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IoT Based Health Monitoring System using Raspberry Pi and Arduino

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ABSTRACT: Nowadays, chronic heart failure has become a very serious problem. This occurs when heart muscle gets damaged,becomes weak and eventually disrupt the natural pumping action of heart. This is gradually affecting an ever-growing segment of population leading to represent one of the major causes of hospitalization for elderly citizens. The current healthcare model is mostly in-hospital based and includes periodic visits, that has turned as a tedious job for the patients. In this paper, a complete and integrated healthcare model is described enabling Chronic Heart Failure(CHF) patients to daily collect vital signs at home and sending them using Internet of Things (IoT). This allows physicians to monitor patients at a distance and take periodic actions in case of necessity. A set of five parameters has been identified i.e. Electrocardiogram(ECG), Pulse rate, Weight, Temperature and Position detection by using wearable sensors. These sensors are connected to an Arduino and Raspberry Pi. Once the Raspberry Pi is connected to internet, it acts as a server and sends data on a specific URL. The vital parameters can be visualized and monitored on any mobile device including laptops or smartphones which are connected under same network.

KEYWORDS: Raspberry Pi,Arduino, CHF, ECG sensor, Pulse rate sensor, Weight sensor, Temperature sensor, Accelerometer sensor, IoT.

I. INTRODUCTION

CHF is commonly seen in elderly persons because body loses its immunity gradually with ageing. CHF is a leading cause of hospital admission particularly for older adults reaching a prevalence of 1.3%, 1.5%, and 8.4% in 55–64 years old, 65–74 years, and 75 years or older segments, respectively [1]. In medical field continuous patient monitoring is required at hospitals and patient's home also. The CHF patients need an intensive care and continuous monitoring to avoid Heart attack and heart related disorders. The objective of this paper is to continuously monitor ECG signal and some other vital signs of CHFto avoid re-hospitalization that in turn increase patient satisfaction. It is achieved by a minimum set of vital signs threshold values that are fed in microcontroller to monitor the vital signs measured through a pool of wireless, non-invasive biomedical sensors. The Physicians monitor patients at distance and take timely actions in case of emergency [2].

IoT is an ideal emerging technology to influence the internet and communication technologies. IoT connects living and non-living things through internet. Traditionally in the object oriented paradigm everything in the world is considered an object, but in the IoT paradigm everything in the world is considered as a smart object, and allows them to communicate each other through the internet technologies by physically or virtually. IoT allows people and things to be connected anytime, anyplace, with anything and anyone, by using ideally in any path/ network and any service [3].

Smart Healthcare plays a significant role in healthcare applications through embedding sensors and actuators in patients and their medicines for monitoring and tracking purposes. IoT is used by clinical care to monitor physiological statuses of patients through sensors by collecting and analysing their information and then sending analysed patient's data remotely to processing centres to make suitable actions [3].

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II. RELATED WORK

The term internet of things was first proposed by Kevin Ashton in 1982. "Internet of Things (IoT) is the network of physical objects or "things" embedded with electronic devices, software technologies, sensors, and network connectivity, which facilitates these objects to collect and exchange data for availing various services". It is a concept demonstrating a connected set of anything, any one, any time, any place, any service and any network connection [5]. IoT is a combination of hardware and software technologies along with embedded devices which enables to provide services and facilities to any one, anytime, anywhere required using any network [4].

Recently, wearable devices, such as smart wristwatch, ring, bracelet and hair lace, are widely applied to offer continuous healthcare, e.g., physiology parameter monitoring for remote healthcare, heart rate records a part of workout intensity or training, and calorie burn during fitness. These smart watches, health monitors, pedometers, activity trackers and virtual reality headsets are all part of the emerging landscape of wearable technology. It promises to not only change the way we exercise and communicate but also support the emerging healthcare. In the last few years, this field has attracted wide attention from researchers to address the potential of the IoT in the healthcare field by considering various practical challenges. As a part of this, there are now numerous applications, services, and prototypes in the area [4].In (IoT), it is possible to collect, record and analyse new data streams faster and more accurately by making devices gather and share information directly with each other and the cloud. The Internet of Things will impact several application domains. The applications can be classified based on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact [6].

Modern people keep an expectation that new device and new technology simplifies our day to day life. The researchers and innovators always try to find new things in order to satisfy the people but still the process is infinite. In the 1990's, internet connectivity began to proliferate in enterprise and consumer markets, but was still limited in its use because of the low performance of the network interconnects. In the 2000's internet connectivity became the norm for many applications and today is expected as part of many enterprise, industrial and consumer products to provide access to information. However, these devices are still primary things on internet that require more human interaction and monitoring through apps and interfaces. One research reveals, the IoT which includes PCs, tablets and smart phones, will grow to 26 billion units installed in 2020 representing an almost 30-fold increase from 0.9 billion in 2009 [3].

The health care applications using IoT are increasing day by day since many sensordevices are available. The IoT has potential to give rise to many medical applications such as remote health monitoring, physical fitness programs, and elderly care. The IoT healthcare system mainly tries to work on the existing wireless sensor networks, embedded device technologies and ubiquitous computing. IoT systems need to provide the services to any one at anytime and anywhere. So we there is a need of architecture to implement the health care systems more efficiently and with less cost. Here we briefly explain the wireless health care system which can be enabled to use along with IoT systems. It consists of health sensors, smart phone devices and server system to control and manage the information. The sensors will take input values and will send to the server using smart phone. The server processes the data and informs patients. These health care systems help the patients to take to decisions suggested by the application [4].

Mainly the previous methods which has been used for monitoring the patient's health from a distance location included Radio Frequency Identification and Bluetooth technology which indeed served the purpose and the said work was accomplished, but the prime obstacle which came into picture was transmitting the collected data from the sensors to the receiver's side since Radio Frequency Identification and Bluetooth technology are meant for short distance communication. This problem limited the possible range of communication to be facilitated between the server and client. Further work demonstrated the inclusion of ZigBee based patient monitoring system which slightly improved the range of communication but was inefficient since it can be only used in indoor wireless applications and moreover, the communication was prone to be attacked from unauthorized people leaving an unsecured system model. Such an existing problem was then solved by the new emerged technology known as GSM (Global System for Mobile communications) which is used for transmitting mobile voice and data services over a wide range. Although increasing the range of communication to a significant extent, it too came up with a limitation that it can interfere with certain electronics, such as pace makers and hearing aids. Such interference is due to the fact that GSM uses a pulse-transmission technology. As a result, many locations such as hospitals and airplanes require cell phones to be turned off.

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III. PROPOSED METHODOLOGYAND DISCUSSION

The proposed system is mainly divided into three stages viz., the transmitting section, the processing unit and the receiver section. The transmitting end mainly consists of biological sensors which are used to pick up the biopotential signals from the patient's body.

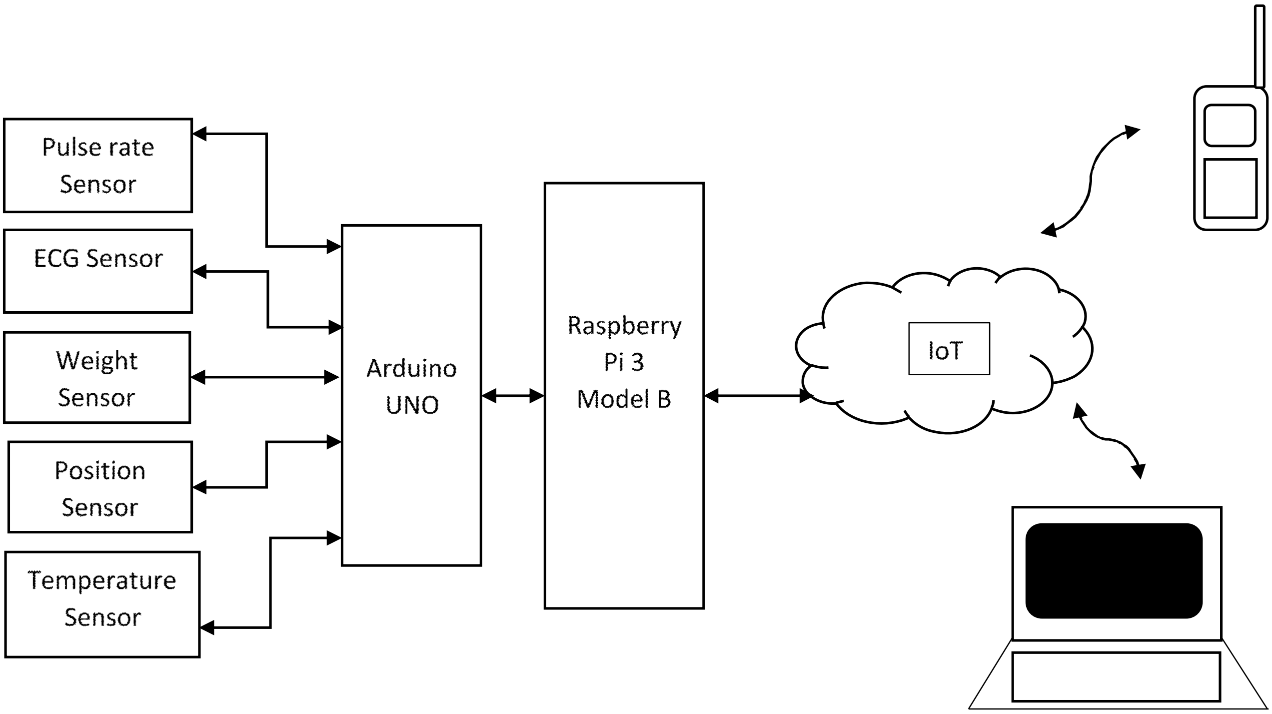

Fig.1.System Block Diagram

These sensors are held in contact with the subject under treatment in order to extract the biological signals. Such signals are raw and unamplified in nature and hence are passed to Processing system. The second stage consists of Arduino and Raspberry Pi. The Arduino UNO is programmed with Arduino Software known as Integrated Development Environment(IDE) that provides a workspace where the sensors are coded. The program files are created after coding the sensors are then transmitted to Raspberry Pi and further serially communicated to Arduino UNO. The Raspberry Pi collects all the information from Arduino UNO and separately stores it in a file for displaying it on a Web page. For this purpose, it uses Web Server known as Easy PHP which is a DevServer. Easy PHP is referred to as Hypertext Pre-processor which is a widely used general purpose scripting language especially suited for Web development. Now all the collected parameters regarding the patient's health are displayed online through a specific URL and can be viewed using mobile devices which can be a laptop, smartphone or a personal computer.

A. *Raspberry Pi:*

The proposed system works with Raspberry Pi 3 Model B that is a third generation Raspberry Pi. This powerful credit-card sized single board computer can be powered by a micro USB socket with 5 Volts, 2.5Amperes. It can be used for many applications and has replaced the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Even though maintaining the popular board format, the Raspberry Pi 3 Model B brings a more powerful processor, 10x faster than the first generation Raspberry Pi. Additionally, it gives wireless LAN and Bluetooth connectivity making it the ideal solution for powerful connected designs. The processor that has been used in Raspberry Pi 3 Model B is Broadcom BCM2387 chipset, 1.2GHz Quad-Core ARM Cortex-A53. It can be boosted from Micro SD card, running a version of Linux operating system or Windows 10 IoT [7].

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B. *Arduino:*

The proposed system works with Arduino/Genuino Uno that is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. We can simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Arduino/Genuino Uno can be programmed with the Arduino Software (IDE). The Arduino project provides the Arduino integrated development environment (IDE), that is a cross-platform application written in the programming language Java. It has been originated from IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting. It provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus [8].

C. *Windows 10 IoT:*

Microsoft rebranded Windows Embedded to Windows 10 IoT core. It is an amazing cross-platform development system that gives Windows 10 programming environment on an embedded device. It is a family of operating systems from Microsoft designed for use in embedded systems. Since the basis of project is to gather patient information and transmit it through IoT, hence there arise a requirement of an environment that can allow the said work. In such case Windows 10 IoT core serves the purpose. It is basically a software that is to be installed on Raspberry Pi thereby allowing the information to be transmitted over internet.

D. *Visual Studio:*

For program development and other connection related activities of Raspberry Pi, Visual Studio is needed. It is basically a workspace where one can code Raspberry Pi and customize it for the specified purpose.

IV. SENSORS

A. *ECG Sensor(AD8232):*

It is a fully integrated single-lead ECG front end with a lower supply requirements upto 3.5V, 170 micro Amperes. It is an integrated signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement.

This design allows for an ultra-low ADC or an embedded microcontroller to acquire the output signal easily [10].

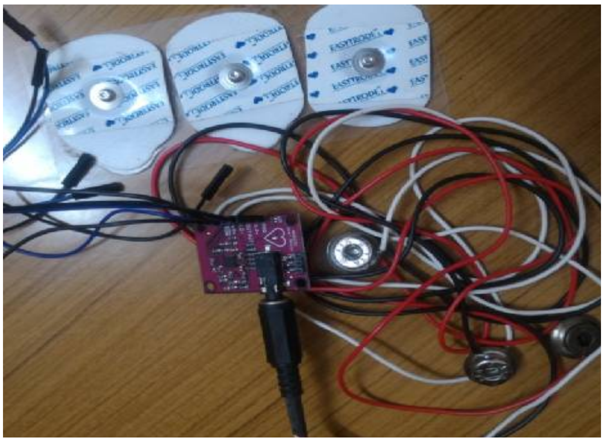

Fig.2.ECG Sensor

B. *Position Sensor(ADXL*335):

It is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs and consumes low power. The power typically ranges from 1.8V to 3.6V, 350 micro Amp. The sensor is a polysilicon surface-micro machined structure built on top of a silicon wafer. Polysilicon springs suspend the structure over the surface of the

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wafer and provide a resistance against acceleration forces. Deflection of the structure is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves.

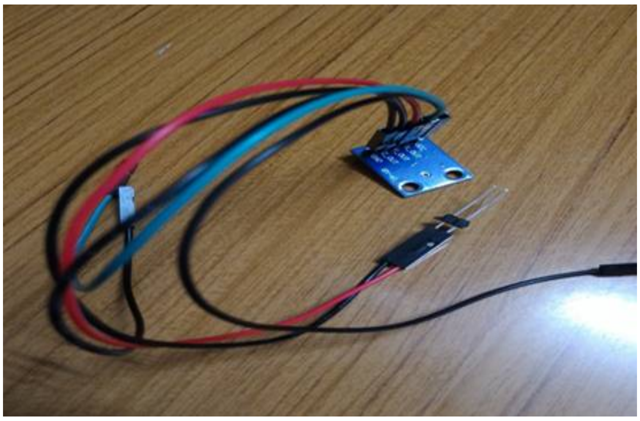

Fig.3.Position Sensor

Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration.Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration [11].

C. *Weight Sensor(HX711)*:

It is a precision 24-bit analog to-digital converter (ADC) designed for weigh scales and industrial control applications. There are two selectable differential input channels and an on-chip active low noise PGA with selectable gain of 32, 64 and 128. It also has an on-chip power supply regulator for load-cell and ADC that eliminates the need for an external supply regulator to provide analog power. It has an on-chip oscillator and power-on-reset with a simple digital control and serial interface. Operating supply voltage ranges from 2.6V to 5.5V. There is no programming needed for the internal registers. All controls to the HX711 are through the pins [12].

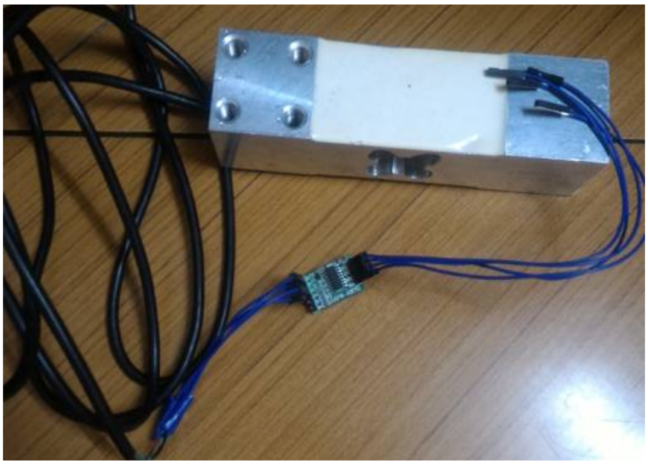

Fig.4.Weight Sensor

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D. *Temperature Sensor(LM35):*

It is a precision IC temperature sensor that is used to measure the hotness and coldness of an object. It produces an electrical output (10mV/degree Celsius) that will be proportional to the temperature of object and is calibrated in degree Celsius. It is a three terminal device where the terminals are +5V, Output and Ground. Since the entire circuitry is sealed and is not subjected to oxidation it gives higher accuracy of ±0.4 degree Celsius at room temperature [13].

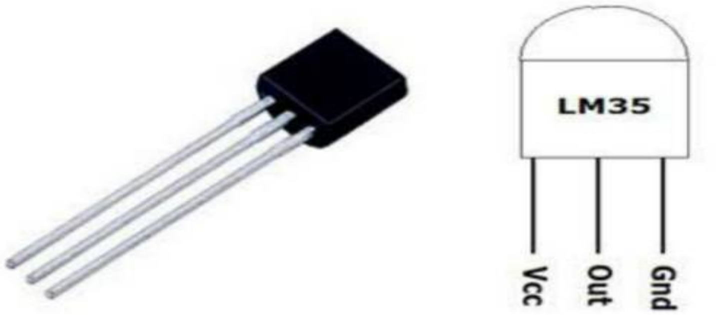

Fig.5.Temperature Sensor [9]

Since the entire circuitry is sealed and is not subjected to oxidation it gives higher accuracy of ±0.4 degree Celsius at room temperature [13]

E. *Pulse Rate Sensor(LM358):*

It is a well-designed plug-and-play heart-rate sensor for Arduino. It can be used by students, artists, athletes, mobile developers who want to easily incorporate live heartrate data into their projects. The sensor clips onto a fingertip or earlobe and plugs right into Arduino with some jumper cables. It also includes an open-source monitoring app that graphs pulse in real time. The cable is a flat colour coded ribbon cable with 3 male header connectors with RED wire = +3V to +5V, BLACK wire = GND and PURPLE wire = Signal [14].

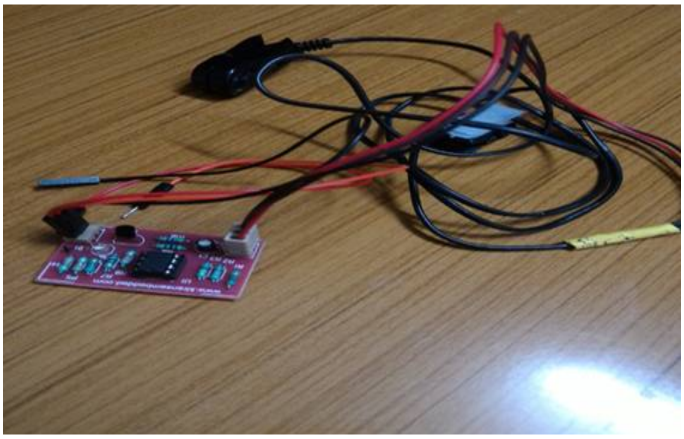

Fig.6.Pulse Rate Sensor

The sensor consists of an LED that shines light into the fingertip or earlobe, or other capillary tissue, and sensor reads the light that bounces back. The back of the sensor is where the rest of the parts are mounted. This is due to the fact that they should not get in the way of the of the sensor on the front [14].

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V. SIMULATION RESULTS

The expected result is Raspberry Pi and Arduino collects and stores the medical data through the sensors attached. The collected data is transferred to the doctor's side through IoT that helps in improving the health of patients.

Fig.7. Output of Pulse Rate Sensor

Fig.7 shows the output of pulse rate sensor that is a graph of time versus heart beat pulses. The reading from sensor is taken every 5 seconds and the value is updated accordingly.

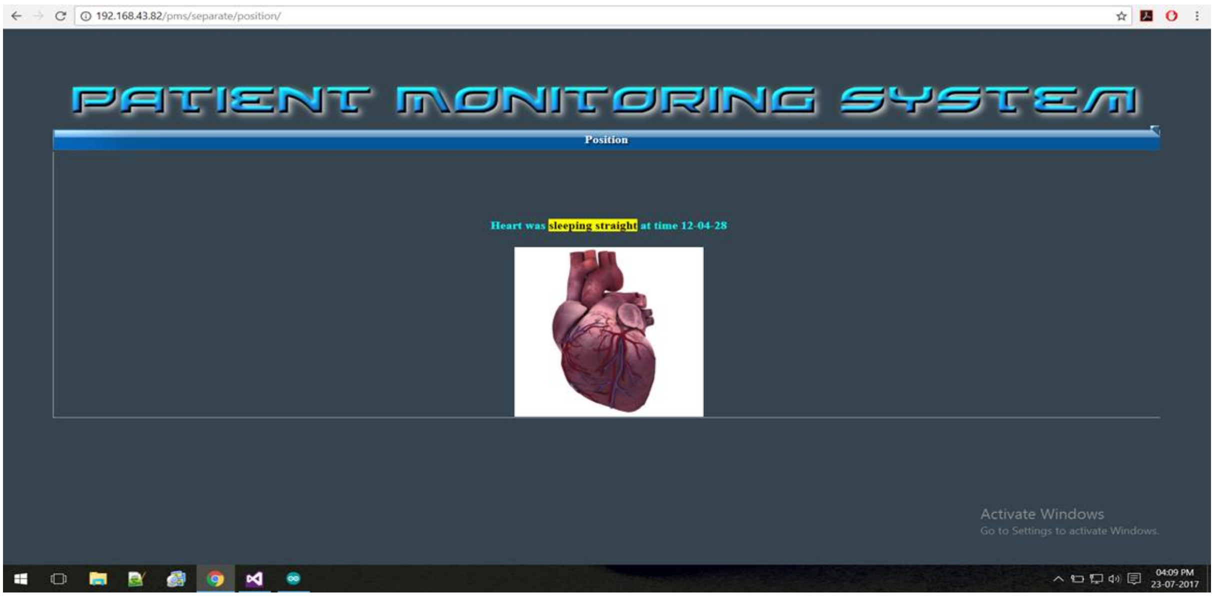

Fig.8. Output of Position Sensor

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Fig.8 shows the output of Position Sensor that is used to determine the current position of the patient i.e. whether the patient is standing or sleeping.

Fig.9 shows the output of Weight Sensor which is a graph of time in seconds versus weight in Kg. The weight sensor used in this project is a prototype showing the possibility of using it for monitoring patient's weight.

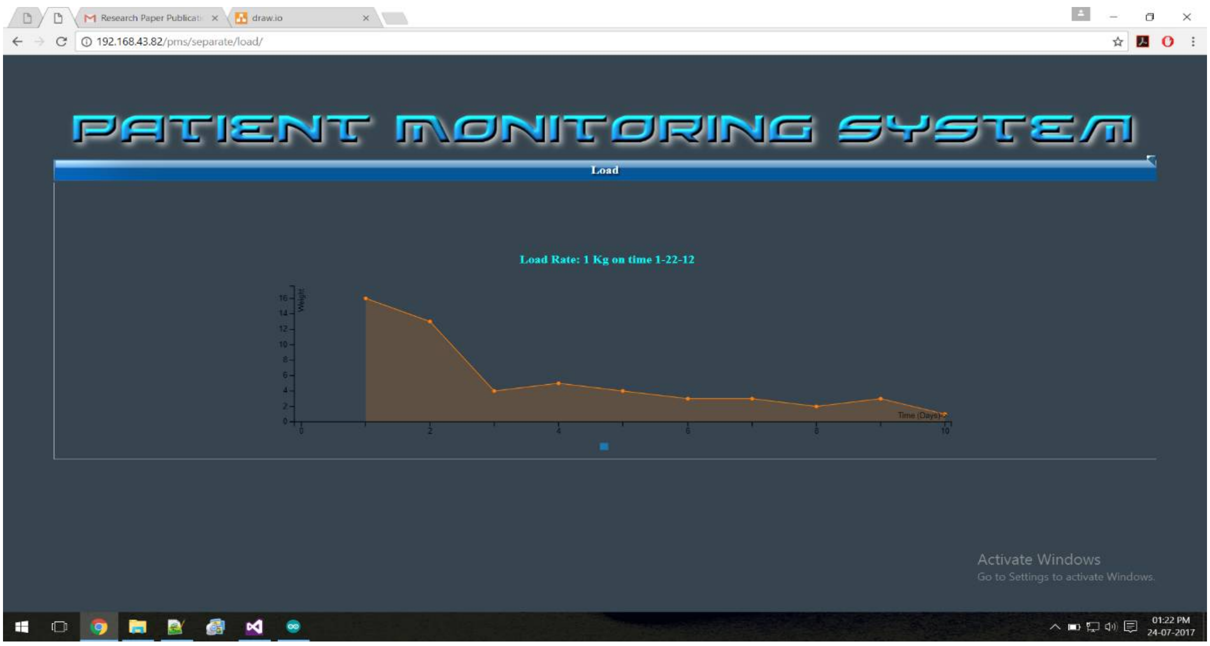

Fig.9. Output of Weight Sensor

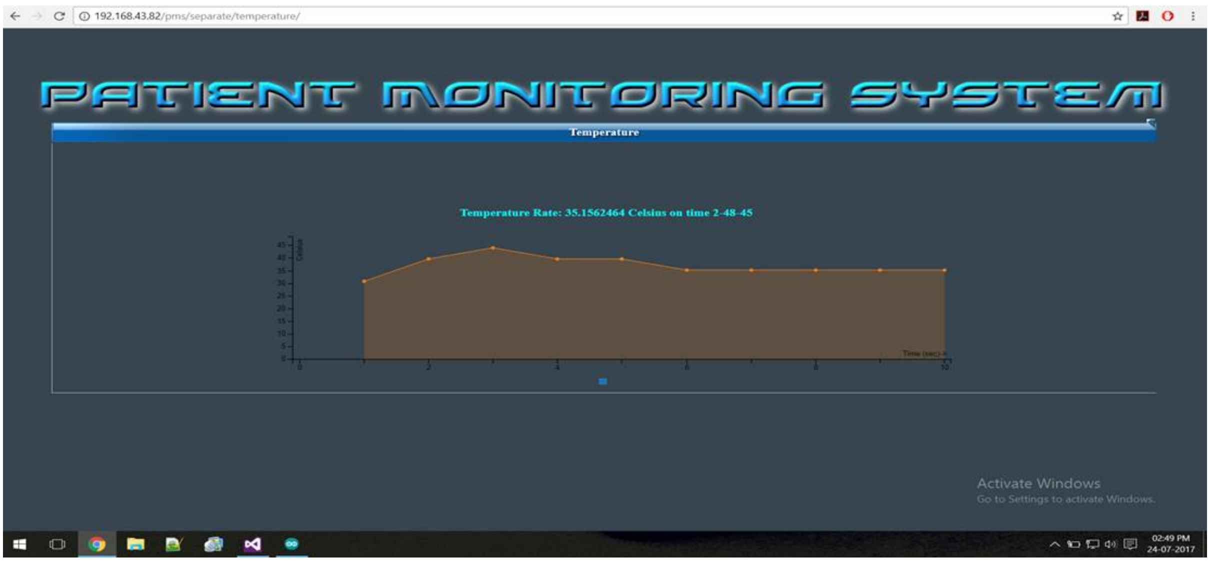

Fig.10.Output of Temperature Sensor

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Fig.10 shows the output of Temperature Sensor that is a graph of temperature in degree Celsius versus time in seconds.

Fig.11 shows the output of ECG Sensor which is a graph of time in seconds versus amplitude of ECG signal in milli-volts(mV).

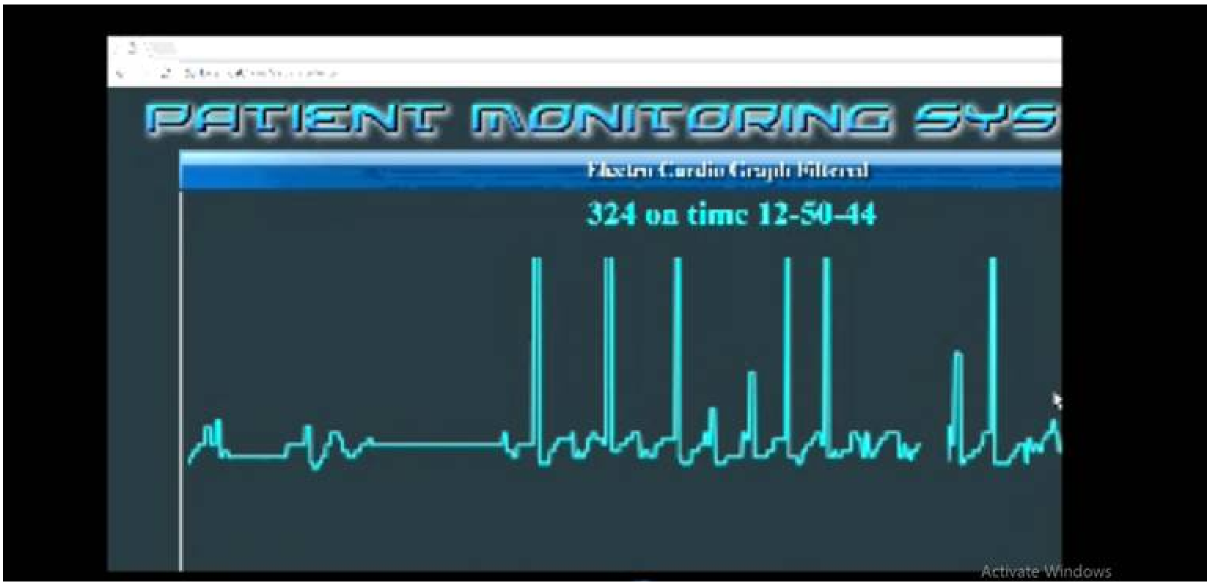

Fig.11. Output of ECG Sensor

VI. CONCLUSION AND FUTURE WORK

A wireless healthcare monitoring system by means of using mobile devices and sensors can be implemented in a global network with the help of Arduino and Raspberry Pi. The devices and IoT gathers and share information with each other, making it possible to collect, analyse and monitor data more accurately. Thus IoT can be used for monitoring the patient and providing services in a timely manner. The proposed system can be enhanced and extended by using other invasive as well as non-invasive sensors for picking up essential medical potentials of a patient. This can be further analysed, stored and transferred on a global platform. Mega Arduino can also be used that is capable of interfacing many sensors at the same time. This will help showing results parallely so that ease of connection and time saving can be facilitated.

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