IoT FOR HEALTHCARE

Architecture of IoT for Healthcare , IoT based Health Monitoring System using Arduin, Smart continuous glucose monitoring (CGM) and insulin pens, Remote Patient Monitoring- IoT Heart Rate Monitoring, remote monitoring of physiological parameters, ECG, EEG, Diabetics and BP.

IoT FOR HEALTHCARE

1.1. INTRODUCTON:

The term “Internet of Things” (IoT) was first used in 1999 by British technology pioneer Kevin Ashton to describe a system in which objects in the physical world could be connected to the Internet by sensors.Ashton coined the term to illustrate the power of connecting Radio-Frequency Identification (RFID) tags13 used in corporate supply chains to the Internet in order to count and track goods without the need for human intervention.

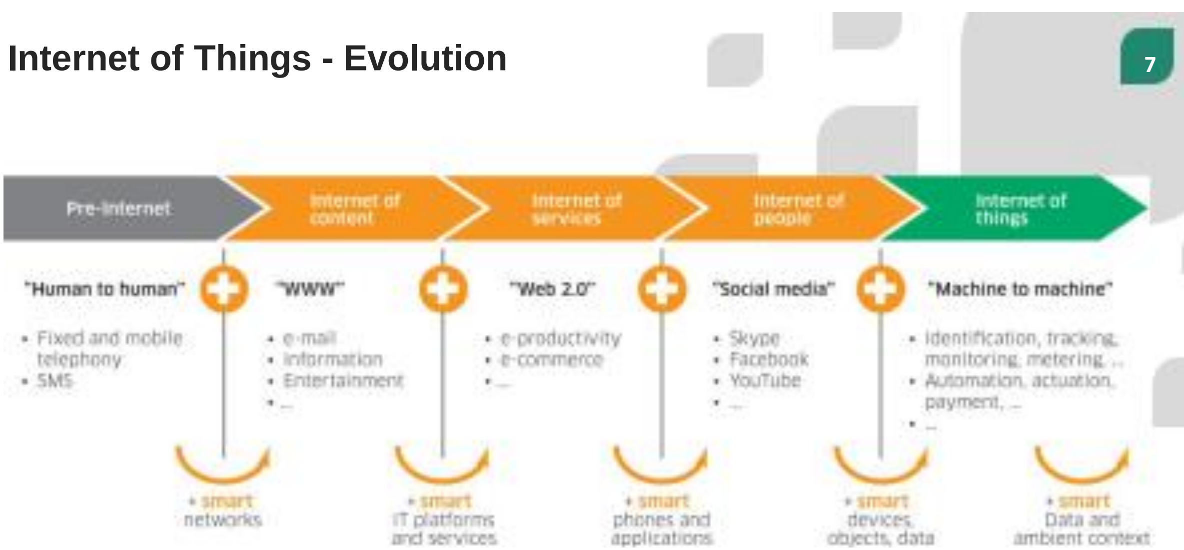

Fig 1.1: Evolution of IoT

By the late 1970s, for example, systems for remotely monitoring meters on the electrical grid via telephone lines were already in commercial use.14 In the 1990s, advances in wireless technology allowed “machine–to–machine” (M2M) enterprise and industrial solutions for equipment monitoring and operation to become widespread. Many of these early M2M solutions, however, were based on closed purpose–built networks and proprietary or industry.

From a broad perspective, the confluence of several technology and market trends20 is making it possible to interconnect more and smaller devices cheaply and easily:

• Ubiquitous Connectivity—Low–cost, high–speed, pervasive network connectivity, especially through licensed and unlicensed wireless services and technology, makes almost everything “connectable’’.

• Widespread adoption of IP–based networking— IP has become the dominant global standard for networking, providing a well–defined and widely implemented platform of software and tools that can be incorporated into a broad range of devices easily and inexpensively.

• Miniaturization— Manufacturing advances allow cutting-edge computing and communications technology to be incorporated into very small objects. Coupled with greater computing economics, this has fueled the advancement of small and inexpensive sensor devices, which drive many IoT applications.

• Advances in Data Analytics— New algorithms and rapid increases in computing power, data storage, and cloud services enable the aggregation, correlation, and analysis of vast quantities of data; these large and dynamic datasets provide new opportunities for extracting information and knowledge.

• Rise of Cloud Computing– Cloud computing, which leverages remote, networked computing resources to process, manage, and store data, allows small and distributed devices to interact with powerful back-end analytic and control capabilities.

From this perspective, the IoT represents the convergence of a variety of computing and connectivity trends that have been evolving for many decades. At present, a wide range of industry sectors – including automotive, healthcare, manufacturing, home and consumer electronics, and well beyond -- are considering the potential for incorporating IoT technology into their products, services, and operations.

RELATION WITH EMBEDDED SYSTEMS

Embedded systems are part and parcel of every modern electronic component. These are low power consumption units that are used to run specific tasks for example remote controls, washing machines, microwave ovens, RFID tags , sensors, actuators and thermostats used in various applications, networking hardware such as switches, routers, modems, mobile phones, PDAs, etc. Usually embedded devices are a part of a larger device where they perform specific task of the device. For example embedded systems are used as networked thermostats in Heating, Ventilation and Air Conditioning (HVAC) systems, in Home Automation embedded systems are used as wired or wireless networking to automate and control lights, security, audio/visual systems, sense climate change, monitoring, etc. Embedded microcontrollers can be found in practically all machines, ranging from DVD players and power tools to automobiles and computed tomography scanners. They differ from PCs in their size and processing power. Embedded systems typically have a microprocessor, a memory, and interfaces with the external world, but they are considerably smaller than their PC counterparts. Frequently, the bulk of the electronic circuitry can be found in a single chip.

Fig 1.2: Real Time Kernal

A sensor detects (senses) changes in the ambient conditions or in the state of another device or a system, and forwards or processes this information in a certain manner.

Analog Sensors produce a continuous output signal or voltage which is generally proportional to the quantity being measured.

Physical quantities such as Temperature, Speed, Pressure, Displacement, Strain etc. are all analog quantities as they tend to be continuous in nature.

Digital Sensors produce discrete digital output signals or voltages that are a digital representation of the quantity being measured.

Digital sensors produce a binary output signal in the form of a logic “1” or a logic “0”, (“ON” or “OFF”).

An actuator is a component of a machine or system that moves or controls the mechanism or the system. An actuator is the mechanism by which a control system acts upon an environment An actuator requires a control signal and a source of energy.

1.2 ARCHITECTURE OF IOT

Three- and Five-Layer Architectures are most basic architecture as shown in Figure 1.3

Application Layer
Network Layer
Perception Layer

Business layer
Application
Processing Layer
Transport Llayer
Perception Layer

Fig 1.3: Architecture of IoT

Perception layer is the physical layer, which has sensors for sensing and gathering information about the environment. It senses some physical parameters or identies other smart objects in the environment.

Network layer is responsible for connecting to other smart things, network devices, and servers. Its features are also used for transmitting and processing sensor data.

Application layer is responsible for delivering application specic services to the user. It denes various applications in which the Internet of ings can be deployed, for example, smart homes, smart cities, and smart health.

transport layer transfers the sensor data from the perception layer to the processing layer and vice versa through networks such as wireless, 3G, LAN, Bluetooth, RFID, and NFC.

Pre processing layer is also known as the middleware layer. It stores, analyzes, and processes huge amounts of data that comes from the transport layer. It can manage and provide a diverse set of services to the lower layers. It employs many technologies such as databases, cloud computing, and big data processing modules.

Business layer manages the whole IoT system, including applications, business models, and users' privacy.

1.3 SMART CONTINUOUS GLUCOSE MONITORING (CGM)

Continuous glucose monitoring automatically tracks blood glucose levels, also called blood sugar, throughout the day and night. You can see your glucose level anytime at a glance. You can also review how your glucose changes over a few hours or days to see trends. Seeing glucose levels in real time can help you make more informed decisions throughout the day about how to balance your food, physical activity, and medicines.

How does a continuous glucose monitor (CGM) work?

- A CGM works through a tiny sensor inserted under your skin, usually on your belly or arm.
- The sensor measures your interstitial glucose level, which is the glucose found in the fluid between the cells.
- The sensor tests glucose every few minutes. A transmitter wirelessly sends the information to a monitor.
- The monitor may be part of an insulin pump or a separate device, which you might carry in a pocket or purse.
- Some CGMs send information directly to a smartphone or tablet.
- Several models are available and are listed in the American Diabetes Association's product guide
- A tiny CGM sensor under the skin checks glucose. A transmitter sends data to a receiver. The CGM receiver may be part of an insulin pump, as shown here, or a separate device.

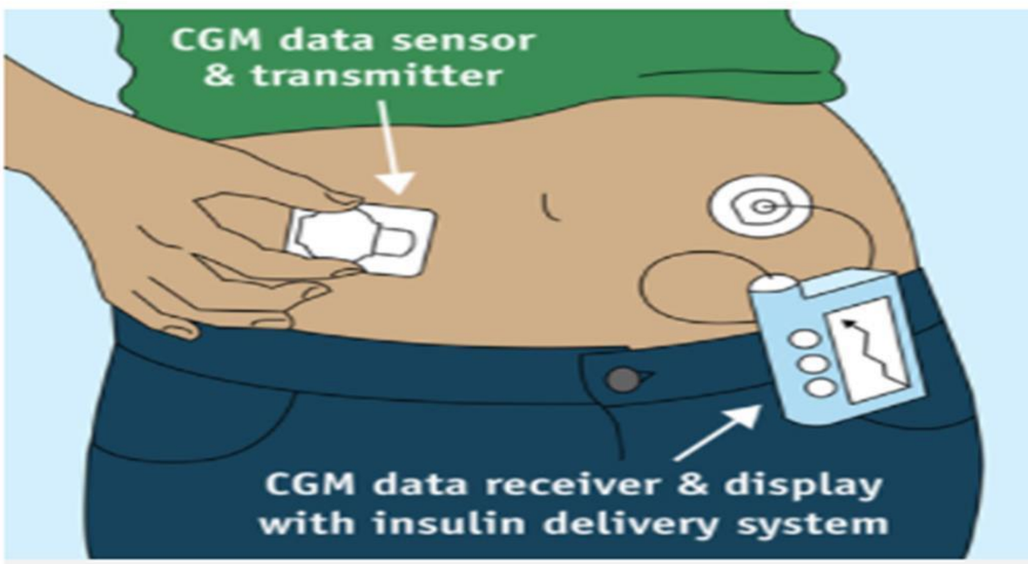

Fig 1.4: Continuous Glucose Monitoring System

Special Features of a CGM:

- CGMs are always on and recording glucose levels—whether you're showering, working, exercising, or sleeping. Many CGMs have special features that work with information from your glucose readings:

- An alarm can sound when your glucose level goes too low or too high.
- You can note your meals, physical activity, and medicines in a CGM device, too, alongside your glucose levels.
- You can download data to a computer or smart device to more easily see your glucose trends.
- Some models can send information right away to a second person's smartphone—perhaps a parent, partner, or caregiver. For example, if a child's glucose drops dangerously low overnight, the CGM could be set to wake a parent in the next room.
- Currently, one CGM model is approved for treatment decisions, the Dexcom G5 Mobile. That means you can make changes to your diabetes care plan based on CGM results alone. With other models, you must first confirm a CGM reading with a finger-stick blood glucose test before you take insulin or treat hypoglycemia

Special Requirements Needed to Use a CGM

- Twice a day, you may need to check the CGM itself.
- You'll test a drop of blood on a standard glucose meter. The glucose reading should be similar on both devices.
- You'll also need to replace the CGM sensor every 3 to 7 days, depending on the model.
- For safety it's important to take action when a CGM alarm sounds about high or low blood glucose.
- You should follow your treatment plan to bring your glucose into the target range, or get help.

Fig 1.5: Checking CGM reading with standard glucose meter reading

1.4 INSULIN PENS:

- People with diabetes use insulin pens to inject insulin, a vital hormone for people who have diabetes. They contain a cartridge, a dial to measure dosage, and a disposable needle.

- Insulin pens are growing in popularity, and many people with diabetes nowadays use a pen to administer insulin.

- The pens allow more simple, accurate, and convenient delivery than using a vial and syringe.

- Not every person with diabetes will need to take insulin. However, those that do sometimes find that sticking to an insulin schedule can be demanding, disruptive, and draining.

- Some people prefer insulin pens as a way to make taking insulin less intrusive and inconvenient.

Types of insulin pen

- A disposable pen: This contains a prefilled insulin cartridge. Once used, the entire pen unit is thrown away.

- A reusable pen: This contains a replaceable insulin cartridge. Once empty, a person discards the cartridge and installs a new one.

- A person must replace the disposable needle after each injection of insulin. With proper care, reusable insulin pens can last for several years.

1.5 IOT BASED HEART RATE MONITORING

Heartbeat Sensor is an electronic device that is used to measure the heart rate i.e. speed of the heartbeat. Monitoring body temperature, heart rate and blood pressure are the basic things that we do in order to keep us healthy. In order to measure the body temperature, we use thermometers and a sphygmomanometer to monitor the Arterial Pressure or Blood Pressure.

Heart Rate can be monitored in two ways: one way is to manually check the pulse either at wrists or neck and the other way is to use a Heartbeat Sensor. Monitoring heart rate is very important for athletes, patients as it determines the condition of the heart (just heart rate). There are many ways to measure heart rate and the most precise one is using an Electrocardiography But the more easy way to monitor the heart rate is to use a Heartbeat Sensor. It comes in different shapes and sizes and allows an instant way to measure the heartbeat. Heartbeat Sensors are available in Wrist Watches (Smart Watches), Smart Phones, chest straps, etc. The heartbeat is measured in beats per minute or bpm, which indicates the number of times the heart is contracting or expanding in a minute.

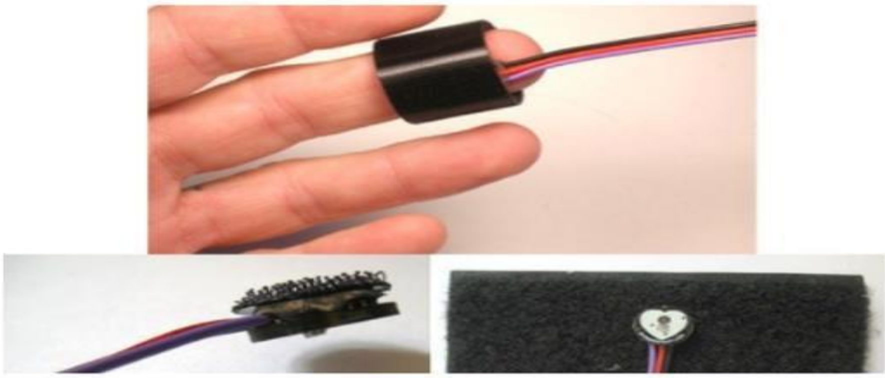

Fig 1.6: Pulse Sensor

The Pulse Sensor is a plug-and-play heart-rate sensor for Arduino. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data into their projects. The essence is an integrated optical amplifying circuit and noise eliminating circuit sensor. Clip the Pulse Sensor to your earlobe or fingertip.

Then it into your Arduino, you are now ready to read heart rate. The front of the sensor comes with the heart logo. This is where you place your finger. On the front side, you will see a small round hole, from where the green LED shines. Just below the LED is a small ambient light photosensor APDS9008 which adjust the brightness in different light conditions. On the back of the module you will find MCP6001 Op-Amp IC, a few resistors, and capacitors. This makes up the R/C filter network. There is also a reverse protection diode to prevent damage if you connect the power leads reverse.

Fig 1.7: Front side and Backside of Pulse Sensor

Pulse Rate (BPM) Monitor using Arduino & Pulse Sensor:

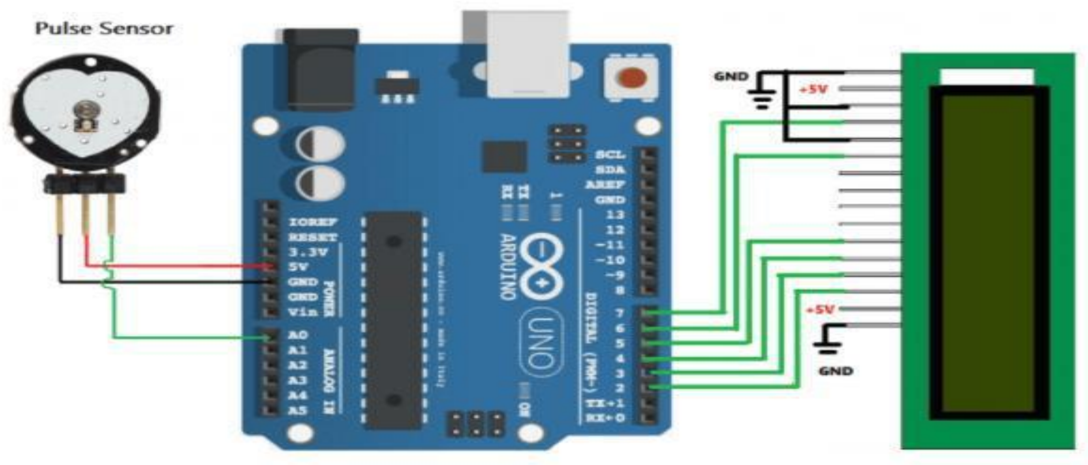

Fig 1.8: Connecting Aurdino with Pulse sensor and LCD Display

- The connection is pretty simple. Connect the VCC pin of the Sensor to Arduino 5V Pin & GND to GND. Connect the Analog output pin of the sensor to the A0 pin of the Arduino.
- When a heartbeat occurs, blood is pumped through the human body and gets squeezed into the capillary tissues.
- Consequently, the volume of these capillary tissues increases. But in between the two consecutive heartbeats, this volume inside capillary tissues decreases.
- This change in volume between the heartbeats affects the amount of light that will transmit through these tissues. This can be measured with the help of a microcontroller.

Fig 1.9: Displaying the measured Heart Rate

- The pulse sensor module has a light that helps in measuring the pulse rate. When we place the finger on the pulse sensor, the light reflected will change based on the volume of blood inside the capillary blood vessels.

- This variation in light transmission and reflection can be obtained as a pulse from the output of the pulse sensor.

- This pulse can be then conditioned to measure heartbeat and then programmed accordingly to read as heartbeat count using Arduino.

Accuracy

The pulse sensor is one of the simplest sensors for understanding the principle behind Pulse Rate Measurement. However, when it comes to accuracy and stability the Sensor falls far behind. The better alternative of this sensor is the Easy Pulse Sensor which is highly stable. Apart from the easy pulse sensor, if you want to measure the blood oxygen along with the heart rate, you can use MAX30100 Pulse Oximeter Sensor. You can perform side by side evaluation to compare the performances of different pulse sensors.

1.6. IOT BASED ECG MONITORING:

An electrocardiograph (ECG) is a test that is used to measure the electrical activity of the heart. Read about when it is done and related tests such as an exercise ECG stress test or event monitoring. IoT based ECG Monitoring System using AD8232 ECG Sensor & NodeMCU ESP8266. We will monitor the ECG waveform/Graph generated from AD8232 Sensor online using an IoT platform. Heart diseases are becoming a big issue for the last few decades and many people die because of certain health problems. Therefore, heart disease cannot be taken lightly. So there should be a technology that can monitor the heart rate and heart behavior of the patient regularly. By analyzing or monitoring the **ECG signal** at the initial stage the various heart disease can be prevented.

By i**nterfacing AD8232 ECG Sensor with NodeMCU ESP8266** Board and monitor the **ECG Waveform** on Serial Plotter Screen. Similarly, you can send the ECG waveform over the IoT Cloud platform and monitor the signal online from any part of the world using the PC or simply using the Smartphone. There is no need for staying in the Hospital to monitor heart activity/behavior just because you can monitor it online from anywhere. Thus it can be said advancement in **Patient Health Monitoring System**.

What is an ECG?

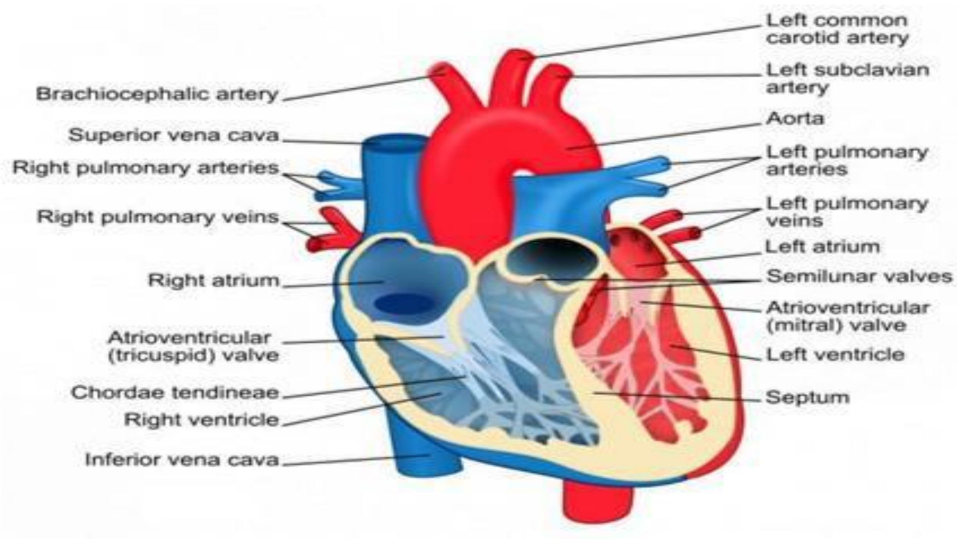

Fig 1.10: Cross Section of Heart

ECG can be analyzed by studying components of the waveform. These waveform component indicate cardiac electrical activity. The first upward of the ECG tracing is the P wave. It indicates atrial contraction. The QRS complex begins with Q, a small downward deflection, followed by a larger upwards deflection, a peak (R); and then a downwards S wave. This QRS complex indicates ventricular depolarization and contraction. Finally, the T wave, which is normally a smaller upwards waveform, representing ventricular re-polarization as shown in Figure 1.11

Fig 1.11: ECG Waveform

Medical uses of ECG

- An electrocardiogram can be a useful way to find out whether your high blood pressure has caused any damage to your heart or blood vessels. Because of this, you may be asked to have an ECG when you are first diagnosed with high blood pressure.

- Some of the things an ECG reading can detect are:

1. cholesterol clogging up your heart’s blood supply

2. a heart attack in the past

3. enlargement of one side of the heart

4. abnormal heart rhythms

AD8232 ECG Sensor

This sensor is a cost-effective board used to measure the **electrical activity of the heart**. This electrical activity can be charted as an **ECG or Electrocardiogram** and output as an analog reading. ECGs can be extremely noisy, the **AD8232 Single Lead** Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily

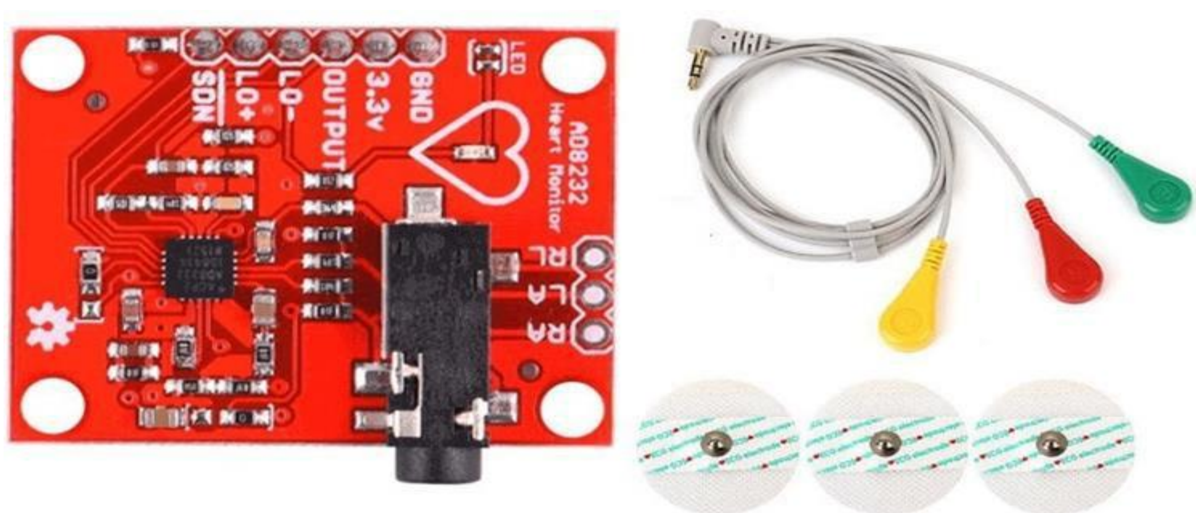

Fig 1.12: ECG Sensor

The AD8232 module breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your own custom sensors. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heartbeat.

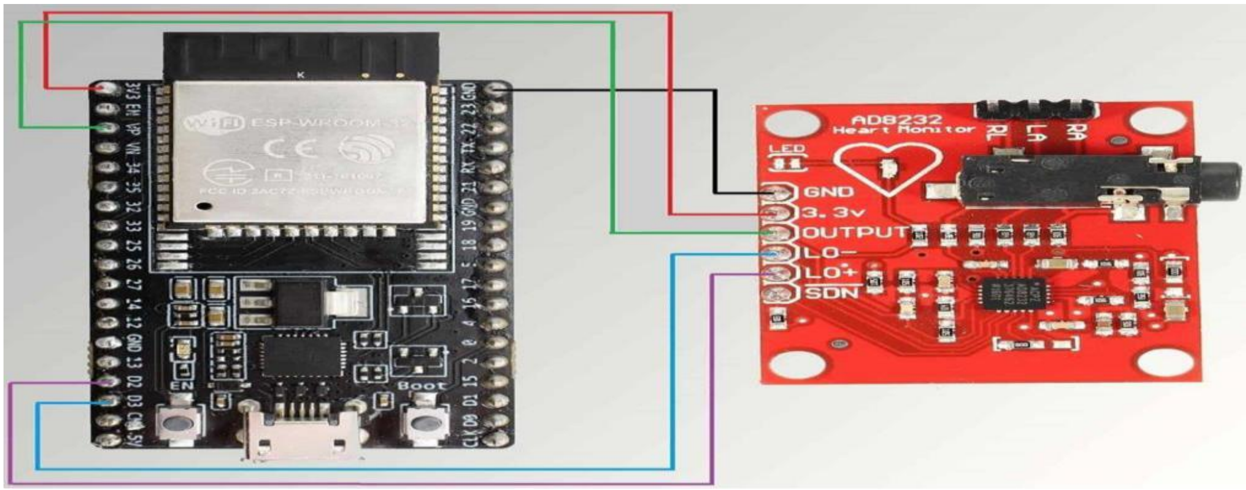

Fig 1.13: Interfacing **AD8232 ECG Sensor with ESP32**

To interface AD832 ECG Sensor with ESP32 IoT chip, follo the circuit diagram above. Supply the AD8232 with 3.3Vfrom ESP32 and connect GND to GND. The output pin of AD8232 is an analog signal and is connected to D2 and D3 OF ESP32. Remember there are so many vendors who makes ESP32. All those ESP32 has different pin mappings. It is recommended to snap the sensor pads on the leads before application to the body. The closer to the heart the pads are, the better the measurement. The cables are color coded to help identify proper placement

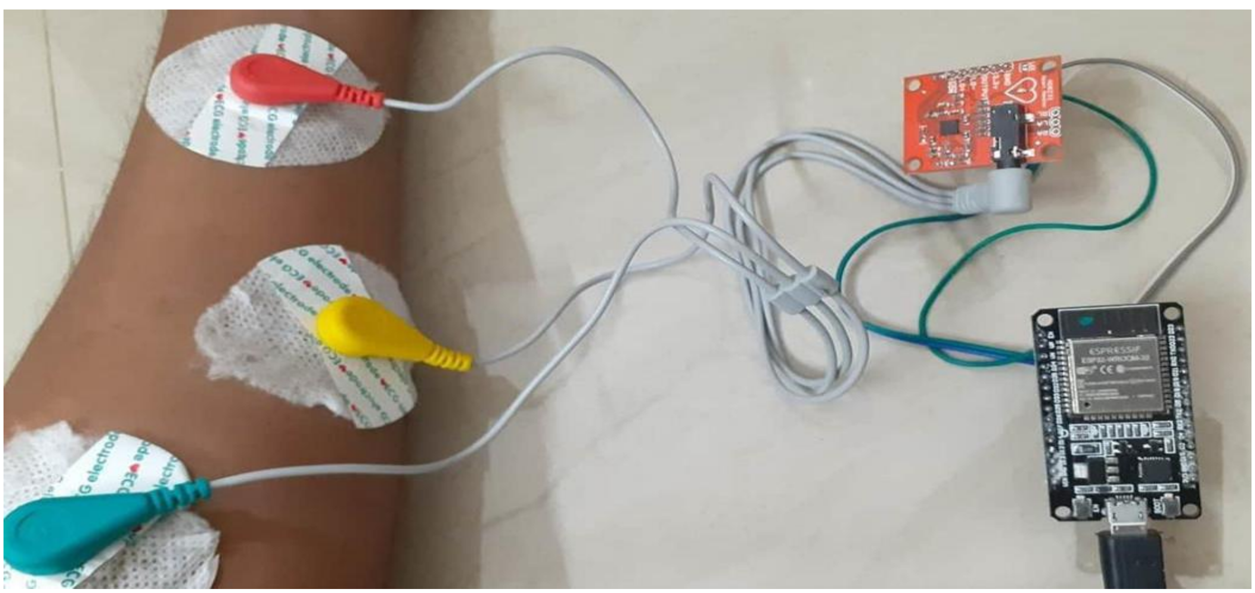

Fig 1.14: ECG Sensor placement in Body

It is recommended to snap the sensor pads on the leads before application to the body. The closer to the heart the pads are, the better the measurement. The cables are color coded to help identify proper placement.

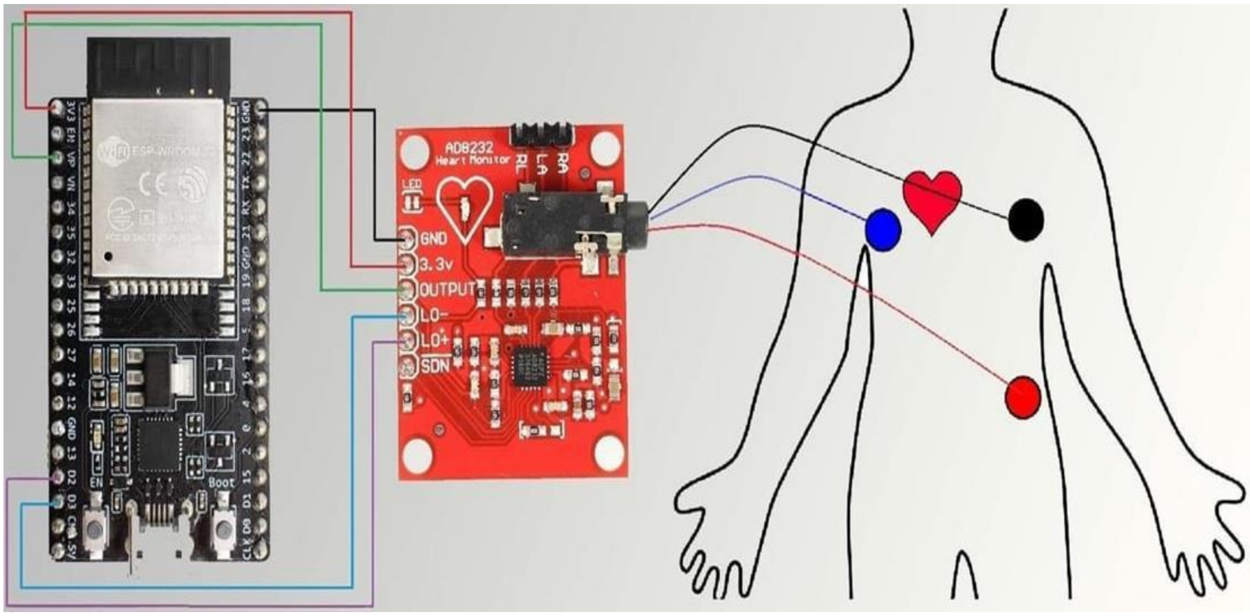

Fig 1.15: Connecting ECG Sensor with aurdino

Setting Up Ubidots Account

- To publish the data to **IoT Cloud**, we need some IoT platform. So **Ubidots** is one such platform. **Ubidots** offers a platform for developers that enables them to easily **capture sensor data** and turn it into useful information. Use the Ubidots platform to send data to the cloud from any **Internet-enabled device**.

- Now setup an Ubidots Device. To create it, go to the **Devices** section **(Devices > Devices)**. Create a new Device with name **esp32**. Once the device is created, create a new variable by renaming the variabale to sensor.

- Let’s setup an Ubidots’ **Dashboard**. To create it, go to the **Dashboard** section (**Data > Dashboard**)

- Click on the + sign in the right side and “Add new Widget”, and select your widget

- Then, select the variable desired to display the data. Ubidots allows you assign a customize widget name, color, period of data to be displayed and much more. To finish the widget creation, press the green icon

- Selct your previously created Device and Variables as shown in the figure below.

- Now select the following parameters from the tools and upload the code to ESP32. In some cases the code does not get uploaded. So press boot button while uploading the code to ESP32.

- Once the code is uploaded to **ESP32 Board**, click on serial monitor. If the ESP32 connects to **wifi**, it will start sending data to Ubidots Cloud.

- You can now go to Ubidots Dashboard and click on esp32, there you will be able to see the ECG Graph.

Fig 1.16: Creating Ubidots Account

1.6 EEG MONITORING:

EEG stands for Electroencephalography. It’s record the electrical activity of brain. During an EEG test , small electrodes like cup or disc type are placed on the scalp. They pick up the brain’s Electrical signals and send them to a machine called Electroencephalogram. It records the signals as wavy lines on to a computer screen or paper in order of microvolt. EEG waves has a frequency range of 0.1 to 100 amplitude which is equal to 2 to 200 micro volt.

A standard non – invasive EEG takes about 1 hour. The patient will be positioned on a padded bed or table , or in comfortable chair. To measure the electrical activityin various part of the brain , a nurse or EEG technician will attach 16 to 20 electrodes to the scalp. The brain generates electrical impulses that these electrodes will pick up. Then a temporary glue will be used to attach them to the skin, no gain will be involved.

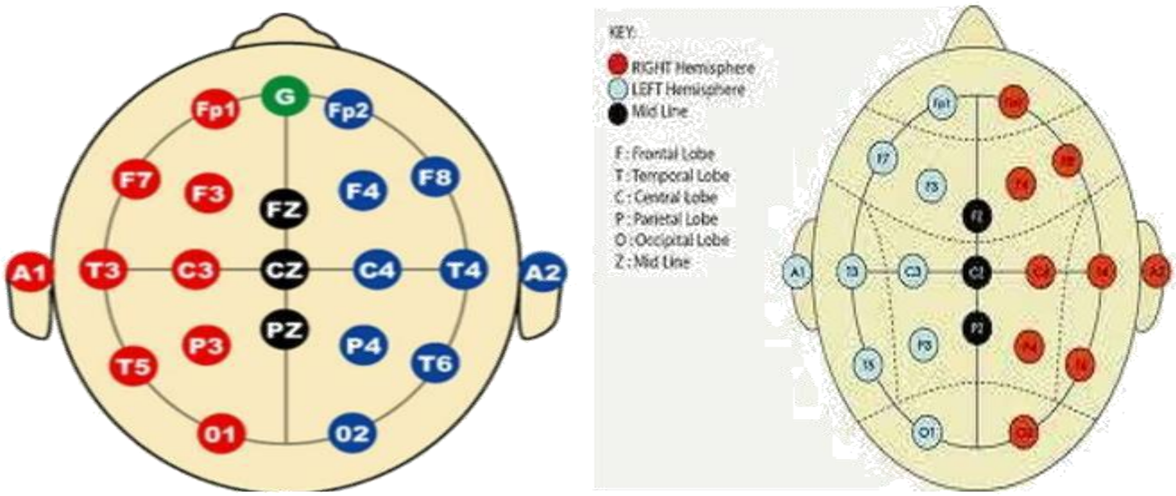

Fig 1.17: Placement of Electrodes in the skull

WHY EEG IS USED?

a. **Where there is a need to diagnose & manage epilepsy.**
b. **Used to investigate other conditions such as head injuries, brain tumours , dementia , hemorrhage.**
c. **Determine the level of brain who are in a coma.**
d. **Identify areas of the brain that are not working properly.**

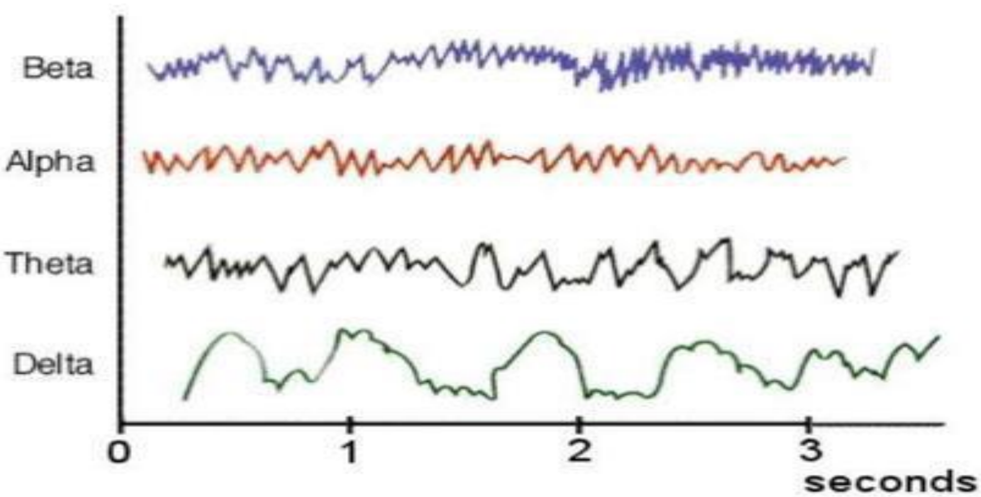

Fig 1.18: EEG Waveform

IoT Based EEG Measurement:

Fig 1.19: MINDWAVE MOBILE

FEATURES of Mindwave Mobile:

- Single Sensor on FP1
- Can detect multiple mental states simultaneously
- Reference electrode on Ear clip to remove ambient noises
- IP involves noise cancellation and signal amplification
- Provides EMG feature for Eye Blink detection

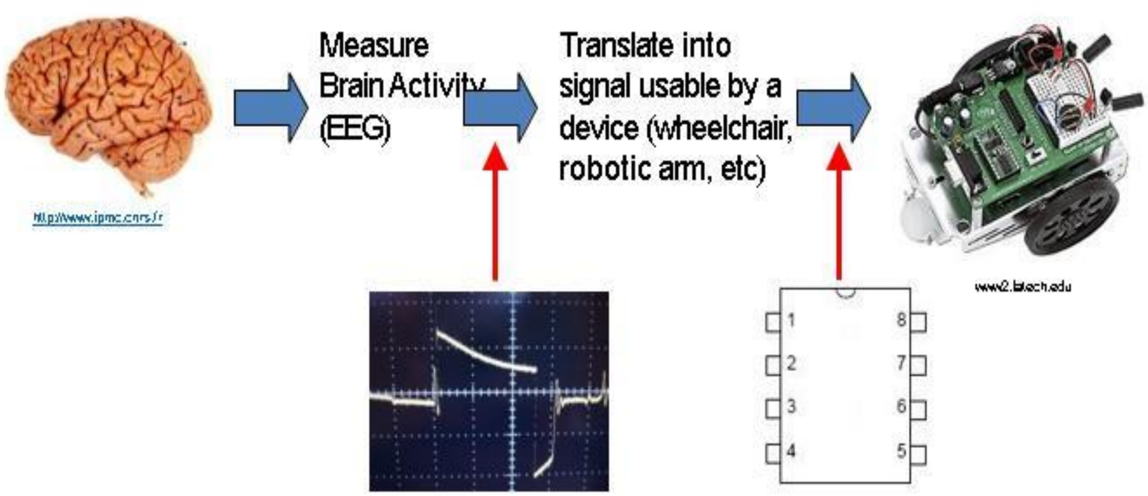

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Fig 1.20:Block Diagram of IoT Based EEG Calculation

APPLICATIONS

- Portable medical applications
- Motor speed control
- Drowsy driver detection
- Light intensity control
- Music play based on mind state
- Mind gaming
- Sports [ready zone analyser]

1.7- DIABETICS MONITORING USING IOT

Chronic diseases are characterized for having long duration and requiring long-term treatments. Patients with chronic diseases usually spend long periods in the hospital to be daily monitored. Some common chronic diseases can be heart disease, cancer, or diabetes. Currently, diabetic disease is very dangerous since it yearly generates the death of many people. Therefore, the diabetic patient needs to be controlled to lead a normal daily life. Diabetes is a chronic disease related to a dysfunction of the pancreas that occurs when that organ does not produce the correct level of insulin or the body does not use the insulin properly [1]. High or low blood sugar levels can cause dysfunction and deterioration of many organs such as the eyes, the nerves, and the blood vessels. Therefore, a continuous and daily monitoring is required to avoid the worsening of the diabetic patient's health.

1.7.1 : 5G ARCHITECTURE FOR A DIABETIC PATIENT MONITORING SYSTEM:

The aim of this monitoring system was to monitor the blood glucose level of the diabetic patient using 5G technology to send the data and artificial intelligence in order to process the information and generate intelligent decisions. The architecture of our smart system for continuous monitoring diabetic patients over 5G technology was composed of a set of sensors,

- **Wearable devices,**
- **An application running in a smartphone, and a server with a database.**

- **Several wireless technologies were used in the architecture. On the one hand, Wi-Fi was used to connect the different sensors to the smartphone. On the other hand, 5G technology was used to connect the smartphones to the cellular network for sending the data to the database server.**

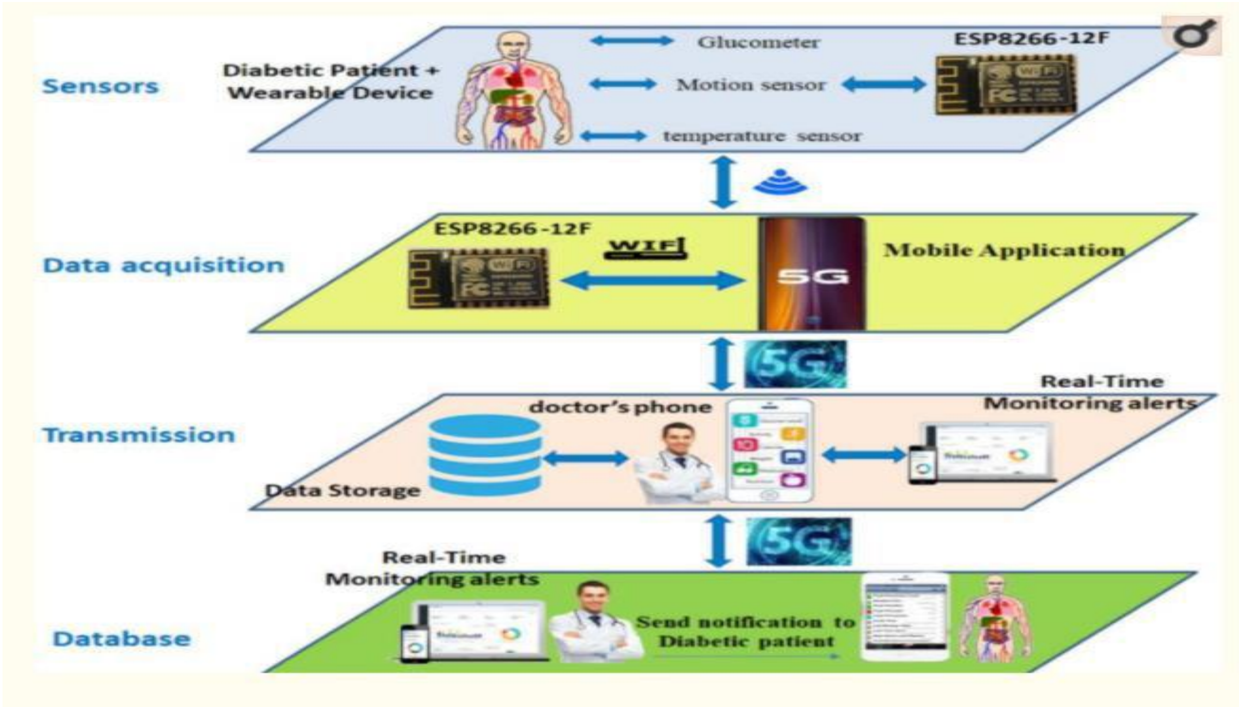


Fig 1.21: Architecture of Diabetic Patient Monitoring

- **Sensors: this layer contains the blood glucose level sensor, temperature sensor, and motion sensor. This layer also contains the ESP8266 module that connects the sensors and gives them a wireless interface for sending the data to the patient's smartphone. Therefore, the sensors are responsible for acquiring the data and transmitting it to the patient's smartphone.**

- **Data acquisition layer: this part contains the patient's smartphone and the application to collect data. Data from the sensors are displayed on the mobile application. Data are also sent to the base station via the 5G network, which allows a large number of simultaneous connections per covered area. Ultimately, it targets up to a million devices per km, i.e., ten times more than 4G.**

- **Transmission layer: the smartphone sends the data to the database using 5G for processing, and sends the data to the doctor's phone for examination.**

- **Database layer: this is a processing unit that stores data from sensors to be processed and classified using several artificial intelligence algorithms. Using machine learning algorithms, the server decides whether the data collected are positive data (true positive (TP)) or negative data (false negative (FN)). When the system detects an abnormal situation, a notification is generated. The server sends a message to the doctor. The doctor checks the notification and sends their advice and treatments, which are displayed on the patient's smartphone.**

Hardware Design and Implementation

- **The device measured body temperature, physical activity of patient, blood glucose level, and oxygen saturation in the blood using various sensors. These parameters were transmitted using the ESP8266-12F module to the smartphone.**

- **The measured values were analyzed and stored in a server in order to have them accessible for the patient's and doctor's smartphones. Finally, data were sent to medical experts to examine them**

IMPLEMENTATION

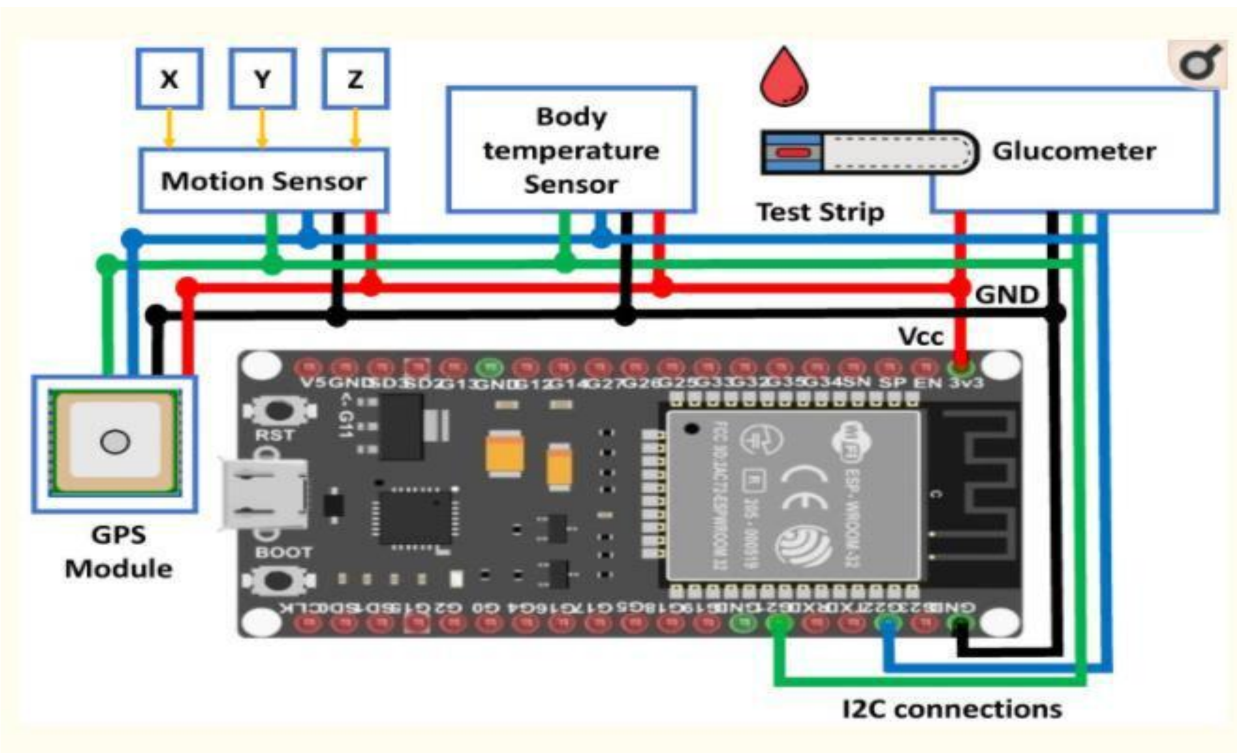


Fig.1.21: Implementation of Blood Sugar Measurement

1.8: MEASUREMENT OF BLOOD PRESSURE:

Blood Pressure is the pressure exerted by circulating blood upon the walls of blood vessels

Types of Blood Pressure

(i)Systolic Blood Pressure:

It is specifically the maximum arterial pressure during contraction of Heart

(ii)Diastolic Blood Pressure :

Diastolic pressure, refers to the lowest pressure within the arterial blood stream due to expansion of heart

IOT BASED BLOOD PRESSURE MONITORING

- To monitor one's health a continuous, non-invasive blood pressure monitoring system is required.
- Usually one's blood pressure is measured manually using a sphygmomanometer and noted down on a chart by a nurse, this requires a lot of manpower and is quite time consuming, even if patients at home could measure their blood pressure they may not fully understand what these readings indicate therefore it must be sent to a doctor for analysis.
- We will be using a method to measure the arterial blood pressure based on the oscillometric technique.
- Using this technique, we will be extracting the systolic pressure and diastolic pressure.
- Further, we will incorporate the concept of the Internet of Things technology into the system so that these values can be readily accessed.

Oscillometric Method

- Oscillometry is now the standard for automatic Blood Pressure measuring systems.
- When a patient's arm is placed in a pressure chamber then the pressure of the chamber fluctuates with the pulse and the magnitude of the fluctuation varies with the pressure of the chamber.
- To measure a person's blood pressure using oscillometry a cuff is placed on their upper arm, the cuff is then inflated.

- When the cuff is inflated to a pressure above the systolic pressure, blood flow through the artery is stopped.

- Then the cuff is slowly deflated, when the cuff is deflated below the systolic pressure, the reducing pressure exerted on the artery allows blood to flow through it and sets up a detectable vibration in the arterial wall.

- The cuff pressure continues to fall, when the pressure falls below the patient's diastolic pressure, the blood begins to flow smoothly through the artery in the usual pulses, without any vibration in the wall.

Fig1.22: Oscillometric Method for measurement of BP

Interconnecting Oscillometric value to IoT

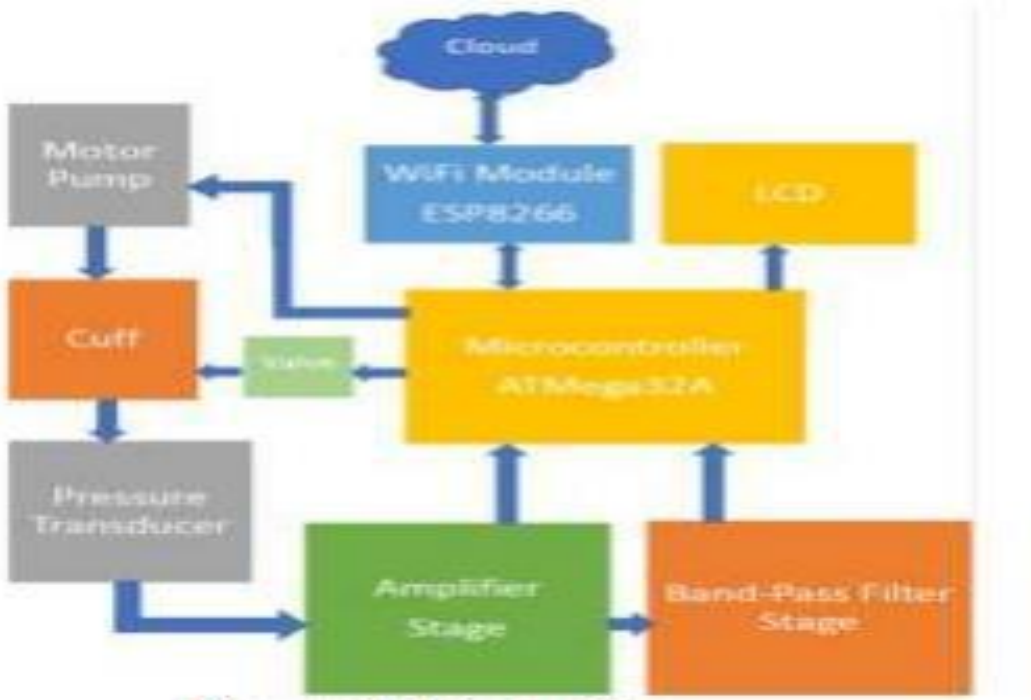


FIG1.23: Interconnecting Oscillometric Value to IoT

PRESSURE TRANSDUCER AND MICROCONTROLLER

- A pressure transducer is a transducer that converts pressure in the cuff into an analog electrical signal;
- this transducer converts the vibrations in the cuff to an analog electric signal.
- This analog signal is then amplified and filtered using circuits to get the desired pulse waveform.
- The Microcontroller used is an ATmega32A,

AMPLIFIER AND FILTERS

- Since the output of the transducer is in milli-volts, an amplifier must be used to increase the resolution of the device.
- An instrumentation amplifier is used to amplify the signal; it is designed for a gain of 220.
- The frequency of human pulse wave ranges from 0.6Hz to around 6.4Hz .
- We use a band-pass filter to extract only this range of frequencies and also to remove noise in the signal.

- Active bandpass filters are used so that only the pulse waveform is amplified and the DC component of the signal is removed

ESP8266

- ESP8266 is a low-cost development board that contains GPIOs, UART, and Wi-Fi. The ESP8266 Wi-Fi module is connected to the microcontroller.

- This blood pressure data is transmitted using the user's Wi-Fi router to the Database, through the internet.

- Things Speak by MathWorks is used to collect and store the data. Thing Speak is an Internet of Things (IoT) platform that lets us collect and store the blood pressure data in the cloud

Interconnecting to IoT

The results of the pressure transducer are then sent to the ESP8266 using UART and this is sent through the Wi-Fi module to ThingSpeak

- As we can see, the results of the monitor designed are close to that of a commercially available monitor and we estimate an error of about ±7 mmHg from our comparisons with the digital monitors available commercially.

- It is also seen that the data is transmitted to ThingSpeak without any errors. Also, it can be noted that use of different cuff sizes lead to different values, thus proper care must be taken to ensure that the appropriate cuff size is used.

Fig.1.24; Output screen in IoT platform

TEXT / REFERENCE BOOKS

1. Millman J and Halkias C., “Integrated Electronics”, TMH, 2nd Edition, 2017.
2. S. Salivahanan, N. Suresh Kumar and A. Vallavaraj, “Electronic Devices and Circuits”, TMH, 2nd Edition, 2017.
3. Adel S. Sedra and Kenneth C.Smith, “Microelectronic Circuits”, Oxford University Press, Sixth Edition, 2009.
4. Behzad Razavi, “Fundamentals of Microelectronics”, 1st edition, wiley publication, 2008.

IoT ENABLED SMART CITIES

Energy Consumption Monitoring, Smart Energy meters to minimize power consumptions, Smart home powered by IoT, Smart Grid and Solar Energy Harvesting, Intelligent Parking System

2.1 SMART CITY

- A smart city is the one that uses information and communication technologies (ICT) to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare.
- Smart cities use intelligent solutions to optimize infrastructure and smart and responsive governance to engage citizens in the management of their city.
- A system of sensors, networks, and applications collect useful data, like traffic congestion, energy use, and CO2 levels.
- Smart cities use IoT devices such as connected sensors, lights, and meters to collect and analyze data. The cities then use this data to improve infrastructure, public utilities and services, and more.

2.2 Smart City Technologies

Smart city devices work to make everyday tasks easier and more efficient, while relieving pain points related to public safety, traffic, and environmental issues. Here are some of the most popular smart city technologies:

1. Smart utility meters

- A top IoT device among utility companies is the smart meter. These devices attach to buildings and connect to a smart energy grid, allowing the utility companies to manage energy flow more effectively.

- Smart meters also allow users to track their energy consumption—leaving a significant financial impact. Insider Intelligence expects utility companies to save $157 billion by 2035 due to smart meter adoption and implementation.

2. Smart grids

- Arguably the greatest implementation of smart architecture and infrastructure is smart grids, which help tremendously with resource conservation. Amsterdam, for example, has been experimenting with offering home energy storage units and solar panels for households that are connected to the city's smart grid.
- These batteries help lower stress on the grid at peak hours by allowing residents to store energy during off-peak hours. The solar panels also let residents sell spare energy from the panels back to the grid.

3. Smart waste management solutions

- Waste management is both costly, inefficient, and can cause traffic buildup. Smart waste management solutions can alleviate some of these pain points by monitoring how full trash cans are at a given point and send that data to waste management companies, providing the best waste pick-up routes.
- Some smart waste bins, like the EVOECO, have the ability to tell users which items should be composted or recycled and can even show messages that share how much an organization can save by recycling.

4. Smart air quality monitors

- There are constantly air particles, dust, dirt, cleaning chemicals, floating around in the air of one's office building or home. Smart air quality monitors can detect these particles and inform users of pollutants.
- Monitoring indoor air quality (IAQ) can better alert people of unsafe pollutant levels via an indicator light or push notifications to one's smart phone or tablet.

Features of Smart Cities

- adequate water supply
- assured electricity supply
- sanitation, including solid waste management
- efficient urban mobility and public transport
- affordable housing, especially for the poor
- robust IT connectivity and digitalization
- good governance, especially e-Governance and citizen participation

2.3 ENERGY MONITORING

- Energy is a very important aspect for any household, industries, agriculture and so.
- Managing the energy efficiently and conserving it intelligently for appliances is very much important.
- The energy usage is directly affected with Coal, oil and so towards power generation.
- Towards this, there has been lot of research work carried out. Researchers have developed Android based Smart home system for monitoring the usage of power to avoid any kind of anomaly.
- Researchers have developed an IoT based Smart Energy Management system where appliances like Fan and Bulb to start with are controlled wirelessly based on humidity and light intensity information
- Achieved using machine to machine communication where devices can be connected wirelessly leading to IoT.
- These inputs are used towards controlling the appliances intelligently rather than just switching on or off.

- In addition the system also keeps computing throughput the day power consumption of the appliances which gives the user knowledge on power being consumed over a period of time.

- These details are updated in Cloud server. This prototype system developed have achieved energy conservation at every household

- In the developed IoT Based Energy Management System where environmental sensors like Temperature and light intensity sensor employed and reading sensed are sent to Arduino Microcontroller.

- Based on sensed reading, the Arduino microcontroller is programmed to control the appliance usage accordingly.

- In addition to controlling the appliance usage, the amount of current drawn by each appliance is computed using Hall Sensor which are sent wirelessly using Wifi module to Raspberry Pi3 where total power consumption of each appliance is computer periodically and same plotted as graph

- The graphical information on power consumption versus time for all appliances with varying environmental conditions is uploaded in cloud server

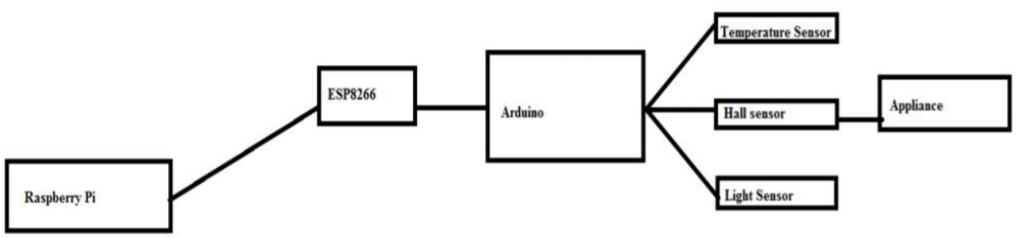


Figure 1: IoT Based Smart Energy Management System

- The BH1750- light intensity sensor will be used to measure the light intensity in the form of lux and send it to the Arduino.

- The Arduino runs a code that obtains the temperature and humidity from the DHT11 sensor. The Arduino then controls fan and light based on the temperature, Humidity and light intensity. Based on the data captured the Arduino will also control the voltage required to be sent to the appliance with the help of transistor.

- The Hall sensor will measure the amount of current sent to the appliance and send it to the Arduino. The Arduino will then send the current consumed to the raspberry pi. The pi will receive the current consumed and calculate the power consumed and then upload it to a webpage and also will plot a graph based on the amount of current consumed.

Algorithm

- The power consumption of the appliances is measured every 30 seconds and sent to the Raspberry pi.
- The Arduino calculates the current consumed in amperes and sends it to the pi.
- The pi then calculates the power with the help of voltage.
- The Maximum power consumed by the appliance at highest usage is 60 watts but with the help of this system the maximum goes only up to 45 watts.
- The power consumed is stored in a list and from the list we can calculate the average total power consumed in the day.
- The temperature and brightness is obtained from the real time environment
- The Arduino controls the transistor based on the value obtained from the sensor.
- The Current consumed by the appliance is obtained from the Hall sensor
- The Current value is sent to the Pi.
- The Pi calculates the power and uploads it to the HTML page and plots the graph.

2.4 SMART ENERGY METER

- Smart Metering is a technique of digitizing the energy system using smart meters that provides businesses a way to track how much energy they are using so that they can adjust the usage when required.
- A Smart Meter is an intelligent digital device that is designed to replace the traditional electricity and gas meter. It can be equipped with a display screen that shows the exact

energy usage in real-time. Installing a smart meter helps you get rid of estimated bills by allowing you to control and reduce energy consumption.

- It comes with the functionality that allows sending meter readings to energy suppliers and gathering information remotely. Smart cities can leverage smart meters to collect data that provides insights on infrastructure, public services and population.

- The best way to integrate smart meters within its infrastructure is by using an IoT platform that comes with the data processing capabilities.

- It will not only allow you to collect data from smart meters but can also help you set up a custom visualization dashboards.

2.4.1 WORKING OF IoT ENABLED SMART METER

- A smart meter works, depending on its functionality, whether it is used for measuring electricity or gas. IoT-enabled smart meter uses features of embedded systems, i.e., a combination of software or hardware.

- To install a smart meter, there is no need to replace the existing energy meter. Instead, a small modification is done on the already installed meters to convert them into smart meters.

- We shall explain the working of a smart meter that uses the ESP8266 Wi-Fi module and Arduino that cannot only send you the notification but also monitor energy uses. ACS712 current sensor can be used to measure energy consumption.

Following are some of the components that can be used in the working of a smart meter:

- Arduino UNO
- ACS712-30 Amp Current Sensor
- ESP12/NodeMCU
- Male-Female
- ACS712 sensor works on the principle of Hall-effect and is used to measure the magnetic field around a conductor carrying current.

- Arduino can read the current sensor value via analog pin and transfer it to the Wi-Fi module with serial communication. MQTT broker can be used to monitor energy uses over the internet.
- The smart meter reading is generated 24*7 in real-time and is sent to the edge of the network where edge computing can be applied to implement business logic for the data captured by a meter. For example, the cost of electricity can be calculated in real-time.
- Consumers can set a threshold value for electricity units. Logic can be implemented to turn off the meter automatically if it crosses the threshold amount set by the consumer. If a user increases the threshold value, the meter can automatically turn on. Therefore, smart meters can also be used for the better conservation of electricity.

2.4.2 Benefits of Smart Meters:

- **Convenience**

  Unlike the manual process, the electricity department won't require a representative who goes to every home or building to take readings and generate the bill. Using Smart Meters, readings can be automatically sent to the electricity department. No one needs to fumble around in the darkness to get to gas or energy meters.

- **Accuracy**

  You won't receive estimated bills anymore with smart meters because usage figures are directly sent to the electricity department in real-time. The traditional way of energy billing requires a higher degree of guesswork. Also, there's no room for human error as the intelligence of IoT is implemented in generating energy bills.

- **Safety from faulty appliances**

  Since in-home displays equipped with a smart meter can show us how much energy is being used at a specific time, we can notice sudden spikes that can be related to a faulty appliance. Identifying such appliances can ensure safety and help you efficiently consume energy.

- **Good Energy Habits**

  Installing smart meter helps everyone adopt good energy habits. As in-home displays show what we are consuming. It helps us all use energy wisely and get rid of wastage.

- **Environment Protection**

  Smart meters can also help the environment by eliminating the need to build more power plants or avoiding the use of less efficient power plants because customers can lower their energy demand.

  Customers' demand can be reduced through incentive programs or energy-saving programs. Thus benefits the environment by reducing greenhouse gas and air emissions.

2.4.3 USE CASES OF SMART METERS

- **Water Management**

We all have heard a lot about the importance of water conservation and heard various statements like we should not let the water run while brushing our teeth, don't let the water tap run unwantedly and so on. It becomes essential to save water in areas where droughts are perpetual. Also, water conservation is necessary for smart cities and smart homes to perform efficiently.

Therefore, the smart water management program is gaining a lot of traction nowadays as it provides consumers the ability to monitor water consumption and provide information to citizens.

Smart meters for water supply can be linked with smart water sensors that can track not only water consumption but also temperature, quality and pressure. These devices can directly communicate with consumers and water utility companies and help them understand how much water they are using and wasting and how their consumption compares to city averages

Using smart water meters, consumers can track their monthly water consumption and get accurate bills at their fingertips.

IoT can help enable smart water management in many ways, for example, charging fine with a bill automatically if someone overuses the water in a month or turning off the water supply remotely if a person forgets to turn it off before leaving the house.

There can be multiple use cases of how IoT-enabled smart meter helps in water management.

- **Power Consumption**

Power consumption is a crucial aspect of electricity supply. People should be aware of energy preservation for future use. Smart electricity meters can help preserve energy by allowing consumers to monitor power consumption in real-time.

Smart meters notify consumers when their power consumption goes beyond the threshold value. With real-time tracking of power consumption, consumers can become more aware of saving energy and making efforts to consume less energy.

Also, they can identify the changes in power consumption by switching to different devices or appliances.

- Smart Meter Technology allows utilities to empower their customers to make smart decisions about energy usage by providing detailed and helpful feedback on energy, gas or water consumption.
- Also, it can improve transparency on monthly bills by offering accurate pricing based on usage.

Better and sustainable environment can be created by providing consumers the leverage to manage their necessary resources efficiently.

2.5 SMART GRID

- The population of the earth will reach 9.7 billion people by 2050, according to a recent report by the United Nations.
- As people move to more populated areas, cities are facing the challenges of providing enough power to accommodate everyone while using outdated power grids.
- Built in the 1890s, current electric grids are unreliable, costly and inefficient.
- A single fallen tree branch can cause black outs in entire areas for hours.
- Not to mention, congested roadways and increased emissions continue to impact the health and happiness of people across the globe.

- The Internet of Things (IoT) has the power to reshape the way we think about cities across the world.

- IoT connects people and governments to smart city solutions with the invention of Smart Grid technology, designed to improve upon and replace the older architecture

- The Smart Grid is critical to building a secure, clean, and more efficient future, according to the International Energy Agency (IEA).

- The Smart Grid is part of an IoT framework, which can be used to remotely monitor and manage everything from lighting, traffic signs, traffic congestion, parking spaces, road warnings, and early detection of things like power influxes as the result of earthquakes and extreme weather.

- The Smart Grid does this through a network of transmission lines, smart meters, distribution automation, substations, transformers, sensors, software and more that are distributed to businesses and homes across the city.

- Smart Grid technologies all contribute to efficient IoT energy management solutions that are currently lacking in the existing framework.

- What makes the IoT Smart Grid better is two-way communication between connected devices and hardware that can sense and respond to user demands.

- These technologies mean that a Smart Grid is more resilient and less costly than the current power infrastructure.

2.5.1 Smart Grid, Smart Energy: Benefits of IoT Monitoring and Regulation

- Current power grids aren’t made to withstand the immense draw on resources and the need to transmit data for billions of people across the globe.

- The Smart Grid can detect energy spikes and equipment failure, prevent power outages, and route power to those in need more quickly.

- Few benefits of transitioning to IoT Smart Grid technology:

1.Smarter Energy Use

Smart Grid technologies will help to reduce energy consumption and costs through usage and data maintenance.

For example, intelligent lighting through smart city technology will be able to monitor usage across different areas, immediately adapt to settings like rain or fog, adjust output to meet the time of day or to meet traffic conditions, and detect and address lighting outages instantly.

For consumer applications, users can adjust the temperature of their home thermostats through apps while they are at work or on vacation.

2.Cleaner Energy Use

Smart Grid technologies are less demanding on batteries, carbon efficient, and designed to reduce the peak load on distribution feeders.

The U.S. Department of Energy is currently integrating green technology into their IoT smart management for more sustainable solutions.

Optimized wind turbines, solar cells, microgrid technologies, and feeder automation systems have the potential to benefit all levels of the distribution chain

3.Lower Costs

According to the Department of Energy, today's electrical system power outages and interruptions cost Americans at least $150 billion each year, putting the price tag at about $500 per person.

As the world's population continues to rise, the older grids won't be able to keep up with the increasing demands.

Smart Grids are designed to lower costs through smart energy IoT monitoring and source rerouting the instant a power failure is detected.

4. Improved Transportation and Parking

IoT smart sensors can collect data in real-time to relay information to drivers and authorities.

This will ultimately reduce traffic congestion, provide better parking solutions, alert drivers to traffic incidents and structural damage to city landscapes, and allow for automatic payments at road tolls and parking meters.

In the future, IoT technology is even expected to be able to wirelessly charge electric vehicles.

5. Help with Waste and Water Management

Smart cities improve efficiency and reduce costs in their waste and water management solutions.

IoT applications can provide real-time data to track inventory and reduce theft/loss.

Cloud-based analytics and traffic control can improve scheduling and time spent on truck routes.

Smart energy analytics can gather data on water flow, pressure, temperature and more to help consumers keep track of their usage habits.

Timers and infrastructure modules can help regulate usage and reduce waste.

6. Energy Enablement in Developing Countries

The previously mentioned IEA report discusses that "smart grids could be used to get electricity to sparsely populated areas by enabling a transition from simple, one-off approaches to electrification (e.g. battery-based household electrification) to community grids that can then connect to national and regional grids."

These grids will be critical for the deployment of new power infrastructures in developing countries that are beginning to experience the impacts of population overflow. Starting with new technology ensures the best path to economic growth.

7. Greater Insight into Regional Issues

Optimized smart city solutions mean greater insight into regional issues. Imagine a smart grid set up to respond to a regional drought or wildfires in a dry area. Similarly, adaptive city fog lighting would be great for a city in the northeast U.S., but ineffective somewhere else. Customized technology and better data collection can help to improve the daily lives of countless regional populations.

These are just a few of the many benefits that IoT-enabled smart grid solutions can provide. Once fully integrated, smart grid technologies can change the way we work, play, and interact with the world around us.

2.6 INTELLIGENT PARKING SYSTEM

- The industrial growth of the world is reflected by the increase in the number of automobiles on the streets throughout the world , which has caused a lot of parking related problems.
- The slow paced city planning has increased the problem even more .
- The search for the parking space is a time consuming process which not only affects the economic activities' efficiency, but also the social interactions and cost .
- Network companies cannot provide updated information of the parking facilities on the internet as the parking facilities do not cooperate with the companies. Certain big cars are not able to fit into the normally available parking spaces.
- Hence there is a need for a system; which can take all relevant information into consideration, for finding the parking vacancy.
- Human errors are the major source of traffic accidents, therefore building in-car technologies for checking the parking lot, avoiding accidents and guidance to the parking facility is turning out to be an integral area for research.
- The objective of such technologies is the reduction of the burden on driver, improvement of the traffic capacity, and provision of reliable and secure car functions .
- The parking meters which rely on coins or tokens is an inefficient system as it requires man power for management of the parking and exact change for paying the parking charges .
- Parking control and enforcement systems provide efficient and effective monitoring of meter and it also keeps a check on any violations of the parking lot.
- This results in best possible use of the parking space for increasing the revenue. However, it requires man power which needs some capital .

- Currently used parking system is not an efficient one; as the drivers are allowed to park without any restriction, and the parking facility cannot be used to its full extent.

2.6.1 The services which the Intelligent Parking System should provide in the future are

- The parking availability information system and parking reservation system should provide advanced navigation services.
- The mobile electric commerce system and a continuously working gate system should collect the toll charges electrically.
- An automated navigation system should assist in safe driving.
- An in-facility navigation system should provide the best possible traffic management.
- Provision of effective security for the safety of cars. Provision of strong functions for facilitating administrators and managers in management of the parking facility.
- The information related to the availability of unoccupied lot; before the driver enters the facility is provided by the parking availability information system.
- An empty parking lot can be reserved by the driver through the parking reservation system.
- The continuous entry and exit system facilitates a driver by getting rid of time consuming processes such as getting a ticket, and the freedom of selecting any payment method.
- The in-facility navigation system is used for finding the vacant lot and then guiding the driver to that parking space.

TEXT / REFERENCE BOOKS

1. Behzad Razavi, “Fundamentals of Microelectronics”, 1st edition, wiley publication, 2008.
2. Donald. A. Neamen, “Electronic Circuits Analysis and Design”, McGraw Hill Education (India) Private Ltd., 3rd Edition, 2010.
3. Robert L. Boylestad and Louis Nasheresky, ”Electronic Devices and Circuit Theory”, Pearson Education, 11th Edition, 2013.
4. Floyd, “Electronic Devices”, Pearson Education, 9th Edition, 2012.

Smart Farming:

Animal Intrusion detection in farms, soil moisture detection and Irrigation system, Pest monitoring and control, Livestock monitoring system, IoT based Greenhouse Environment Monitoring and controlling

3.1 What is smart agriculture?

There are many ways to refer to modern agriculture. For example, AgriTech refers to the application of technology in agriculture in general.Smart agriculture, on the other hand, is mostly used to denote the application of IoT solutions in agriculture.So what is smart agriculture using IoT? By using IoT sensors to collect environmental and machine metrics, farmers can make informed decisions, and improve just about every aspect of their work – from livestock to crop farming.For example, by using smart agriculture sensors to monitor the state of crops, farmers can define exactly how many pesticides and fertilizers they have to use to reach optimal efficiency. The same applies to the smart farming definition.

Fig 3.1: Smart Agriculture

3.2: IoT Based Agriculture:

Although smart agriculture IoT, as well as industrial IoT in general, aren’t as popular as consumer connected devices; yet the market is still very dynamic.The adoption of IoT solutions for agriculture is constantly growing. Namely, COVID-19 has had a positive impact on IoT in the agriculture market share. In fact, **as per recent reports,** the smart framing market share is set to reach \$6.2 billion by 2021. At the same time, the global smart agriculture market size is expected to triple by 2025, reaching \$15.3 billion (compared to being slightly over \$5 billion back in 2016). Because the market is still developing, there is still ample opportunity for businesses willing to join in. Building IoT products for agriculture within the coming years can set you apart as an early adopter, and as such, help you pave the way to success.

3.2.1: **The Benefits of smart farming: How's IoT shaping agriculture:**

- Technologies and IoT have the potential to transform agriculture in many aspects. Namely, there are **5 ways IoT can improve agriculture**:
- **1)Data, tons of data, collected by smart agriculture sensors,** e.g. weather conditions, soil quality, crop's growth progress or cattle's health. This data can be used to track the state of your business in general as well as staff performance, equipment efficiency, etc.
- **2)Better control over the internal processes and, as a result, lower production risks**. The ability to foresee the output of your production allows you to plan for better product distribution. If you know exactly how much crops you are going to harvest, you can make sure your product won't lie around unsold.
- **3)Cost management and waste reduction thanks to the increased control over the production**. Being able to see any anomalies in the crop growth or livestock health, you will be able to mitigate the risks of losing your yield.
- **4)Increased business efficiency through process automation**. By using smart devices, you can automate multiple processes across your production cycle, e.g. irrigation, fertilizing, or pest control.
- **5)Enhanced product quality and volumes**. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.
- As a result, all of these factors can eventually lead to **higher revenue**.
-

3.2.3: Things to consider before developing your smart farming solution (Challenges):

1. The hardware

2. The brain

3. The maintenance

4. The mobility

5. The infrastructure

6. Connectivity

7. Data collection frequency

8. Data security in the agriculture industry

1. The hardware:

To build an IoT solution for agriculture, you need to choose the sensors for your device (or create a custom one). Your choice will depend on the types of information you want to collect and the purpose of your solution in general. In any case, the quality of your sensors is crucial to the success of your product: it will depend on the accuracy of the collected data and its reliability**.**

2. The brain:

Data analytics should be at the core of every smart agriculture solution. The collected data itself will be of little help if you cannot make sense of it. Thus, you need to have powerful data analytics capabilities and apply predictive algorithms and machine learning in order to obtain actionable insights based on the collected data**.**

3. The maintenance:

Maintenance of your hardware is a challenge that is of primary importance for IoT products in agriculture, as the sensors are typically used in the field and can be easily damaged. Thus, you need to make sure your hardware is durable and easy to maintain. Otherwise you will need to replace your sensors more often than you would like.

4. The mobility:

Smart farming applications should be tailored for use in the field. A business owner or farm manager should be able to access the information on site or remotely via a smartphone or desktop computer. Plus, each connected device should be autonomous and have enough wireless range to communicate with the other devices and send data to the central server.

5. The infrastructure:

To ensure that your smart farming application performs well (and to make sure it can handle the data load), you need a solid internal infrastructure. Furthermore, your internal systems have to be secure. Failing to properly secure your system only increases the likeliness of someone breaking into it, stealing your data or even taking control of your autonomous tractors.

6.Connectivity:

The need to transmit data between many agricultural facilities still poses a challenge for the adoption of smart farming. Needless to say, the connection between these facilities should be reliable enough to withstand bad weather conditions and to ensure non-disruptive operations. Today, IoT devices still use varying connection protocols, although the efforts to develop unified standards in this area are currently underway. The advent of 5G and technologies like space-based Internet will, hopefully, help find a solution to this problem

7. Data collection frequency:

Because of the high variety of data types in the agricultural industry, ensuring the optimal data collection frequency can be problematic. The data from field-based, aerial and environmental sensors, apps, machinery, and equipment, as well as processed analytical data, can be a subject of restriction and regulations. Today, the safe and timely delivery, and sharing of this data is one of the current smart farming challenges.

8. Data security in the agriculture industry

Precision agriculture and IoT technology imply working with large sets of data, which increases the number of potential security loopholes that perpetrators can use for data theft and hacking attacks. Unfortunately, data security in agriculture is still, to a large extent, an unfamiliar concept. Many farms, for example, use drones that transmit data to farm machinery. This machinery connects to the Internet but has little to zero security protection, such as user passwords or remote access authentications. Some of the basic IoT security recommendations include monitoring data traffic, using encryption methods to protect sensitive data, leveraging AI-based security tools to detect traces of suspicious activity in real-time, and storing data in the blockchain to ensure its integrity. To fully benefit from IoT, farmers will have to get familiar with the data security concept, set up internal security policies, and adhere to them.

3.3. IoT based Smart Irrigation:

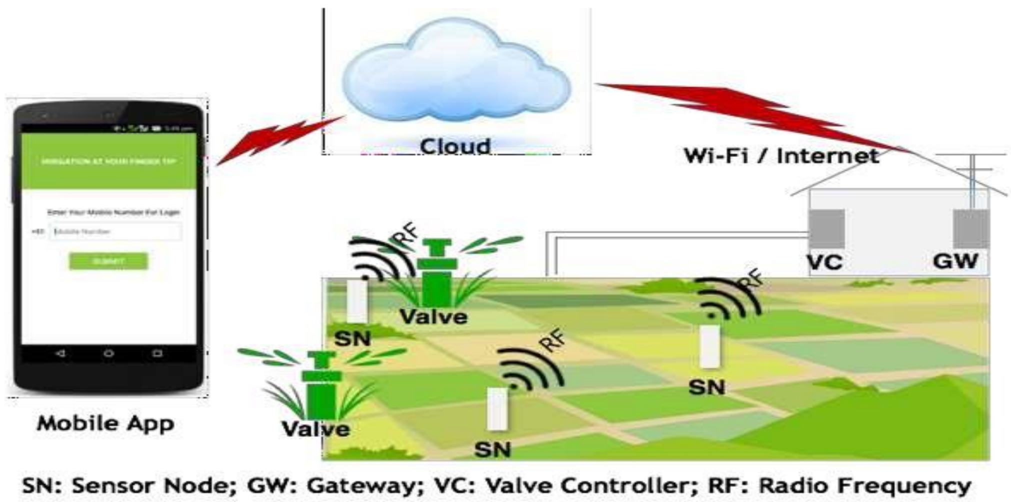


Fig3.2: Smart Irrigation System

India's population crossing 1.39 Billion (139 Crores), So balance between the optimum population growth and a healthy of nation is far to be achieved. The rising population need for increased agricultural production Irrigated agriculture has been important source increased agricultural production .“IOT based smart irrigation system” is for to create an IOT base automated irrigation mechanism which turns the pumping motor ON and OFF pass command through IOT platform. The Internet of Things (IoT) is the inter-networking of “physical devices” also referred to as "connected devices" and "smart devices”. Sometimes referred to as the Internet of Everything (IoE) and Machine to Machine (M2M) communicating.IOT is expected to offer advanced connectivity of devices, systems, and services that covers a variety of **protocols, domains, and applications**

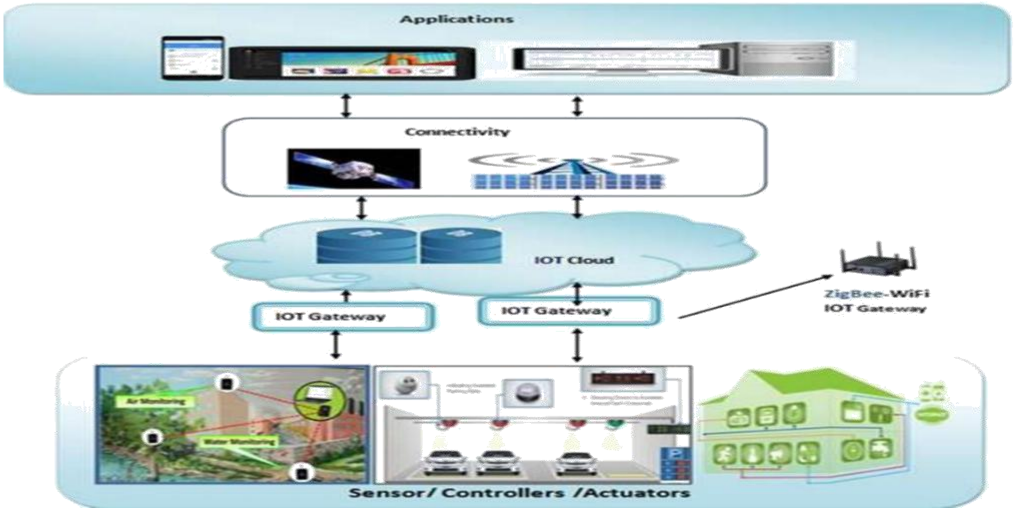


Fig 3.3: IoT platform

System Component: Hardware and Software:

1. **Arduino:** It is an open-source platform based on easy-to-use hardware and software:

- **Hardware :-Arduino**
- Arduino board designs use a variety of **microprocessors** and **controllers** in system

1) To read inputs - light on a sensor

To twitter message - and turn it into an output –

Software:-Arduino (IDE= Integrated Development Environment)

Use: **Check Conditions:**

Writing Sketches: Programs written using Arduino Software (IDE) are called sketches

Upload: Compiles your code and uploads it to the configured board

New: Creates a new sketch

Save: Saves your sketch

Serial Monitor: File, Edit, Sketch, Tools,

Window Application (Motor Control)

- This Window Application install in with: Smartphone, tablets or Computers
- Give command : ON/OFF from this type of application
- GSM stands for **Global System for Mobile Communications**
- GSM supports outgoing and incoming
- voice calls, Simple Message System (**SMS or text messaging**), and data communication

Raspberry Pi 3:

Fig 3.4: Rasberipiee

Soil Moisture sensor:

- Use: To measure the moisture content of the soil.
- Copper electrodes are used to sense the moisture content of soil.

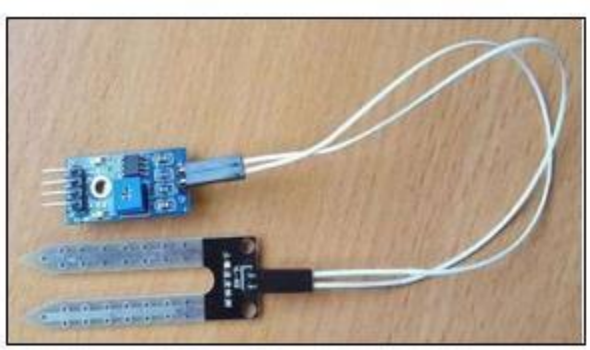


Fig 3.5: Soil Moisture sensor

The *water level* sensor mechanism to detect and indicate the *water level* in an water source.

Fig3.6: Water Level Sensor

How the system works?

➢ **Step 1:**

— Login :(Enter Username/Password) and

— Give Command(ON/OFF) to your application

Fig.3.7:Login

➢ **Step 2:**

- IOT base platform: Collect and send all Analog data to GSM Shield
- GSM Shield connected in RP3 (Raspberry Pi 3)(Microcomputer)
- Now command(ON/OFF) command pass to RP3

Fig3.8:IoT Platform

Step3:

Fig 3.9: Connection with Aurdino

Step 4:

Microcomputer (Raspberry Pi 3)

RP3 is just like main controller of this system: Convert all analog data into digital form

Fig 3.10: Connecting to Raspberry Pi

Step 5:

➢ **Check Conditions:**

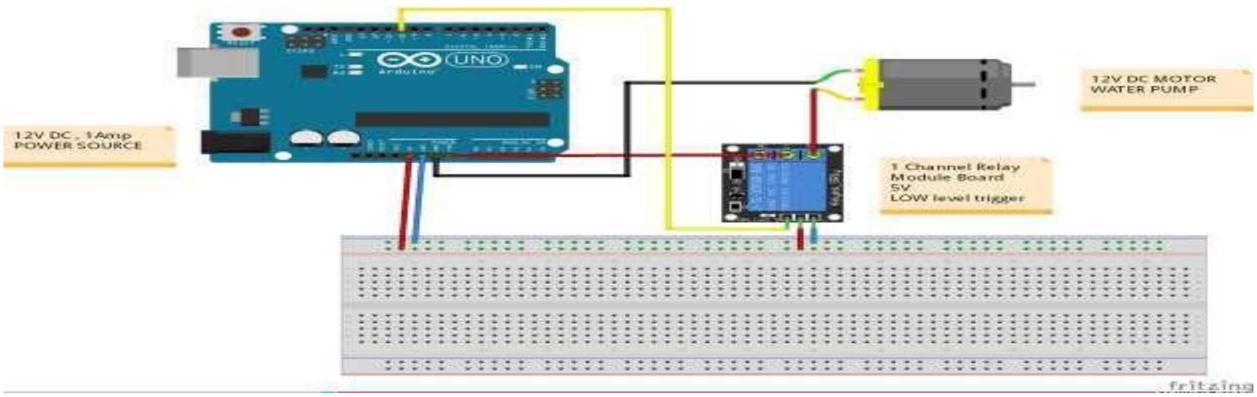
1. If soil moisture content is greater than a fixed value, then there is no need of irrigation
2. If the soil moisture content is less than a fixed value,

then start irrigation.

3. If the water reaches the prescribed point of water level, then sensor gives data to system to stop the irrigation.

➢ **Command sends to Relay Module**

Step 6:



➢ Raspberry Pi 3 Connected -Arduino give command ON/OFF to relay

➢ Relays are switches that open and close Motors Based on Command of Arduino

Step 7:

➢ The Arduino GSM Shield SIM connect to the internet send/receive SMS messages from Smartphone and tablet or computer

Step 8:

Farmer is getting SMS:

- **Motor: ON or OFF**
- **Current moisture content (Ex. 50%)**
- **Current water level (Ex: 90 DEPTH Feet)**

Fig 3.11: Farmers using IoT app for Smart Irrigation

Advantages:

- Water Conservation
- Real-Time Data give
- Lowered Operation Costs
- Efficient and Saves Time
- Increase in productivity
- Reduce soil erosion and nutrient leaching

Challenges:

- **Complexity :** The IOT is a diverse and complex network
- **Privacy/Security**:
- **Lesser Employment of Manual Staff or unskilled workers:**
- **Equipment is costlier.**
- **Awareness of Indian farmer for this technology**

3.4: ANIMAL INTRUSION DETECTION

- India is an agricultural country. Agriculture has always been India's most important economic sector. Though most of the India's population depends on agriculture, there are still a lot many problems faced by farmers.
- Human animal conflict is a major problem where enormous amount of resources is lost and human life is in danger. In recent times the numbers of these kinds of conflicts are increasing. So this zone is to be monitored continuously to prevent entry of this kind of animals or any other unwanted intrusion.
- Human-animal conflicts arises due to encroachment and poaching, humans move into the forest to satisfy their livelihood, for claiming of land for agricultural practices and rapid industrialization causes spreading of urban ground and animals enter the nearby villages for water during the summer due to dryness in water body.
- Elephants or wild boar tramp the vegetation in farm land in need of nutritious food. Need of the animal or human put the other in real danger, in this process, resources are spoiled and sometimes even the life is lost. **Human- elephant conflict is more in south**
- Asia and in Africa. Usually farms are protected with electrical fence, animal which tries to enter the field behave in abnormal manner.

3.4.1:Why IoT is needed here?

- Electrocution causes intense pain in animals
- In forest zone and agricultural field human animal conflict is a major problem where enormous amount of resources is lost and human life is in danger.
- Due to this People lose their crops, livestock, property, and sometimes their lives. So this zone is to be monitored continuously to prevent entry of wild animals.
- With regard to this problem, IoT is needed to develop the system which will monitor the field continuously. That is at first it will detect intrusion around the field using sensor, then camera will capture the image of the intruder and classifying them using image processing and then taking suitable action based on the type of the intruder.
- Finally sends notification to farm owner and forest officials using GSM.

METHODOLOGY:

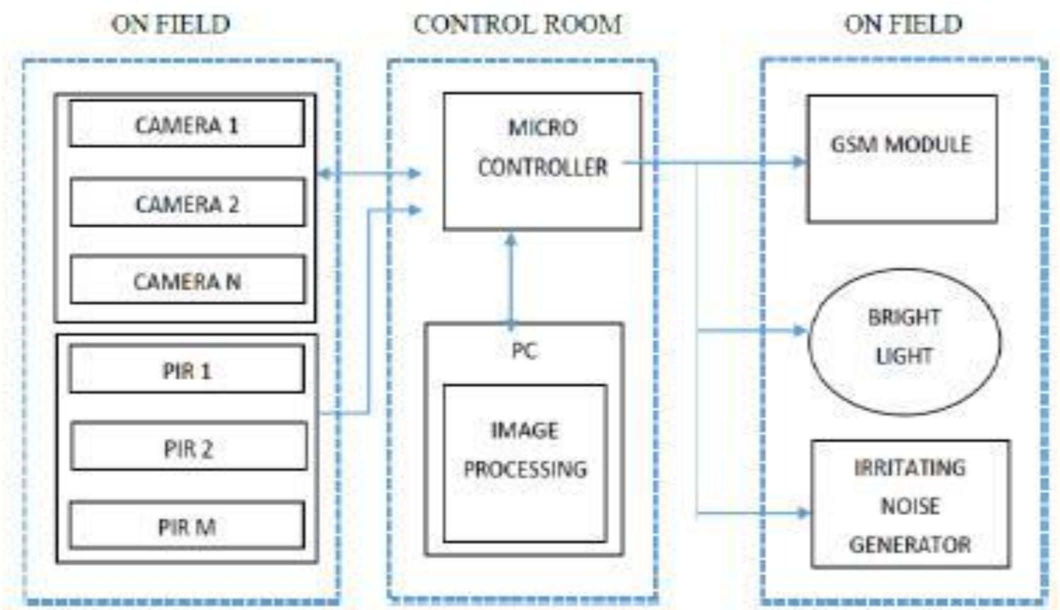


Fig 3.12: Methodology for Animal Intrusion Detection

PIR Sensors and camera act as first round of security where the animal Movement is detected using the sensor and the sensor in turn triggers the camera to take the picture of the animal and transmit the image for processing via microcontroller i.e., through WSN. The microcontroller transmits the image from the camera to the PC in the command center where the image processing and classification of animal is done.

Once the animal is found to be a threat the PC will send the signal to the repellent system via microcontroller to take appropriate action.

Input

- Along the borders of the farm the PIR Sensors and the camera are pole mounted. The number of sensors are relatively twice of that of camera.
- The sensors have a range of about 30 meters and that of camera is 50 meters.
- The camera are powered by battery and solar panel. Once an animal is been detected by the sensor, it gives the signal to the camera via microcontroller that takes up the image of the respective scope of area in which the signal has come from.

- The camera will then send the image for processing and classification of animal whether it is threat or not.

How PIRs Work

PIR sensors are more complicated than many of the other sensors because there are multiple variables that affect the sensors input and output. The PIR sensor itself has two slots in it, each slot is made of a special material that is sensitive to IR. The lens used here is not really doing much and so we see that the two slots can 'see' out past some distance (basically the sensitivity of the sensor). When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a *positive differential* change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected**.**

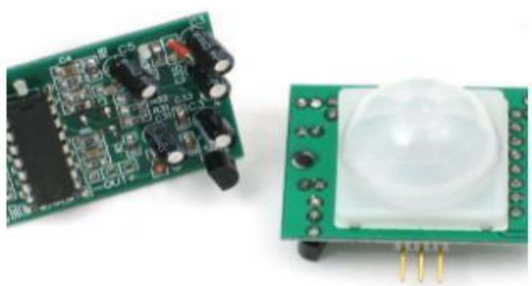


Fig.3.13: PIR Sensors

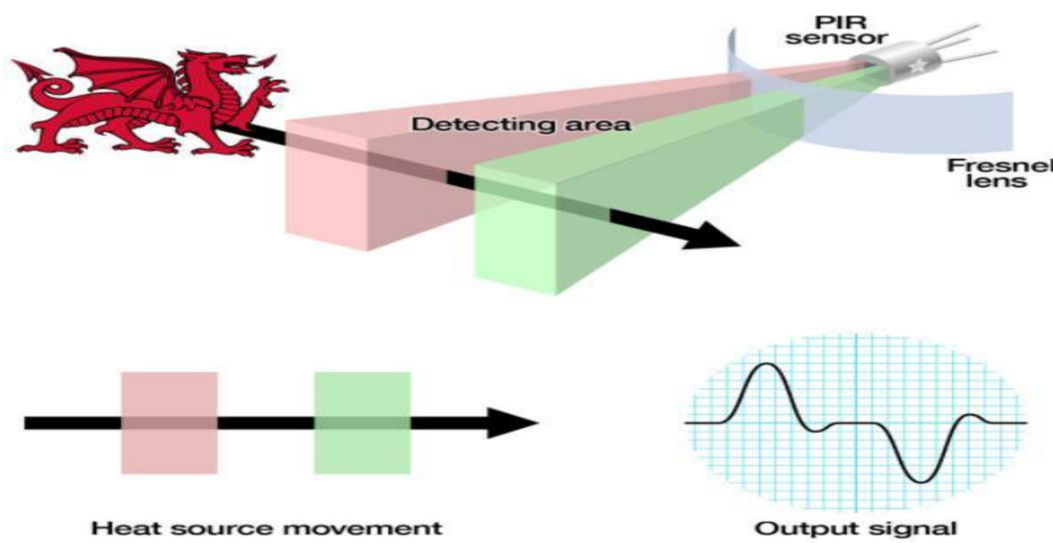


Fig3.14: Working of PIR Sensors

Lenses in PIR Sensor:

PIR sensors are rather generic and for the most part vary only in price and sensitivity. Most of the real magic happens with the optics. This is a pretty good idea for manufacturing: the PIR sensor and circuitry is fixed and costs a few dollars. The lens costs only a few cents and can change the breadth, range, sensing pattern, very easily.In the diagram up top, the lens is just a piece of plastic, but that means that the detection area is just two rectangles. Usually we'd like to have a detection area that is much larger. To do that, we use a simple lens such as those found in a camera: they condenses a large area (such as a landscape) into a small one (on film or a CCD sensor). For reasons that will be apparent soon, we would like to make the PIR lenses small and thin and moldable from cheap plastic, even though it may add distortion. For this reason the sensors are actually Fresnel lenses. The Fresnel lens condenses light, providing a larger range of IR to the sensor.

Processing:

- The images that is sent by the camera is received by the PC for classification of animal. Database is created and the set of sample images are stored in it.
- The program consists of functions such as indexImage, imageSet and retrieveImage.
- The ImageSet is used to hold a collection of images. IndexImage is used to create an image search index. indexImage is used with the retrieveImage function to search for images. The captured image is given as query image to the processing system.
- The retrieve Image function takes two arguments, a query image and the image stored in the database. The resultant is the indices corresponding to images within image Index that are visually similar to the query image.
- The image IDs output contains the indices in ranked order, from the most to least similar match. The value match range is from 0-1.If the value is 0, then the image is not matched. If it is 1, then the query image is same as that of the stored image.
- If the value is found between that of 0-1, then the query image falls under the category of the stored image i.e., the contents in the query image are same as that of the stored image.
- If the name of the image matches with that of the regular expression of the image then the animal is elephant otherwise it is a leopard. If the score is in the range of 0.1 to 0.9, then the image is matched with that of the stored image. Once the wild animal is identified then the resulting repellent system is applied. If the animal found is an elephant then the Bright light is emitted. If it is found to be a Leopard, then the irritating loud noise is used. Consequently a SMS is sent to the forest officials and also to the field owner as alert information. If the detected object is not a threat then no SMS is sent. By this way false alarm can be prevented.

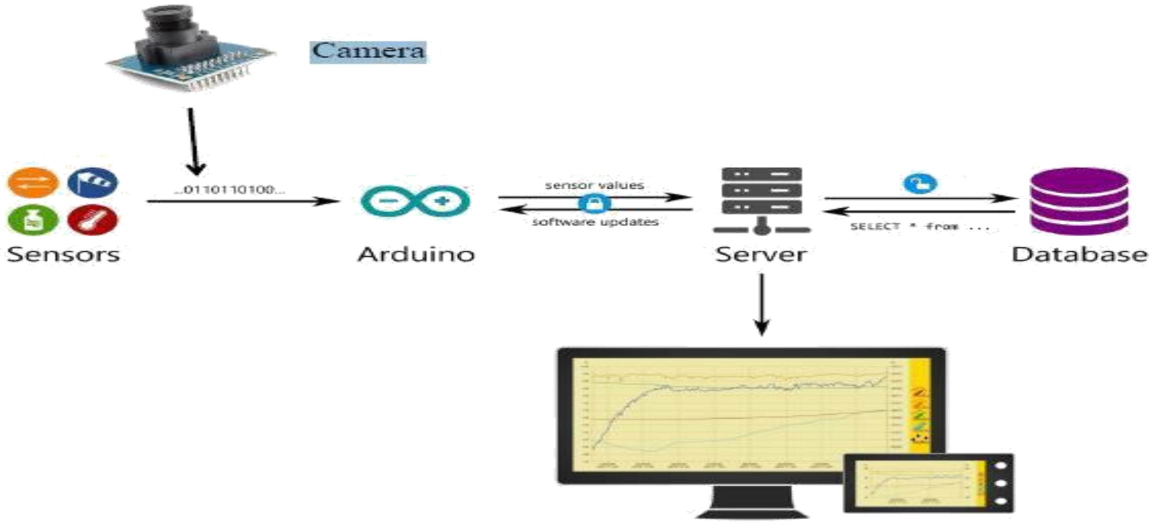


Fig3.15: Recording

OUTPUT:

- Once the animal is classified to be a threat, necessary actions are taken. SMS notification will be sent to the farmer and the forest official regarding the location of the animal and what type of animal has been trying to intrude the farm.
- Along with the SMS notification, repellent system of Bright light and irritating loud noise is used simultaneously with interval of 4 seconds is used upon the animal. The repellent system works continuously forbetter effectiveness in scaring away the animal

3.5: **PEST MONITORING AND CONTROL**

- Insects and Rodents have always been a nuisance for farmers.
- They feed on their efforts and infest on crops to spread various diseases. Controlling and maintaining their population is therefore important for a farmer to ensure crop health.
- Pesticides and insecticides have played a major role in preventing infestations. However, they pose different environmental and social consequences.
- Extreme use of pesticides can result in severe water & soil contamination and can also intoxicate plants with harmful chemicals.
- Additionally, insects and bugs become reluctant against them with continuous exposure that forces farmers to rely on heavier pesticides.

- Even though other methods like genetic seed manipulation are also being used to make crops more robust against the pest attack, they are quite expensive for practical application.

Execution of IoT for pest control:

Execution of Internet of Things in the agriculture sector has brought in a major development related to on-filed pest management. A farm owner can now use different sensors to monitor the growth of pests and take further countermeasures to manage them.

- Sensor used for Pest Detection:
- 1) Low-power Cameras and Sensors
- 2) High-power Thermal Sensors
- 3) Fluorescence Image Sensing
- 4) Acoustic Sensors
- 5) Gas Sensors

Sensor used for Pest Detection:

1) Low-power Cameras and Sensors:

Image capturing sensors for pest detection is famous among farmers due to its low cost and high return on investment. They install a low-cost image sensor in traps that captures the images of pests in it and send it to a centralized platform wirelessly. Based on the number of insects present in the traps, the farmers determine the location of insect infestation and take steps to remove them from fields. Along with its low cost, this sensor also offers advantages in terms of high scalability and mobility

2) High-power Thermal Sensors:

Low-power image sensors only click random images of insects that are visible from the naked eye. However, various pathogens ranging in millimeters also cause different crop diseases in the fields.

Thermography is a method that use thermal and infrared sensors to measure the amount of light reflected by a surface. Every surface reflects distinct amount of light energy which is also called its spectral signature. Plants and soil have a special spectral spectrum that is pre-recorded in spectrometers. In case a pathogen covers the surface of the plant leaves, the spectrum range of the plant will change indicating an attack by the pests. This method is highly effective in detecting the insects and their lifecycle stage. However, this method is expensive and sensitive to change in environmental conditions.

3) Fluorescence Image Sensing:

- In this method, the amount of chlorophyll present in a plant is measured based on its change in fluorescence parameters. An optical camera capture images of a plant leaves and then compare it with existing images of a healthy leaf. Change in chlorophyll patterns indicates the presence of pathogens or pests.

- Even though, this method detects the presence of pests in a crop, its applicability in fields is highly limited due to scalability issues. Moreover, this method can only be used with crops that contain chlorophyll.

4) Acoustic Sensors:

- Detecting bugs and rodents through sound detection is another effective way to ensure plants quality. Wireless acoustic sensors situated at random locations in a field can pick up sound waves of insects. Locations with high sound waves indicate a higher concentration of bugs. A farmer can thus spray pesticides on these locations to ensure the quality of crops.

- This cost-effective method offers high accuracy in detecting pest infestations and can be used at a wider scale. However, its accuracy depletes drastically in rainy and windy weather conditions.

5) Gas Sensors:

- Plants when stressed produce specific volatile chemical compounds. These compounds differ based on the stress that they feel. For instance, compound secreted due to environmental change will be different then the compound emanated due to pest infestation. Hence, these compounds have to be studied before they can be used for identifying attack caused due to bugs or rodents.

- Once these compounds are studied, a gas sensor can be used to identify the attack by pests or type and nature of the infection. The only drawback with these methods is that of the sampling required to collect volatile compounds for data analysis.

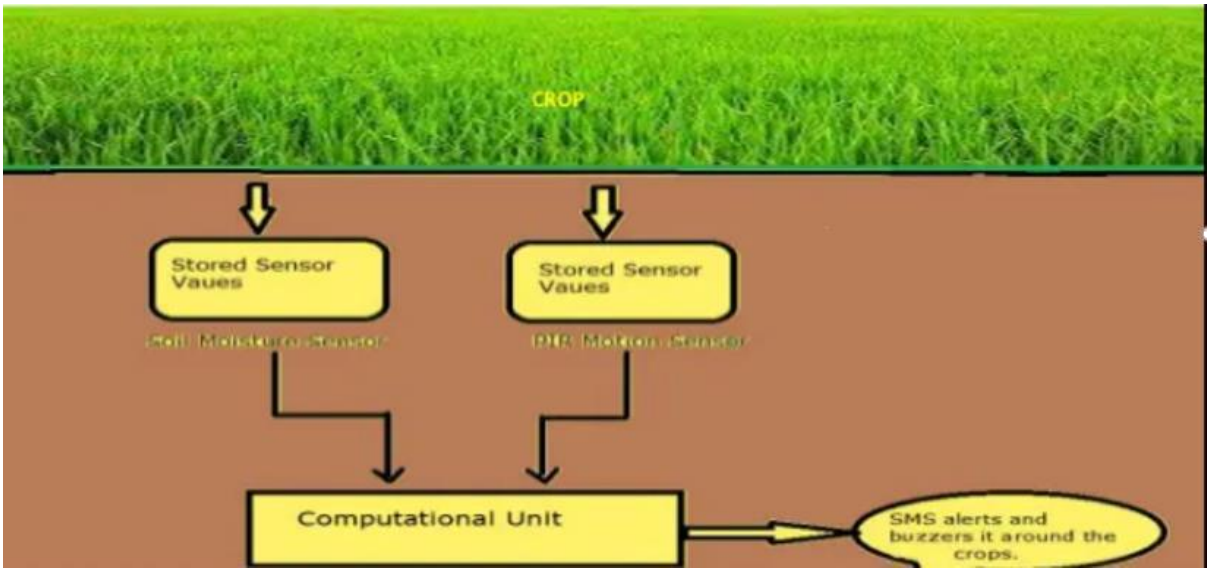


Fig3.16: Implementation

Advantages Offered by IoT Based Pest Control Systems:

- These sensors are assisting farmers to target locations in their fields infected by insects and pathogens. The data collected through these sensors is instantly transferred to a centralized platform wirelessly. By using this platform, a farmer can monitor the health of its crop form distant locations and protect it from the attack of insects and rodents.
- 1) Monitoring Pest Infestation and Crop Health
- 2) Weather monitoring and Analytics
- 3) Automated crop health monitoring

1) Monitoring Pest Infestation and Crop Health:

Through distant monitoring, a farmer can easily collect information about the presence of insects and rodents. Sensors placed in different corners of the field detect the infestation of pests or pathogens and transmit it to a dashboard. A farmer can use this dashboard to instantly connect with his fields and manage crop health. Remote pest monitoring has drastically reduced manual inspection and random site visits. The farmers can now target areas that are affected by bugs and spray pesticides on required areas only. This considerably reduces the unnecessary use of pesticides, minimizing the chances of crop intoxication and environmental contamination. The collected data can also be used to identify the insects' breed and their population in the affected crop zones.

2) Weather monitoring and Analytics:

` The data gathered from pest detection sensors when recorded and analyzed properly can predict the attack by pests. Tracking the weather conditions and breeding patterns can also assist in identifying the threat level of pest populations. During the breeding seasons, the probability of infestations is extreme. Moreover, rodents feed on crops to accumulate fat before they hibernate. Predictive analytics make use of such information to establish patterns and trends of probable pest outbreaks and swarm attacks. Based on the type of pest infestation and their population, the analytics feature can also recommend steps for future prevention and information for complete treatment.

3) Automated crop health monitoring:

Integrated pest management (IPM) is a process that is encouraged to favor ecological, social, and economic consequences of pest control. It is an approach that focuses on the limited usage of pesticides to manage pest damage and incur the least possible pesticide-related hazards. The implementation of IoT in the IPM system will automate time-consuming operations such as manual data point measurement and inspection. Automation makes the process more accurate, cost-effective, and assist farmers to take instant actions based on the response from the sensors. Use of pesticides will also be optimized which will further decrease environmental contamination and harm to crop health

- It is important for a farm owner to control and remove pests from its field to ensure crop health. The advent of IoT in the agriculture sector has enabled a farmer to remotely monitor and control pest infestation. With a one-time investment, a farmer can integrate an IoT powered pest control system to its farm and accurately detect the presence of bugs and rodents without manual inspection. However, the complete capability of IoT in farming rests with the combined usage of its agriculture-based applications. Distant pest control along with crop management, weather monitoring, and livestock management is enabling the development of various modern farming approaches that were never witnessed by the agriculture sector in the past.

3.6. LIVESTOCK Monitoring System

Need for Livestock Monitoring:

- The farmers of agricultural farms manage and monitor different types of livestock.
- The manual inspection and monitoring of livestock are tedious since the cattle do not stay at fixed locations.

- Fencing many cattle requires a considerable cost and involves farmers' physical intervention to keep an eye to stop them from crossing beyond the access points.
- Visual tracking of livestock and fencing is a time-consuming and challenging job.

Livestock Monitoring System Architecture:

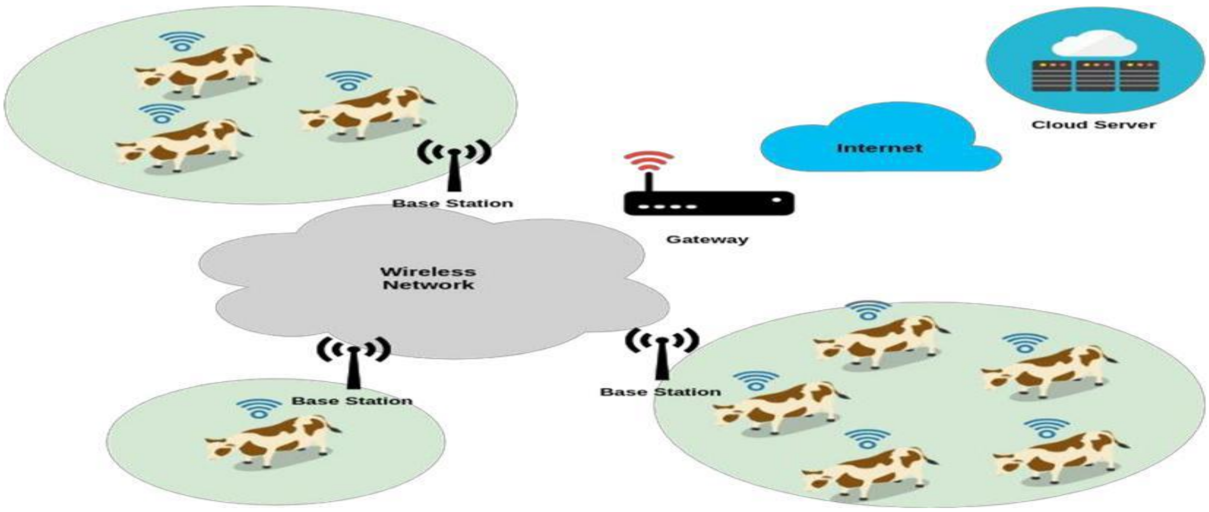


Fig3.17: Livestock Monitoring

- ➢ **Real time cattle tracking**: Cattle tracking and traceability system that gives any time, anywhere access to the cattle information.
- ➢ **Temperature detection**: To determine accurate and time sensitive heat detection.
- ➢ **Blood Pressure Detection:** Timely blood pressure tracking of cattle.
- ➢ **Calving Alerts:** Timely calving detection and alerts to preventing losing calves. Time sensitive and special prolonged calving alerts.
- ➢ **Advanced Mobility Solution:** Key information at your fingertips. Easy searching and tracking of cattle.
- ➢ **Smart Notification:** Time-sensitive events now appear directly on your smartphone, displayed as splash pop-up notifications.
- ➢ **24/7 Wireless reading:** Easy setup using farm's wifi. Wireless communication to monitor milk cows and dry cows.
- ➢ **Lasting Battery:** Specially designed battery for lasting period.

IoT based Monitoring:

- A geographical safe zone is created for cattle based on IoT and GPRS, where the cattle are assigned dedicated IoT sensors.
- The cattle can be easily remotely monitored and controlled without having any need for farmers to intervene for livestock management physically.
- The smart system collects the data regarding the location, well-being, and health of the livestock.
- This kind of livestock management may help prevent the spread of COVID-19, lower the farming costs, and enable remote monitoring.

Different types of Cattle:

- Varieties of cattle in a paddock have genetically different grazing, sleeping, and playing patterns.
- Goats and sheep are more active, and they have different food intake and digestion systems than cows and buffalos.
- The current livestock management systems mostly employ IoT and GPS sensors connected to satellite and GPRS for navigation and communication, respectively.
- GPS and GPRS sensors consume device energy and communication bandwidth.
- Besides, the same set of sensors is installed for all livestock categories despite genetic diversity among animals in the same herd. In addition, the conventional tracking systems track the movements of livestock without any profound geographical boundaries that become challenging in case the animals go very far from the main access points.
- The farmers are notified by the system when cattle try to go beyond the defined boundary of the zone. Besides, the navigation and communication are automatically controlled according to the genetic diversity of different animals.

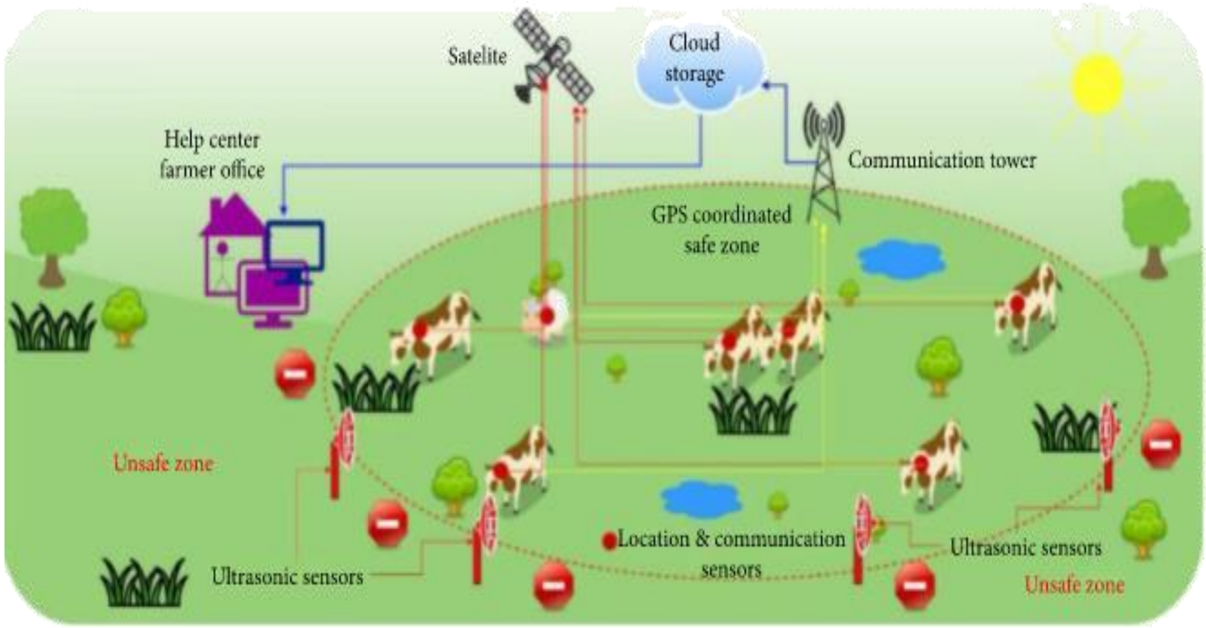


Fig3.18: The conceptual Framework

- The red ellipse represents a drawn geographical safe zone for the livestock. Ultrasonic sensors installed at the elliptical boundary of the safe zone identify the movements of the cattle.
- The ultrasonic sound waves propagate and discover the presence of livestock, and its distance is calculated. If the distance of the cattle crosses the defined safe-distance threshold, the communication navigator is activated.
- The animals in the herd are equipped with navigation sensors that sense the locations of animals by navigating through the satellite.
- The system calculates the distance of each animal from the safe zone geographical boundary and alarms the farmer when the distance of the animal gets close to a threshold value.

The proposed system glimpses the exact location of animals in case the animals are out of the safe zone for a specified period. The motion sensor suspends the navigation and communication when the animal is recorded in a static state to optimize the energy and communication bandwidth for significant utilization

3.7. IOT BASED GREENHOUSE MONITORING AND CONTROLLING SYSTEM:

- Managed areas for the production of plants are greenhouses.
- Because current greenhouse plants restrict themselves, they are not automatically controlled and have to be manually operated with various documents.
- The system suggested must be monitored and controlled continuously to ensure optimal growth of plants, e.g. temperature, moisture, soil humidity, light intensity etc.
- This system shows a management mechanism for children's nurseries over the Internet of Things (IOT).
- The System can check for evident conditions, such as humidity, soil immersion, temperature, fire proximity, strength of light, etc.
- With NodeMCU esp8266, all data from the environment parameters are sent to the nube. If a
- parameter exceeds the limit set, the associated actuator is switched on.
- If the Earth parameter does not meet the required value, the microcontroller turns on the motor. A mobile phone and desktop allows the user to display and monitor parameters.
- The ecosystem plays a crucial role in plant development. The amount of moisture inside the greenhouse cannot be adequately understood by farmers in the greenhouse.
- The condition in the green building they just understand manually, and they experience it on their Experience plays a significant part in their regular activities at the end of the day.
- The plants would have to water if the soil has minimum water content, but if it is too moist, in the greenhouse the roof will be opened during day time.
- Efficiency in greenhouse plant production must be achieved to achieve effective growth increases, so that high production rates can be achieved at lower cost, higher quality and low environmental burdens.
- The greenhouse can be controlled by IOT which involves refrigeration, ventilation, immersion of the soil, etc. This System can be managed by concentrating on environmental criterion such as temperature and humidity.
- A individual can automatically monitor the environmental parameters of the greenhouse
- The need for ON/OFF switchgear functions eliminates automation plays an important role in performing things automatically.
- Automation does not eradicate or suppress human error entirely, but it minimises it at certain stages. It is the need of the world of today for anything to be practical or controlled remotely

Fig 3.19: Greenhouse Monitoring

Methodology:

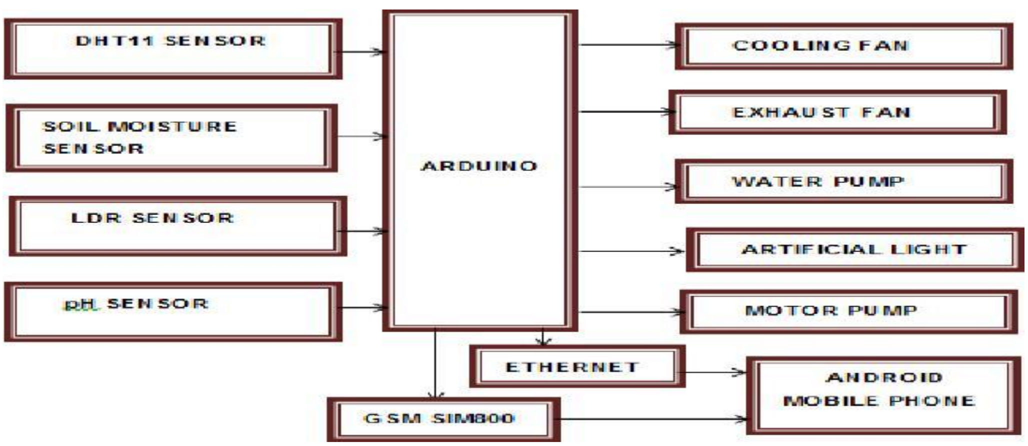
- The implemented greenhouse system consists of two section, monitoring section and controlling section.
- The monitoring section consists of DHT11 sensor, LDR sensor, Soil moisture sensor and pH sensor to monitor the environmental parameters.
- A GSM modem and Ethernet are also used to send environmental parameters to android mobile phone.
- The controlling section consists of cooling fan, exhaust fan, water pump, artificial light and motor pump.
- Arduino microcontroller forms the heart of the system.
- 

Fig 3.20: Block Diagram

SENSOR:

Four sensors, DHT11 sensor, LDR sensor, Soil moisture sensor and pH sensor are used.

(i)DHT11 Sensor:

DHT11 sensor is used to measure both temperature and humidity. It is a low cost temperature and humidity sensor. It has high reliability, high efficiency and long-time stability. It has a thermistor for measuring the temperature and a humidity measuring component for measuring humidity

Fig3.21: DHT11 Sensor

(ii). Soil Moisture Sensor:

- Soil moisture sensor measures the moisture content in soil.
- This soil moisture sensor consists of two metal rods held apart at a fixed distance by some insulating material
- Two metal rods pass current through the soil and resistance is measured. If the water is more, resistance is low and if the water is less, resistance is high.
- It also consists of a potentiometer to vary the sensitiveness of the sensor.
- Features are low power consumption, high sensitivity, Arduino compatible interface and the operating voltage is 5V

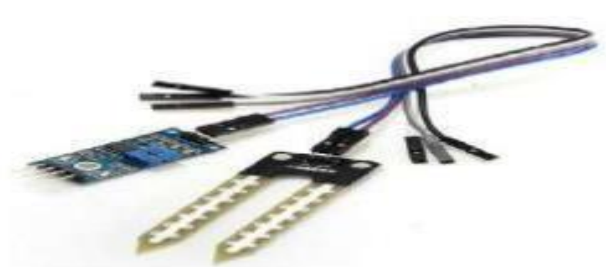


Fig3.22: Soil Moisture Sensor

LDR sensor module:

- LDR (Light Dependent Resistor) sensor module is used to measure light intensity.

- It has both analog output pin and digital output pin. If light intensity increases, resistance of LDR decreases.
- If light intensity decreases, resistance of LDR increases. The sensor has a potentiometer knob that can be used to adjust the sensitivity of LDR towards lightLDR is also known as photoconductor.
- Cadmium Sulphide (CdS) is used to make LDR.
- Cadmium Sulphide is deposited on an insulator in the shape of a zigzag line.
- The reason for zigzag path is to increase dark resistance and therefore decrease the dark current

pH sensor

- pH sensor is used to measure pH of the soil. The pH indicates a solution's acidity or alkalinity.
- pH sensor consists of a pH probe and a pH sensor module.
- The pH probe has two electrodes, one is a glass electrode and other is reference electrode.
- Both electrodes are hollow bulbs containing a potassium chloride solution with a silver chloride wire suspended into it.
- pH probe measures the electrochemical potential between a known liquid inside the glass electrode and an unknown liquid outside.
- pH sensor module consists of potentiometer to vary the value of the sensor.

GSM SIM800:

- GSM SIM800 is a quad band GSM device.
- It works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz.
- It can transmit voice, SMS and data information with low power consumption.
- It is very compact in size. It is easy to use as plug in GSM modem. It supports Bluetooth function.
- Its operating voltage is 3.3V to 5V

Fig3.23: GSMSIM800

- All the components are initialized by supplying the required power of +5V. Four sensors, DHT11 sensor, LDR sensor, Soil moisture sensor and pH sensor are used. A cooling fan, exhaust fan, water pump, artificial light and motor pump are also connected to the Arduino. An Ethernet is used to send environmental parameters to android mobile phone. All environmental parameters are sending to server through Ethernet and stored in the database. So the user can monitor and control parameters through android mobile application. For this, an android application is developed. The user can log in the application by using username and password. Username and password is stored in database. The present status of the environmental parameters is sent to the mobile user when the mobile user sends the SMS “STATUS”. When the temperature comes to the normal range, the mobile user turns off the fan by sending the SMS “FANOFF”. High humidity affects plants transpiration and photosynthesis process. When plants absorb water and minerals from the soil through their roots, transpiration assists these nutrients to the leaves.If the humidity is too high, the process slows down, preventing the absorption of nutrients.Without the release of moisture, plants lose their ability to cool themselves. When humidity exceeds a defined level, the system sends SMS to the mobile user and the mobile user turns on the exhaust fan by sending the SMS “EFANON”. When the humidity comes to the normal range, the mobile user turns off the exhaust fan by sending the SMS “EFANOFF”

TEXT / REFERENCE BOOKS

1. Donald. A. Neamen, “Electronic Circuits Analysis and Design”, McGraw Hill Education (India) Private Ltd., 3rd Edition, 2010.
2. Millman J and Halkias C., “Integrated Electronics”, TMH, 2nd Edition, 2017.
3. S. Salivahanan, N. Suresh Kumar and A. Vallavaraj, “Electronic Devices and Circuits”, TMH, 2nd Edition, 2017.
4. Adel S. Sedra and Kenneth C.Smith, “Microelectronic Circuits”, Oxford University Press, Sixth Edition, 2009.
5. Behzad Razavi, “Fundamentals of Microelectronics”, 1st edition, wiley publication, 2008.

IoT BASED INDUSTRIAL AUTOMATION

IoT based gas leakage monitoring system, Temperature and liquid level monitoring in boilers, Fire detection system, wireless video surveillance robot, Automatic Solar Tracker

4.1 IoT based gas leakage monitoring system

- Internet of things endeavor towards making life simpler and faster by automating the entire small tasks associated with the life of human.
- Today, everything is getting smart due to the technological progress such as of IOT.
- As IOT is very beneficial for automating the tasks, the advantage of IOT can also be comprehensive for enhancing the convenient safety methods.
- Security plays a significant role while constructing home, buildings, industries as well as towns.
- The enlarged focus of certain gases in the environment can be exceptionally unsafe, in recent time, everyone needs a facility which reduces time and effort and expect their work to be as easy as possible.
- One such area where man prefers to get the work faster and easier is cooking.
- Most commonly LPG is used for cooking purpose which was introduced by Dr. Walter Snelling.
- It is a amalgamation of propane and butane along with saturated contents in addition to unsaturated hydrocarbon contents.
- Usually in home or industries, most of the disaster happens due to gas leakages, which leads to several accidents and also causes human life.

- In order to handle such situation, the proposed gas leakage detection and monitoring system is developed

4.2 Temperature and liquid level monitoring in boilers

Boiler is the major part of industries and power plants. Mostly thermal power plants have boilers to produce electrical energy from steam. But thermal power plants are located in remote areas due to it harmful environment. By increasing the power demand and decreasing the cost for operating and maintenance are increase the reliability of the power plant. To satisfy the power need of the nation, power production is done in thermal power plant for 24 hours in 365 days without fail.

But monitoring process is not possible for each and every second. Monitoring process is very important for safety of the workers and high secured operation of the power plant. The aim of the project is to develop monitoring of boiler parameters using wireless communication and to avoid the accidents in hazardous places wherever the humans not able to work. Boiler parameters are monitored by using sensors. Temperature, humidity, water level and gas are the parameters to be monitored and monitored values are visualized through think speak by using Internet of Things.

4.3 Fire detection system

Fire Alarm Systems are very common in commercial building and factories, these devices usual contain a cluster of sensors that constantly monitors for any flame, gas or fire in the building and triggers an alarm if it detects any of these. One of the simplest way to detect fire is by using an **IR Flame sensor**, these sensors have an IR photodiode which is sensitive to IR light. Now, in the event of a fire, the fire will not only produce heat but will also emit IR rays, yes every burning flame will emit some level of IR light, this light is not visible to human eyes but our flame sensor can detect it and alert a microcontroller like Arduino that a fire has been detected.

Flame sensor module has a photodiode to detect the light and an op-amp to control the sensitivity. It is used to detect fire and provide a HIGH signal upon the detection. Arduino reads the signal and provides alert by turning on the buzzer and LED. The flame sensor used here is an IR based flame sensor.

1. Flame Sensor

A **flame detector** is a sensor designed to detect and respond to the presence of a flame or fire. Responses to a detected flame depend on the installation but can include sounding an alarm, deactivating a fuel line (such as a propane or a natural gas line), and activating a fire suppression system. The IR Flame sensor used is also called **Fire sensor module** or **flame detector sensor** sometimes.

There are different types of flame detection methods. Some of them are: Ultraviolet detector, near IR array detector, infrared (IR) detector, Infrared thermal cameras, UV/IR detector etc.

When fire burns it emits a small amount of Infra-red light, this light will be received by the Photodiode (IR receiver) on the sensor module. Then we use an Op-Amp to check for a change in voltage across the IR Receiver, so that if a fire is detected the output pin (DO) will give 0V(LOW), and if the is no fire the output pin will be 5V(HIGH).

An **IR based flame sensor is used**. It is based on the YG1006 sensor which is a high speed and high sensitive NPN silicon phototransistor. It can detect infrared light with a wavelength ranging from 700nm to 1000nm and its detection angle is about 60°. The flame sensor module consists of a photodiode (IR receiver), resistor, capacitor, potentiometer, and LM393 comparator in an integrated circuit. The sensitivity can be adjusted by varying the onboard potentiometer. Working voltage is between 3.3v and 5v DC, with a digital output. A logic high on the output indicates the presence of flame or fire. A logic low on output indicates the absence of flame or fire.

Applications of flame sensors

- Hydrogen stations
- Combustion monitors for burners

- Oil and gas pipelines
- Automotive manufacturing facilities
- Nuclear facilities
- Aircraft hangars
- Turbine enclosures

Components Required

- Arduino Uno (any Arduino board can be used)
- Flame sensor module
- LED
- Buzzer
- Resistor
- Jumper wires

Working of Flame Sensor with Arduino

Arduino Uno is a open-source microcontroller board based on the ATmega328p microcontroller. It has 14 digital pins (out of which 6 pins can be used as PWM outputs), 6 analog inputs, on-board voltage regulators etc. Arduino Uno has 32KB of flash memory, 2KB of SRAM and 1KB of EEPROM. It operates at a clock frequency of 16MHz. Arduino Uno supports Serial, I2C, SPI communication for communicating with other devices. The table below shows the technical specification of Arduino Uno.

Microcontroller	ATmega328p
Operating voltage	5V
Input Voltage	7-12V (recommended)

Digital I/O pins	14
Analog pins	6
Flash memory	32KB
SRAM	2KB
EEPROM	1KB
Clock speed	16MHz

The **flame sensor detects the presence of fire** or flame based on the Infrared (IR) wavelength emitted by the flame. It gives logic 1 as output if a flame is detected, otherwise, it gives logic 0 as output. Arduino Uno checks the logic level on the output pin of the sensor and performs further tasks such as activating the buzzer and LED, sending an alert message.

4.4 Wireless Video Surveillance Robot

Surveillance means the process of monitoring a situation, region or person. This usually occurs in a scenario where military border surveillance and enemy territory is essential to the security of a country. Human Monitoring is achieved by deploying close to sensitive areas of staff to constantly monitor the changes. But humans have limitations and deployment in places that are not always possible. There are also additional risks losing the staff in case of being caught by the enemy. With advances in technology over the years, it is possible to monitor remote areas of importance by using robots instead of humans. Besides the obvious advantage of not having to risk any personnel, land and air robots can also look for details that are not visible to humans.

This surveillance robot requires a lot of essential hardware components for proper functioning. Due to advancement in technology, these surveillance robots are used in remote as well as domestic areas. The main components used in the system and their specifications and functions are as follows,

1. ARDUINO MICROCONTROLLER: Arduino microcontroller is based on UNO AtMega328. It is used to receive commands sent by the user via the internet and processes according to the code and also used to control the motors. Wi-Fi module ESP8266 is also connected with the arduino so that Wi-Fi facility can be provided to the robot.

2. DC MOTORS: Motors that operate on 12V DC power supply are used. These are rotary electrical machine that converts direct current electrical energy into mechanical energy. The motors used are of 30 rpm speed of operation.

3.ULTRASONIC SENSOR :Ultrasonic sensor is a device that can measure the distance to an object (obstacle) by using sound waves at a particular frequency. It provides a 3cm to 3m range. It can work in any lighting conditions. Thus the robot easily dodges obstacles present on its way.

4. INFRARED SENSOR: An infrared sensor is used to sense and determine the nature and aspects of the surroundings by emitting infrared radiation. This sensor has the ability to emit infrared radiation and detects the reflected radiation that is being reflected by an object or the surroundings. The range is between 2 cm to 30 cm and the operating voltage is around 3v to 5v. This infrared sensor is attached to the robot to detect edges present on its path.

5. LEAD ACID BATTERY: Two 6V batteries are connected in series to provide a 12V power supply for the motors. From these batteries power supply is also given to the arduino and other parts that require power supply for their effective performance.

6. WI-FI MODULE: The ESP8266 12e module which is low cost, self contained chip consists of TCP/IP protocol stack that is used to provide network access to any microcontroller. It is highly compact in size and is easily a portable one and thus this is interfaced with the arduino to provide the robot with Wi-Fi facility.

4.5 Automatic Solar Tracker

The circuit design of solar tracker is simple but setting up the system must be done carefully.

Four LDRs and Four 100KΩ resistors are connected in a voltage divider fashion and the output is given to 4 Analog input pins of Arduino.

The PWM inputs of two servos are given from digital pins 9 and 10 of Arduino**.**

Components Required

- Arduino UNO
- Servo Motor
- Light Sensors
- LDR
- Resistors

Working

LDRs are used as the main light sensors. Two servo motors are fixed to the structure that holds the solar panel. The program for Arduino is uploaded to the microcontroller. The working of the project is as follows.

LDRs sense the amount of sunlight falling on them. Four LDRs are divided into top, bottom, left and right.

For east – west tracking, the analog values from two top LDRs and two bottom LDRs are compared and if the top set of LDRs receive more light, the vertical servo will move in that direction.

If the bottom LDRs receive more light, the servo moves in that direction.

For angular deflection of the solar panel, the analog values from two left LDRs and two right LDRs are compared. If the left set of LDRs receive more light than the right set, the horizontal servo will move in that direction.

If the right set of LDRs receive more light, the servo moves in that direction.

Setup

Step-1

Take cardboard. Make a hole in the middle and four holes on four sides so that LDR fit into that.

Stick the solar panel to the cardboard and bring two wires of the panel out .

Step 2

Now cut one of the two leads of the LDR so that one lead is shorter and other is longer.

Insert these four LDRs into four holes .Bend the straight Perforated metal strip .

Place the bent metal strip on the back side of the cardboard.Apply glue to the LDR to fix them firmly.

Step 3

Solder the two leads of LDR as shown

To the other ends of LDR Solder resistors of 10k ohm

Join the four leads of the 4 LDRs by connecting with a wire.

Step 4

Now take a bus wire.This is used to connect the Outputs of four LDRs to Arduino board.

Insert it into metal strip as shown in the image.

Now Solder the four wires to four LDRs at any point between LDR and resistor.

Step 5

Insert another two wire bus into the perforated metal strip as shown.This is used for supplying Vcc and GND to LDR circuit.

Solder one wire to the leads of LDRs which are connected to resistors and other wire to the other leads.

Short the leads of LDRs connected to resistors using a wire .

Step 6

Now connect a servo motor to the Perforated metal strip using Screw.

Apply glue to the servo to fix it firmly.

Step 7

Take another straight Perforated metal strip and bend it

Step 8

Now place the set up of solar panel and first servo motor to the metal strip of second servo motor .

TEXT / REFERENCE BOOKS

1. Adel S. Sedra and Kenneth C.Smith, "Microelectronic Circuits", Oxford University Press, Sixth Edition, 2009.
2. Behzad Razavi, "Fundamentals of Microelectronics", 1st edition, wiley publication, 2008.
3. Donald. A. Neamen, "Electronic Circuits Analysis and Design", McGraw Hill Education (India) Private Ltd., 3rd Edition, 2010.
4. Robert L. Boylestad and Louis Nasheresky, "Electronic Devices and Circuit Theory", Pearson Education, 11th Edition, 2013.
5. Floyd, "Electronic Devices", Pearson Education, 9th Edition, 2012.

IoT FOR SOCIETY

- Medical Waste Management, Weather update system with IoT, Women security system, GPS Smart Sole, wearable glove to enable sign to speech conversation, IoT based air pollution meter

5.1-IOT MEDICAL WASTE MANAGEMENT SYSTEM

Bio medical wastes are waste generated from hospitals at various wards. There are different kinds of biomedical waste such as Anatomical waste, Animal waste, biology and biotechnology discarded medicine and cytotoxic drugs, Incineration Ash, Waste sharps, Soiled waste, Solid waste, Liquid waste, Chemical waste.

This waste must be transported from hospitals to common treatment facility where these wastes are recycled using treatment equipments in order to avoid pollution.

System mandates the hospital staffs to record the wastage generated at the point of generation(ward level) by scanning the bar coded bags and it is transported to Common Treatment Facility (CTF).

In this project we are used readymade nilkamal bin around 500kg for biomedical waste.

We upgrade the nilkamal bin base with platform and weight sensors.

With help of Lower metal platform distribute the weight equally all direction.

Four weight sensor are fitted between wheel and platform to work as cantilever.

All the sensor interconnected with controller box.

A controller box reads the weight from weight sensors and send to the mobile through Bluetooth module.

We used Bluetooth 4.0 protocol communication between Bluetooth device and mobile.

GSM/GPS/GPRS module is also used to read the real time location by controller and send to the server with other weight data.Controller box has 8 hr battery back up with recharging system inbuilt.

Android app were reading real time data like total weight, old weight ,new added weight, Barcode scanning, upload button to send data on server and allows configure weight sensor once year.

Fig5.1: Hospital Waste Management

Hospital is not willing to pay high amount to dispose the bio medical waste, therefore hospital gives bribes to throw the biomedical waste in local garbage..

Traditional biomedical waste weight measurement system is time consuming for both hospital and contractor.

If weight is only 100 gram extra then contractor asking extra money as same as 1kg.

SOLUTION:

Weight sensor is in between lower metal platform and wheels in the form of cantilever. Means one end is fixed and all weight on other end of weight sensor.

Lower metal platform body is used for weight equal distribution on weight sensors. It is provide accurate measurement if weight is in corner.

Fig5.2: Weightless Sensor

1. Controller unit send the real time data to mobile like total weight,

new weight and old weight using Bluetooth.

2. Mobile APP upload the real time data with barcode data over the cloud.

3. 8hr battery backup with recharging system.
4. Bio medial waste truck can be monitor using GPS/GSM/GPRS module

ADVANTAGE:

Real time data reading and uploading to server.

Remove writing work.

Insert a bio medical waste directly into the bin remove traditional method weight measurements of every waste.

GPS tracking the Bio medical waste truck.

Charging and battery backup system.

5.2- IOT BASED AIR QUALITY MONITORING :

- The main objective of this work is to monitor the air eminence in industrial and urban areas.
- In this Arduino platform is used to communicate the data simply and quickly.
- WSN (Wireless sensor network) acts as the trans receiver. communication technology.
- The projected monitoring system can be transferred to or shared by different applications. Through IOT we can able to visualize the values from the globe.

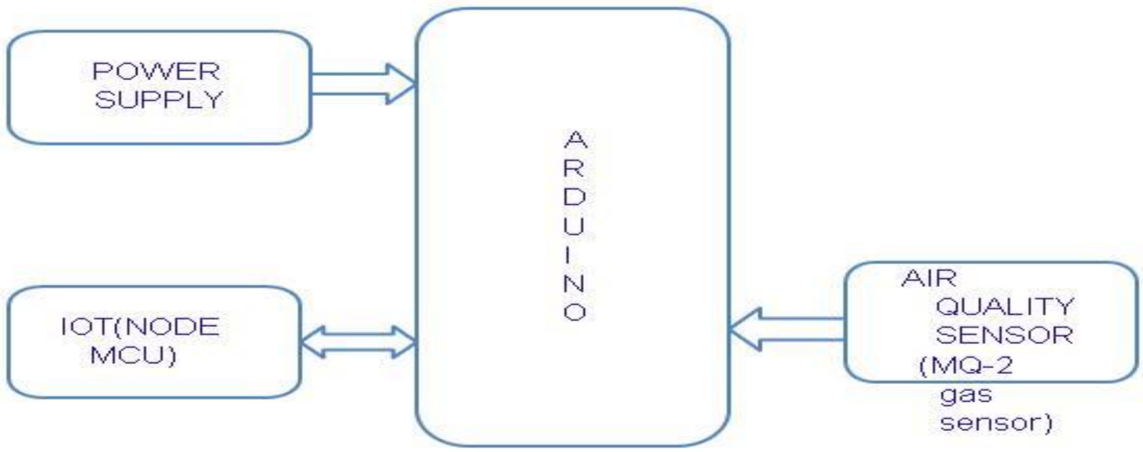


Fig 5.3: Block Diagram

AIR QUALITY SENSOR:

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

Fig 5.4: Air Quality Sensor

Gas Sensor(MQ2) module is useful for gas leakage detection. (home and industry). It is suitable for detecting H2, LPG, CH4, CO, Alcohol, smoke or Propane

Due to its high sensitivity and fast response time,measurement can be taken as soon as possible

Due to its high sensitivity and fast response time, measurement can be taken as soon as possible

The sensitivity of the sensor can be adjusted by potentiometer

The system to monitor the air of environment using arduino micro controller.Iot technology proposed to improve quality of air Gas sensor gives the sense of different type of dangerous gases. It supports new technology and healthy life concept.

ADVANTAGES

- Sensors are easily available.
- Detecting a wide range gases like CO2,CO etc.
- Simple , compact and easily handle.
- Continous update of change in percentage of quality.

APPLICATIONS

- Roadside pollution monitoring.
- Industrial perimeter monitoring.
- Site selection for reference monitoring stations.

Indoor air quality monitoring

5.3: Weather Update System :

- A weather station is a device that collects data related to the weather and environment using many different sensors.
- Weather station is also a facility that can use for measuring atmospheric conditions to provide information for weather forecasts and to study the weather and climate.
- Therefore, Weather Station using Internet of Thing is proposed to help user access data about weather anywhere in real-time.
- Limited way for user to know about weather such as temperature, humidity and pressure.
- User can’t be alerted of the strong winds, heat waves or any other weather- related emergency.
- Difficulty in making weather forecasts without data.

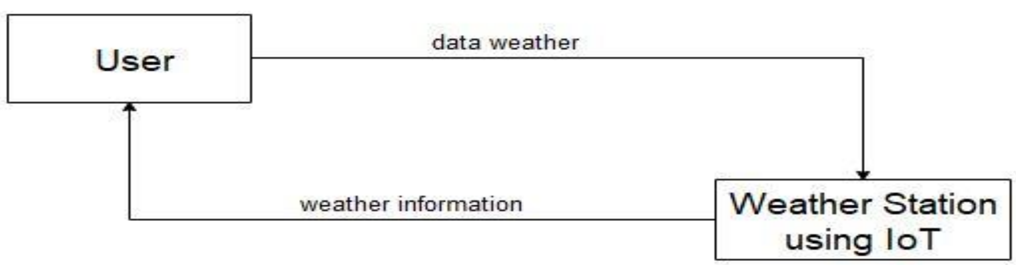


Fig 5.5: Block Diagram

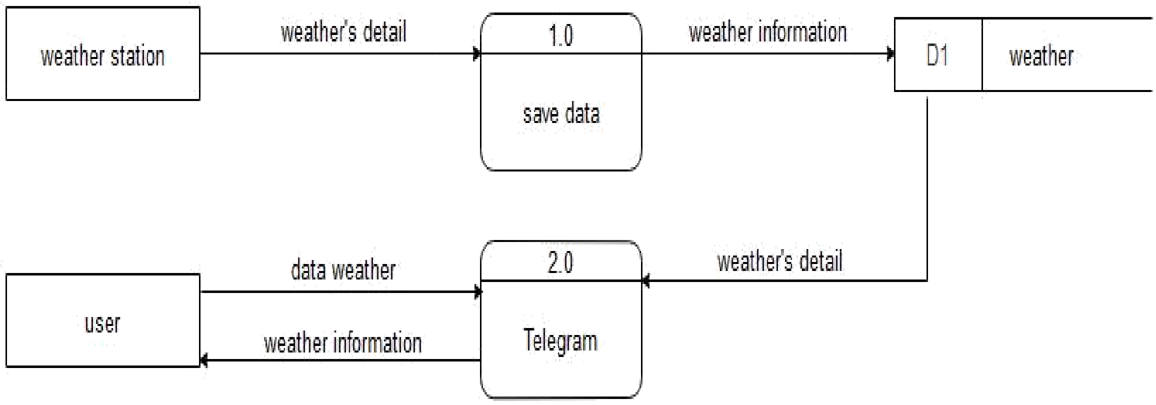


Fig5.6: Dataflow Diagram

5.4: WEARABLE GLOVE TO ENABLE SIGN TO SPEECH CONVERSATION

These are special type of gloves that allow **speech and hearing-impaired** people to communicate with those who don't use or understand **sign language**.The gloves are equipped with sensors that recognize sign language and **translate it into text** on a smart phone, which then converts the **text to spoken words**

HISTORY behind "ENABLE TALK"

Giving a **voice to the voiceless** has been a cause that many have championed throughout history, but it's safe to say that none of those efforts involved packing a bunch of **sensors** into a glove.

A team of **Ukrainian students** has done just that in order to translate **sign language** into **vocalized speech** via a **smartphone**.

With the motto "We're giving a voice to movements," **Team QuadSquad** came in **1st place** for their glove prototype in the **Software Design Competition** of the **2012 Microsoft Imagine Cup**.

The **Inspiration of the Gloves** came from observing fellow college students who were **deaf have difficulty communicating with other students**, which results in them being **excluded from activities**.

Initially, the team looked at commercially available **gloves** that could be modified to interpret a range of signs, but in the end, they opted to **develop their own**

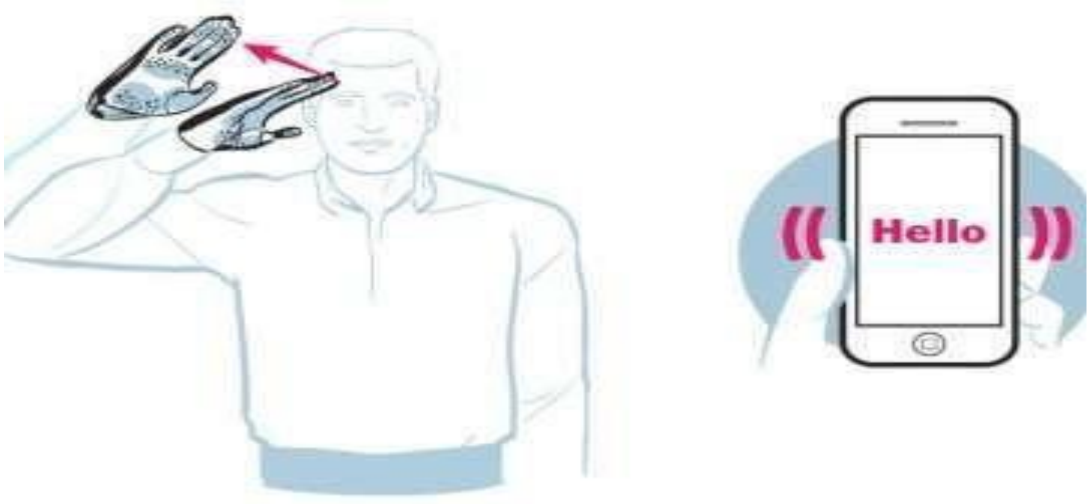


Fig.5.7: Say "HELLO" to the Less Fortunates !!!

In the glove, a total of 15 flex sensors in the fingers measure the degree of bending while a compass, accelerometer, and gyroscope determine the motion of the glove through space. The sensor data are processed by a microcontroller on the glove then sent via Bluetooth to a mobile device, which translates the positions of the hand and fingers into text when the pattern is recognized.Using Microsoft APIs for Speech and Bing, the text is spoken by the phone running Windows Phone 7.

Fig5.8: VR Gloves Schematics

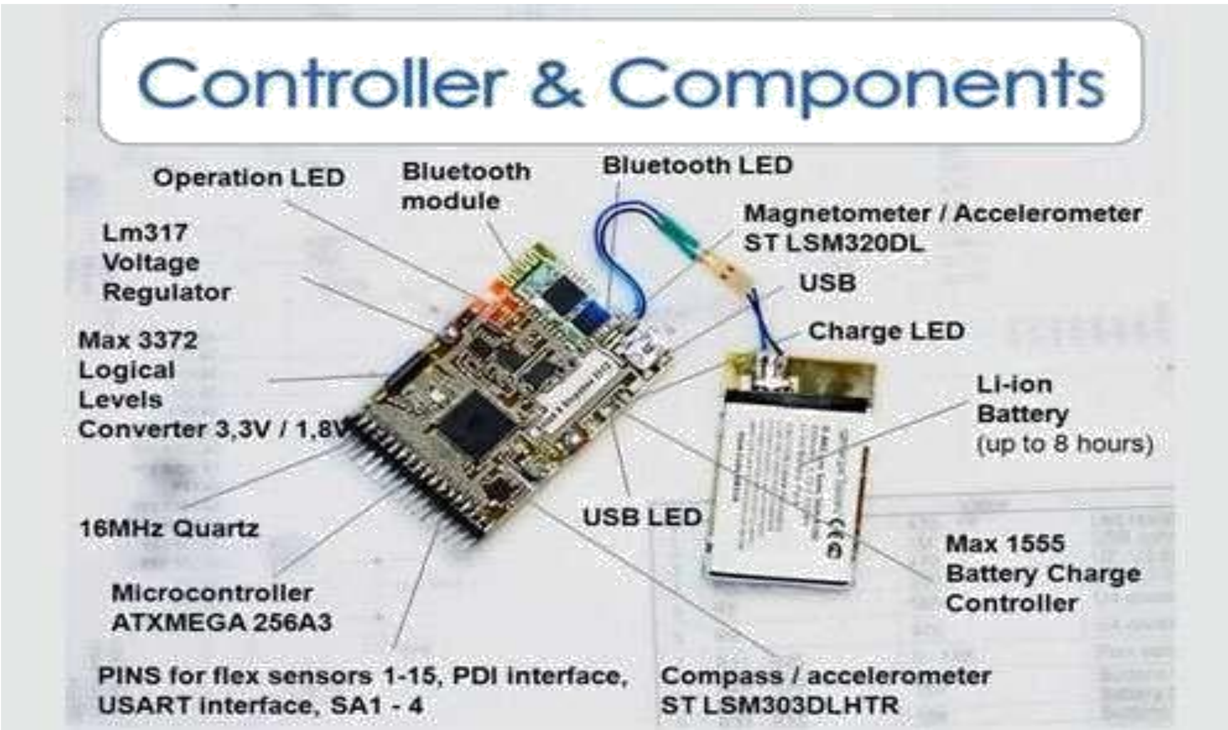


Fig 5.9 : Hardware Component

The system can now only translate a small number of phrases, such as “Nice to meet you” so building up the library of recognized signs is of great importance.

To do this, the team plans to work with native signers and deaf college students all over the World. Additionally, the recognition algorithms must be revised to improve accuracy from its current 90 percent to 99 percent.The team also wants to improve the processing speed, which is vital for regular conversation flow. Working with other developers, the glove will ultimately be supported on Android and Apple iOS. While **EnableTalk** is initially targeting the deaf community, the smart glove technology that they are developing has a much broader market, one that is embracing the very **real prospect of wearable computing.**The same hardware in Enable Talk could easily be adapted to make keyboard commands faster or even be used as an alternative to a mouse, just as **the Leap Motion** is aiming to do through a completely different approach. In fact, touch computing has eliminated the mouse on mobile devices and speech recognition like **Siri and Evi** could eliminate the need for a keyboard. And of course, one of the most recognizable uses of a smart glove is to interact with a **Graphic Interface**.

5.5 : WOMEN SECURITY SYSTEM:

Crime against Women

Domestic Violence – Hitting, kicking, biting, shoving, restraining, throwing objects.

Criminal Violence - threats, sexual abuse, emotional abuse, control &domineering, intimidation, stalking, and economic deprivation, rape, abduction, kidnaping and murder

Social Violence -Eve-teasing, forcing wife/daughter-in-law to go for feticide etc.

To build a security system for women that is completely automated and requires no human interference whatsoever.

The device is an integration of multiple hardware devices.“Smart band” which continuously communicates with Smart phone that has access to the internet.

Application on Smart Phone programmed and loaded with human behavior and reactions.

Signals generated by Smart Band transmitted to the application on Smart Phone.

Application with access to GPS and Messaging Services preprogrammed to send help request messages and location coordinates to nearest police station, relatives and people in the near radius.

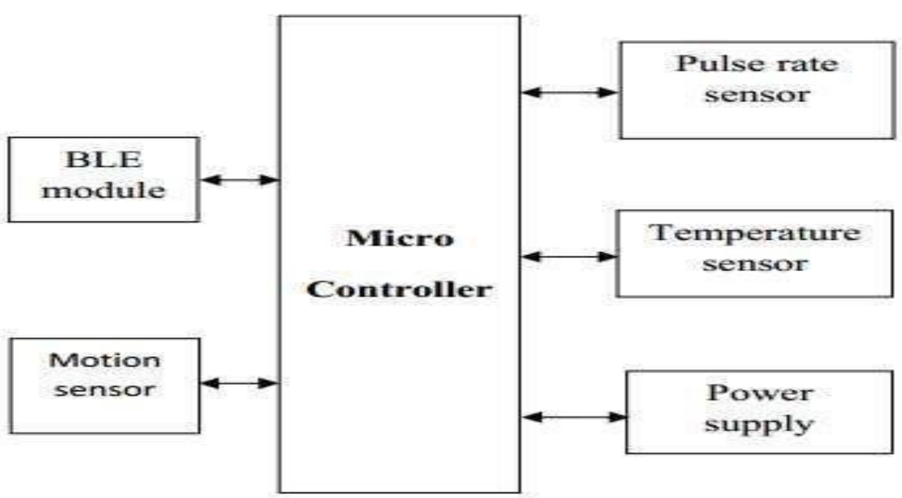


Fig5.10: Block Diagram

Approach-Working

The Smart phone is connected to Smart Band through Bluetooth Low Energy (BLE).
Smart Band communicates with the Smart Phone via a specially designed API
Wrist unit collects data from human being using body temperature sensor, pulse rate sensor and switches.
The application continuously monitors the pulse rate, temperature and motion detected by smart band.
Control Unit collects information from smart wrist unit and location co-ordinates from GPS module.
GSM Module will then send the location coordinates and help messages from control unit to the base station from which the messages are forwarded to the nearest police station, relatives and close by public if the incident occurs.

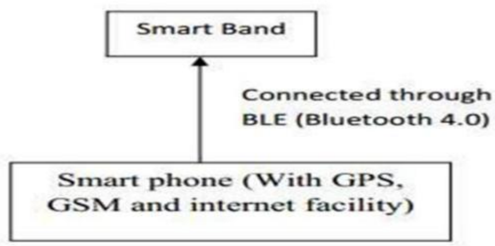


Fig 5.11: Smart Band Module

TEXT / REFERENCE BOOKS

1. S. Salivahanan, N. Suresh Kumar and A. Vallavaraj, “Electronic Devices and Circuits”, TMH, 2nd Edition, 2017.
2. Adel S. Sedra and Kenneth C.Smith, “Microelectronic Circuits”, Oxford University Press, Sixth Edition, 2009.
3. Behzad Razavi, “Fundamentals of Microelectronics”, 1st edition, wiley publication, 2008.
4. Donald. A. Neamen, “Electronic Circuits Analysis and Design”, McGraw Hill Education (India) Private Ltd., 3rd Edition, 2010.
5. Robert L. Boylestad and Louis Nasheresky, ”Electronic Devices and Circuit Theory”, Pearson Education, 11th Edition, 2013.
6. Floyd, “Electronic Devices”, Pearson Education, 9th Edition, 2012.