Login page and link for web server

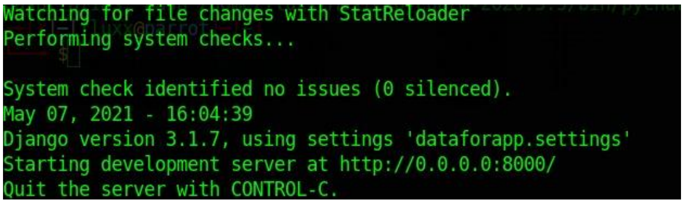

Figure 12 - App Server Created

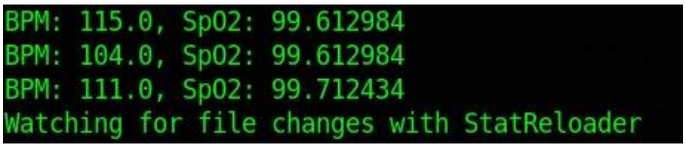

Figure 13 - monitored BPM and SpO2 levels via web application

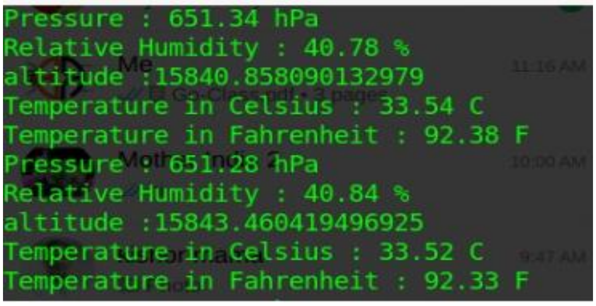

Figure 14 - Monitored temperature, pressure, relative humidityand altitude values via web application

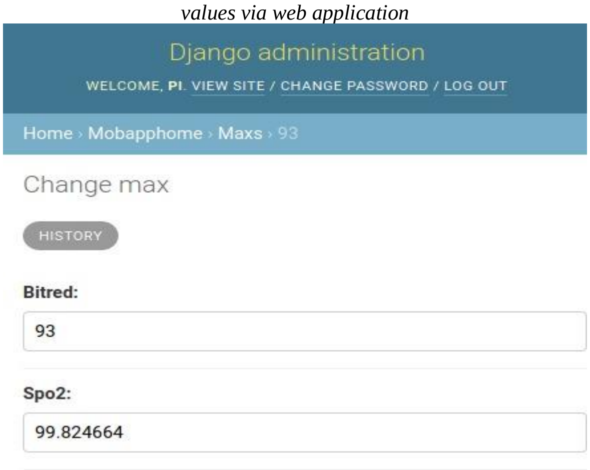

Figure 15, 16. - Accessing Data via web application using mobile browser

Table 1. Comparison of temperature measurement

Lab Thermometer (°C)	Proposed System (°C)	Difference (°C)
35.5	35.7	-0.2
34.8	34.6	0.2
34.9	34.1	0.8
34.9	34.2	0.7
32.1	31.8	0.3
32.2	31.9	0.8
33.2	32.7	0.6
32.8	32.6	0.3
31.8	31.4	0.4
30.8	30.2	-0.6

Table 2. Comparison of pressure measurement

Pressure Transmitter (hPa)	Proposed System (hPa)	Difference (hPa)
651.02	651.28	-0.26
651.02	651.25	-0.23
651.02	651.29	-0.27
651.01	651.30	-0.29
651.01	651.27	-0.26
651.01	651.28	-0.27
651.01	651.30	-0.29
650.01	651.29	-0.28
650.00	651.31	-0.31
650.00	659.28	-0.28

Table 3. Comparison of relative humidity measurement

Lab RH sensor (%RH)	Proposed System (%RH)	Difference (%RH)
84	86	-2
84	85	-1
83	84	-1
83	85	-2
82	83	-1
81	83	-2
80	83	-3
80	82	-2
80	81	-1
79	81	-2

Table 4. Comparison of SpO2 levels

Gilma Pulse Oximeter (%)	Proposed System (%)	Difference (%)
99.3	99.6	0.3
99.3	99.6	0.3
99.3	99.6	0.3
99.3	99.7	0.4
99.3	99.7	0.4
99.3	99.7	0.4
99.3	99.7	0.4
99.3	99.7	0.4
99.3	99.7	0.4

Table 5. Comparison of heart rate measurement

Gilma Pulse Oximeter (bpm)	Proposed System (bpm)	Difference (bpm)
111	110	1
109	113	-4
114	113	1
111	115	-4

108	109	-1
112	108	4
109	112	-3
110	109	1
109	109	0
110	112	-2

From Table 1. To Table 5., It is observed that the accuracy differences between senser readings in standard tested devices and the proposed model are within standard level of inaccuracy caused by the individual sensors (+/-error) and hence provide satisfactory results of the above monitored parameters.

V. CONCLUSION AND FUTURE SCOPE

The proposed system can provide a convenient method for effective real time monitoring of parameters like temperature, pressure, humidity, heart rate etc. The mentioned sensors were tested for values and measured out for inaccuracies in comparison to existing technology. From the above analysis, it can be concluded that the proposed model is accurate in its measurements and is ready to be launched and implemented in future markets to come. The proposed model can also be developed further by installing GPS sensors, Gyro sensors, Compass and a variety of other sensors to widen its multifunctionality factor. The need for self and environmental monitoring is pivotal for the upcoming years and every individual should carry with them at least one means of monitoring with them at all times. With the current COVID situation, new products are being tested out on the daily and implemented in different sectors. This can often times lead to shortage due to cost expenses. This is where the proposed model can flourish offering multiple services at a low expense rate for the years to come. We can move forward and embrace a world where we wouldn't have to worry about keeping records manually as everything is automatically stored securely over our private and is available at the click of a button.

VI. ACKNOWLEDGEMENTS

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