Smart Health Monitoring and Management Using Internet of Things, Artificial Intelligence with Cloud Based Processing

[1]Prateek Kaushik , [2]Usha Batra, [3]Ashu Gautam

[1]Student, [2]Professor, [3]Assistant Professor
Dept. of Computer Science & Engineering
G D GOENKA UNIVERSITY, Gurugram, India

Abstract: This paper discuss the latest technology which is transforming Health industry in an exceptional way. Internet of things and Artificial Intelligence has transformed Health Industry in an exponential manner. Machine Learning techniques such as supervised machine learning techniques and unsupervised machine learning techniques, Deep Learning such as Auto-Encoder, Restricted Boltzmann Machine and Convolutional Neural Network, Electro-Cardiogram Sensors and Actuators. Such skyrocketing technology applications help monitoring personal health using wearable sensors which offers smart and reliable solutions. With exponential increase of using such technologies increases chances of getting diagnoses early and in real-time.

Keywords: Internet of things, Cloud Platforms, Artificial Intelligence, Supervised machine learning techniques, Unsupervised machine learning techniques, Deep learning, Convolutional Neural Networks, Sensors and Actuators, Microcontrollers and Electro-Cardiogram.

1. INTRODUCTION

According to World Health Organization, it is estimated that average life expectancy has increased by 5% during 2011 till 2015. Although, more than 16,000 children under age 5 died every day because of not having proper access to medication and diagnosis. As per WHO report, more than 65% people across globe are overweight and suffer from obesity. More than 200 million women in the world do not have access to proper Health care services.

Primary reason for using such technology is to reduce traditional way of diagnosing patients which take several number of long hours and Healthcare professional has to be present with the patient to monitor the activities. To get rid of this, Patient-Oriented Approach is adopted. According to United Nation Report, it is predicted that older people population will increase by 2 billion in 2050 and the report also states that 89% of the aged people will live independently and out of this 89%, more than 65% people suffer from at least one chronic disease making it difficult for them to properly take care of themselves.

To trigger down Health problems is to remotely access the Health because it will give real-time information about Heart-Rate, Pulse Rate, ECG, High Blood Pressure, Low Blood Pressure Statistics in real-time because of wearable technology. Internet of Technology is now the world's most powerful communication paradigm because each object in our daily life has become part of the internet and Internet of Technology offers exceptional communication and computing capabilities.

2. INTERNET OF TECHNOLOGY

Internet of Things based monitoring devices enables continuous and spontaneous monitoring of people such as obesity, Pulse Rate, Heart-Rate, Blood Sugar Level, Blood Pressure level and hypertension. In 1999, Kevin Ashton, co-founder of the Auto-ID Centre at the Science Institute of Technology, declared RFID chips that could easily enable 'objects' to communicate over the wireless network.

IoT consist physical devices which can communicate over a network based on wireless technology for example sensors and actuators. A sensor is a physical device which can receive and respond to a signal transmitted in the form of motion, heat, light or chemical reaction. Once it detect the signal, it is able to convert it into analog signal or digital signal. Similarly, a transducer converts one form of energy to another form of energy but transducer do not provide the quantifiable data of conversion whereas sensors converts one form of energy into another form and also provide quantifiable data to measure. Some common examples of sensors are Temperature Sensor, Pulse Rate Sensor, Heart-Rate Sensor, Proximity Sensor and Humidity Sensor. Whereas Actuators are capable of converting one form of energy into mechanical energy or in basic terms it is regarded as 'mover'. It requires electric current, hydraulic fluid pressure or pneumatic pressure which are used to convert any form of signal into mechanical energy.

The most important parameters to assess Health of quality of any patient relies on Blood Pressure Level, Pulse Rate, Heart Beat Rate, Sugar Level and ECG Rate. To monitor all the parameters remotely, doctor will likely to take help of wireless technology such as Wireless Sensor Networks (WSN). It is a group of dedicated sensors for collecting the data and organizing the data and storing them at central location. ZigBee is a type of WSN Technology which is commonly used for Real-time Health Monitoring System.

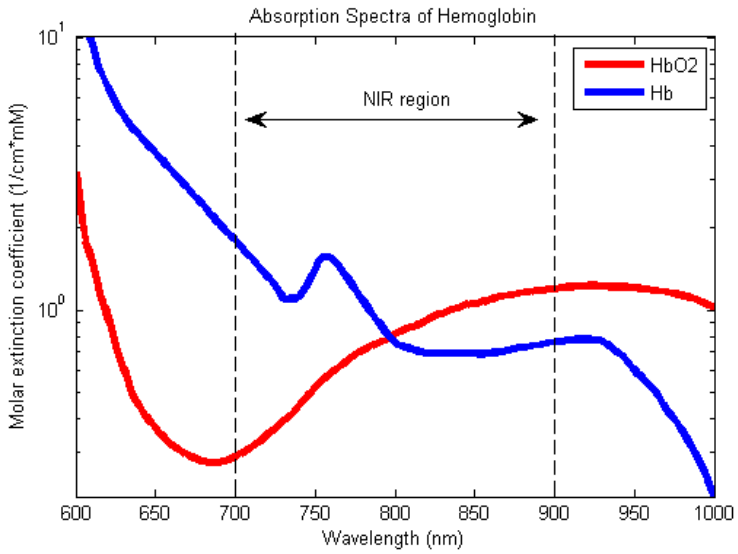
2.1 PHYSICAL SENSORS

Physical sensors such as Pulse Oximeter Sensor which is used to measure the amount of oxygen dissolved in patient's blood on the basis of Haemoglobin and Deoxyhaemoglobin which are useful in the situation when the patient's oxygen level is unstable. Each Pulse Oximeter Sensor consist two light emitting diode in which one emits red light and other emits infrared light. It also consist of photo-detector which measures the intensity of transmitted light at each wavelength and by reading the differences calculated of the blood oxygen, the probe is then placed on a suitable part of the body to work properly for example: fingertip or ear lobe.

2.1.1 METHOD FOR MONITORING OXYGEN SATURATION IN BLOOD USING PULSE OXIMETER SENSOR

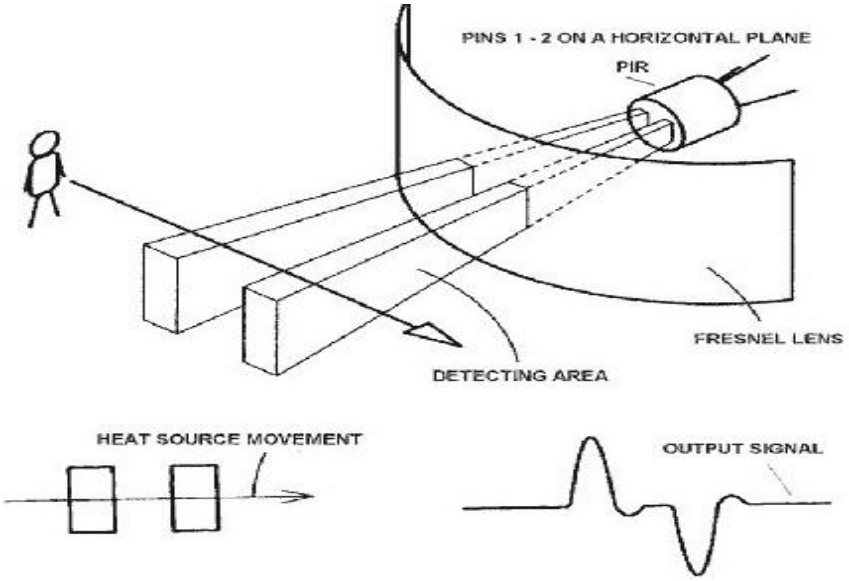
- **TRANSMISSION METHOD:** The light emitting diode, transmitter, receiver and the photo-detector are placed on opposite side of the finger. During this method, most suitable part of the body, usually a fingertip is placed between the LED's and the Photo-Detector. When the fingertip is placed in between, it absorbs light and some part will be absorbed by the photo detector. Now with each heart-beat, the volume of blood flow will increase and in result more light will be absorbed by the fingertip and less light will reach to photo detector.

  Hence, if the graph is plotted of the received light signal, it will consist of peak in between heart beats and trough at each heartbeat. The difference between peak value and trough (bottom) value depicts the blood flow at heart beat. [1]
- **REFLECTANCE METHOD:** The light emitting diode and photo detector are placed on the same side, next to each-other. In this method, fixed light reflection back to the sensor due to fingertip placed on it. More reflection of light will occur if the volume of blood flow increases gradually and reflection will go back to the sensor.
  Hence, if the graph is plotted of the received light signal, it will consist of peaks at each heartbeat and constant reflection will be present in the form of fixed low volume. Difference of the two will result in reflection value due to blood flow at heart beat.



The oxygen content can then be calculated easily by comparing the how much red light is absorbed as compared to infra-red light.

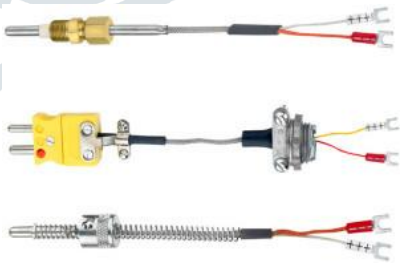
2.1.2 PIR SENSOR: Another type of sensor used for measuring the infrared light is called as PIR Sensor. PIR Sensor or Pyroelectric Sensor works in the view in which every object that has a temperature above absolute zero emit heat energy. That heat energy is emitted in the form of radiation radiating at infrared wavelengths which is invisible to the human eye but can be detected using PIR Motion Detectors. [3]



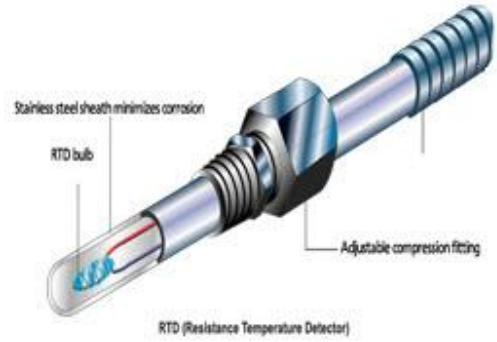
2.1.3 ULTRASONIC SENSOR: This type of sensor is similar to sonar and radar in which radio emits echoes or sound waves emitted by radio or by electronic device to evaluate the attributes of a target by generating high frequency sound waves.

2.1.4 TEMPERATURE SENSOR: It collects the data about temperature from a particular source and converts the data into understandable form for a device. There are following types of temperature sensors are available:[2]

2.1.4.1 THERMOCOUPLES: It is low-cost, self-powered and can be used for long distance. It detects the temperature by measuring change in voltage. It consist of two metals, one is open and second is closed. Metals work on Thermo-Electric Effect Principle, when two unequal metals produce a voltage, then a thermal difference between the two metals is calculated. Thus, the temperature goes up and the output voltage of thermocouple increases significantly.



2.1.4.2 RESISTOR TEMPERATURE DETECTOR: Also known as RTD sensor which is one of the most accurate sensor in which a resistor temperature detector, the resistance is proportional to the temperature. RTD sensor based on different method such as two-wired, three-wired and four-wired method.



2.1.4.3 **THERMISTORS:** It is low-cost, adaptive to environment and is easy to use. It is capable of changing the resistance when the temperature changes. It consist of negative temperature coefficient which means the resistance get decreased if temperature increases.

2.1.4.4 **IR SENSOR:** It sense temperature by emitting Infrared radiation. It is a type of non-contacting sensors for example by holding an IR Sensor in front of the desk, it detects the temperature of the desk by radiation. This type of sensors are classified as of two types one is thermal infrared sensors and second is infrared sensors.

2.4 COMMUNICATION

Internet of Things consist of smart devices which are able to communicate with each other. It enables them to exchange data over the wireless network on the basis of communication protocols such as BLE stands for Bluetooth Low Energy, IPv6 Internet Protocol Version 6, Low Power Wireless Personal Area Networks 6LoWPAN, ZigBee, Z-Wave, Near-field Communication and RFID Radio Frequency Identification.

2.4.1 **BLE:** It is known as Bluetooth Low Energy device which allows devices to communicate without cables while providing high level of security. It is of low-cost and consumes less power for operating. It follows a process known as pairing to exchange the information. During the process, the Bluetooth enabled device can connect with other devices located in close proximity. It uses the Adaptive Frequency Hopping Technology which enables BLE to achieve robust transmission in the noisy environment. BLE technology has successfully reduced the number of channels to 40 2-Mhz wide channels instead of 79 1-Mhz wide channels.

2.4.2 **IPv6:** Internet Protocol Version 6 offers highly scalable address scheme of 128 bits whereas IPv4 offers only 32 bits address scheme. IPv6 is more secure because it can run end-to-end encryption. The integrity-checking and 128bit encryption used for standard component in virtual private network, available for all connections and supported by compatible devices and systems.

2.4.3 **6LoWPAN:** It is the name of internet area IETF. The concept of it is to process the capabilities of low power devices to be able to participate in Internet of Things. It follows encapsulation method for transmitting data over the Personal Area Network IEEE 802.15.4 based networks.

2.4.4 **ZigBee:** ZigBee is interoperable and standardize network and application layers in which the devices belonging to different owners can connect. The ideal operation of ZigBee carried out in Home Automation and Smart Energy because of different

ZigBee devices can be connected. As the number of ZigBee devices increases, communication paths between devices multiply and eliminate the risk of Single-Point Signal Failure.

2.4.5 **Z-Wave:** Z-Wave is a wireless communication protocol used for Home Automation. It consist of two-way communication using mesh topology, which helps in low-cost wireless connectivity to Home Automation. It consist of Smart Home Hub which is a controller connected to the internet. Whenever a Z-Wave smart controller receives command from Smart Home Application on a digital device, it provides the routing of data across the network of connected devices.

2.4.6 **NFC:** Near Field Communication is a short-range wireless connectivity standard which uses magnetic field lines to transmit the data or to make communication between two electronic devices for exchanging the information. It is based on Peer-to-Peer Approach in which the devices have to be in contact or near about 4cms to make the connection and to transfer the data. It consist of three models such as NFC Reader/Writer, NFC Peer-to-Peer and NFC Card Emulation.

2.4.7 **RFID:** Radio Frequency Identification, an automatic technology to identify objects without the line of sight and able to record data. RFID consists of a reading device called a reader which is a powerful device with ample memory and computational resources. It consist two types of tag in which first tag is Passive tag in which they have limited computational capacity, are able to detect collisions and are able to make communication between two devices feasible. Second tag is Active tag which is able to sense the channel and is also able to detect collisions.

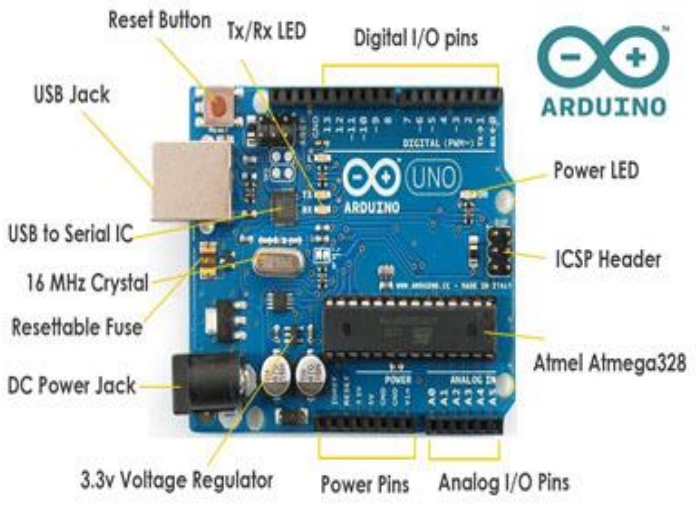
2.5 WIRELESS TRANSCIEVERS

A wireless transceiver works as transmitter and receiver in which an electronic switch allows the transmitter and receiver to be connected to the same network to prevent the transmitter damaging the receiver. Wireless Transceivers are Bluetooth Low Energy Device, Wi-Fi and iBeacons.

2.6 MICROCONTROLLER

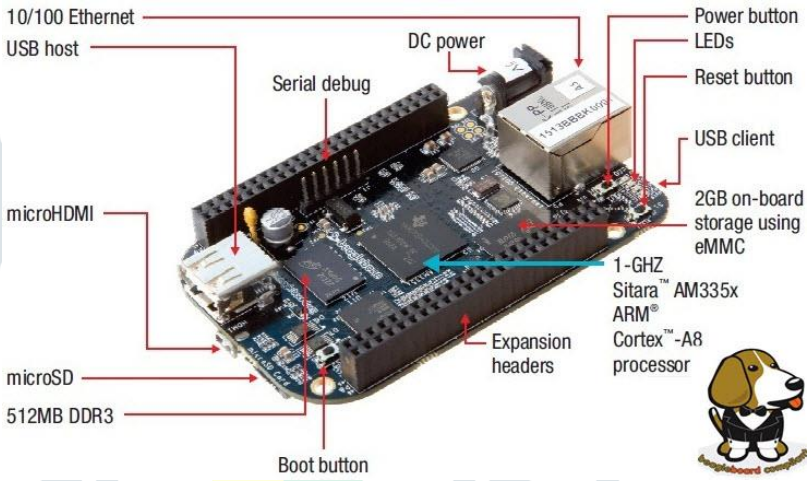
It is a printed circuit board (PCB) with circuitry and hardware board features. It includes Bus type, Memory, Port type, Port Number, Processor Type and Operating System.

2.6.1 **Arduino UNO:** It is the most popular open source electronic prototyping platform for creating electronic applications. It consist of ATmega328P microcontroller, 32KB of Flash memory, 5V Operating voltage, Input voltage, Output voltage, Digital I/O Pins, Analog Input Pins, DC Current per I/O and DC Current for 3.3V Pin.



2.6.2 **Raspberry Pi Development Board:** It is a low-cost development board and it is of credit-card sized computer that can be plugged into TV or monitor and uses a standard mouse and keyboard. It can be used in digital projects maker and at weather stations. It consist of 1.2GHz, 64bit quad-core Processor, 802.11n Wireless LAN, Bluetooth 4.1, Bluetooth Low Energy, 1GB Ram, 4USN Ports, 40GPIO Pins, Full HDMI Port, Combined 3.5mm audio jack and composite video, Camera interface, Display interface, Micro SD Card slot and VideoCore IV 3D graphics core.

2.6.3 **BeagleBoon Black Development Board:** It is one of the most popular open source computer and it comes with built-in wireless networking capability. It is easy to use, low-cost and community supported development platform for embedded application developers. It takes upto 5 minutes after booting in Linux to start the development using a single USB cable. It consist of AM335x 1GHz ARM Cortex-A8 Processor, 512 MB DDR3 RAM, 2GB 8bit eMMC on board flash storage, NEON floating-point accelerator, 2x PRU 32-bit microcontroller and 3D Graphics accelerator.



2.7 Cloud Platforms

Internet of Things consist of various number of cloud platforms for storing data, pre-processing data and analyse the data. It takes the massive amount of data generated through sensors, actuators, applications and store on cloud for initializing the real time access. [6]

2.7.1 **Thingworx:** It is one of the leading Internet of things platform used for Healthcare Industry for storing large amount of data captured through various number of sensors and is stored on cloud. It offers easy connectivity with electronic devices such as RFID and sensors, pre-built gadgets for the dashboard, removes complexity and integrated machine learning.

2.7.2 Microsoft Azure Internet of things Suite: It provides multiple services to Internet of things solutions. It expands profitability and productivity with pre-built connected solutions. It analyses large amounts of processed data. It consist of easy device registration, integrated software like SAP, Oracle and etc., dashboards, visualization tools and real time streaming.

2.7.3 Google Cloud Internet of things Platform: It is among the best platform built for Internet of things to easily connect, store and manage large amount of data captured through sensors. It provides large amount of storage, cuts cost for server maintenance, business through fully protected, intelligent and responsive Internet of things data, capable of analysing large amount of data, efficient and scalable.

2.7.4 IBM Watson Internet of things Platform: It is a powerful platform powered by IBM Bluemix and hybrid cloud PaaS known as Platform as a Service development platform. It provides real-time data exchange, secure communication, cognitive systems and also provides weather data services.

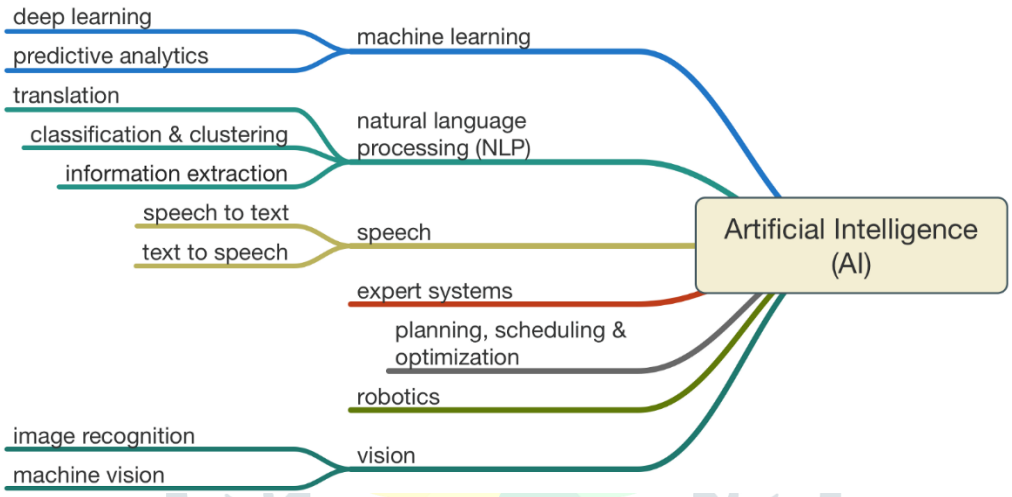
2.7.5 AWM Internet of things Platform: Amazon also provided cloud services for Internet of things applications providing various features like device management, secure gateway for devices, authentication and encryption and device shadow.

2.7.6 Cisco Internet of things Cloud Connect: It helped digital transformation and provides mobility, cloud based suits. It provides easy deployment options for electronic devices, data and voice connectivity, device and IP session report, Billing is customizable and flexible deployment options.

2.7.7 Oracle Internet of things Platform: It provides real-time Internet of Things data analysis which is captured using various sensors. Most important feature is, it provide high-speed messaging in real-time. It is PaaS (Platform as a Service), cloud based platform. It is secure, scalable, provides real-time insights, integrated and provides faster market solutions.

3. ARTIFICIAL INTELLIGENCE

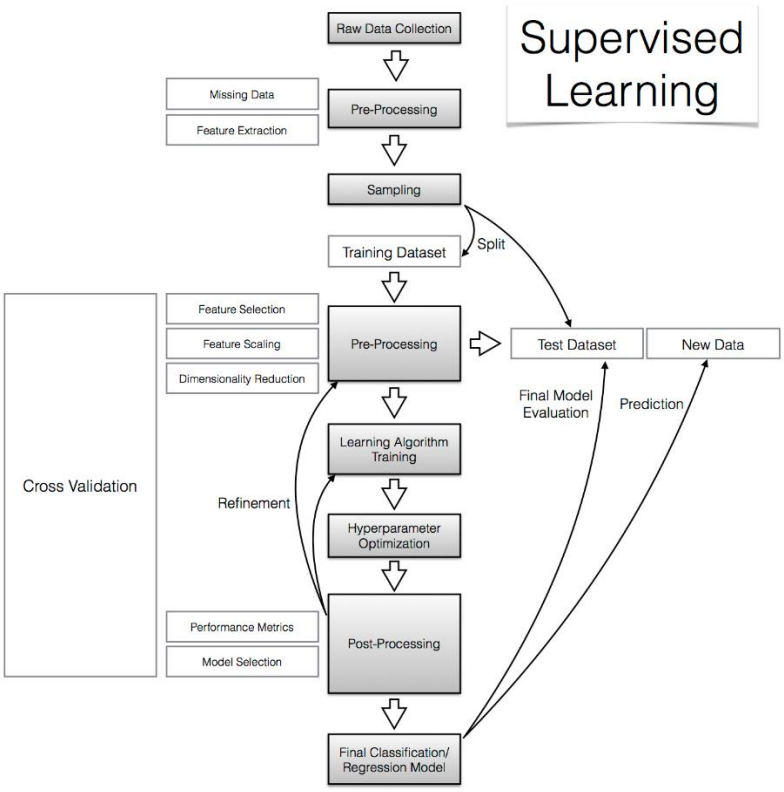
AI roots are found in 1300 CE when Roman Llull's theory of reasoning machine proposed but it became public interest in late 1950s when China invested billions of dollars for the development of AI. Since then other nations also started investing in AI. Now AI is helping Health Industry in every aspect such as real-time monitoring of Pulse rate, Heart beat rate, ECG rate and Blood pressure level etc. AI can be defined as "*the simulation of human intelligence by learning, reasoning and self-correction by machines such as computer systems.*"



AI main aim is to replicate human intelligence which is accomplished by learning and reasoning which is termed as machine learning. Machine learning is the modelling of different situations and improve through experience. Unequalled amount of data is generated through various number of sensors around the world which has made machine learning most essential technology to be used in modern world today. Machine learning techniques are able to analyse hidden insights in the data. Working principle of machine learning is to supply more amount of data and more accurate hidden insights can be analysed. Machine learning is composed of two learning algorithms Supervised Machine Learning Algorithm and Unsupervised Machine Learning Algorithm.

3.1 SUPERVISED MACHINE LEARNING ALGORITHM

The supervised machine learning algorithms are able to classify objects on the basis of their label.



It composed of several classification algorithm and these are as follows

3.1.1 **LINEAR CLASSIFIER:** The goal of supervised machine learning linear classifier is to group similar objects which share similar features values. It is done by combining the features of the objects linearly to find similar characteristics and hence it is the fastest classification classifier. It can work with large number of dimensions commonly known as columns in real world datasets.

3.1.2 **LOGISTIC REGRESSION:** This type of classifier is used to predict to outcomes either true or false. It uses single estimator to process the multinomial logistic regression model. It is able to make outcomes as more detailed and precise. Logistic regression is more suited to define the relationship between categorical variable rather than numerical variable. The major assumptions carried out in logistic regression are is that a variable should be dichotomous in nature, there should be no outliers in the data and there should not be very high multicollinearity between the dependent and independent variables.

3.1.3 **NAIVE BAYESIAN NETWORK:** Naïve Bayes classifier consist of two nodes. Observed node and unobserved node in which observed node act as children and unobserved node act as parent. It is mostly carried out for large-scale computation, decision-tree induction, and standard benchmark datasets. The main disadvantage of using Naïve Bayesian algorithm is the independency problem which is solved using Averaged one-dependency estimator.

3.1.4 **MULTILAYER PERCEPTRON:** It is a type of neural network in which at least three nodes are present such as input layer, hidden layer and output layer. It composed of quadratic equation for solving the convex and non-convex, unconstrained minimization neural network problems. Perceptron classifier is used for learning from a batch of dataset composed of training set and test set after train test split suing scikit library.

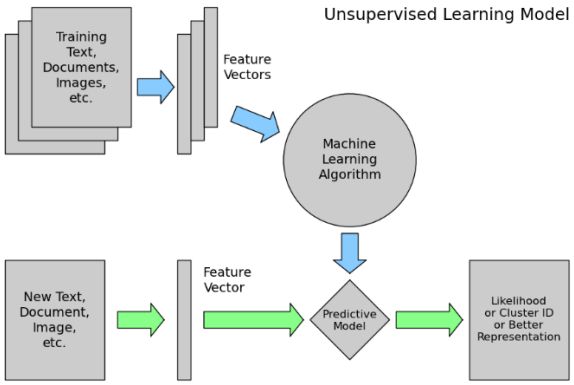
3.1.5 **SUPPORT VECTOR MACHINE:** Support vector machines or SVM is closely similar to multilayer perceptron neural network in which the data classes is split into halves or equal ratios by creating the largest possible distance between the hyperplane and the instances.

3.1.6 **DECISION TREES:** Decision trees is a type of supervised machine learning algorithm which classify objects on the basis of features values and sorts them. It consist several nodes in which one node represents feature or an instance and each branch represents a value that instance is carrying or that can be assumed. It is generally used in data mining techniques for predictive modelling in which mapping of objects variable or instances is done to predict the target value. It can also be called as regression trees because they are used to predict continuous value or target variables

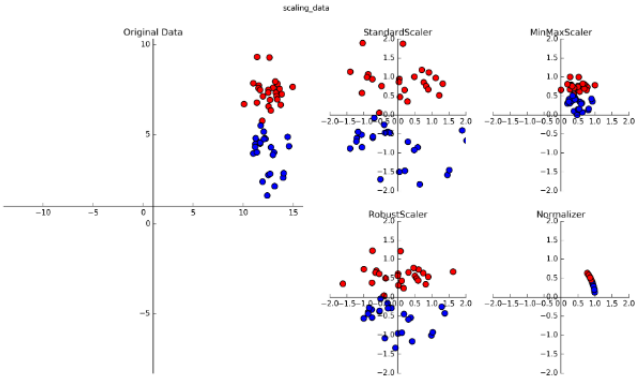
3.1.7 **RANDOM FOREST ALGORITHM:** It merges several decision trees and the combination of decision trees yields more accurate answer. The most important advantage of using random forest algorithm is that it can be applied to classification problems and regression problems simultaneously. Unlike decision tree model which look for the most important feature among all the features by splitting the data, random forest algorithm finds the best feature among all random features.

3.2 UNSUPERVISED MACHINE LEARNING ALGORITHM

Unlike supervised machine learning algorithm in which labels are present to predict the outcome but in unsupervised machine learning algorithm there is no label present for example finding the topics in a document which can appear in the topics discussed in each document, so the task is to extract topics. Unsupervised machine learning algorithm consist of several algorithms discussed below. [7]



3.2.1 **PRE-PROCESSING AND SCALING:** Pre-processing means adjusting the features in a way so that the data visualization is more suitable for algorithms. It can be done by importing "mglearn" library for pre-processing the data. Types of pre-processing discussed below.



3.2.1.1 **STANDARD SCALER:** It ensures that the mean of each feature is zero and variance is one for bringing all the features at same magnitude.

3.2.1.2 **ROBUST SCALER:** It also ensures that the features are at the same magnitude. Additionally, it uses quartiles and median values instead of using mean and variance which often ignore noisy values regarded as outliers which disrupt the accuracy of the algorithm.

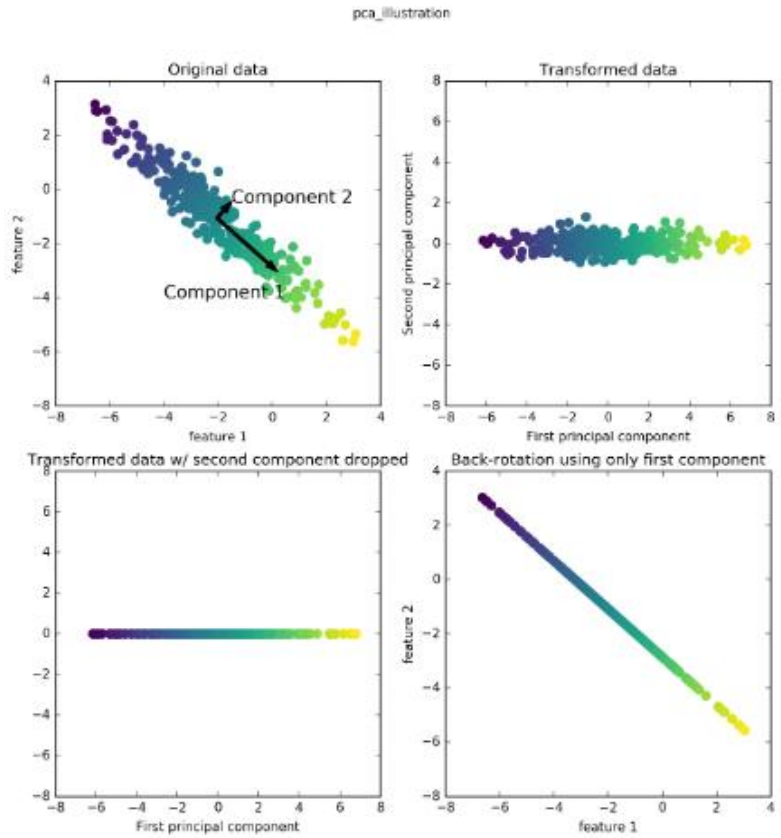
3.2.1.3 **MIN-MAX SCALER:** It shifts the all the features between binary values 0 and 1. Therefore, plotting a 2Dimensional graph indicating data contained in a rectangle like shape between 0 and 1.

3.2.1.4 **NORMALIZER:** It is a type of scaler which is completely different from other scaling techniques because it uses Euclidean distance in which each feature should have Euclidean length of one. This type of normalization is used only the direction of data variables is significant rather than the length of feature vector.

3.2.2 **DIMENSIONALITY REDUCTION:** In real world, datasets contain huge number of dimensions which are difficult and costlier to process for analyses. To reduce the unnecessary dimensions, dimensionality reduction term is coined in which following methods are used.

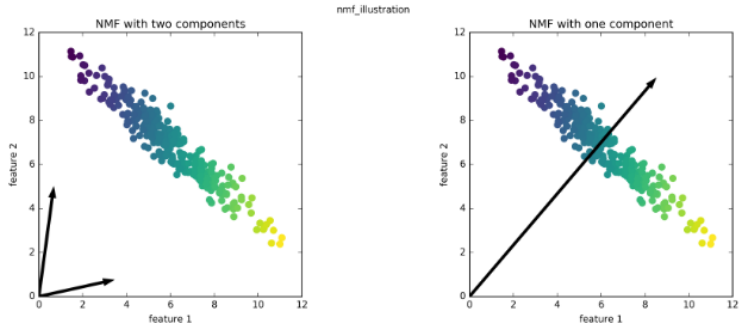
3.2.2.1 **PRINCIPLE COMPONENT ANALYSIS:** In this method is used, dataset is rotated in such a way so that features are statistically uncorrelated. The rotation is done on the basis of selecting subset of features which are able to define the characteristics of the dataset. By importing "mglearn" library, Principle component analyses can be perform using python command.

```
mglearn.plots.plot_pca_illustration()
plt.suptitle("pca_illustration");
```



3.2.2.2 **NON-NEGATIVE MATRIX FACTORIZATION(NMF):** It aims to extract useful features using similar techniques like PCA, unlike PCA in which each data point is a weighted sum of orthogonal components and shows variance of each orthogonal component, in NMF the coefficients and components should be equal to zero or greater than zero that means they should not be negative at all. Due to which, NMF is able to compute sum of non-negative weighted components to identify the original components which makes up the whole dataset. Hence it provides for interpretable results than PCA.

```
mglearn.plots.plot_nmf_illustration()
plt.suptitle("nmf_illustration")
```



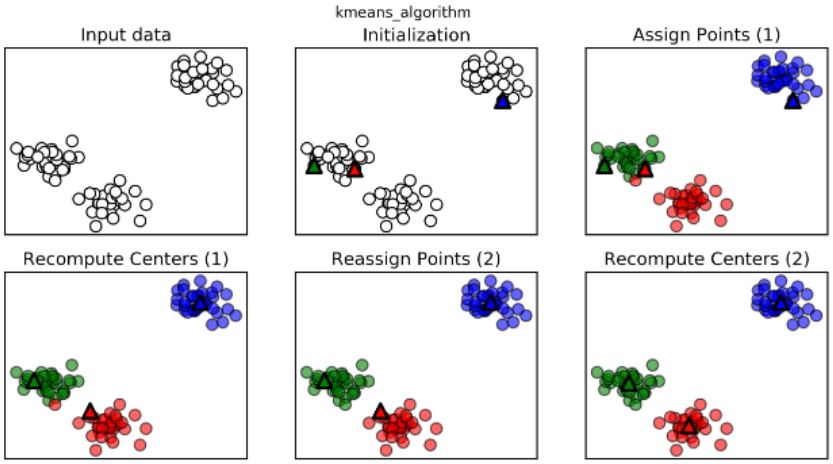
3.2.2.3 **MANIFOLD LEARNING WITH t-SNE:** It is a complex method used for providing better scatter plot visualization. Manifold learning t-SNE algorithm used to compute a new representation of the training data. The only exception is it cannot replicate the test set for visualization because it is able to replicate or transform the training set. It starts with a random 2Dimensional representation for each data point and then align them at best possible distance such that closer points should be close enough to closer points in original space and farther points should be farther from farther points in original space.

3.2.3 **CLUSTERING**

Clustering is a type of unsupervised machine learning technique in which partition of dataset is done in clusters which share similar characteristics. There are following types of clustering techniques available

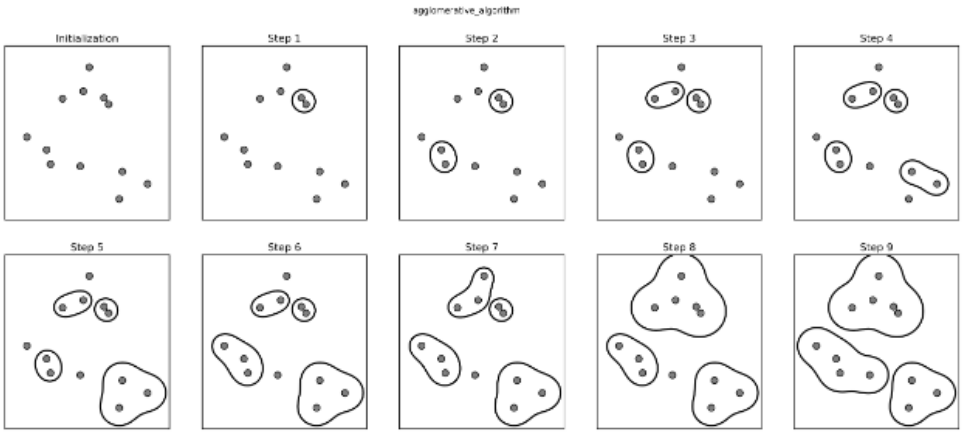
3.2.3.1 **K-MEANS CLUSTERING:** It is one of the simplest algorithm used for clustering data. The working of this algorithm is to assign each data point to the closest cluster and then setting each cluster as them mean of the data points that are assigned to it.

```
mglearn.plots.plot_kmeans_algorithm()
plt.suptitle("kmeans_algorithm");
```



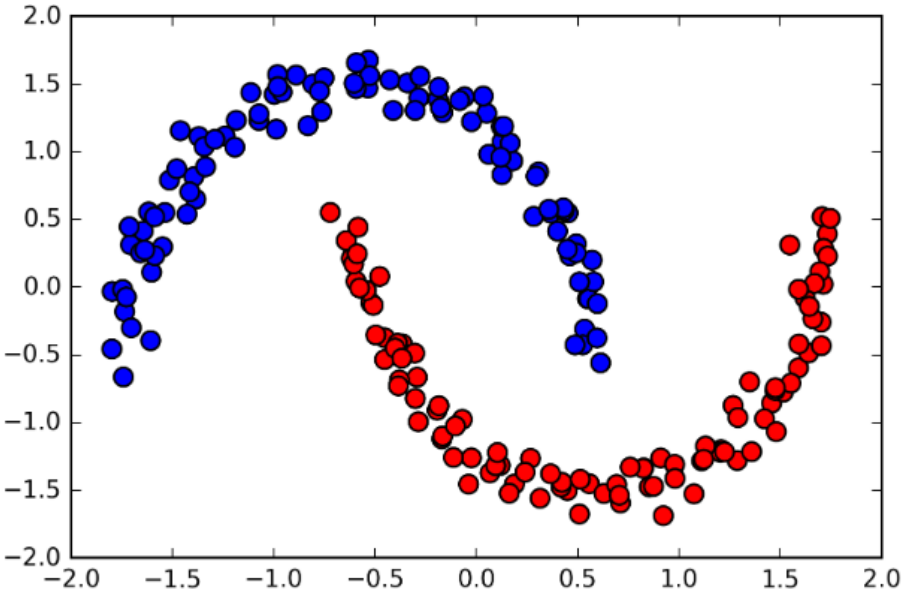
3.2.3.2 **AGGLOMERATIVE CLUSTERING:** Its working rule is similar to KMeans clustering but the only difference is that it merges two similar kind of clusters until the stopping criteria is met which is defined by scikit-learn package.

```
mglearn.plots.plot_agglomerative_algorithm()
plt.suptitle("agglomerative_algorithm");
```



3.2.3.3 **DBSCAN:** It is known as "Density based spatial clustering of applications with noise". In all the previous algorithms, it is require to set the parameter number of clusters but in DBSCAN it is not required because it is able to automatically detect the complex clusters shape. It works best in crowded regions of the feature space in which all data points are close to each other.

```
dbscan = DBSCAN()
clusters = dbscan.fit_predict(X_scaled)
# plot the cluster assignments
plt.scatter(X_scaled[:, 0], X_scaled[:, 1], c=clusters, cmap=mglearn.cm2, s=60)
```



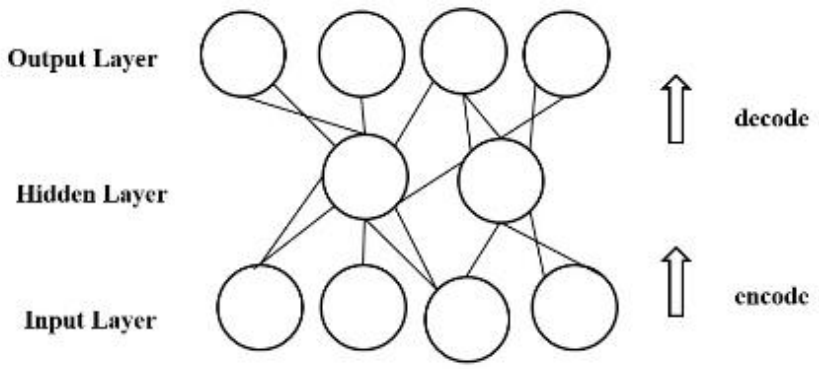
3.3 **DEEP LEARNING FOR MEDICAL SENSORY DATA:** Deep learning is the fastest growing technology of Artificial Intelligence because of its ease of object recognition and speech recognition. Deep learning is gaining popularity because nowadays deployment of low-cost sensors and their connectivity through LAN, WAN and MAN networks. Deep learning models are of following types discussed below.

3.3.1 **AUTO-ENCODER:** It consist of two phases, encoder and decoder which are defined to learn a new representation of the data by trying to reconstruct the input data. Encoder consist of input **x** and hidden transformation **h** using non-linear mapping.

$$\mathbf{h} = \varphi(\mathbf{W}\mathbf{x} + \mathbf{b})$$

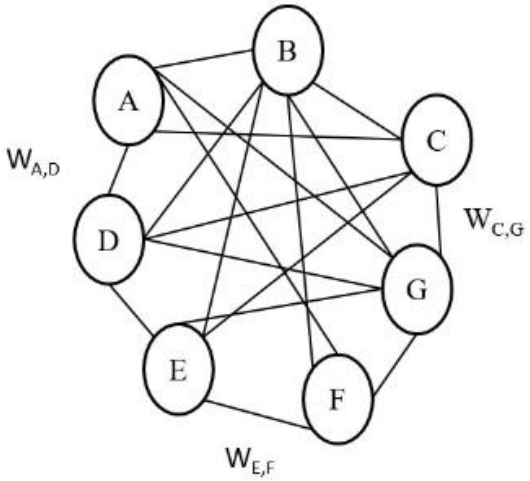
Then decoder uses the same formula for decoding the representation to its original state.

$$\mathbf{z} = \varphi(\mathbf{W}'\mathbf{h} + \mathbf{b}')$$

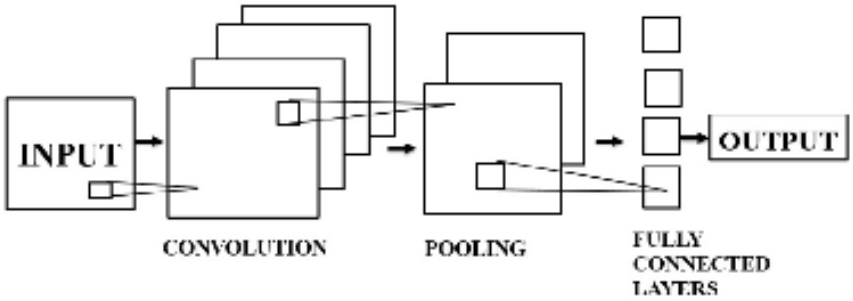


3.3.2 RESTRICTED BOLTZMANN MACHINE: RBM is a two-layer neural network which forms a bipartite graph having symmetric connection in which it is composed of two working units such as visible unit **v** and hidden units **h.**

$$E(\mathbf{v},\mathbf{h};\theta) = -\sum_{i=1}^{I}\sum_{j=1}^{J} w_{ij} v_i h_j - \sum_{i=1}^{I} b_i v_i - \sum_{j=1}^{J} a_j h_j$$



3.3.3 CONVOLUTIONAL NEURAL NETWORK: It was proposed by LeCun for image processing having two main properties which are spatially shared weights and spatial pooling. CNN algorithms accepts 2Dimensional input data for computer vision applications.



3.3.4 MAJOR DEEP LEARNING METHODS NOTATIONS:

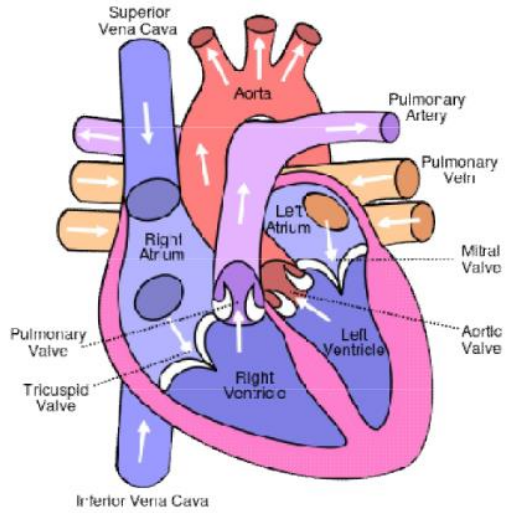
Notations	Definition
x	Samples
y	Outputs
v	Visible vector
h	Hidden vector
q	State vector
W	Matrix of weight vectors
M	Total number of units for the hidden layer
w_{ij}	Weights vector between hidden unit h_j and visible unit v_i
S_j	Binary state of a vector
s_i^q	Binary state assigned to unit i by state vector q
Z	Partition factor
d_j	Biased weights for the j-th hidden units
c_i	Biased weights for the i-th visible units
z_i	Total i-th inputs
v_i	Visible unit i
w_{kj}^2	Weight vector from the k-th unit in the hidden Layer 2 to the j-th output unit
w_{ji}^1	Weight vector from the j-th unit in the hidden Layer 1 to the i-th output unit
W_{ji}^1	Matrix of weights from the j-th unit in the hidden Layer 1 to the i-th output unit
$E(q)$	Energy of a state vector q
σ	activation function
$P_r(q)$	Probability of a state vector q
$E(v,h)$	Energy function with respect to visible and hidden units
$pdf(v,h)$	Probability distribution with respect to visible and hidden units

4. **ECG**

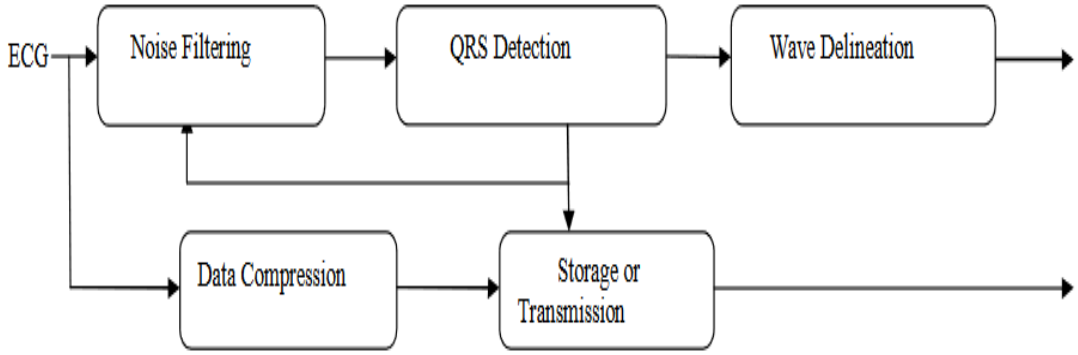
ECG or EKG both stands for electrocardiogram discovered by Willen Einthoven when he was working in Leiden, used a string galvanometer which was invented in 1901. He found that it is more sensitive than capillary electrometer invented in 1897 by French engineer Clement Ader. The heart is composed of four chambers commonly known as two upper chambers and two lower chambers. The upper chambers contains left atria and right atria and the lower chambers contains left ventricles and right ventricles. The purpose of atria is to receive blood from the body and the purpose of right atrium is to receive oxygen-devoid blood from the body and left atrium receives oxygen-rich blood from the lungs.

The right pump receives the blood from the body and supply it to the lungs. Thus heart is controlled via electrical system in which electrical impulse creates a region in which diffusion of calcium ions, sodium ions and potassium ions across the membrane of cells occurs. The impulse is so strong that it transfers ions to atria by which it get squeezed and pump blood from the heart. Hence, the body system regulates this motion so that the entire cardiovascular system can work properly.

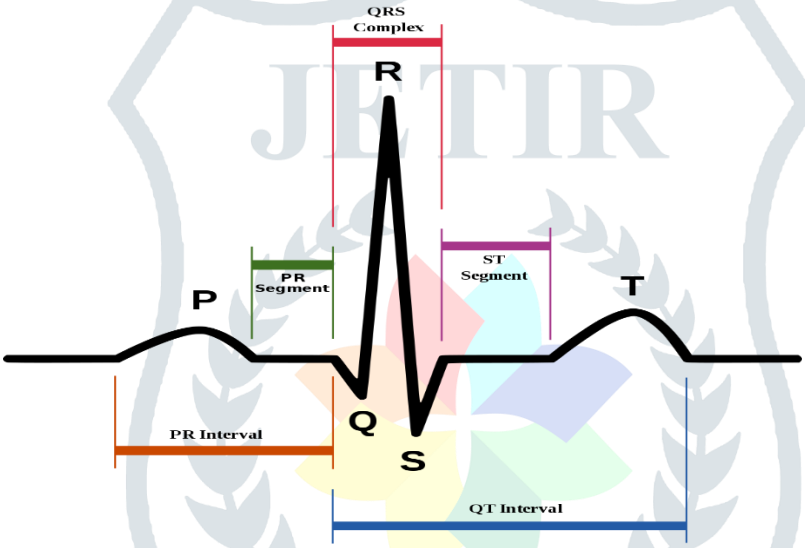
Then comes ECG device which detects the small electrical ions on the skin and amplifier amplifies them when the heart depolarizes at each heartbeat which causes each heart muscle to have a negative charge known as membrane potential.



4.1 **ECG WORKING PRINCIPLE:** When the depolarization happens at each heartbeat in which the negatively charged ions are depolarized by influxing positive charged ions in which each heart muscle gets depolarized. [8]



The whole process is carried out when each small ion rises and fall in the polarization and depolarization process in which it strikes with the voltage between two electrodes placed at either side of the heart which shows wave on a screen.



4.2 ECG MEDICAL DEVICE IMPORTANT PARAMETERS: It consist of RR interval, P-wave, PR interval, PR segment, QRS complex, ST segment, ST interval, QT interval explained below.

4.2.1 **RR INTERVAL:** When the heart rate is between 60bpm and 100bpm, the interval is known as current R wave and the next R wave.

4.2.2 **P-WAVE:** When the depolarization is carried out at each heartbeat, an electrical vector is directed from SA node to the AV node and goes from right atrium to the left atrium which known as P-wave and its time is 80 milliseconds.

4.2.3 **PR-SEGMENT:** The PR segment connects P wave and QRS complex when the electrical activity goes down towards the ventricles which shows flat wave on ECG screen. Its duration is 50 milliseconds to 120 milliseconds.

4.2.4 **PR-INTERVAL:** It is the time taken between the P-wave and and QRS complex in which the time taken by electrical impulse to travel from sinus node through AV node to ventricles. Its duration is 120 milliseconds to 200 millisecods.

4.2.5 **QRS-COMPLEX:** It is the time taken of depolarization at left and right ventricles. It has higher amplitude wave than P-wave. Its duration is 80 milliseconds to 120 milliseconds.

4.2.6 **ST-INTERVAL:** It is the time taken from the J point to the end of T-wave. Its duration is 320 milliseconds.

4.2.7 **ST-SEGMENT:** It connects with QRS complex and T-wave where ST-Segment represents the depolarization at ventricles. Its duration is 80 milliseconds to 120 milliseconds.

4.2.8 **QT-INTERVAL:** The total time taken the simulation of QRS complex to T-wave. If the QT interval is prolonged then sudden death take place. Its duration is 420 milliseconds.

5. CONCLUSION

This research paper described a personalized smart health monitoring device using wireless sensors and latest technology. We are able to detect anomaly in real-time if the patient is in danger. Using ECG and other sensor real-time health monitoring can be done even if the distance between the doctor and patient is thousands of miles away using cloud server as discussed above which increases the chances of getting diagnosis at early stage. Due to the evergrowing population, life expectancy has decreased by a great factor because of lack in resources and emergency aid that should be provided when the patient is in danger.

Smart health monitor system can be used for indoor and outdoor pupose and by using latest algorithms discussed above will greatly improve the efficiency to the existing health monitor systems. By this, the accurate and precise measurement of patient's health parameter can be done inn real-time. In this paper, machine learning and deep learning techniques are discussed which works as a catalyst to improve the perfomance of any health montior system such supervised machine learning algorithms, unsupervised machine learning algorithms, auto-encoder, convolutional neural network and restricted boltzmann machine. Hence, AI and IoT have succesfully solved the problems related to patient's health with outcomes comparable to that human clinicians.

REFERENCES

[1] https://www.researchgate.net/publication/318426723.

[2] https://ieeexplore.ieee.org/document/8389199/all-figures.

[3] https://www.researchgate.net/publication/228343525_A_health_monitoring_

system_using_smart_phones_and_wearable_sensors?enrichId=rgreq-06383924bd6357a336409624c539330c-

XXX&enrichSource=Y292ZXJQYWdlOzIyODM0MzUyNTtBUzoxMDIzNTMxMzA3NTQwNDhAMTQwMTQxNDI

5NjA5Nw%3D%3D&el=1_x_2&_esc=publicationCoverPdf.

[4] https://www.mdpi.com/2076-3417/7/6/596.

[5] https://www.semanticscholar.org/paper/Real-Time-Health-Monitoring-System-on-Wireless-Choudhary-

Gupta/62c157b984d8b687fd0abfd5a822b48658f96808.

[6] https://www.academia.edu/14881042/Health_Monitoring_and_Management_Using_Internet-of

Things_IoT_Sensing_with_Cloud-based_Processing_Opportunities_and_Challenges.

[7]https://www.researchgate.net/publication/322869981_A_Research_Study_on_Unsupervised_Machine_Learning_Alg

orithms_for_Fault_Detection_in_Predictive_Maintenance.

[8] https://www.semanticscholar.org/paper/A-Review-Paper-on-Analysis-of-

Electrocardiograph-(- JoshiTomar/b0b7af84b7500811be28b8a8eb21a1416c780b58