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IoT BASED PATIENT MONITORING SYSTEM USING RASPBERRY PI 3 and LabVIEW

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ABSTRACT:

Continuous monitoring of critical patients and their biological parameters are transmitted to doctor’s console, and doctor’s domain address in person using Internet of Things technology (IoT). The design involves measurement of all critical parameters of patients using sensors. Vital parameters measured are temperature, respiration, and pulse rate, humidity and oxygen saturation level using dht11 sensor, MQ sensor, pulse sensor and pulse oximeter sensor. The input sensors are interfaced with an Arduino board and then the signals are transferred to the Raspberry Pi controller and the vital parameters are transmitted to the centralized monitor, where the front end is designed using Lab VIEW software. Using IoT, physicians are notified about the sudden change in patient’s condition. The graphical representation of the patient’s data is displayed in the doctor’s console using Lab VIEW, and the critical readings of the patient are sent to the doctor’s domain address through IoT. Thus, critical patients can be monitored by the doctors from wherever they are, enabling more care and attention towards the patient’s health by the doctor.

Key words: PMS (Patient Monitoring System), ICU (Intensive Care unit), ECG (electrocardiograph)

INTRODUCTION

To overcome the existing problem which requires doctor’s attention over the patient continuously, this can be overcome by interfacing all the biological parameters of the patient through LabVIEW. The Authors [Balamurugan et al., 2013] uses the remote monitoring using modernized communication. The measured signals are interfaced with Arduino boards, which are being placed near each and every patient. These signals from the Arduino boards are all transferred to a single Raspberry Pi controller, which acts as a server. From the controller, the data are transmitted to the LabVIEW software for the simulation process as a front-end output. Abasi et al., [2017] have implemented the web publishing tool in lab VIEW. The data are also sent to the doctors with the help of IoT to their personal domains. The biological-parameters such as respiration, pulse, temperature, humidity and pulse oximetry are being monitored. Hence by the help of our project critical patients can be monitored continuously and can be given adequate treatment. The current existing system monitors only the ECG signals and remaining parameters are not available. The major problem faced by the patients in the Intensive Care Unit is that they can’t be monitored continuously using IoT. Hence this project aims at the continuous monitoring of very critical patients and their biological parameters are transmitted to the doctor’s console. Any major changes in the patients’ health can be intimated to the doctor’s concerned by the application.

PATIENT MONITORING SYSTEM: The patient monitoring system (PMS) is most fairly used in Intensive Care Units and Critical Care Units for the monitoring of patient’s vital parameters. Yoon et al., [2013] reviewed the recent trends and challenges in patient monitoring system. It is a single integrated system that measures various parameters such as blood pressure, temperature, heart rate, respiratory rate, and ECG. In exceptional cases, more advanced and sophisticated body measurements such as brain activity muscle activity, etc. are also monitored. The basic function of the PMS is to monitor and activate various alarms whenever a parameter goes critical. PMS is available as both stand alone and centralized configurations. PMS is mainly classified into Analog and Digital types and as Monitors/Defibrillators. In analog type oscilloscopes, only dedicated channel is used for electrocardiographic monitoring (ECG). So, medical monitors tended to be highly focused. One monitor would track a patient’s blood pressure, while another would measure pulse oximetry, and ECG. And Later analog models were introduced with dual channels displayed in the same screen usually to monitor blood pressure and respiration movements. So, these machines were played a vital role in saving human lives but they had several restrictions including to electrical interference, Sensitivity, base level fluctuations, and absence of digital readouts and apprehensions. Due to the development of discrete time signal processing (DTSP) technology the Biomedical displays are evolved enormously, and all equipped with latest DTSP technology models which leads to the advantages of reduction in size and portability. Baig et al., [2013] have a depth analysis to achieve the smart health monitoring system. Nowadays the trend is developed towards multiparameter displays that can track and display many different parameters at once. The measured parameters consist of pulse oximetry (amount of saturated oxygen percentage in blood referred to as SpO_2 measured by an infrared cuff), ECG (electrocardiograph of the PQRS waves of the heart with external pacemaker or without an external heart pacemaker), blood pressure (either non-invasively with an inflatable blood pressure cluff or invasively with an inserted blood pressure transducer), and temperature measurement through a thermoelectric transducer. In critical situation, other important parameters can be measured and monitored such as output of cardiac (through an Swan-Ganz catheter), respiration (through airway respiratory rate or through a thoracic transducer belt, an ECG channel), capnography (CO_2 parameter referred to an End-Tidal Carbon Dioxide concentration), etc. Also, the tracking of biological parameters along time (X axis) digital medical have automated digital readouts of the average and peak parameters displayed on the monitor and high/low alarm levels can be set and also alert the staff when some biological parameters exceeds the lower limits using emergency signals. Several models with latest technology have the multiparameter monitors with network connectivity i.e., it can send their biological output to a central intensive care unit monitoring station where a single staff can able to respond the several patient monitors simultaneously. Telemetry Ambulatory can also be attained by battery-operated models with a portable type which are carried by the patient and which transmit their parameters through a wireless data communication.

Defibrillator/Monitor: Some EMS services digital biological patient monitors especially those used an incorporate defibrillator into the patient monitor itself. These defibrillators typically have the competences of an ICU monitor, but have manual defibrillation capability. This is particularly precise for EMS services who needs a compact and very easy to use defibrillator and monitor also have the capability of pacing like adhesive pads which often can be used for defibrillation, pacing and monitoring that are useful to the patient in a frontal subsequent configurations. The defibrillator monitors often have a dedicated monitoring parameter such as, invasive BP, SET pulse oximetry, and waveform capnography.

PLANNED SYSTEM: The main aim of the planned system is to design a patient monitoring system, which overcomes the existing problem which requires doctor's attention over the patient continuously by interfacing all the biological parameters through Lab VIEW. The doctors now can continuously monitor the patient's vital parameters using IoT, the various objectives of the system are to simulate bio-signals like Respiratory signals, Pulse signal, Temperature signal and Oxygen Saturation, the measured signals are interfaced with Lab view and are transmitted to the centralized monitor through IoT, thus transmission of vital signal to Doctor console using IoT and creating an alert in case of emergency.

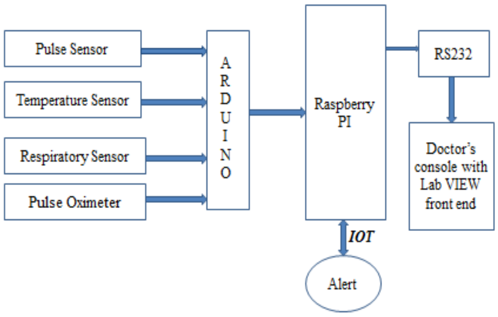

Fig 1: Block diagram of Planned System

The Bio-signals from the sensors such as Pulse, Temperature, Respiratory and Pulse Oximeter are interfaced with Arduino. The Arduino board is connected with Raspberry Pi controller. It acts as a server for IOT in transmission of Bio-signals. The Bio-signals of the patients are transmitted to the doctor in case of alert using IOT technology. The Lab VIEW is interfaced with Raspberry Pi Controller using RS-23 communication. The Lab VIEW software is used as the front-end panel, the doctor console for the display of detected Bio-signals. The Hardware design includes various hardware such as the Temperature sensor (DHT1-1), Respiratory sensor (MQ sensor), Pulse sensor, Pulse Oximeter, Arduino, Raspberry Pi 3, RS232, Ethernet shield. Initially all the four sensors are connected to a bread board, from which they are connected to the ground and the supply. From the bread board, all the sensors are connected to the Arduino board, which acts as a node between the sensors and the controller Raspberry Pi, the controller acts as a mini computer. It also acts as the server from which the Ethernet shield is connected and the output from the sensor is processed and the output is given. From the Arduino board, the RS232 communication port is connected which acts as the bridge for the communication of sensors to the graphical display of the Lab VIEW results. From the Raspberry Pi controller, the keyboard, mouse and the monitor are connected. This controller has the python operating system which has the internet website domain where the data of the patient are transferred and saved.

ZigBee: It is an open global standard wireless technology developed to address the unique needs of low-power, low-cost wireless Mobile to Mobile networks. The Authors [Myung et al., 2011] uses the Bluetooth based blood pressure monitors. Physical radio specification Standards operates on IEEE 802.15.4 and operates in unlicensed bands including 900MHz, 2.4GHz, 868MHz and 900 MHz.

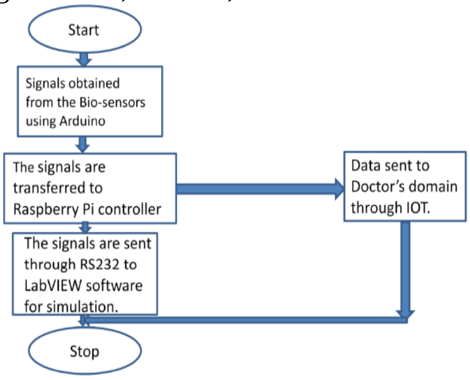

Fig 2: Flow chart of Proposed System

Hardware Description:

Temperature Sensor: For temperature measurement, the sensors used are NTC temperature sensor or a thermostat. It is actually, a variable resistance type, when it is subjected to temperature that changes its resistance with the change in temperature. These are made up of semi conductive materials such as polymers or ceramics to provide a larger variation in the resistance with just a very small change in temperature. The term NTC (Negative Temperature Coefficient), which means that the temperature increases and resistance is decreases.

Features:

- Temperature range: 0-50°C
- Operating voltage: 3-5V
- Humidity range: 20-80%

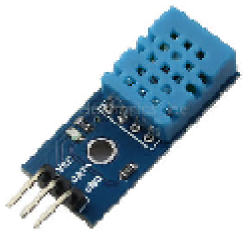

Fig 3: Temperature Sensor

Respiratory Sensor: The gas sensors are MQ series which uses an electro-chemical sensor with a small heater inside. They are highly sensitive for gasses and also used in room temperature. It can be calibrated with a known concentration of the measured gas. The generated analog output of the sensor can be readout by an Arduino analog input.

Features: Very high sensitivity and quick response time.

The output of the sensor is an analog resistance.

Fig 4: Respiratory Sensor

Pulse Sensor: The sensor operation is very modest. The power supply of the board is from 3V to 5V, the necessity of Enable pin to trigger the IR sensor. And place the tip of your forefinger slightly over the sensor face. Your finger should not press too hard on the sensor. After a couple of seconds, the circuit stabilizes and the LED flashing with your heart beat synchronously.

Features:

Working voltage is 5V.

Working current is 4mA

Fig 5: Pulse sensor

Pulse Oximeter: It is a non-invasive method for patient oxygen saturation and the reading of peripheral oxygen saturation is not always equal to the reading of arterial oxygen saturation from blood arterial gas analysis, but the two are connected well for the non-invasive, convenient, safe, inexpensive pulse oximetry method is valued for measuring oxygen saturation in medical use. In its most common transmissive application mode, a sensor is placed on a patient's body on a very thin surface, usually an earlobe, or fingertip or a foot in-case of an infant. The two wavelengths of light passed by the sensor through the body part and the light is detected by the photo detector. The detector measures the wavelength by change in absorbance of the wavelengths and allow it to determine the absorbance due to the pulsating arterial blood alone, without skin, venous blood, fat, muscle, and bone.

Fig 6: Pulse Oximeter

Pl2303 (Communication Port): The Converter used is USB to UART is a very suitable tool for Embedded applications. It is easy to interface which uses UART modules like GPS, GSM, Wi-Fi Bluetooth. It can easily send data directly to Personal Computer for analyzing the biological data Here in this project PL2303 is used for USB to UART converter which is manufactured by Prolific Technology. It can easily connect to Personal Computer through USB port. It uses a USB to TTL serial tool, using the PL2303 chip.

Fig 7: Pl2303 USB to UART

ARDUINO UNO: An Arduino Program can be written in any programming language for the target processor. It has an editor with features of text, pasting and cutting, replacing and searching text, syntax highlighting, automatic indenting, brace matching, and provides a modest method to compile and upload the target programs to the Arduino board. It also has features of text console and message area and a toolbar for common functions. It refers to open-source electronics platform. It is an innovative board designed particularly for artists, hobbyists and those who are interested in creating a new product for new applications which will related to society to create a new interactive object.

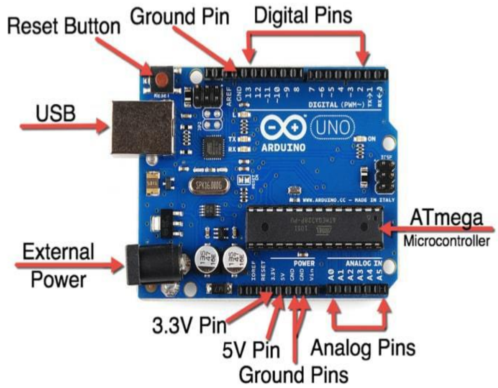

Fig 8: Arduino Circuit Board

The above Arduino board includes a microcontroller, which is programmed using C/C++ programing with an integrated development environment. which use basic programming variables, structures and functions. Arduino is also based on Google Android Open Accessory Development Kit. The Figure No:9 shows the Arduino screen for programing which contains setup and loop function. A sketch program written with the Arduino software. Sketches are nothing but test files which is saved on the development computer with file extension. ino and the Arduino pre-1.0 Software saves the sketch with the file extension. pde. The Arduino board supports both the languages C and C++ using special code structuring. The Arduino software has a library functions for wiring the hardware for input and output connections. The written code requires only two basic functions, for starting the sketch that is setup and loop. With the help of boot loader, the hexadecimal encoding is loaded into the Arduino board firmware.

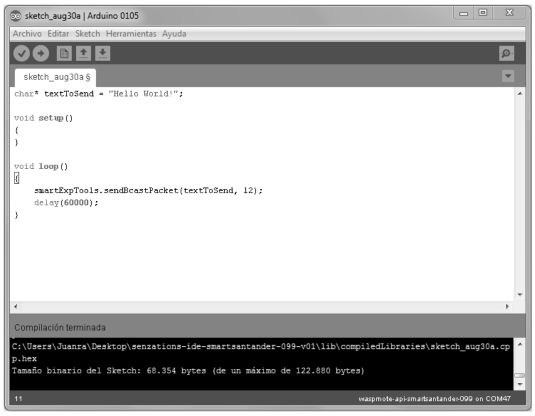

Fig 9: Arduino Screen

The Arduino C/C++ sketch, as seen by the IDE programmer, consists of only two functions:

Setup: This setup function is called only once when a sketch starts after the board reset or powered on. It is mainly used to initialize the input and output pin modes and the library function for the program.

Loop: After setup has been initialized, it will execute the function loop in the main program repeatedly. The board is controlled until the board is powered off or reset. Now a day the LED light and a load resistor between ground and pin 13 to perform board test and program functions. The Integrated Development Environment contains a text editor for message area, writing code, a text console, a toolbar with buttons for common functions. It connects the Genuino and Arduino hardware to communicate upload programs to the board.

Raspberry Pi Controller: The Raspberry pi is a credit card size and a single computer board that can be used as a computer to perform the tasks like spreadsheets, Word processing and games.

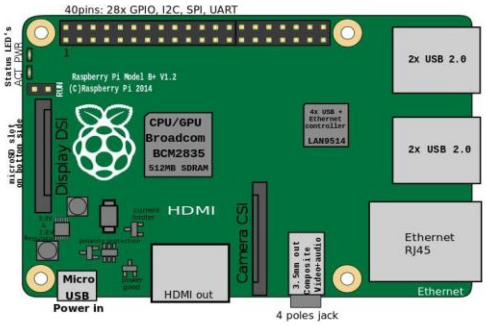

Fig 10: Blocks of Raspberry Pi

Memory: The model A board is designed with SDRAM of 256MB and model B with designed capacity of 51MB. It is a small credit card size PC compare with other Personal Computers. In raspberry pi board, the RAM memory is available from 256MB to 512MB.

CPU: The brain of the raspberry pi board is the Central processing unit where the instruction and commands to be carried out through the logical and arithmetic operations.

GPU: It is the specialized chip in the raspberry pi board to speed up the operation of image calculations and it supports OpenGL.

Ethernet Port: It acts as a main gateway for raspberry pi for communicating with the interface devices.

GPIO Pins: This pin is used to accept the input and output commands based on the program functions. It also accepts digital GPIO pins. These pins are used to connect other electronic components. For example, the pin can connect to the sensor which will detect the temperature and transmit the digital signal.

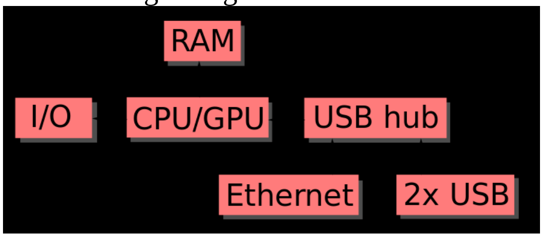

Fig 11: Functional Block of the Raspberry Pi

Power source connector: It is the small switch placed on shield. It will connect the external power source to the board.

Display: There are two types of connections such as Composite and HDMI. Either LCD or LED TV are connected with the low-cost HDMI cable for display purpose.

Features:

- CPU: 64-bit Quad-core ARM Cortex A53 clocked with 1.2 GHz.
- GPU: Video Core IV multimedia 400MHz.
- Memory: SDRAM 1GB LPDDR2-900
- USB ports: 4.
- Video outputs: Composite video
- Network: Ethernet and 802.11n Wireless LAN. 10/100Mbps.

Software Description: Lab VIEW is a virtual instrumentation tool which incorporates graphical programming for research process laboratory and also in industries for simulation and controlling the process. (Laboratory Virtual Instrument Engineering workbench). It is the most powerful tool and instrumentation software and multipurpose analysis for automation and measurement. Its graphical programming user interface called GUI programming is very easy to build a block of the process instead of coding which makes errors while compiling. This tool eliminates the errors in an easy manner. It is more flexible than standard laboratory instruments because it is software based. Using this LabVIEW tool, the programmer simulates the instrument need for the particular applications and can change easily with the help of GUI tool, it can also be called virtual instruments because any type of instrument can be used with the help of GUI tool. We can easily troubleshoot the program and modify the program in a very easy manner.

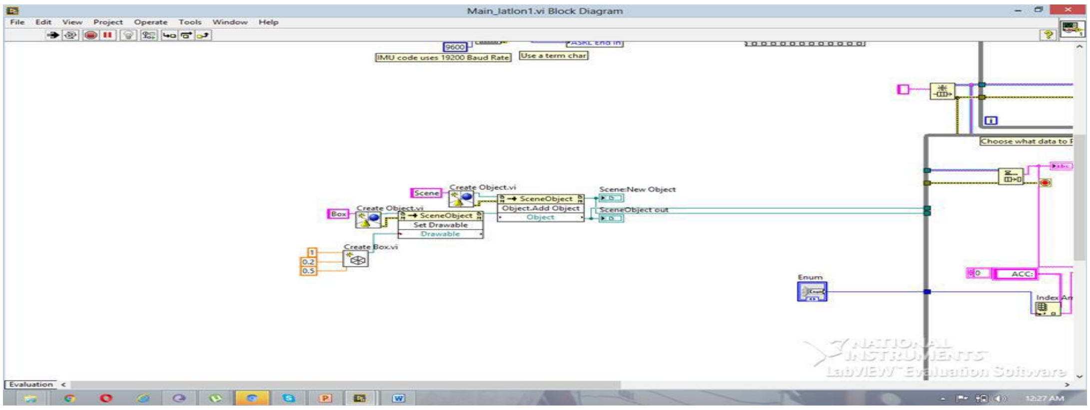

Fig 12: LabVIEW Program 1

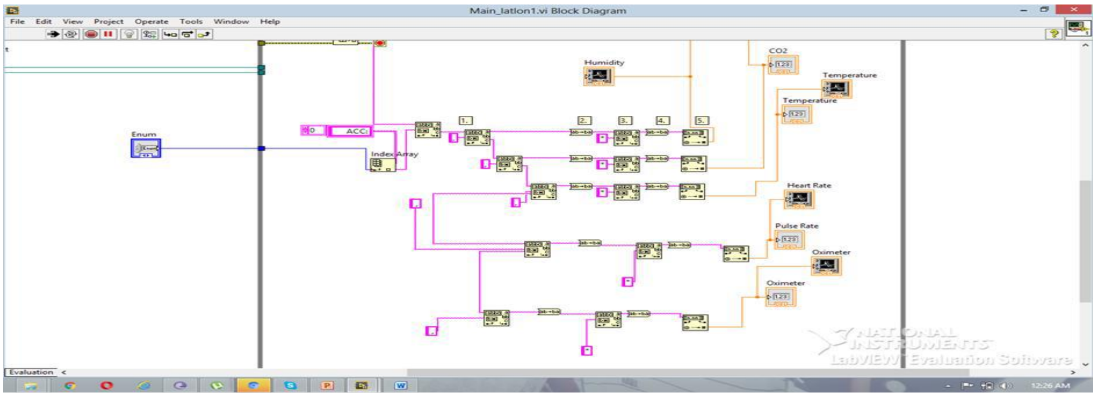

Fig 13: LabVIEW Program 2

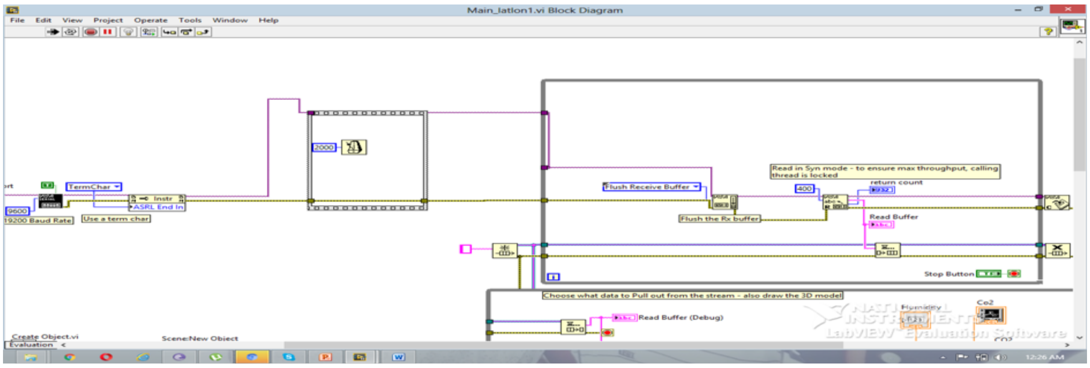

Fig 14: LabVIEW Program 3

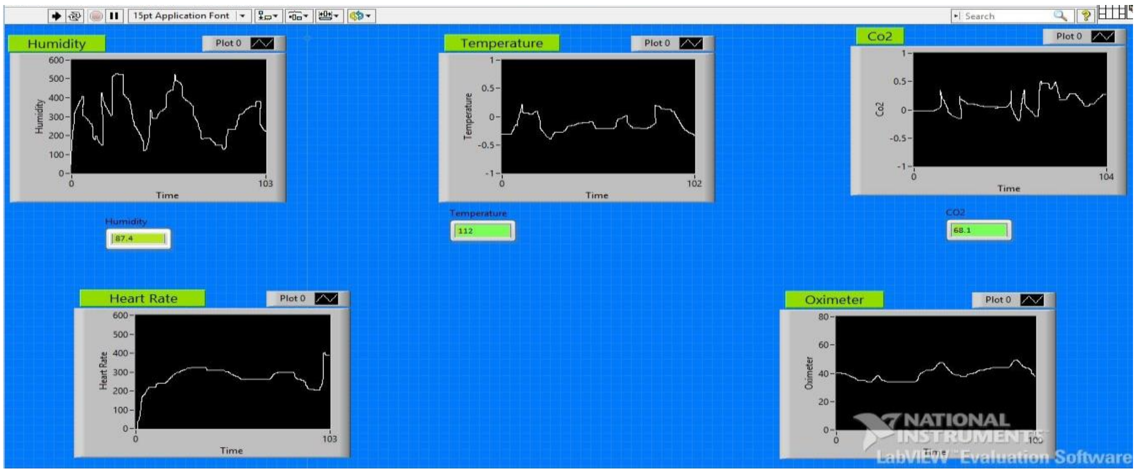

Fig 15: Sensor signal from Patient

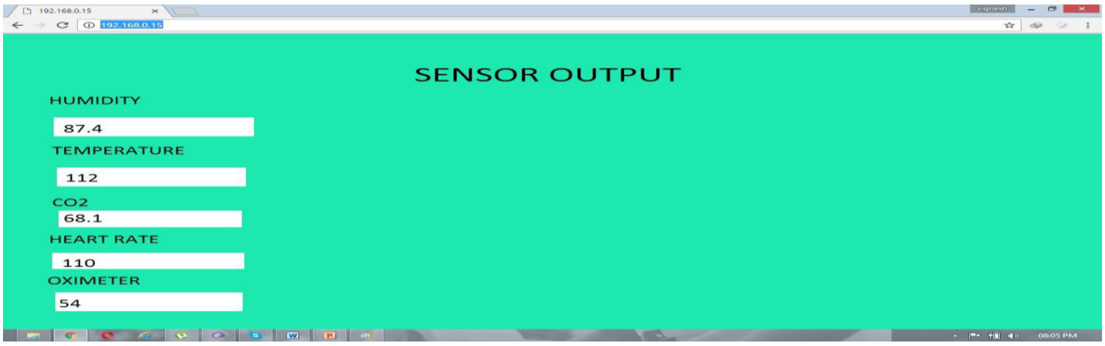

Fig 16: Sensor output in numerical Value

Result and Conclusion: The graphical representtation of the bio-signals from the sensors is displayed in the LabVIEW front end panel which is placed in the doctor's console. The result from this project was obtained temperature of the patient, heart rate, CO_2, Oxygen saturation Whenever there is an increase of patient body temperature and heartbeat rate the authorized care givers get message so that they can take some immediate measures. The results obtained can be visualized on GUI created on LabVIEW and far distance physicians can see also with help of internet but they should have link to access it. The LabVIEW GUI was designed on LabVIEW 2014.

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