Visvesvaraya Technological University, Belagavi.

PROJECT REPORT

on

"SMART HEALTH MONITORING SYSTEM"

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CERTIFICATE

This is to Certify that the dissertation work **"Smart Health Monitoring System"** carried out by AISHWARYA KV, PUNEETH KVSK, Y. HARISHWAR SAGAR, SATWAIK SIHI bonafide students of **CMRIT** in partial fulfillment for the award of **Bachelor of Engineering** in **Electronics and Communication Engineering** of the **Visvesvaraya Technological University, Belagavi,** during the academic year **2019-20**. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said degree.

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CHAPTER 1

INTRODUCTION

1.1 SMART Health Monitoring System

SMART health monitoring system is a technology to enable monitoring of patients outside of conventional clinical settings (e.g. homes, rural health camps, institutions, enterprises), which may increase access to care and decrease healthcare delivery costs. It stands for Self-Monitoring Analysis and Reporting Technology. Incorporating it in chronic-disease management can significantly improve an individual's quality of life. It allows patients to maintain independence, prevent complications, and minimize personal costs. Smart health monitoring system facilitates these goals by delivering care right to the home. In addition, patients and their family members feel comfort knowing that they are being monitored and will be supported if a problem arises. Key features of Smart health monitoring system, like remote monitoring and trend analysis of physiological parameters, enable early detection of deterioration; thereby, reducing number of emergency department visits, hospitalizations, and duration of hospital stays The need for wireless mobility in healthcare facilitates the adoption of Smart health monitoring system both in community and institutional settings. The time saved as a result of Smart health monitoring system implementation increases efficiency, and allows healthcare providers to allocate more time to remotely educate and communicate with patients.

Digital health is the convergence of digital technologies with health, healthcare, living, and society to enhance the efficiency of healthcare delivery and make medicines more personalized and precise. The discipline involves the use of information and communication technologies to help address the health problems and challenges faced by people under treatment. These technologies include both hardware and software solutions and services, including web-based analysis, email, mobile phones and applications, text messages, wearable devices, and clinic or remote monitoring sensors. Generally, digital health is concerned about the development of interconnected health systems to improve the use of computational technologies, smart devices, computational analysis techniques, and communication media to aid healthcare professionals and their clients manage illnesses and health risks, as well as promote health and wellbeing. Digital health is a multi-disciplinary domain involving many stakeholders, including clinicians, researchers and scientists with a wide range of expertise in healthcare, engineering, social sciences, public health, health economics and data management

As an outgrowth of the Digital Revolution characterized by "the mass production and widespread use of digital logic circuits, and its derived technologies, including the computer, digital cellular phone, and the Internet," key elements of digital health include wireless devices, hardware sensors and software sensing technologies, microprocessors and integrated circuits, the Internet, social networking, mobile/cellular networks and body area networks, health information technology, genomics, and personal genetic information.

In India specialists and patient proportion is around 1:1568 at odds with the World Health Organization standard of 1:1000. The 60,000 doctors and 28,000 post graduation doctors are moved on from different colleges once a year. There are around 11.65 lakh medical caretakers enlisted in Nursing Council of India. In that just 42% are in dynamic service. As per the suggests an attendant patient proportion of 1:1 in intensive care unit, 1:3 in the general care unit and 1:6 in the emergency ward. On the off chance 45 nurses are require for the every 15 patient, as 15 will work in every shift. You additionally require 30% leave save. This is the reason there is an immense deficiency of medical attendants. We require double the current number of nursing experts to adjust the diminishing patient-nurture proportion. In this way, it is clear there is just a single doctor for 2000 patients and requires twofold sum paramedical staff for present existing staff. It is impractical to rise to the patient and specialist proportion and multiplying the paramedical staff. Smart Health Monitoring System through IoT approach is utilized to decrease the endeavors of the doctors and paramedical staff. This strategy is likewise comfort for the patient since it lessens the enormous hardware, which presently utilized as a part of ICU's.

1.2 IoMT (Internet of Medical Things) or Healthcare IoT

The Internet of Medical Things (IoMT) is the collection of medical devices and applications that connect to healthcare IT systems through online computer networks. Medical devices equipped with Wi-Fi allow the machine-to-machine communication that is the basis of IoMT. IoMT devices link to cloud platforms such as Amazon Web

Services, on which captured data can be stored and analyzed. IoMT is also known as healthcare IoT. Examples of IoMT include remote patient monitoring of people with chronic or long-term conditions; tracking patient medication orders and the location of patients admitted to hospitals; and patients' wearable mHealth devices, which can send information to caregivers. Infusion pumps that connect to analytics dashboards and hospital beds rigged with sensors that measure patients' vital signs are medical devices that can be converted to or deployed as IoMT technology.

As is the case with the larger Internet of Things (IoT), there are now more possible applications of IoMT than before because many consumer mobile devices are built with Near Field Communication (NFC) radio frequency identification (RFID) tags that allow the devices to share information with IT systems. RFID tags can also be placed on medical equipment and supplies so that hospital staff can remain aware of the quantities they have in stock. The practice of using IoMT devices to remotely monitor patients in their homes is also known as telemedicine. This kind of treatment spares patients from traveling to a hospital or physician's office whenever they have a medical question or change in their condition. The security of sensitive data -- such as protected health information regulated under the Health Insurance Portability and Accountability Act -- that passes through the IoMT is a developing concern for healthcare providers.

The Internet of Things (IoT) technology is becoming increasingly common in the healthcare industry. The primary applications of IoT in the field of intelligent medicine includes the visualization of material management, digitization of medical information, and digitization of the medical processes.

1.2.1 Applications Of IoMT:

Complete Real-Time Monitoring

From research to circulation, the entire production process can utilize RFID tags to accomplish comprehensive product monitoring. This is especially important when the product gets shipped. A reader installed on the production line can automatically identify each drug’s information and transmit it to the database as the product gets packaged. During the distribution process, any intermediate information gets recorded at any time meaning that it is possible to monitor from end to end.

Digital Hospital

Internet of Things has broad application prospects in the field of medical information management. At present, the demand for medical information management in hospitals is mainly in the following aspects: identification, sample recognition, and medical record identification. Identification includes patient identification, physician identification, sample identification (including drug identification), medical equipment identification, laboratory identification, and medical record identification (including symptoms and identification of disease).

Patient Information Management

The patient's family medical history, the patient's medical history, various examinations, medical records, drug allergies, and other electronic health files can assist doctors to develop treatment programs. Doctors and nurses can measure the patient's vital signs, and, during treatments such as chemotherapy, they can use real-time monitoring information to eliminate the use of wrong drugs or wrong needles that can automatically remind nurses to carry out drug checks and other work.

Medical Emergency Management

There are some unusual circumstances, such as when there are large numbers of casualties, an inability to reach family members, or the critically ill. In such scenarios, RFID technologies' reliable and efficient storage and testing methods will help with the rapid identification of relevant details such as the patient's name, age, blood type, emergency contact, and previous medical history. This will speed up admission procedures for emergency patients and leave more precious time for treatment. Of particular importance is the installation of 3G video equipment in ambulances. As patients are on their way to the hospital, the emergency room is already getting introduced to the patient's condition and can effectively prepare for emergency rescue. If the location is very far from the hospital, there is a probability of using remote medical imaging systems as part of the emergency rescue process.

Tracking and alerts

On-time alert is critical in event of life-threatening circumstances. Medical IoT devices gather vital data and transfer that data to doctors for real-time tracking, while dropping notifications to people about critical parts via mobile apps and other linked devices.

Reports and alerts give a firm opinion about a patient's condition, irrespective of place and time. It also helps make well-versed decisions and provide on-time treatment. Thus, IoT enables real-time alerting, tracking, and monitoring, which permits hands-on treatments, better accuracy, apt intervention by doctors and improve complete patient care delivery results.

Remote medical assistance

In event of an emergency, patients can contact a doctor who is many kilometers away with a smart mobile apps. With mobility solutions in healthcare, the medics can instantly check the patients and identify the ailments on-the-go. Also, numerous healthcare delivery chains that are forecasting to build machines that can distribute drugs on the basis of patient's prescription and ailment-related data available via linked devices. IoT will Improve the patient's care In hospital. This in turn, will cut on people's expanse on healthcare

1.3 Glucometer

Diabetes can also be detected using non-invasive methods. Diabetes mellitus is a major health problem worldwide. This health condition arises from many complex metabolic disorders leading to high glucose levels in a person. High glucose levels can lead to many health disorders such as kidney failure, blindness, heart diseases and even premature death. Frequent testing and accurate determination of glucose levels is essential for diagnosis, effective management and treatment of diabetes mellitus. Therefore, there have been constant efforts to develop efficient and sensitive techniques for the determination of blood glucose levels. A number of invasive enzymatic and non-enzymatic methods and systems have been reported for the detection of glucose. Conventionally, glucose level is determined from a small volume of blood sample collected by finger pricking. Though the test may not pose any risk to a healthy adult who goes for the diabetes checkup in every 2 to 3 months, but it is very painful to the diabetic patients because every time they have to prick the finger. The current invasive method is based on the enzymatic catalysis principle where a thin needle is used to prick the finger of the patient to minimize the discomfort. To avoid such painful diagnosis, extensive research has been devoted towards developing non-invasive techniques that measure blood glucose levels without taking the blood sample. Non-invasive techniques used for blood glucose determination are by electrical impedance, NIR spectroscopy, breath analysis, ultrasound and thermal spectroscopy. A glucose meter is a medical device for determining the approximate concentration of glucose in the blood. The meter then displays the level in units of mg/dl or mmol/l. The tests are used for type 1 diabetes, latent autoimmune diabetes of adults and type 2 diabetes. Home tests for type 2 diabetes came more slowly than for type 1.

In this work, we report a non-invasive system for the determination of blood glucose levels from the detection of the breath acetone. Acetone is one of the volatile organic compounds (VOCs) present in the exhaled breath. The acetone present in the exhaled breath is a metabolic product of the body fat-burning. The breakdown of excess acetyl-CoA from fatty acid metabolism in diabetic patients leads to increase in the levels of acetone in the blood. This acetone reaches lungs and exhaled or is excreted through urine. Therefore, the breath acetone levels could be a measure of the blood glucose levels of a person. The breath acetone concentration ranging from 1.7 ppm to 3.7 ppm can be detected in diabetic patients, whereas it varies between 0.3 and 0.9 ppm for healthy humans. Over 1000 VOC's have been detected to date in the ppmv (parts per million by volume) concentrations. Our proposal aims at the measurement of blood glucose level through the interaction of human breath with the gas sensor. The sensor measures acetone in the breath and proportional blood glucose value is calculated.

1.3.1 History

In 1962, Clark and Ann Lyons from the Cincinnati Children's Hospital developed the first glucose enzyme electrode. This biosensor was based on a thin layer of glucose oxidase (GOx) on an oxygen electrode. Thus, the readout was the amount of oxygen consumed by GOx during the enzymatic reaction with the substrate glucose. Due to this work he is considered the "father of biosensors," especially with respect to the glucose sensing for diabetes patients.

Another early glucose meter was the Ames Reflectance Meter by Anton H. Clemens. It was used in American hospitals in the 1970s. A moving needle indicated the blood glucose after about a minute.

The technical background for our proposal is the breathalyzer invented by Robert Frank Borkenstein. This instrument is to detect the alcohol content of drunken person. In this, the person is asked to blow towards the blower and the alcohol content in his body is developed by the algorithm and displayed the screen space provided.

Home glucose monitoring was demonstrated to improve glycemic control of type 1 diabetes in the late 1970s, and the first meters were marketed for home use around 1981. The two models initially dominant in North America in the 1980s were the Glucometer, introduced in November 1981, whose trademark is owned by Bayer, and the Accu-Chek meter (by Roche). Consequently, these brand names have become synonymous with the generic product to many health care professionals.

Home glucose testing was adopted for type 2 diabetes more slowly than for type 1, and a large proportion of people with type 2 diabetes have never been instructed in home glucose testing. This has mainly come about because health authorities are reluctant to bear the cost of the test strips and lancets.

1.3.2 Types of glucose meters

Noninvasive glucometers :

Non-invasive techniques used for blood glucose determination are by electrical impedance, NIR spectroscopy, breath analysis, ultrasound and thermal spectroscopy. A glucose meter is a medical device for determining the approximate concentration of glucose in the blood. The meter then displays the level in units of mg/dl or mmol/l.

Hospital glucose meters :

Special glucose meters for multi-patient hospital use are now used. These provide more elaborate quality control records. Their data handling capabilities are designed to transfer glucose results into electronic medical records and the laboratory computer systems for billing purposes.

Continuous glucose monitors :

Continuous glucose monitor systems can consist of a disposable sensor placed under the skin, a transmitter connected to the sensor and a reader that receives and displays the measurements. The sensor can be used for several days before it needs to be replaced. The devices provide real-time measurements, and reduce the need for fingerprick testing of glucose levels. A drawback is that the meters are not as accurate because they read the glucose levels in the interstitial fluid which lags behind the levels in the blood.

Blood testing with meters using test strips :

Test strips : A consumable element containing chemicals that react with glucose in the drop of blood is used for each measurement. For some models this element is a plastic test strip with a small spot impregnated with glucose oxidase and other components. Each strip is used once and then discarded. Instead of strips, some models use discs, drums, or cartridges that contain the consumable material for multiple tests.

Volume of blood sample : The size of the drop of blood needed by different models varies from 0.3 to 1 μl. (Older models required larger blood samples, usually defined as a "hanging drop" from the fingertip.) Smaller volume requirements reduce the frequency of unproductive pricks.

Testing times : The times it takes to read a test strip may range from 3 to 60 seconds for different models.

Display : The glucose value in mg/dl or mmol/l is displayed on a digital display.

Cost : The cost of home blood glucose monitoring can be substantial due to the cost of the test strips. In 2006, the consumer cost of each glucose strip ranged from about $0.35 to $1.00. Manufacturers often provide meters at no cost to induce use of the profitable test strips. Type 1 diabetics may test as often as 4 to 10 times a day due to the dynamics of insulin adjustment, whereas type 2 typically test less frequently, especially when insulin is not part of treatment.

1.3.3 Accuracy

Accuracy of glucose meters is a common topic of clinical concern. Blood glucose meters must meet accuracy standards set by the International Organization for Standardization (ISO). According to ISO 15197 Blood glucose meters must provide results that are within ±15% of a laboratory standard for concentrations above 100 mg/dL or within ±15 mg/dL for concentrations below 100 mg/dL at least 95% of the time. However, a variety of factors can affect the accuracy of a test. Factors affecting accuracy of various meters include calibration of meter, ambient temperature, pressure use to wipe off strip (if applicable), size and quality of blood sample, high levels of certain substances (such as ascorbic acid) in blood, hematocrit, dirt on meter, humidity, and aging of test strips. Models vary in their susceptibility to these factors and in their ability to prevent or warn of inaccurate results with error messages. The Clarke Error Grid has been a common way of analyzing and displaying accuracy of readings related to management consequences.

More recently an improved version of the Clarke Error Grid has come into use: It is known as the Consensus Error Grid. Older blood glucose meters often need to be "coded" with the lot of test strips used, otherwise, the accuracy of the blood glucose meter may be compromised due to lack of calibration.

1.4 Digital Thermometer

A thermometer is a device that measures temperature or a temperature gradient. A thermometer has two important elements: (1) a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer or the pyrometric sensor in an infrared thermometer) in which some change occurs with a change in temperature; and (2) some means of converting this change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer or the digital readout on an infrared model). Temperature is a statistical property of particles in motion. Mercury expands when warmed and thus indicates temperature. Electron mobility in semiconductor is similarly influenced but more easily scaled and thus makes a better thermometer. A mercury thermometer routes the expanding liquid from the reservoir bulb into a narrow and uniform passage, optically magnified by the surrounding glass, to provide visible motion against an engraved scale.

A digital thermometer measures current $\propto$ (eqV/kT-1) where T is absolute temperature and the remaining terms are physical, operational, or mathematical constants derived from the semiconductor physics. Clever feedback circuits amplify, duplicate, cancel and reference these currents to make stable temperature measurements. It is a battery-operated thermometer with connected measuring sensor and easy to read LCD display. It generates great accurate temperature readings. The size of the digital thermometer makes it ideal for any situations where you need an accurate reading and the easy-to-read screen displays the temperature of the environment in Celsius.

1.4.1 History

The thermometer was not a single invention, however, but a development. The expansion and contraction of the air caused the position of the water/air interface to move along the tube. Such a mechanism was later used to show the hotness and coldness of the air with a tube in which the water level is controlled by the expansion and contraction of the gas.

These devices were developed by several European scientists in the 16th and 17th centuries, notably Galileo Galilei. As a result, devices were shown to produce this effect reliably, and the term thermoscope was adopted because it reflected the changes in sensible heat (the concept of temperature was yet to arise). The difference between a thermoscope and a thermometer is that the latter has a scale. Though Galileo is often said to be the inventor of the thermometer, what he produced were thermoscopes. The first person to put a scale on a thermoscope is variously said to be Francesco Sagredo (1571–1620) or Santorio Santorio in about 1611 to 1613.

The word thermometer (in its French form) first appeared in 1624 in La Récréation Mathématique by J. Leurechon, who describes one with a scale of 8 degrees. The word comes from the Greek words θερμός, thermos, meaning "hot" and μέτρον, metron, meaning "measure". In 1714 Dutch scientist and inventor Daniel Gabriel Fahrenheit invented the first reliable thermometer, using mercury instead of alcohol and water mixtures. In 1724 he proposed a temperature scale which now (slightly adjusted) bears his name. He could do this because he manufactured thermometers, using mercury (which has a high coefficient of expansion) for the first time and the quality of his production could provide a finer scale and greater reproducibility, leading to its general adoption. In 1742, Anders Celsius (1701–1744) proposed a scale with zero at the boiling point and 100 degrees at the freezing point of water, though the scale which now bears his name has them the other way around. French entomologist René Antoine Ferchault de Réaumur invented an alcohol thermometer and temperature scale in 1730 that ultimately proved to be less reliable than Fahrenheit's mercury thermometer.

1.4.2 Calibration, Accuracy & Precision

Thermometers can be calibrated by the defining points in the International Temperature Scale of 1990, though in practice the melting point of water is more commonly used than its triple point. Nowadays manufacturers will often use a thermostat bath or solid block where the temperature is held constant relative to a calibrated thermometer. Other thermometers to be calibrated are put into the same bath or block and allowed to come to equilibrium, then the scale marked, or any deviation from the instrument scale recorded. For the digital devices calibration will be stating some value to be used in processing an electronic signal to convert it to a temperature.

A thermometer calibrated to a known fixed point is accurate (i.e. gives a true reading) at that point. Most thermometers are originally calibrated to a constant-volume gas thermometer. In between fixed calibration points, interpolation is used, usually linear. This may give significant differences between different types of thermometer at points far away from the fixed points. For example, the expansion of mercury in a glass thermometer is slightly different from the change in resistance of a platinum resistance thermometer, so these two will disagree slightly at around 50 °C. There may be other causes due to imperfections in the instrument, e.g. in a liquid-in-glass thermometer if the capillary tube varies in diameter.

The precision or resolution of a thermometer is simply to what fraction of a degree it is possible to make a reading. For high temperature work it may only be possible to measure to the nearest 10 °C or more. Clinical thermometers and many electronic thermometers are usually readable to 0.1 °C. Special instruments can give readings to one thousandth of a degree. However, this precision does not mean the reading is true or accurate, it only means that very small changes can be observed.

1.5 Phonocardiogram

The phonocardiogram (PCG) detects and records heart sounds, the sounds made by the various cardiac structures pulsing and moving blood. The sound is caused by the acceleration and deceleration of blood and turbulence developed during rapid blood flow. Heart-sound auscultation is both a science and an art. The science of the sounds that relate to a specific heart problem has been well established. The ability to discern the sounds or to recognize the sounds that are being heard is perhaps the art, although time-frequency techniques have been employed to analyze the phonocardiogram. The sounds result from vibrations created by closure of the heart valves, Four sounds are usually produced by the heart, but only two are ordinarily audible, the first when the atrioventricular valves (tricuspid and mitral) close at the beginning of systole and the second when the aortic valve and pulmonary valve (semilunar valves) close at the end of systole. With electronic amplification, the less intense sounds can be detected and recorded. The phonocardiogram is obtained with a miniature sensor in the tip of a small tubular instrument that is introduced via the blood vessels through the finger. The phonocardiogram usually supplements the information obtained by listening to body sounds with an auscultation and is of special diagnostic value when performed simultaneously with measurement of the electrical properties of the heart (electrocardiography) and pulse rate. In this project, we have built an **Arduino based heartbeat monitor** which counts the number of heartbeats in a minute. Here we have used a **heartbeat sensor module** which senses the heartbeat upon putting a finger on the sensor.

1.5.1 History

John Keefer filed a patent for the phonocardiogram in 1970 while he was an employee of the U.S. government. The original patent description indicates that it is a device which via electrical voltage mimics the human hearts sounds. Phonocardiography originated in an attempt to time the occurrence of heart sounds in the cardiac cycle in relation to the mechanical activity of the heart, as recorded in the apex beat or in arterial pulsations. The method evolved from an era when the observer manually inserted a signal in a pulse tracing at the time he heard the sounds. Later, this was done by mechanical synchronous record, then by an electric signal produced by a telephone pickup which stimulated a frog muscle to contract, then by direct recording through a capillary electrometer, or string galvanometer, and finally by electron tube amplification. Low-inertia capsule and mirror with photographic recording were also used, as well as other ingenious variations. Present day phonocardiography has developed mainly through improved instrumentation with low-noise level amplifiers and satisfactory filters. Spectral phonocardiography is the most important advance.

1.5.2 Accuracy

Heart-rate sensors' accuracy depends on a variety of factors. PCG uses optical heart-rate sensor. Most fitness trackers and smartwatches today uses photoplethysmography (or PPG sensors), which projects an IR light on the skin. There are two basic heart rate monitor designs: one uses a strap worn around your chest, and the other is a wristwatch-style tracker. The chest strap proved the most accurate of the heartrate-measuring devices, with a 99.6% accuracy. The wrist-worn devices, however, proved to be far less accurate. Basically accuracy of PCG using a heart beat sensor is based on how near the sensor is placed to the heart.

CHAPTER 2

LITERATURE SURVEY

Ahn et al. [1] implemented a system for measuring the physiological signals in sitting position such as PCG and pulse oximeter by using a smart health monitoring, that senses the non-constrained bio-signals like heart rates, pulse ratres and can be monitored using a monitoring system such as the one they had developed providing a classic example of the application of iot in healthcare.

Almotiri et al. [2] proposed a system of m-health that uses mobile devices to collect real-time data from patients in and store it on network servers connected to internet enabling access only to a certain specific clients. This data can be used for the medical diagnosis of patients and is achieved by using a number of wearable devices and body sensor network.

Barger et al. [3] made a smart house facility using a sensor network to monitor and track the movements, heart activity, generic body temperature of the patient in hoke and a prototype of the same is also being tested. The primary objective of their work is to check if their system is capable to outsmart the behavioral patterns and have discussed about the same in their work.

Chiuchisan et al. [4] proposed a framework to prevent the threats to patient in smart remote monitoring. The proposed system intimates the patient's relatives and doctors about any inconsistency in their health status or their body movements and also about the temperature of the patient and atmosphere of the room so that the necessary precautionary measures can be taken.

Dwivedi et al. [5] developed a framework in order to secure the clinical information that has to be layered of the glucose levels in a patient & their healthcare information system framework which is a combination of Public Key Infrastructure, Smartcard and Biometrics technologies.

Gupta et al. [6] proposed a model which measures and records PCG, glucose levels and other vital health parameters of the patient using Raspberry Pi and can be of a great use for the hospitals and patients as well as their family members.

Gupta et al. [7] present an approach using IOT, based on Intel Galeleo development board that collects the various parameters (PCG, ECG, Glucose level, Cholesterol level) and uploads it to the database from where it can be used by the doctors and also reduce the pain born by the patients to visit hospital each and every time to check their health parameters.

Lopes et al. [8] proposed a framework based on IoT for the people diagnosed with diabetes so as to study and find the IoT technologies in healthcare segment that can benefit them and their community. They took two use cases to study the latest IoT technologies and its application that can be used mainly for the disabled people.

Nagavelli and Rao [9] proposed a novel method to predict the severity of the sickness from the patient's medical record using mining based statistical approach which they said as degree of disease probability threshold. And in order to meet their goal they have revamped an0 algorithm that is mostly needed to derive the hyperlink weight of the websites.

Sahoo et al. [10] studied the healthcare management system and about the large amount of patient data that is generated from various reports. They further analyzed the health parameters to predict the future health conditions of the patient or the said subject. They use a cloud based data storing platform platform to achieve the same using the means of probability.

Tyagi et al. [11] explored the role of IoT in healthcare and studied its technical aspects to make it reality and identify the opportunities for which they propose a cloud based conceptual framework in which the patients' medical data and information can be securely transferred, with the permission of patient and their family by building a network among patient, hospital, doctors, Labs etc. The primary reason behind this is to relieve patient from the expensive clinical aid, overcome the shortage of doctors and therefore providing enhanced care and service to patients.

Xu et al. [12] presented a data model to record and use the IoT data. They designed and developed a resource-based Ubiquitous Data accessing method to collect and publish IoT data globally to so that it can be accessed anywhere, anytime. They also present an emergency medical service based on IoT and how to collect and use the IoT data on different platforms.

CHAPTER 3

HARDWARE

The hardware components required for this project are listed below:

- Arduino Uno
- Gas Sensor (MQ6)
- Temperature Sensor (LM35)
- Heart Beat Sensor
- Wifi Module (ESP8266)
- Voltage Regulator (LM317t)
- LCD Display

3.1 Arduino Uno

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable.[4] It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo.

The word "uno" means "one" in Italian and was chosen to mark the initial release of the Arduino Software. The Uno board is the first in a series of USB-based Arduino boards, and it and version 1.0 of the Arduino IDE were the reference versions of Arduino, now evolved to newer releases. The ATmega328 on the board comes pre-programmed with a bootloader that allows uploading new code to it without the use of an external hardware programmer. While the Uno communicates using the original STK500 protocol, it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Each of the 14 digital pins and 6 analog pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference() function.

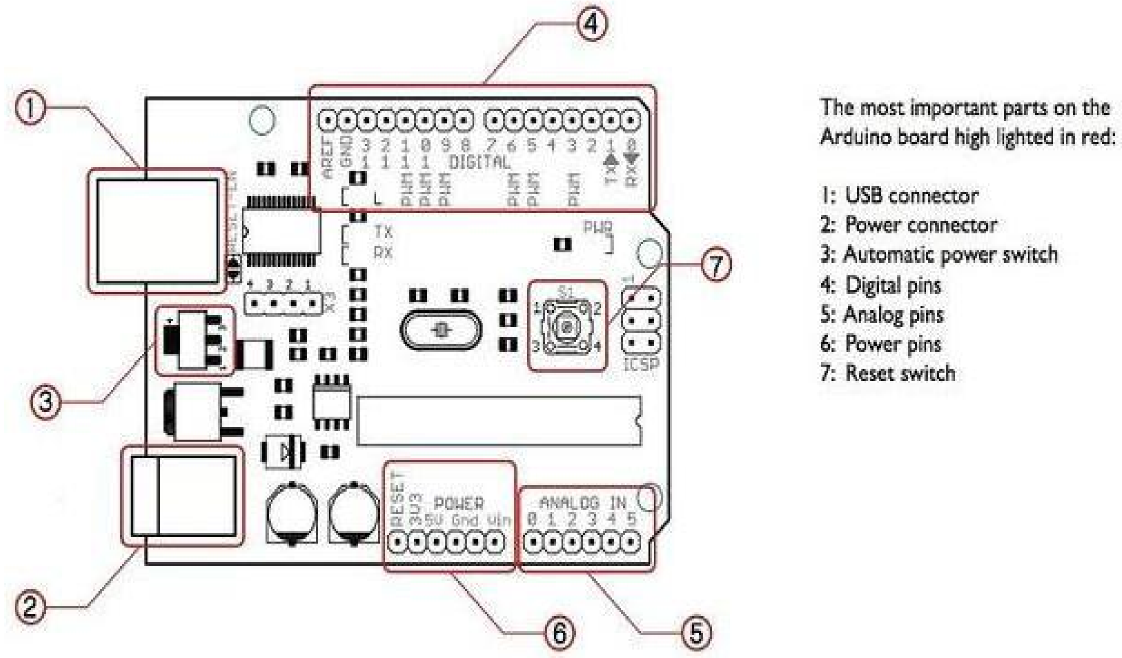


Figure 3.1 Arduino uno microcontroller for data acquisition and processing

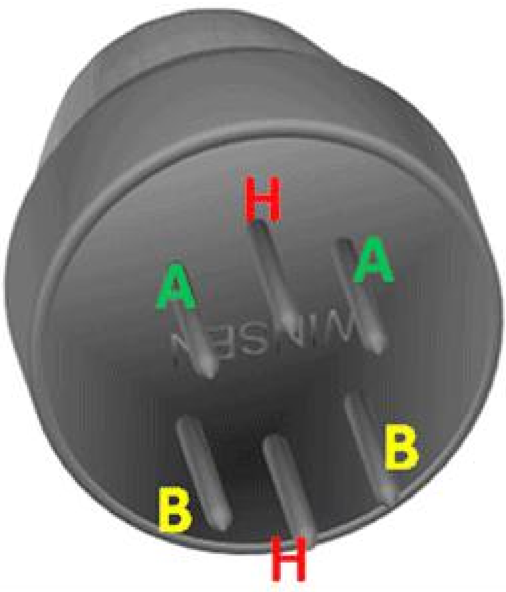
In addition, some pins have specialized functions: Serial / UART: pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL serial chip. External interrupts: pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. PWM (pulse-width modulation): 3, 5, 6, 9, 10, and 11. Can provide 8-bit PWM output with the analog Write() function. SPI (Serial Peripheral Interface): 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).

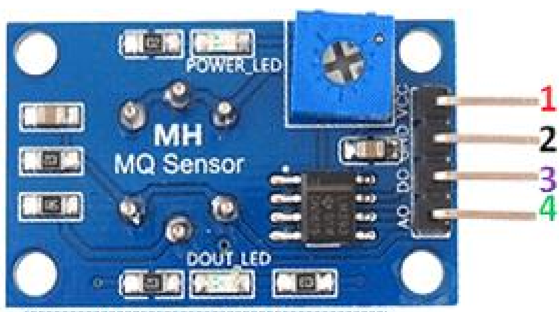
These pins support SPI communication using the SPI library.

- TWI (two-wire interface) / I^2C: A4 or SDA pin and A5 or SCL pin.
- AREF (analog reference): Reference voltage for the analog inputs.

3.2 Gas Sensor (MQ6)

This is a simple-to-use acetone sensor. The MQ-6 can detect gas concentrations (acetone) anywhere from 200 to 10000ppm and with further modification can give glucose level in mg/dl. This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. The drive circuit is very simple; all you need to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC. The gas sensitive material used in MQ-6 gas sensor is SnO_2, which is of lower electrical conductivity in clean air. When there is combustible gas in the environment where sensor resides, the electrical conductivity of the sensor increases with the increase of the combustible gas concentration in the air. The change of electrical conductivity can be converted to the output signal corresponding to that of the gas concentration by using a simple circuit. The sensitivity of MQ-6 gas sensor to acetone, propane, butane and liquefied petroleum gas is quite high, and the natural gas can also be well detected. This sensor can detect a variety of combustible gases, making it a low-cost sensor for a variety of applications.





Pin No.	Pin Name
1	Vcc(+5V)
2	Ground
3	Digital Out
4	Analog out

Figure 3.2.1 Pin Description of MQ6 Gas sensor for Glucose and Acetone level sensing

We have designed and tested this gas sensor in webench designer. Webench designer tool provides the schematics of gas sensor as given in Figure 3.2.2. The gas sensor detects the acetone level in our breath and gives the data to the launch pad which then processes it. The used gas sensor is MQ6 which has a shield, pot, sensor, output pins along with power supply and ground. The power supplied is 3.3V. When the sensor detects acetone LED changes its colour from red to blue.

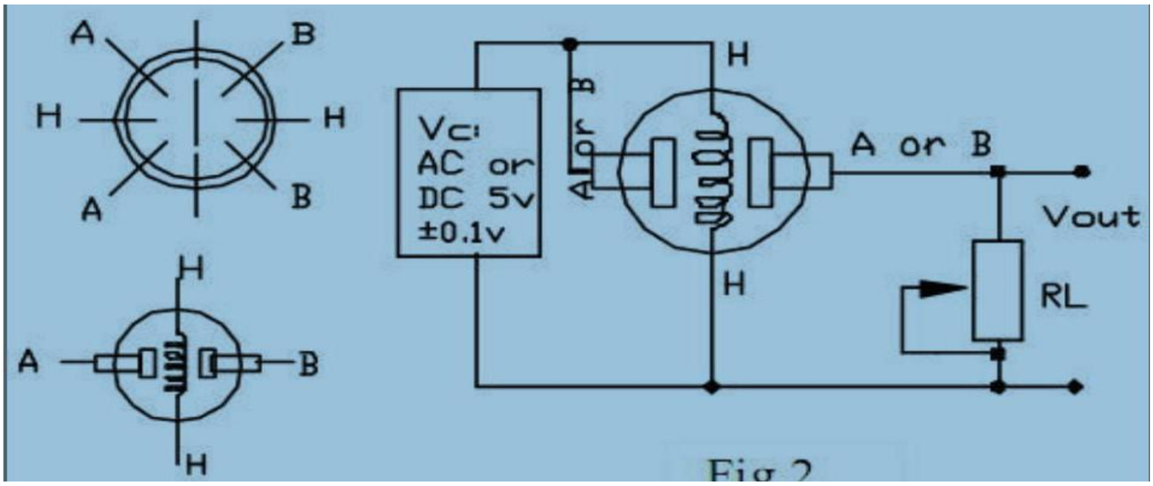


Fig 3.2.2(a) Schematic Design for MQ6 Gas Sensor

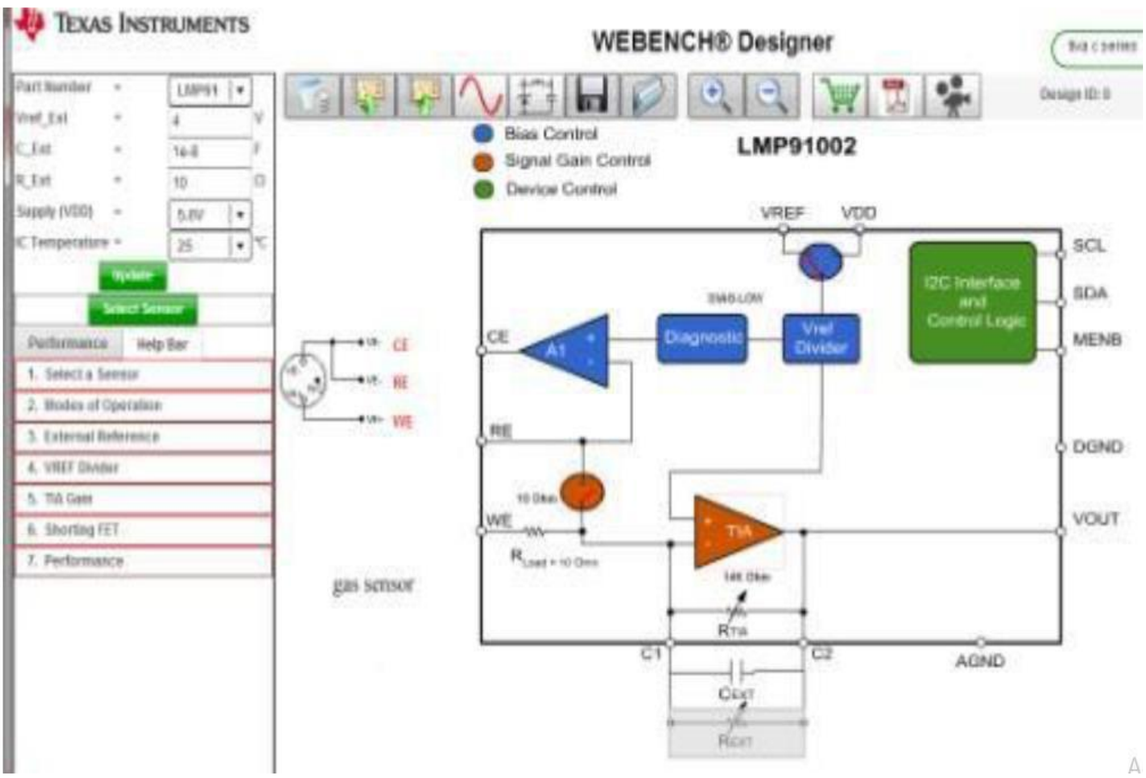


Fig 3.2.2(b) webench design for mq6 gas sensor

3.3 Temperature Sensor LM35

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 °C temperature rise in still air.

Figure 3.3.1 LM35 Temperature sensor schematic and ports

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full−55°C to 150°C temperature range. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to read out or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60µA from the supply. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

The LM35 IC has 3 pins-2 for the power supply and one for the analog output as shown in figure 3.3.1. It is a low voltage IC which uses approximately +5VDC of power. The output pin provides an analog voltage output that is linearly proportional to the Celsius (centigrade) temperature. Pin 2 gives an output of 1 millivolt per 0.1°C (10mV per degree).So to get the degree value in Celsius, all that must be done is to take the voltage output and divide it by 10-this give out the value degrees in Celsius. The circuit connections are made as follows: Pin 1 of the LM35 goes into +5V of the Arduino, Pin 2 of the LM35 goes into analog pin A0 of the Arduino, Pin 3 of the LM35 goes into ground (GND) of the Arduino.

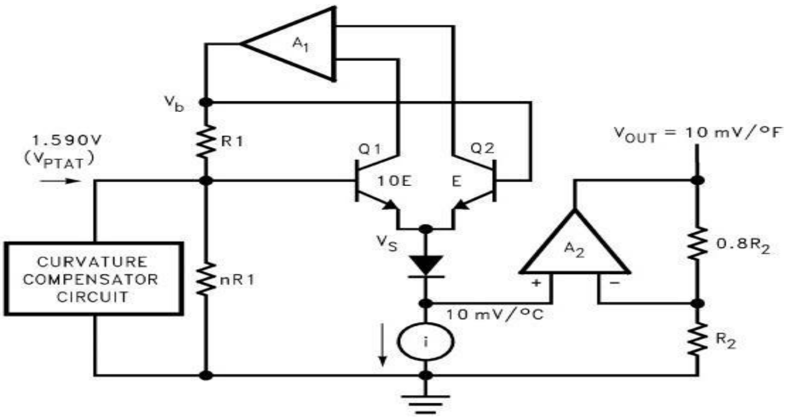


Figure 3.3.2 Internal design of LM35 Temperature sensor

There are two transistors in the center of figure 3.3.2. One has ten times the emitter area of the other. This means it has one tenth of the current density, since the same current is going through both transistors. This causes a voltage across the resistor R1 that is proportional to the absolute temperature, and is almost linear across the range. The "almost" part is taken care of by a special circuit that straightens out the slightly curved graph of voltage versus temperature. The amplifier at the top ensures that the voltage at the base of the left transistor (Q1) is proportional to absolute temperature (PTAT) by comparing the output of the two transistors. The amplifier at the right converts absolute temperature (measured in Kelvin) into either Fahrenheit or Celsius, depending on the part (LM34 or LM35).The little circle with the "i" in it is a constant current source circuit. The two resistors are calibrated in the factory to produce a highly accurate temperature sensor. The integrated circuit has many transistors in it -- two in the middle, some in each amplifier, some in the constant current source, and some in the curvature compensation circuit. All of that is fit into the tiny package with three leads.

3.4 Heartbeat Sensor (Photo-Plethysmography sensor)

Heart beat sensor is designed to give digital output of heat beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each heartbeat. This digital output can be connected to microcontroller directly to measure the Beats per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse.

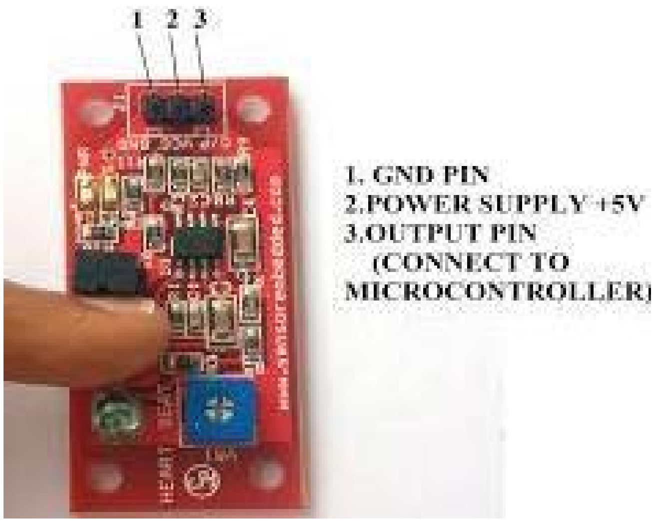


Figure 3.4.1 Schematic and port information of heartbeat sensor

The principle of photo-plethysmography is that the low intensity infrared light when incident on the human body, it gets absorbed by the muscles, bones and venous and arterial blood. The absorption of light is mostly due to the blood and is directly proportional to the flow of blood, which gives us a direct measurement of the voltage from the photo plethysmography sensor. It only gives a qualitative measure of the blood flow. Although it gives a measure of the heart rate monitor at a very low cost. The use of these reflective optical sensor simplifies the build process of the sensor part of the project as both the infrared light emitter diode and the detector are arranged side by side in a leaded package, thus blocking the surrounding ambient light, which could otherwise affect the sensor performance. It is designed in a printed circuit board, which carries both sensor and signal conditioning unit, and its output is a digital pulse which is synchronous with the heartbeat. The output pulse can be fed to either an ADC channel or a digital input pin of a microcontroller for further processing and retrieving the heart rate in beats per minute (BPM).

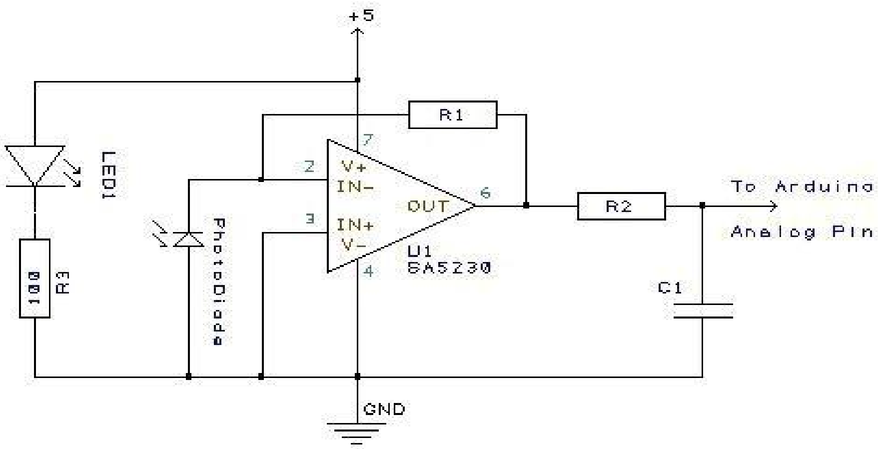


Figure 3.4.2 Detailed circuitry of input and processing of heartbeat sensor

This sensor provides an analog signal and the sensor can be driven with 3V or 5V, the current consumption of the sensor is 4 mA, which is great for mobile applications. The sensor comes with three connecting points. The sensor schematic consists optical heart-rate sensor, noise cancellation RC circuitry and filters, which can be seen in Figure 3.4.2 and an operational amplifier is used for reliable amplified analog output.

3.5 WIFI Module (ESP8266)

The ESP8266 is a 3V Wi-Fi module very popular for its Internet of Things applications. It is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller Wi-Fi enabled system on chip (SoC) module developed by Espressif system. ESP 8266 maximum working Voltage is 3.6V. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using AT commands or Hayes-style commands.

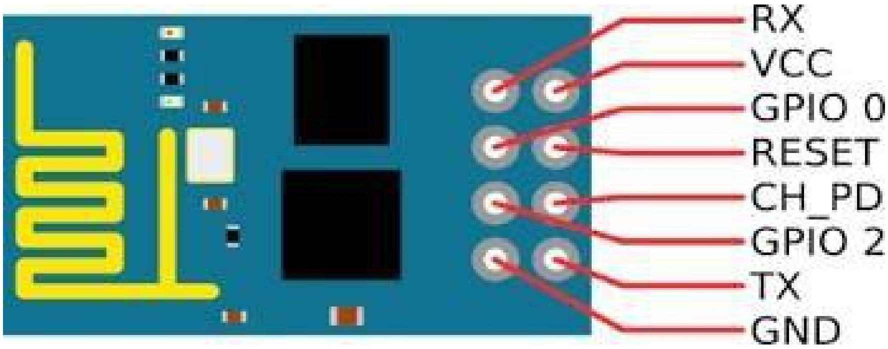


Figure 3.5.1 Pin description of ESP8266 Wi-Fi module

The ESP8285 has 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi. It employs a 32-bit RISC CPU based on the Tensilica Xtensa L106 running at 80 MHz (or overclocked to 160 MHz). It has a 64 KB boot ROM, 64 KB instruction RAM and 96 KB data RAM. External flash memory can be accessed through SPI.

ESP8266 comes with capabilities of

- 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2)
- General-purpose input/output (16 GPIO)
- Inter-Integrated Circuit (I²C) serial communication protocol
- Analog-to-Digital conversion (10-bit ADC)
- Serial Peripheral Interface (SPI) serial communication protocol
- UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2)
- Pulse-width modulation (PWM).

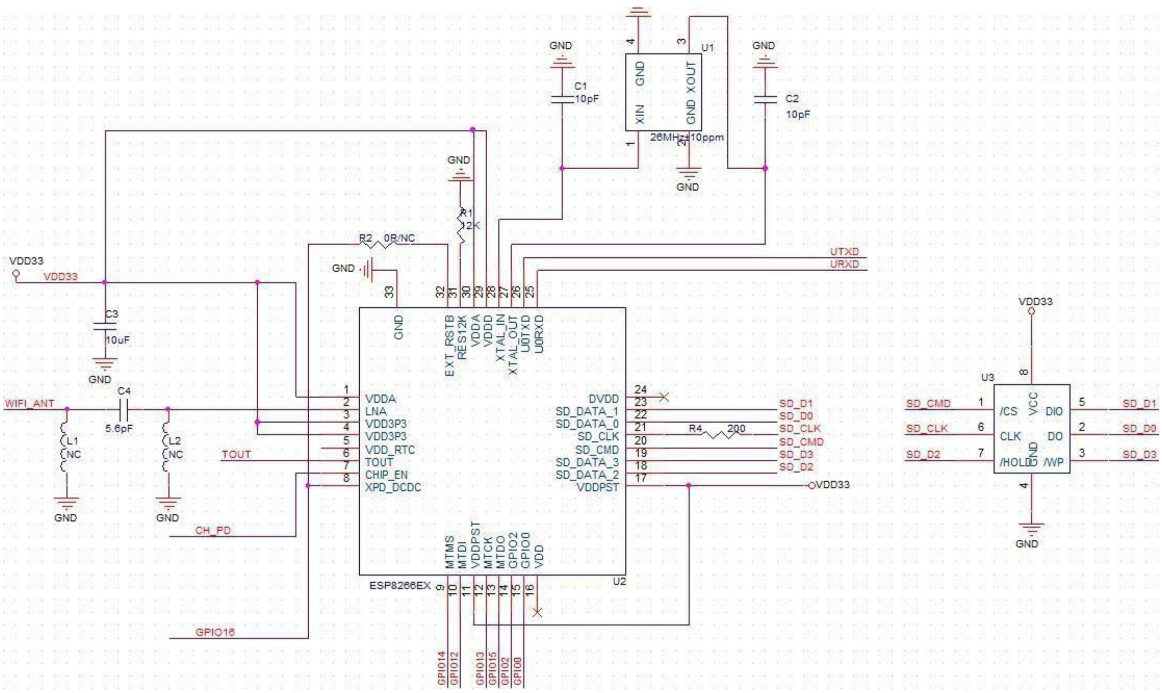


Figure 3.5.2 ESP8266EX schematic

ESP8266 module is low cost standalone wireless transceiver that can be used for end-point IoT developments. To communicate with the ESP8266 module, microcontroller needs to use set of AT commands. Alternately, serving as a Wi-Fi adapter, wireless internet access can be added to any microcontroller-based design with simple connectivity through UART interface or the CPU AHB bridge interface. ESP8266 on-board processing and storage capabilities allow it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. With its high degree of on-chip integration, which includes the antenna switch balun, power management converters, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area. The following current consumption is based on 3.3V supply, and 25℃ ambient, using internal regulators. Measurements are done at antenna port without SAW filter. All the transmitter's measurements are based on 90% duty cycle, continuous transmit mode.

3.6 Voltage Regulator (LM317t)

The LM317T is an adjustable 3-terminal positive voltage regulator capable of supplying different DC voltage outputs other than the fixed voltage power supply of +5 or +12 volts, or as a variable output voltage from a few volts up to some maximum value all with currents of about 1.5 amperes over an output-voltage range of 1.25 V to37 V.

With the aid of a small bit of additional circuitry added to the output of the PSU we can have a bench power supply capable of a range of fixed or variable voltages either positive or negative in nature. It requires only two external resistors to set the output voltage. The device features a typical line regulation of 0.01 % and typical load regulation of 0.1 %. It includes current limiting, thermal overload protection, and safe operating are a protection. Overload protection remains functional even if the ADJUST terminalis are disconnected.

The fixed 3-terminal regulator is useful in applications were an adjustable output is not required making the output power supply simple, but very flexible as the voltage it outputs is dependant only upon the chosen regulator. They are called 3-terminal voltage regulators because they only have three terminals to connect to and these are the Input, Common and Output respectively.

The LM317T is a fully adjustable 3-terminal positive voltage regulator capable of supplying 1.5 amps with an output voltage ranging from around 1.25 volts to just over 30 volts. By using the ratio of two resistances, one of a fixed value and the other variable (or both fixed), we can set the output voltage to the desired level with a corresponding input voltage being anywhere between 3 and 40 volts.

The LM317T variable voltage regulator also has built in current limiting and thermal shut down capabilities which makes it short-circuit proof and ideal for any low voltage or home made bench power supply. The output voltage of the LM317T is determined by ratio of the two feedback resistors R1 and R2 which form a potential divider network across the output terminal as shown below.

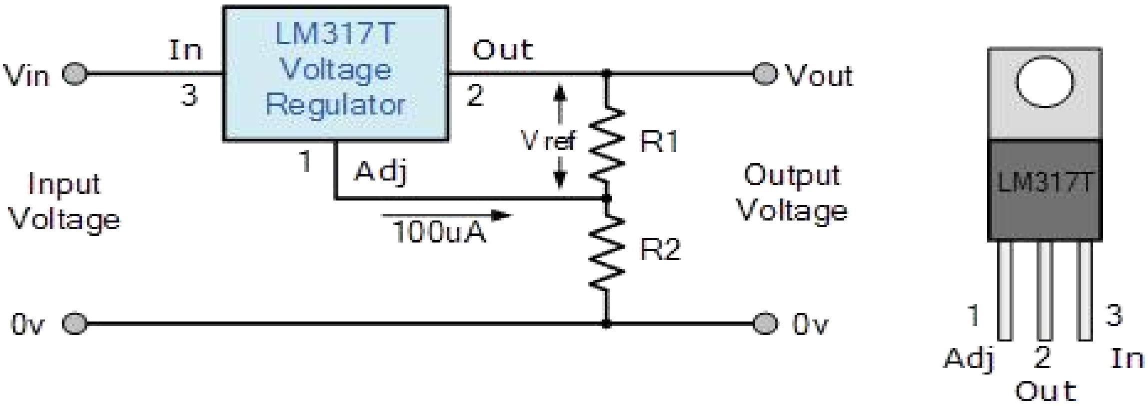


Figure 3.6 Schematic and circuit diagram of LM317t voltage regulator

The voltage across the feedback resistor R1 is a constant 1.25V reference voltage, V_{ref} produced between the “output” and “adjustment” terminal. The adjustment terminal current is a constant current of 100uA. Since the reference voltage across resistor R1 is constant, a constant current i will flow through the other resistor R2, resulting in an output voltage of:

$$V_{OUT} = 1.25\left(1+\frac{R_2}{R_1}\right)$$

Then whatever current flows through resistor R1 also flows through resistor R2 (ignoring the very small adjustment terminal current), with the sum of the voltage drops across R1 and R2 being equal to the output voltage, Vout. Obviously the input voltage, Vin must be at least 2.5 volts greater than the required output voltage to power the regulator. Also, the LM317T has very good load regulation providing that the minimum load current is greater than 10mA. So to maintain a constant reference voltage of 1.25V, the minimum value of feedback resistor R1 needs to be 1.25V/10mA = 120 Ohm and this value can range anywhere from 120 ohms to 1,000 ohms with typical values of R1 being about

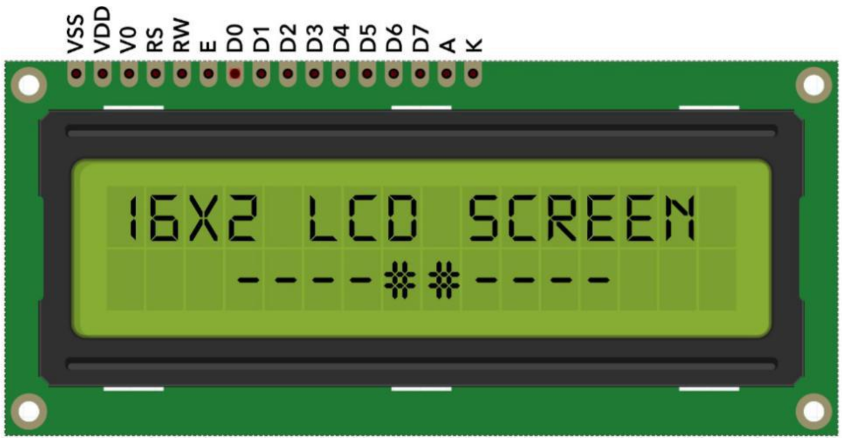
220Ω's to 240Ω's for good stability. If we know the value of the required output voltage, Vout and the feedback resistor R1 is say 240 ohms, then we can calculate the value of resistor R2 from the above equation. For example, our original output voltage of 9V would give a resistive value for R2 of:

R1.((Vout/1.25)-1) = 240.((9/1.25)-1) = 1,488 Ohms or 1,500 Ohms (1k5Ω) to the nearest preferred value.

Of course in practice, resistors R1 and R2 would normally be replaced by a potentiometer so as to produce a variable voltage power supply, or by several switched preset resistances if several fixed output voltages are required.

3.7 LCD Display

LCD (liquid crystal display) is the technology used for displays in notebook and other smaller computers. Like light-emitting diode (LED) and gas-plasma technologies, LCDs allow displays to be much thinner than cathode ray tube (CRT) technology. LCD consume much less power than LED and gas-display displays because they work on the principle of blocking light rather than emitting it.



No	Symbol	Function
1	VSS	Ground
2	VDD	5V +
3	V0	Contrast
4	RS	Register
5	RW	Read/Write
6	E	Enable
7	D0	Data bus
8	D1	Data bus
9	D2	Data bus
10	D3	Data bus
11	D4	Data bus
12	D5	Data bus
13	D6	Data bus
14	D7	Data bus
15	A	Anode (5V+)
16	K	Cathode (GND)

Figure 3.7 Pin Description of 16x2 LCD Display

An LCD is made with either a passive matrix or an active matrix display grid. The active matrix LCD is also known as a thin film transistor (TFT) display. The passive matrix LCD has a grid of conductors with pixels located at each intersection in the grid. A current is sent across two conductors on the grid to control the light for any pixel. An active matrix has a transistor located at each pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active matrix display can be switched on and off more frequently, improving the screen refresh time. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

All LCDs have 14 or 16 pins. Let's see them in the following.

- GND or VSS: Ground or 0V
- VCC or VDD: Supply Voltage 5V
- VEE: Contrast adjustment through a variable resistor
- RS: Register select. Generally, every Lcd has two types of registers namely *Command Register* and *Data Register*. When RS=0 or low, Command Register is selected and When RS=1 or high, Data Register is selected.
- R/W: Read/Write.When *RW=1,* data is read from Lcd and When *RW=0*, writes the data to Lcd.
- EN: Enable sends data to data pins when a high to low pulse is given.
- Eight Data pins(DB0 to DB7):This 8-Data pins carries 8-bit data or command from an external unit such as micro controller.
- Led+ : Back light of the LCD which should be connected to Vcc or 5V.
- Led- : Back light of the LCD which should be connected to Gnd or 0V.

Interfacing LCD to Arduino:

Here 16x2 Lcd is used which has 16 pins and can be operated in 4-bit mode or 8-bit mode.For 4-bit mode,the data pins DB4 to DB7 are used whereas for 8-bit mode all the data pins have been used.The connections should be made as given below:

- LCD Gnd pin to Ground
- LCD Vcc pin to 5V
- LCD VEE pin to wiper
- LCD RS pin to digital pin 12
- LCD R/W pin to ground

- LCD Enable pin to digital pin 11
- LCD D4 pin to digital pin 5
- LCD D5 pin to digital pin 4
- LCD D6 pin to digital pin 3
- LCD D7 pin to digital pin 2
- LCD Led+ pin to 5V
- LCD Led- pin to ground

CHAPTER 4

SOFTWARE

4.1 Arduino IDE:

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with the program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program to convert the executive code into the text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

Figure 4.1 Arduino IDE

Steeps for implementation of Arduino Uno using Arduino IDE:

- Verify: Compile your code. Any syntax problem will be prompted with errors.
- Upload: Upload the code to your board. When you click the button, the RX and TX LEDs on the board will flicker fast and won't stop until the upload is done.

- New: Create a new code editing window.
- Open: Open an .ino sketch.
- Save: Save the sketch.
- Serial Monitor: Click the button and a window will appear. It receives the data sent from your control board. It is very useful for debugging.
- File: Click the menu and a drop-down list will appear, including file creating, opening, saving, closing, some parameter configuring, etc.
- Sketch: Includes operations like Verify, Upload, Add files, etc. More important function is Include Library – where you can add libraries.
- Tool: Includes some tools – the most frequently used Board (the board you use) and Port (the port your board is at). Every time you want to upload the code, you need to select or check them.
- Help: If you're a beginner, you may check the options under the menu and get the help you need, including operations in IDE, introduction information, troubleshooting, code explanation, etc. In this message area, no matter when you compile or upload, the summary message will always appear. Detailed messages during compile and upload. For example, the file used lies in which path, the details of error prompts.
- Board and Port: Here you can preview the board and port selected for code upload. You can select them again by Tools -> Board / Port if any is incorrect. The editing area of the IDE. You can write code here. Now let's some basic operations in IDE with an example code. Click File > Examples >01.Basics > Blink and a new window will show up.
- Click Tools ->Board and select Arduino/Genuino Uno.
- Then Tools ->Port and select the COM port you just checked on Device Manager or the system prompted you in the taskbar when you plug in the board.
- Click the Upload icon to upload the code to the board. And the icon Compile to compile sketches (usually used to refer to a code file), which always checks the code. Also when you click Upload, the code will be compiled. The sketches can be uploaded to the board when there is nothing wrong with them. Therefore, generally you just need to click Upload. During the upload, the TX LED and the RX LED will be alternately flickering. It means the board is sending signal to the

computer and then receives the signal from the latter. After upload is completed, the two LEDs will go out.

4.2 TCP/UDP TEST TOOL

Ideal for the microcomputer and the communication test, such as an Arduino or Raspberry Pie. In addition to a TCP server and a basic function of a TCP client and UDP communication. Connection confirmation to the designation address in PING. In IP CONFIG You can check the status of Wi-Fi. In addition, the share of the communication content file storage and other applications, - repeat transmission of the same data, there are also features such as sending and receiving in hexadecimal (Hex). Problems or opinions and requests, In addition, or allowed to communicate with a microcomputer, such as Raspberry Pi and Edison, a request that I want to make this kind of app TCP/UDP TEST TOOL is a free software application from the System Maintenance subcategory, part of the System Utilities category. The app is currently available in English and it was last updated on 2016-09-04. The program can be installed on Android. The options given in the TCP/UDP TEST TOOL is shown in figure 4.2

Figure 4.2 TCP/UDP TEST TOOL

CHAPTER 5

PROPOSED SYSTEM

5.1 Block diagram

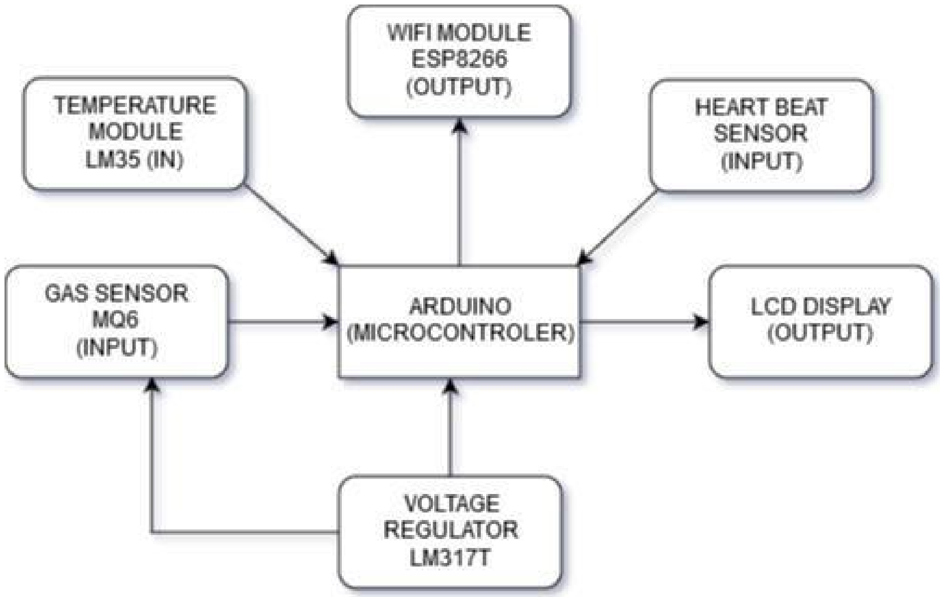


Figure 5.1.1 Overall system Block Diagram and Implementation technique

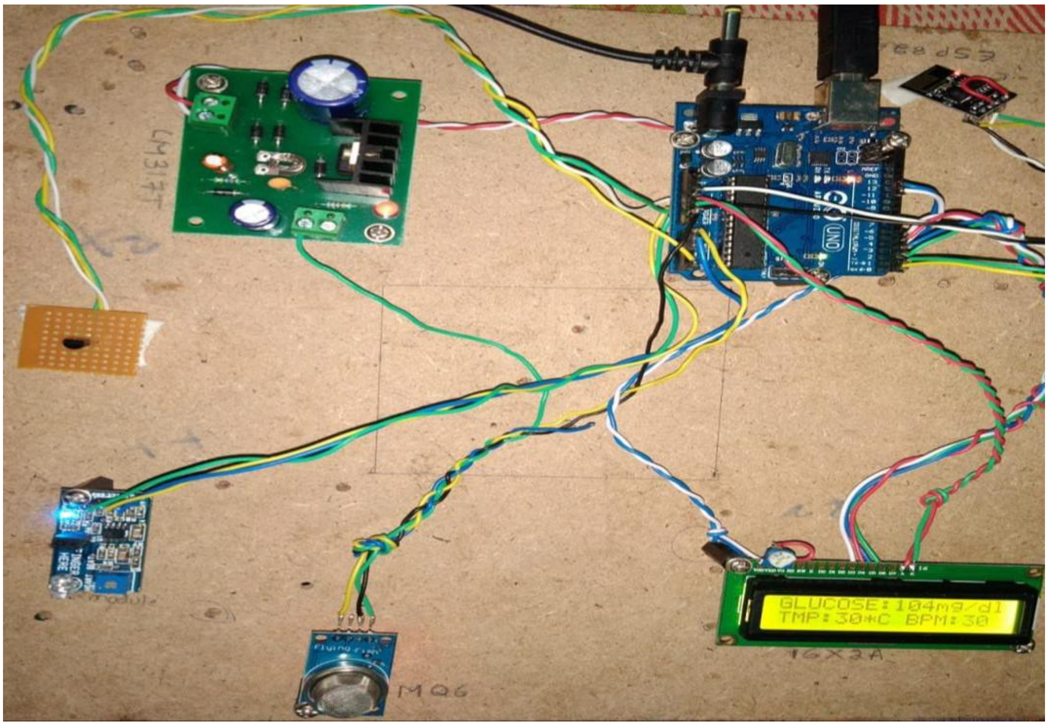


Figure 5.1.2 Hardware Connections of SMART Health Monitoring System

5.2 Phonocardiogram (Heart-beat monitoring)

A Heartbeat Sensor consists of a sensor and a control circuit. The sensor part of the Heartbeat Sensor consists of an IR LED and a Photo Diode placed in a clip. The Control Circuit consists of an Op-Amp IC and few other components that help in connecting the signal to a Microcontroller.

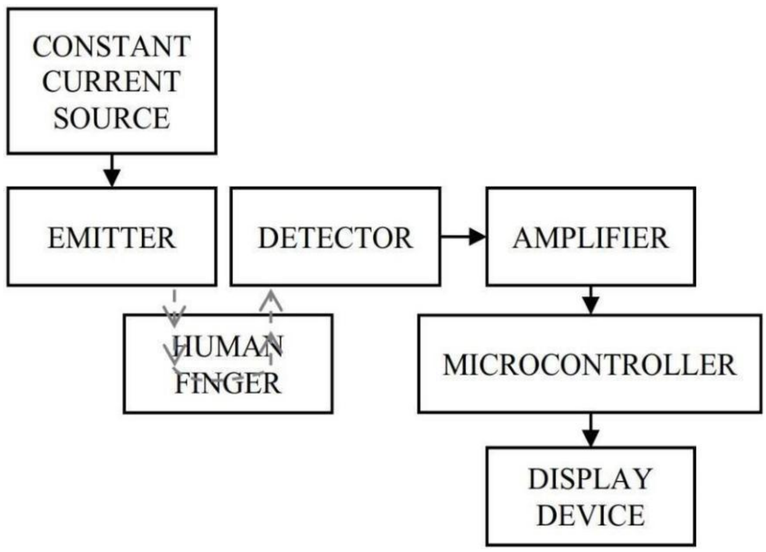


Figure 5.2.1 Overall Input and Output description

The working of the Heartbeat Sensor can be understood better if we take a look at Figure 5.2.2. The figures shows the finger type heartbeat sensor, which works by detecting the pulses. Every heartbeat will alter the amount of blood in the finger and the light from the IR LED passing through the finger and thus detected by the Photo Diode will also vary. Now, when the heart pumps blood through the blood vessels, the finger becomes slightly more opaque; due to this, less amount of light reaches from the IR LED to the detector. With every heart pulse generated, the detector signal gets varied. The varied detector signal is converted into an electrical pulse. This electrical signal gets amplified and triggered through an amplifier which gives an output of +5V logic level signal. The output signal is also directed by a LED display which blinks on each heartbeat rate. The fingertip PPG signal reflects the blood movement in the vessel, which goes from the centre (heart) to the end (fingertips) in a wave-like motion as shown in Figure 5.2.2.

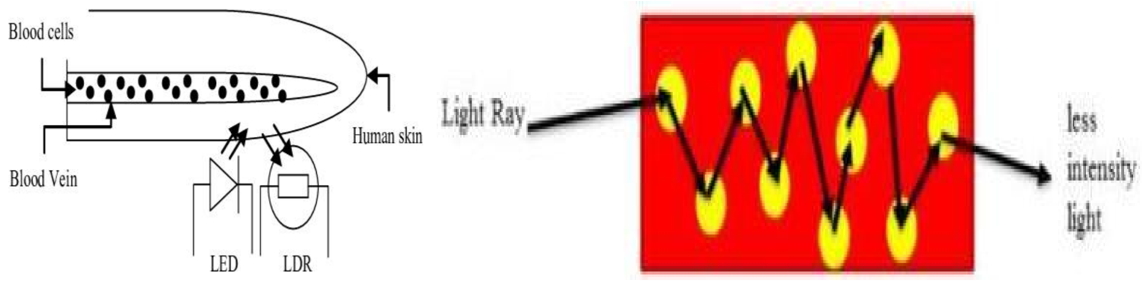


Figure 5.2.2 Detection of pulse from PPG sensor

Arduino controls the whole process of system like reading pulses form Heart beat sensor module, calculating heart rate and sending this data to LCD. We can set the sensitivity of this sensor module by inbuilt potentiometer placed on this module. Heart beat sensor module's output pin is directly connected to pin 8 of arduino. Vcc and GND are connected to Vcc and GND. A 16x2 LCD is connected with arduino in 4-bit mode. Control pin RS, RW and En are directly connected to arduino pin 12, GND and 11. And data pin D4-D7 is connected to pins 5, 4, 3 and 2 of arduino. And one push button is added for resetting reading and another is used to start the system for reading pulses. When we need to count heart rate, we press start button then arduino start counting pulses and also start counter for five seconds. This start push button is connected to pin 7 and reset push button is connected to pin 6 of arduino with respect to ground.

There are several methods for calculating heart rate, but here we have read only five pulses. When first pulse comes, we start counter by using timer counter function in arduino that is millis();. And take first pulse counter value form millis();. Then we wait for five pulses. After getting five pulses we again take counter value in time2 and then we substarct time1 from time2 to take original time taken by five pulses. And then divide this time by 5 times for getting single pulse time. Now we have time for single pulse and we can easily find the pulse in one minute, deviding 600000 ms by single pulse time.

5.3 Digital Thermometer

The digital thermometer is designed using LM35 temperature sensor, Arduino UNO board & LCD. LM35 temperature sensor senses the temperature & converts it into analog value (mV). Then this analog value is fed into analog channel of Arduino UNO. Arduino UNO receives this analog value & convert it into digital signal using in built ADC. After that digitized value is displayed on LCD display.

Output of LM35 temperature sensor is given to analog channel A1 of Arduino for sensing real time temperature. The LM35 temperature sensor is used for sensing environment temperature which gives 1 degree temperature on every 10mV change at its output pin. You can easily check it with voltmeter by connecting Vcc at pin 1 and Ground at pin 3 and output voltage at pin 2 of LM35 sensor. Arduino reads output voltage of temperature sensor by using Analog pin A0 and performs the calculation to convert this Analog value to a digital value of current temperature.

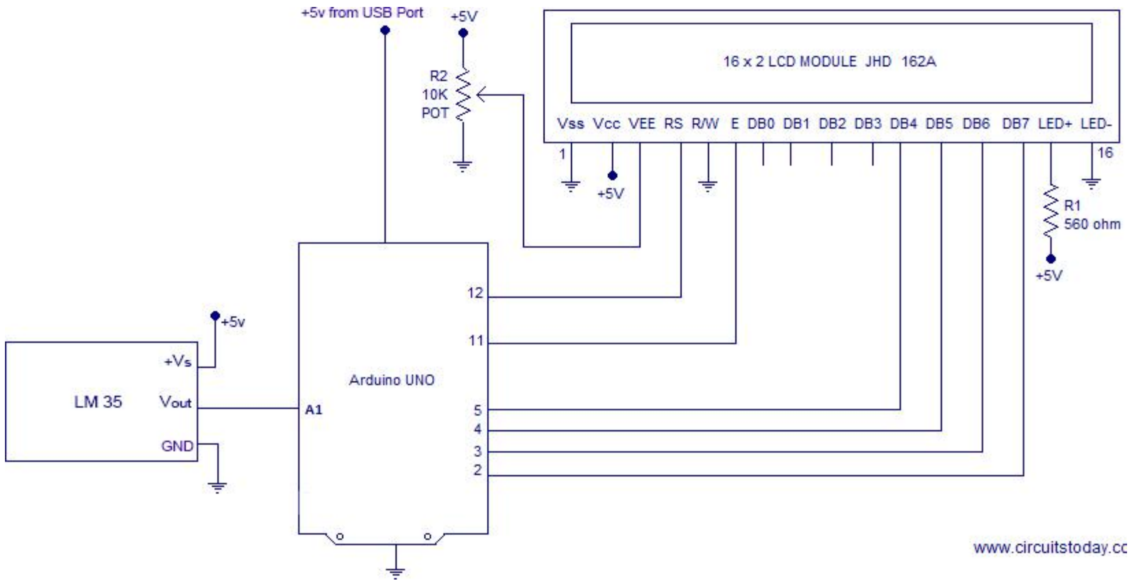


Figure 5.3 Pin description and connection of LM35 sensor

After getting analog value at analog pin we reads that value using Analog read function and stores that value in a variable. And then by applying given formula converts it in temperature.

float analog_value=analogRead(analog_pin);

float Temperature=analog_value*factor*100, where factor=5/1023

analog_value= output of temperature sensor.

After calculations arduino sends these calculations or temperature to 16x2 LCD unit by using appropriate commands of LCD.

5.4 Glucometer

The hardware used here is MQ6 gas sensor, Arduino Uno, Wi-Fi module, LCD display & Smart Phone display. The gas sensor is connected to the arduino which is then connected to the wi-fi module. The wi-fi module is connected with the mobile phone through the tcp/udp application. The application is available in Google Play store and Apple IOS store. The sensor input is fed to the Arduino through a female jack. The supply and ground also comes from the Arduino. The wi-fi module is interfaced with the arduino through wires. The smart phone is connected to the wi-fi module through TCP/IP protocol. The data processed by the arduino is transmitted to the tcp/udp application through the module in which the required data is displayed. The data displayed in the mobile is converted to a word document along with time and date and stored in One Drive or Google Docs & can be shared via mails, messages, etc. The word document is synchronized with any of the cloud server. We can retrieve the data whenever needed.

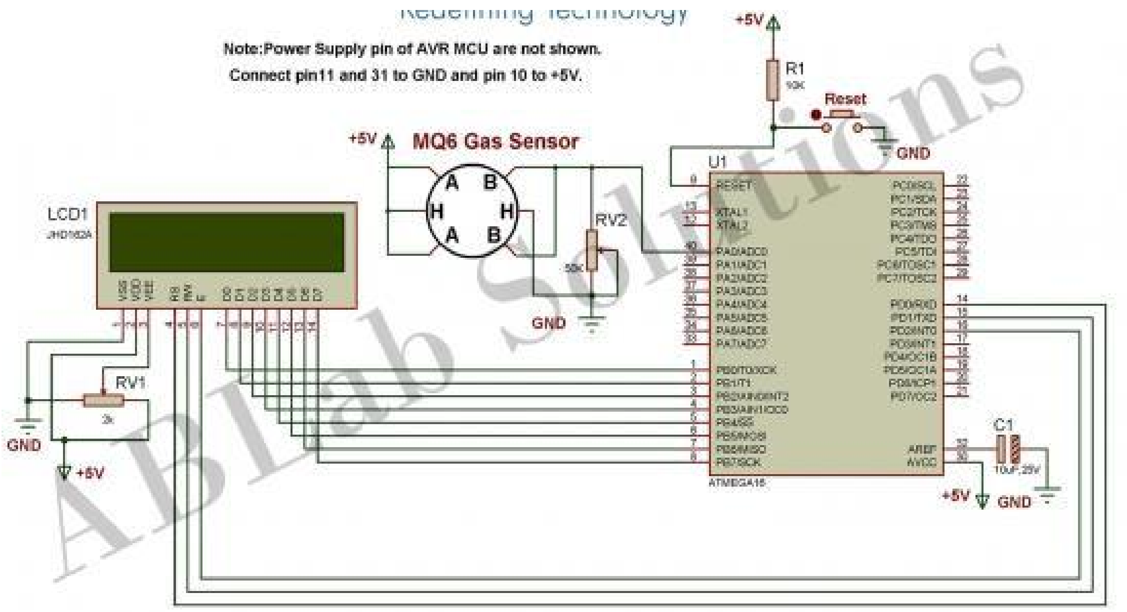


Figure 5.4.1 Pin description and connection of MQ6 gas sensor with Arduino and LCD Display

The gas sensor detects the acetone level in our breath and gives the data to the launch pad which then processes it. When the sensor detects acetone LED blinks. The gas sensor senses the acetone level and transmits the data to the launch pad where the glucose level is calculated & depending on the glucose level a message is displayed "Take Medication". These data is then transmitted to the smart phone through the Wi-Fi module.

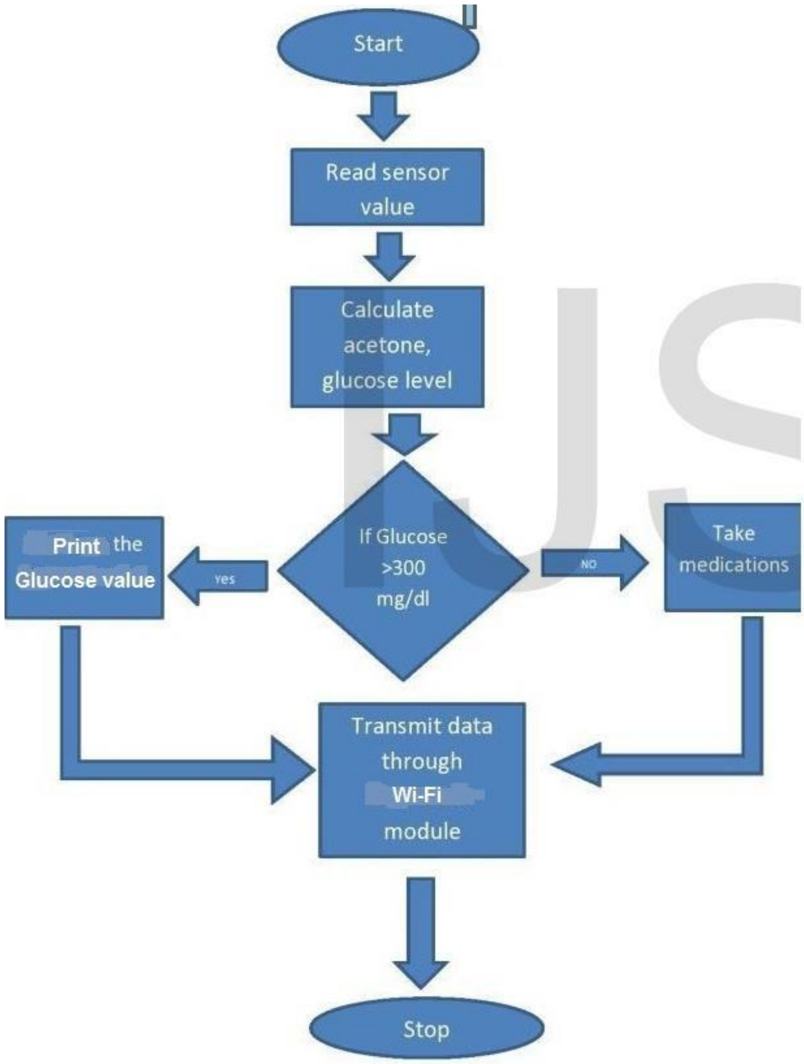


Figure 5.4.2 Working principle of Glucometer

CHAPTER 6

RESULTS

6.1 Glucometer

The data processed in Arduino is displayed in the smart phone through interfacing the wi-fi module. The values shown in the figure is the result. The patient blows his breath before and after consumption of food. The results are shown in three different display units, smart phone (TCP/UDP test tool), LCD display, Arduino IDE. If the glucose valus goes up, an output will be displayed specifying Take Medications. Otherwise, the glucose level value will be displayed.

Range of Acetone (Healthy) = <300 ppm

Range of Healthy Glucose level = 79 to 110 mg/dl

Likewise, for PCG, from the designed model, the values of the pulse beat will be observed by the heartbeat sensor and the observed value will be shown on the 16*2 LCD display, TCP/UDP test tool and Android IDE. It provides the conditions of the patient's pulse beat. Range of PCG (Heart rate) = 60 to 100 bpm

We can also determine the patient's body as well as his surrounding atmospheric temperature which will help in better monitoring of the patient. The observed value will be in terms of centigrade scale and displayed in 16*2 LCD display, TCP/UDP test tool and Android IDE.

Range of Normal Human Body Temperature = 30 to 37 `C

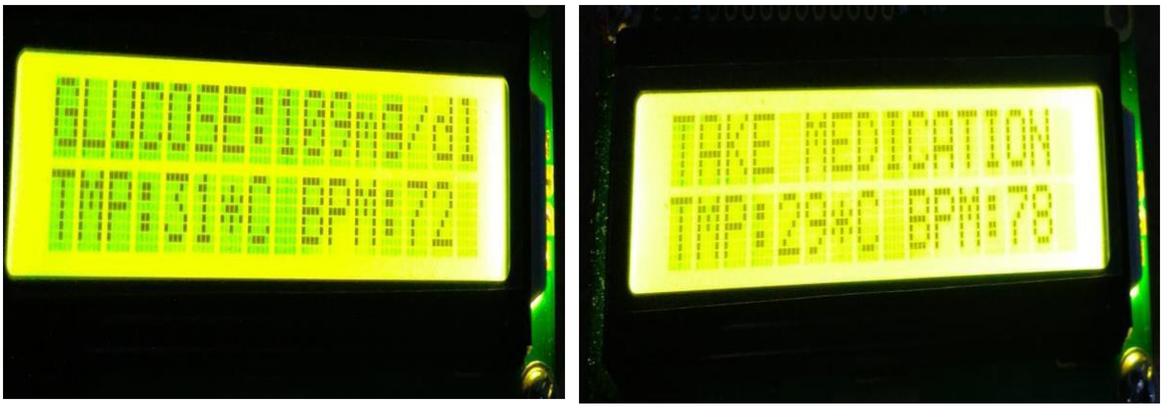


Figure 6.1 Healthy & Unhealthy Sample output display in 16x2 LCD

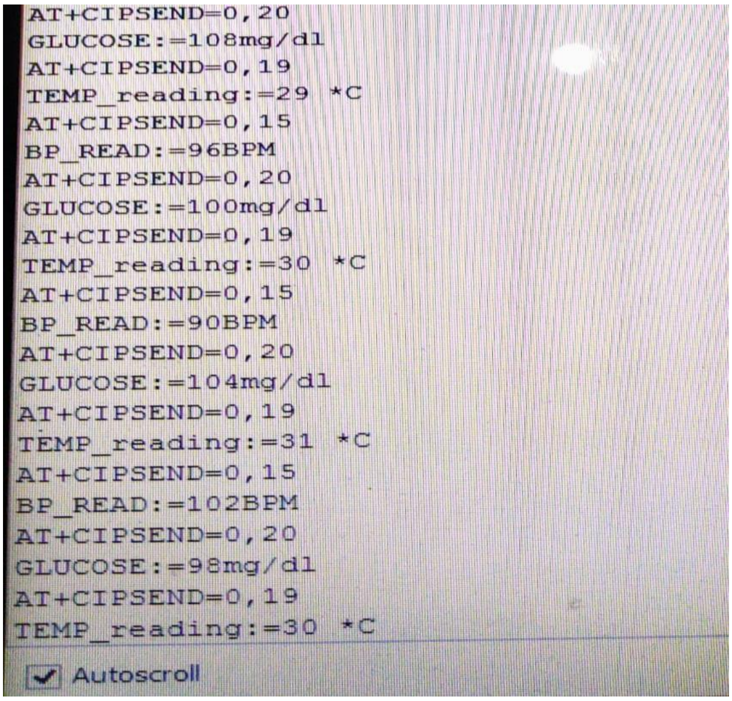


Figure 6.2 Arduino IDE output for Healthy Sample

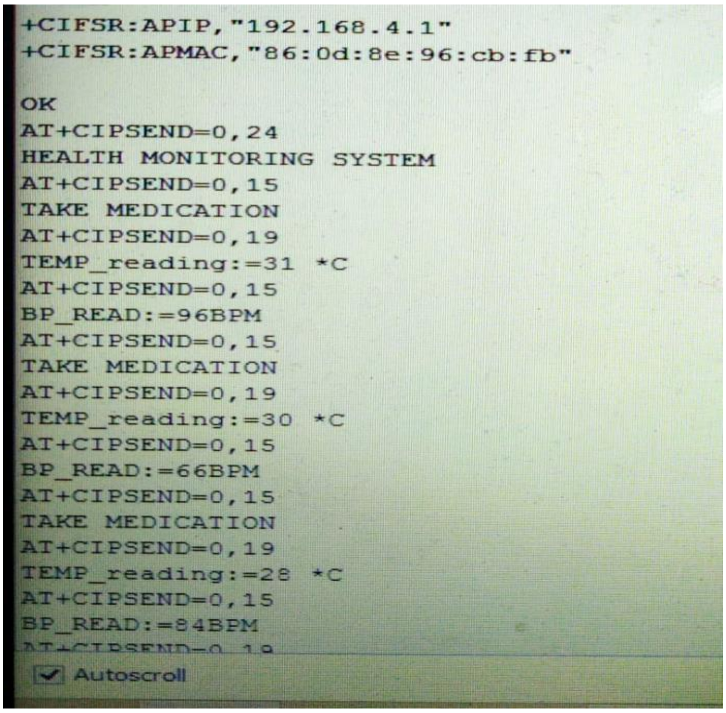


Figure 6.3 Arduino IDE output for Unhealthy Sample

This data will then be uploaded in the cloud server with time and date. The data is converted into text format and is stored in the cloud.

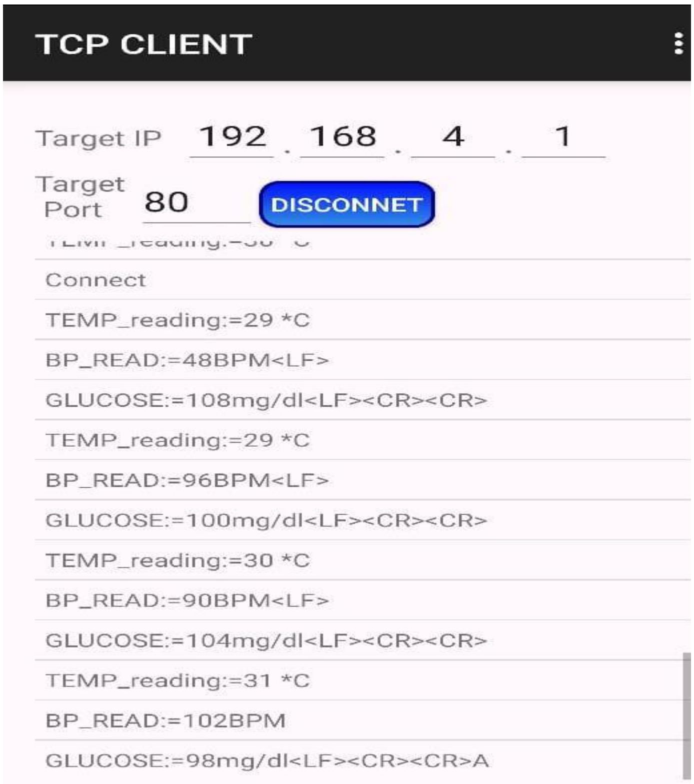


Figure 6.4 TCP/UDP client output for Healthy Sample

Figure 6.5 TCP/UDP client output for Unhealthy Sample

CHAPTER 7

APPLICATIONS AND ADVANTAGES

7.1 APPLICATIONS

- The designed board can be used in rural areas. As it will be very helpful for even un-educated people staying in the village areas.
- The designed board can store the monitored value of the person in the cloud.
- The output/measured value can be accessed by doctors who are in farther distances.
- It is purely non-invasive so it does not require any blood sample from the person undergoing the test.
- Since it is a non-invasive method there no infections, allergies, bacterias produced to the person.
- Does not cause any Harm for the person undergoing the test.
- The output /measured value is highly accurate.
- The output /measured value will display value for a healthy person and display TAKE MEDICATION for an unhealthy person.
- The Process made is easy to use.
- The Output can be seen just by a touch.
- Doctors viewing the health value of the patient can provide Medications through the cloud server.

7.2 ADVANTAGES

- **Lower costs** : Using IoT solutions and connected medical devices allows healthcare providers to monitor patients in real time. This means less unnecessary visits to doctor, and less hospital stays and readmissions thanks to efficient data collection and management.

- **Remote Monitoring** : It allows patient to be monitored in the comfort of their own homes or from a remote location. Sensors are installed and increased availability onto various pieces of medical apparatus (e.g. heart rate monitors) by the bedside of a patient, etc. The data gathered is sent to the hospital where a qualified member of staff analyses it for any abnormalities.

- **Higher patient engagement** : The IoT makes it easier for patients to play an active role in their healthcare journey. Not only are the devices evolving to better meet the needs of remote monitoring (smaller form factors, lighter weight, etc.), but the way patients access data is changing as well. Patients can now use apps and software to access their own health data and see their progress and the impact of the healthcare program on their well-being

.

- **Reduced errors and waste** : Using IoT for data collection and workflow automation is an excellent way to cut down on waste (such as unnecessary tests and expensive imaging), reduce system costs and minimize errors (especially the ones related to human factor).

- **Improved Outcomes of Treatment** : Healthcare solutions that are connected through cloud computing and use big data, can provide caregivers with the ability to access real time data which can be used to make informed decisions and to provide evidence-based treatments.

- **An enhanced** patient experience : Healthcare is all about the patient, so the needs of the patient should always come first. The IoT helps improve that experience by providing timely intervention and diagnosis, improved accuracy, proactive treatments, and better treatment outcomes

- **Better patient experience** : Being connected to the health care system through the Internet of things, patients get more engaged in their treatment, and doctors improve diagnosis accuracy since they have all the necessary patient data at hand.

- **Optical coherence** : This technology provides advantages in signal to noise ratio, high resolution, and depth of penetration, because the inter-ferometric signal can be formed only within the coherence length of the source.

CHAPTER 8

CONCLUSIONS AND SCOPE FOR FUTURE WORK

8.1 CONCLUSION

The SMART health monitoring system provides a low cost, non invasive yet effective replacement for stethoscopes, glucometers and thermometers which can be used in healthcare. This proposed system aims at collecting the data from the devices and updates it to the main server in the healthcare units. So, this process occurs irrespective of the presence of the doctor or the patient's relative beside the patient. The doctor can advice the patient to take any treatment by analyzing the patient's health condition. The medical evaluation process can be made easier by this project using IOT technology and the patient can live a carefree life.

The Glucose level from acetone is found and the same data is updated in cloud. The original goal is to send data to doctors and close ones to be monitored regularly. The work for achieving those goals is on going. This project has a major advantage over others in market due to the non- invasive method. The Wi-Fi range is good and the data connection is required for cloud storage. We have planned to display the details in an LCD display and to dedicate an android and IOS application for the same. It is promising that the product will be useful not only in medical apparatus and instruments field, but also in daily monitoring of human health.

PCG is designed and developed using a low cost Heart Rate Monitoring (HRM) device. Our device is ergonomic, portable, durable, and cost effective. The HRM device is efficient and easy to use. It is in excellent agreement with actual heartbeat rates. This device could be used in clinical and nonclinical environments. It can also be easily used by individual users, e.g. athletes during sporting activities. Using these device we can continuously monitor patients who has heart beat anomalies associated with certain heart conditions. It is made possible by analysing the heartbeat and informing the authorized personnel in time by the use of IOT. All in all, our project achieved a lot of its goals. Our project is implemented to be a low cost, low power, remotely monitorable heart rate monitoring system using IOT technology. We aslo adequately acquired signals/data due to the change in the volume of blood flow through the finger which can be functionally notified using LCD heart rate display, TCP/UDP test tool and Arduino output display.

Digital Thermometer was designed and construct with a microcontroller to digitally sense body temperature accurately and display it in the LCD monitor, TCP/UDP test tool and Arduino output display. This device will allow to measure continuously the accurate body temperature using the LM35 sensor. The temperature sensor used (LM35) is a precision centigrade temperature sensor. From experimental results we can conclude that digital thermometer using Arduino is highly accurate & it nullifies the effect of external parameters. Either a digital and glass thermometer can be used when taking an oral (mouth), rectal (bottom), orauxiliary (arm pit) temperature. So it can be used to measure temperature of different parts of body. Digital thermometer is an innovation to end the error due to parallax reading in liquid in glass thermometer and also comfort the easy access and accurate reading of temperature.

8.2 SCOPE FOR FUTURE WORK

Phonocardiogram can be further improved to increase the robustness of the system; for that, it is highly required to make a robust Data Acquisition System which is least sensitive to noise and can record signals continuously over a long duration of time. Other algorithms can be implemented for feature extraction and classification. The main objective could be to find the best algorithm suitable for heart sound processing. Further, this work can be extended to make a real time system for user identification and verification. The new dimension of the work could be to use the heart sounds to find the heart diseases and other pathological cases.The other aim could be to analyse the heart signals over a long period of time to prove its variability or invariability.

In Glucometers, the initial problem was the use of minimally invasive methods for blood glucose concentration measurements. To address this problem, this project observed using gas sensor as a possible means to measure blood glucose concentrations. Such implementation would be non-invasive. To implement the use of gas sensor, sensors like

MQ6 gas sensors, Figaro TGS822 sensor, SnO2 sensor were chosen and used. To detect absorption of glucose for healthy as well as diseased personnel breath acetone concentration level was used. To simulate blood glucose concentrations, solutions of distilled water and d-glucose was used in a test tube. Concentrations of 50mg/dL, 100mg/dL, 150mg/dL, and 200mg/dL were used. Regression analysis will be done on the data in order to find a model to best predict glucose concentrations based on acetone level on the gas sensors.

Digital thermometer gives the value of hotness or coldness of the body which can be noted down just by a touch of the human finger which will provide high accuracy and provide the temperature reading with a faster speed and will provide the exact notion of the value in the display. Digital thermometer can further more be advanced into home automations, use in cold rooms, food temperature reserve and so on.

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APPENDIX A

SMART Health Monitoring Output using LCD Display, TCP/UDP test tool, Arduino IDE

```
#include<LiquidCrystal.h>
LiquidCrystal lcd(12,11,5,4,3,2);
int ACETON = A0;
int TEMP = A5;
int data =A1;
 int count=0;
unsigned long temp=0;
char buff1[20];
char buff2[20];
char buff3[20];
void setup()
{ Serial.begin(960
0);

pinMode(ACETON,INPUT);
pinMode(TEMP,INPUT);
pinMode(data,INPUT);
lcd.begin(16,2);
lcd.setCursor(0,0);
  lcd.print("HEALTH MONITORING");
    lcd.setCursor(4,1);
  lcd.print("SYSTEM");
     WIFI();
      Serial.write("AT+CIPSEND=0,24\r\n"); // MULTIPLE MODE SELECTION
      delay(50);
      Serial.write("HEALTH MONITORING SYSTEM");
      delay(50);
      Serial.write("\n\r\r"); // MULTIPLE MODE SELECTION
      delay(2000);
      lcd.clear();
}
```

```
void loop()
{
Condition_check();     // Glucose Reading
TEMP_check();          // Temperature Reading
HeartBeat();           // PCG reading
}

void Condition_check()
  {
  int Aceton_reading = analogRead(ACETON);
// Serial.print("Aceton_reading:");
// Serial.println(Aceton_reading);
   delay(500);
   if(Aceton_reading<330)
   {
//    delay(1000);
//    Aceton_reading = analogRead(ACETON);
//    Serial.print("GLUCOSE:");
//    Serial.print(Aceton_reading);
//     Serial.println("mg/dl");
  lcd.setCursor(0,0);
  lcd.print("GLUCOSE:");
  lcd.setCursor(8,0);
  lcd.print(Aceton_reading/3);
  lcd.setCursor(11,0);
  lcd.print("mg/dl");
       sprintf(buff1,"GLUCOSE:=%dmg/dl",Aceton_reading/3);
         Serial.write("AT+CIPSEND=0,20\r\n"); // MULTIPLE MODE SELECTION
      delay(50);
      Serial.write(buff1);
      delay(50);
      Serial.write("\n\r\r"); // MULTIPLE MODE SELECTION
      delay(1000);
    }
       if(Aceton_reading>330)
```

```
  {
  // Serial.println("TAKE MEDICATION");
  lcd.clear();
    lcd.setCursor(0,0);
 lcd.print("TAKE MEDICATION");
    Serial.write("AT+CIPSEND=0,15\r\n"); // MULTIPLE MODE SELECTION
    delay(50);
    Serial.write("TAKE MEDICATION");
    delay(50);
    Serial.write("\n\r\r"); // MULTIPLE MODE SELECTION
    delay(2000);
   }
   }
    void TEMP_check()
 {
 int TEMP_reading = analogRead(TEMP);
 TEMP_reading= TEMP_reading*0.48;
//    Serial.print("TEMP_reading:");
//    Serial.print(TEMP_reading);
//    Serial.println("*C");
 lcd.setCursor(0,1);
 lcd.print("TMP:");
 lcd.setCursor(4,1);
 lcd.print(TEMP_reading);
 lcd.setCursor(6,1);
 lcd.print("*C");
    sprintf(buff3,"TEMP_reading:=%d *C",TEMP_reading);
       Serial.write("AT+CIPSEND=0,19\r\n"); // MULTIPLE MODE SELECTION
    delay(50);
    Serial.write(buff3);
    delay(50);
    Serial.write("\n\r\r"); // MULTIPLE MODE SELECTION
    delay(1000);
   }
   void HeartBeat()
```

```
{
  count=0;
temp=millis();
        while(millis()<(temp+10000))
      {
       if(analogReAD(data)<100)
        {
          count=count+1;
//Serial.println(count);
                 while(analogRead(data)<100);
              }
      }
      count=count*6;
      sprintf(buff2,"BP_READ:=%dBPM",count);
// Serial.print("BP_READ:");
//Serial.print(count);
//Serial.println("BPM");
  lcd.setCursor(9,1);
  lcd.print("BPM:");
  lcd.setCursor(13,1);
  lcd.print(count);
      Serial.write("AT+CIPSEND=0,15\r\n"); // MULTIPLE MODE SELECTION
      delay(50);
      Serial.write(buff2);
      delay(50);
      Serial.write("\n\r\r"); // MULTIPLE MODE SELECTION
      delay(1000);
      temp=0;
       count=0;
    delay(1000);
}
void WIFI(void)
{
  String BUFF, buff_1;
  char ch;
```

```
  Serial.print('A');
  delay(10);
  Serial.print('T');
  delay(10);
  Serial.print('E');
  delay(10);
  Serial.print('0');
  delay(10);
  Serial.print("\r\n");
  Serial.print("1");
  Serial.print(Serial.readString());
  delay(50);
  Serial.write("AT\r\n");
  Serial.print("2");
  Serial.print(Serial.readString());
  delay(50);
  Serial.write("AT+CWMODE=2\r\n");
  Serial.print("3");
  Serial.print(Serial.readString());
  delay(50);
  Serial.write("AT+CIPMUX=1\r\n");
  Serial.print("8");
  Serial.print(Serial.readString());
  delay(50);
  Serial.write("AT+CIPSERVER=1,80\r\n");
 Serial.print("9");
 Serial.print(Serial.readString());
  delay(50);
  Serial.write("AT+CIFSR\r\n");
  Serial.print("10");
  Serial.print(Serial.readString());
  delay(50);
}
```