AI HEALTH TELEMETRY SYSTEM

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Abstract: Wearable gadgets are at the center of almost every conversation about the Internet of Medical Things right now. The demand for self-health monitoring and preventive medicine is increasing due to the huge growth in the number of elderly people until 2020. Developed technologies have the potential to cut the overall expenses of prevention and monitoring by a significant amount. This can be accomplished by continuously monitoring health indicators in various regions, with wearable technologies in particular being studied for this purpose. To structure the medical Internet of Things, these wearable gadgets and mobile apps have been efficiently combined with telemedicine and telehealth. This technology is useful in the medical field, such as analyzing different patterns of medical sensors and developing smart edge devices (sensor node). Sensor nodes use the nearest Wi-Fi connection to send data to the server for further analysis and live graph plotting, as well as historical reporting. By sending a notification based on signal pattern analysis from a medical sensor, we can predict the outcomes before they occur (medical sensor issue or medical emergency).

Keywords—Artificial Intelligence (AI), Machine Learning (ML), Deep learning (DL), Internet of Medical Things (IoMT), Internet of Medical Things (IoT)

I. INTRODUCTION

According to surveys conducted over the years, people, particularly those over the age of 20 turn to the internet to research their symptoms and diagnose the health concern. Due to busy work hours and a general fear of hospitals, people avoid consulting doctors for their diagnoses. The World Health Organization (WHO) defines wellness of the human body as a state of physical and mental fitness that is free from diseases and infirmities. Healthcare can be defined as the affair of ensuring that one's health stays stable and well regardless of any intervention from illnesses and injuries. The majority of healthcare centers in the current world resort to using traditional methods of storing the data, i.e., with pen and paper, which is not always accurate and sometimes, leads to miss in the history. To overcome this hiccup, we have come up with a smart healthcare system, which uses the Internet of Things to connect all vital parameter monitoring devices over one network which has a decision support system. The IoT, in this case, refers to a medical system that can transfer data over a network without any human interaction necessary.

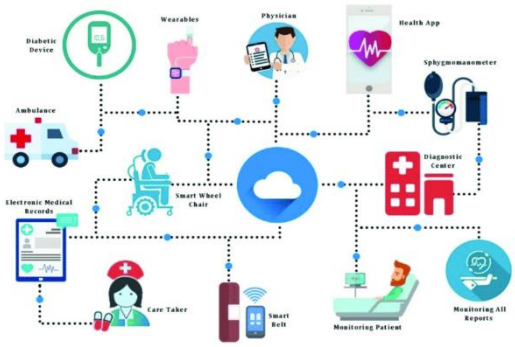

Fig1. Internet of Medical Things (IoMT)

AI in IoT have taken the healthcare business by storm, allowing individuals in remote locations to receive cutting-edge care. The digital healthcare industry is being transformed by machine learning (ML) approaches. In IoT-based remote patient monitoring systems for illness diagnosis and prevention, AI plays a critical role. It is critical that cardiovascular patients' problems be diagnosed as soon as possible in order to maintain their health.
Furthermore, sensors generate a tremendous volume of data in the IoT environment. Because this data contains essential healthcare information, it is critical to study it in order to develop medical technology. In this case, AI and machine learning technologies would be very valuable for data analytics, classification, and prediction of healthcare issues based on this data

AI in Internet of Medical Things

Example of AI in Internet of Medical Things is nothing but applying ML and data analytics in Smart healthcare. This innovation give exact medication that gives state of the art diagnostics and customized medicines with a brief timeframe. AI makes a compelling case for this by offering real-time solutions for determining innovative treatment paths based on previous and real-time data. A

numerous aspects can change healthcare environment using AI-based solutions, this gives automating all activity of take caring a patient like real time data capturing, doctor appointment, lab test, medical prognosis, smart therapy and so on. This AI automation provide better decision making. The NLP uses various algorithms for deriving information from unprocessed data which includes the patient-related notes. Furthermore, machine learning uses historical data to forecast future conditions. To anticipate future conditions, it uses supervised, unsupervised, or reinforced learning.

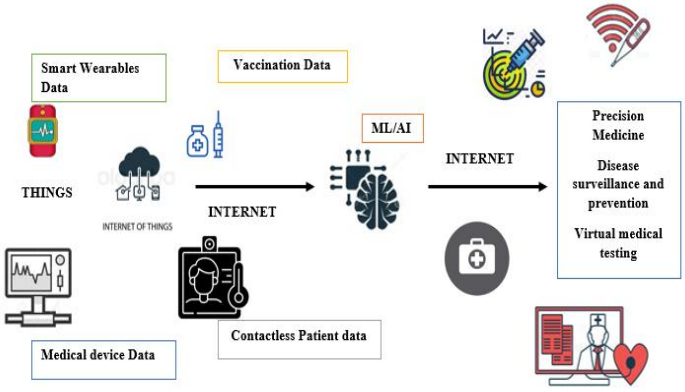

Fig: 2 Basic Architecture of AI Internet of Medical Things

Based on the essential demand for remote patient monitoring and the advantages of using it, the system is design is smart and intelligent remote monitoring system based on telematics. The system uses different bio sensor to acquire signal or data, send data to Edge device, which make use of ML and do edge computing make decision using AI/ML algorithms. The purposed system used to monitor basic parameter of person i.e. oxygen saturation, BP, Heartrate, temperature, cough from remote location.
The information gathered will be saved in a real-time database for future use. With the use of data analytics and machine learning, the edge device can predict based on the collected data. The computed model from machine learning will be given to the edge device after training. The user inputs data in real time to the edge device, which predicts values and explains basic treatment or diagnosis to the user. If the health situation is critical, real-time input values are automatically given to Chabot for diagnosis and video chat with the doctor. In both the android app and the red node dashboard, the system provides a real-time dashboard for Tele-vital data analysis.

II. EXPERMENATAL ANALASIS

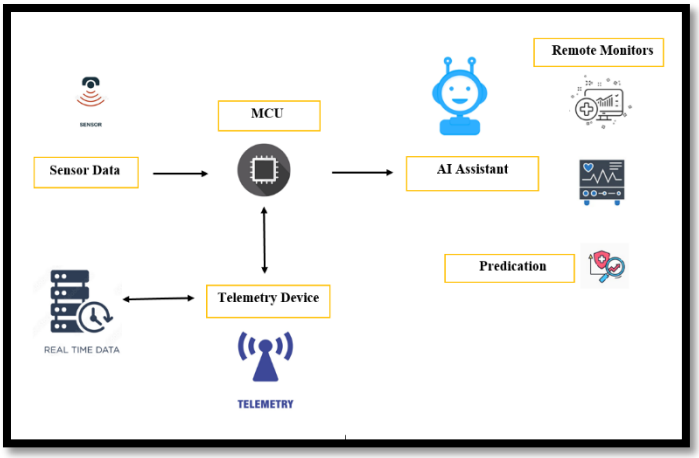

Fig: 3 Block Diagram

A. Basic Device Work Flow

- Block diagram explains a sensor based communication with cloud analysis and AI predication. System uses MCU to record sensor data from rea time sensor.
- A telemetry device is add to MCU for client and server based communication and cloud analytics.
- AI designed such way that the device can predict the user input data using pre trained ML models in edge level.
- System display user vital data in connected app or remote monitor

B. Proposed Methodology

- Biosensor data will be recorded by MCU, in this case MCU is small computing platform called raspberry pi or minicomputer.
- Sensor data are basic vital parameters of person, the data will send from edge device to Real time database through Telemetry Wi-Fi based edge node communication to cloud for analytics and dashboard.
- Input data from user to local AI (edge device) gives prediction and diagnosis report through speech if it important.

- Local AI (raspberry pi) uses Ml Pre trained Model for predication in edge level and gives health status of user based on ML model.
- React based android app will be connected to device, help to provide easy health report.

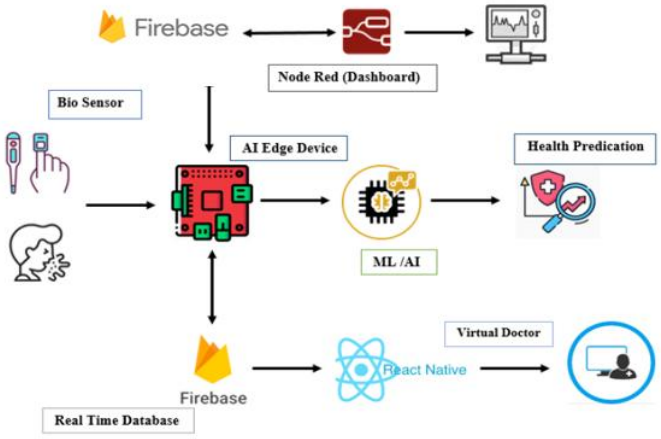

Fig: 4 Work Flow

1.2 Data Collection

- Big data refers to the volume, velocity, and variety of data generated by health care centers at various points in time that contain data relevant to a patient's care, such as demographics, diagnoses, medical procedures, medications, vital signs, immunizations, laboratory results, and radiology images.

- E - Health sources such as sensor devices, streaming machines, and high throughput instruments are becoming increasingly prevalent as data collection technology in the medical field progresses. This healthcare big data is used for a various applications such as diagnosis, drug discovery, precision medicine, disease prediction, and so on.

- In healthcare, big data processing refers to the generation, collection, analysis, and storage of medical data that is too large or complicated to be analyzed using conventional data processing methods.
- The Internet of Things (IoT), Electronic Medical Record/Electronic Health Record (EMR/EHR), which holds the patient's medical history, diagnoses, medications, treatment plans, laboratory test results, genomic sequencing, Medical Imaging, Insurance information, and other medical data, are all examples of big data sources for healthcare.

Fig: 5 Data Source

- The procedure of obtaining and analyzing data from multiple sources is defined as data collection. Data must be amassed and kept in a form that is comprehensible for the existing business problem so that it can be used to develop feasible artificial intelligence (AI) and machine learning solutions.
- In order to solve any supervised machine learning problem, the first step is to collect data. The dataset from which your text classifier is generated is only as good as the dataset from which it is built.
- Data collected from Kaggle, GitHub, Physio net etc.

AI for Healthcare

ML is the method by which advanced computer programs often process massive datasets, potentially from various sources, to discover patterns and associations that are then used to learn an algorithm. When this algorithm is applied to new data, it aims to predict an outcome faster and more accurately than medical experts, free of mistakes caused by the general tendency of human nature and weariness. Training datasets derived from medical imaging devices, electronic medical records, administrative datasets, or wearable biosensors are used to develop (or train) algorithms. The trained algorithms can be used to continuous test new data sets to assess accuracy and reproducibility, and then validated on new, datasets to assess generalizability to new populations and settings.

Hardware

- Raspberry Pi zero
- Arduino Nano BLE 33
- TP4056
- MT3608
- 3.7 V Li Po Battery
- GY-MAX30102 Optical Sensor

Software

- Fire Base
- React Native
- Node Red

III. HARDWARE AND SOFTWARE DESGIN

Power circuit design

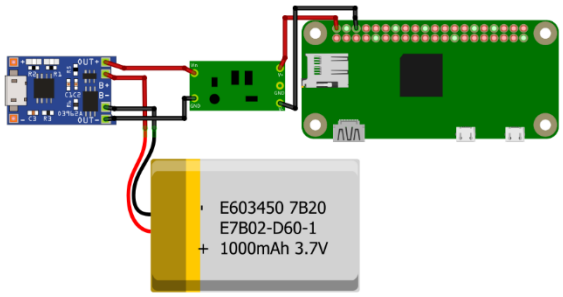

Fig: 6 Power circuit design

A DC/DC converter is required to convert the 3.7V battery voltage to the 5V DC needed to power the Raspberry Pi. This means that while estimating battery life, the power consumption and efficiency of the converter must be taken into account. Efficiency has a multiplicative effect on battery life, so carefully consider your DC/DC converter options and read the datasheet.
You need a battery charge controller if you want to power the Raspberry Pi with a rechargeable battery. Your batteries' incoming current and voltage are controlled by charge controllers. They serve as a safeguard against overcharging and make it possible to securely charge lithium batteries, extending battery life.
A MT3608 3.7V to 5V DC/DC converter that increases your 3.7V to normal 5V is required to resolve this. Take note of the charge controller's output. Connect the input to the converter and the output to the Raspberry Pi's 5V pin. You won't have to worry about not getting the most out of your batteries with this setup. Additionally, because DC/DC converters have built-in circuitry, you don't need to unplug the batteries every time you charge them.
To Calculate Raspberry pi power design:
Consider battery of 1000mAh and current ratings of raspberry pi zero is 180mA
Battery life = battery Capacity/rated current (pi)
Battery life= 1000mAh/180mA=5hr 50mins

MCU and Sensors Circuit Design:

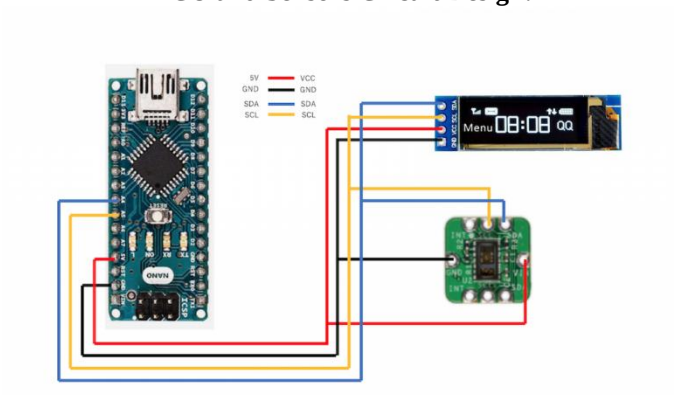

Fig: 7 Main circuit

Arduino Nano BLE 33 sense has a built-in 5 sensor which act as sensor fusion controller with Arm Cortex –M Micro controller. Max30102 which is heart rate sensor, is i2c interface to Arduino Nano BLE 33.

Fig: 8 Bluetooth Communication

BLE is connected to raspberry pi via Bluetooth communication
The Raspberry Pi will receive IoT sensor telemetry from the Arduino through BLE. The sensor telemetry data can then be safely transmitted to the Cloud by the Raspberry Pi using Ethernet or Wi-Fi. According to Bluetooth terminology, the Raspberry Pi serves as the Bluetooth Central device's GATT Client while the Arduino serves as its Bluetooth Peripheral device's GATT Server.

IoT Architecture Design:

BLE will be used by the Raspberry Pi to receive IoT sensor telemetry from the Arduino. The Raspberry Pi can then safely transmit sensor telemetry data to the Cloud via Ethernet or Wi-Fi. According to Bluetooth terminology, the Raspberry Pi serves as the GATT Client for the Bluetooth Central device, while the Arduino serves as the GATT Server for the Bluetooth Peripheral device.

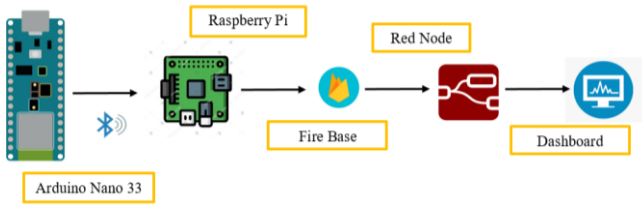

Fig: 9 IoT Architecture Design

For each sensor will have client Characteristic configuration, here we are using python programming for configuring client and server communication. A Python script is executed by the Raspberry Pi. The rasp pi BLE receiver.py script interfaces with BLE devices via Bluez on Linux using the bluepy Python module.
The Arduino Serial Monitor and the terminal output of the Raspberry Pi When the Python script is run, the Raspberry Pi (central device) connects to the Arduino (peripheral device). The Raspberry Pi successfully reads and interprets the Environmental Sensing Service telemetry data in this case it is a Medical vital data
Vita data pushed or set into firebase real time data base, using python script, this may include storing data or monitoring data.
Node red is flow based programming language used to create dashboard and API based communication

ML Implementation on MCU

Data Acquisition:

The vital data is acquired through bio sensors using Pi zero. Data is store in real time data base. Another way of accessing data in very large data base like Kaggle, MIMIC-III, and physio net etc. Acquired vital data to train the ML model for disease predication.

- Data from micro controller unit for real time Data
- Data is Augmented for critical data
- Data is generated using python in google Colab

Data Pre-Processing:

- **Data Cleaning**
- **Data labelling**
- **Data Splitting**

Applying Machine Learning Models:

The module should be trained with ml algorithms to check the health state. Different algorithms were used to train and test the best model. Following the testing, a comparison of ML algorithms is made, and the best model is deployed.

Model Selection and Model Deployment:

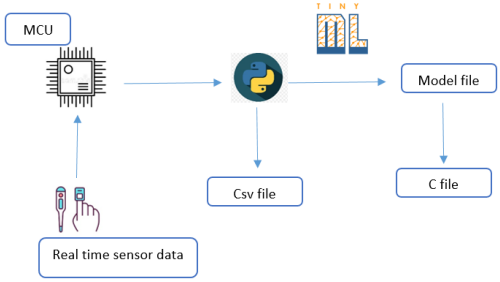

Fig: 10 Data extraction and model selection

Model Selection based on evaluation matric, in my work I used logistic regression and random forest.

Random Forest:

It is ensemble based supervise learning ML algorithm used for classification. In my work I used for binary classification of vital data in real time.

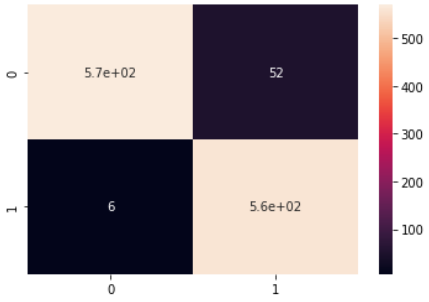

Fig: 11 Confusion matrix of Random Forest

Final score and precision of Random forest

	precision	recall	f1-score	support
0	0.99	0.92	0.95	622
1	0.92	0.99	0.95	566
accuracy			0.95	1188
macro avg	0.95	0.95	0.95	1188
weighted avg	0.95	0.95	0.95	1188

Fig: 10 Final score and precision of Random forest

Logistic regression

Regression based classifier, where it spate the data based on data points in 2d plot or 3d plot for multi dimension.

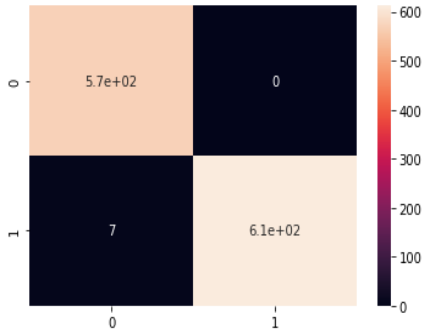

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Fig: 11 Final score and precision of Logistic regression

Comparing both algorithm Random forest gives more accuracy and less false Negative value, therefore Random forest is used.

Model Deployment:

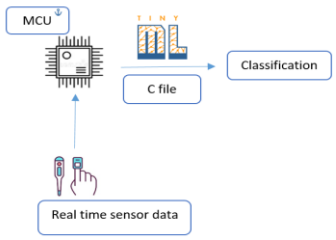

Fig: 12 Model deployment

- Model deployment is done locally after Machine Learning process is done in Goggle Colab. There other cases like we can use AWS IoT and Sage Maker. Model is downloaded into raspberry pi. This process makes Real time predication.
- For now the model is deployed over Arduino Nano BLE 33 MCU, after loading data into train and test data.
- A lib file called micromlgen program me that converts machine learning classifiers to standard C.
- Then we can include this into our program after training data, testing data and saving model as model.h file.
- Later this file is converted into .c file for deployed version.

Design of React app and firebase integration:

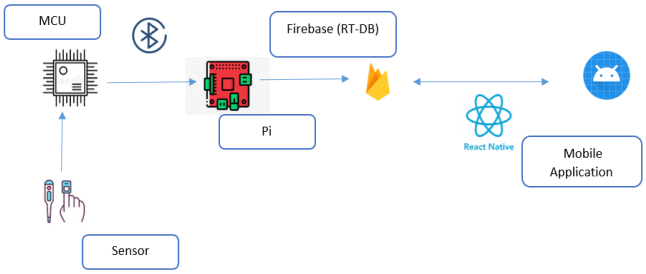

Fig: 13 React App with firebase integration.

- Sensor data is collected by MCU, MCU will have Bluetooth communication with pi for data transfer. Pi act as edge device to push or set data in real time base using http protocol. Data is store in firebase in json format.
- For developing mobile app, mainly need layouts and widgets.
- React native is android and ios app development technology, it is built using java script and it also called JS framework.
- React native work same as client and server model but here server is node.js.
- In app data from firebase is pull to display in widgets.
- Data will transfer from real time data base to react app based server client communication and API data transfer.

IV. WORKING AND RESULTS

Final design of model with power circuit

Fig: 14 Final Model design

React app for real time monitoring of patient with alert notification.

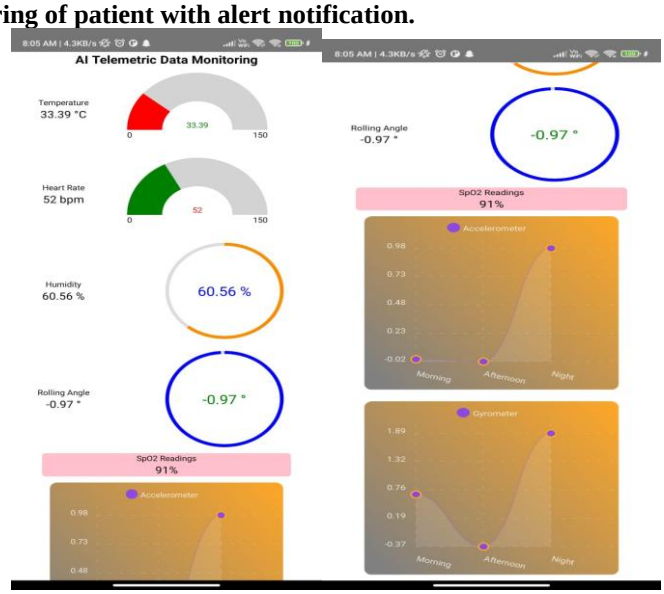

Fig: 15 UI design of Model

Dashboard for vital monitoring in real time

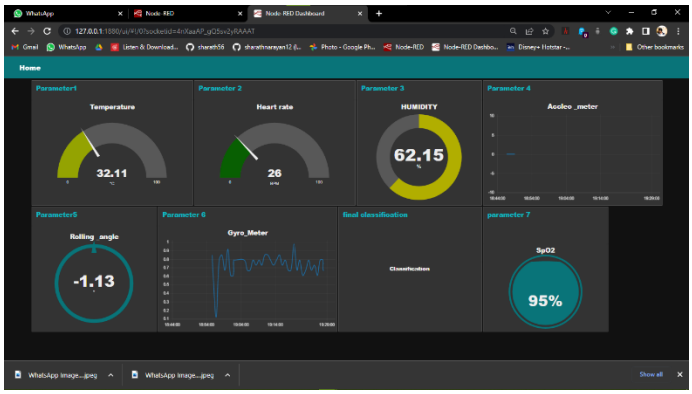

Fig: 16 Dashboard

V. CONCULSION

This main research goal was to create a medical telemetry system for persons with pre-existing diseases, hospital patients, and frequent travelers. Sensor data are the most fundamental health indicators of an individual, and they are sent from edge devices to real-time databases via telemetry Wi-Fi-based edge node connection for analytics and dashboards. Local AI (Raspberry Pi) employs a pre-trained ML model for edge level prediction and reports on the user's health using ML. An Android app built with React will be connected to the device and aid to offer quick health reports. By using this, users gain access to real-time health monitoring at the edge, or remotely. It also provides an ongoing monitoring system for the elderly and those receiving medical care in a hospital.

VI. FUTURE SCOPE

Future improvements to this project can enable a larger range of applications, and we can also enhance the device with the features listed below:

- Wearable Monitoring system in single IC design for edge ML Healthcare.
- We can add some more interesting parameter like Respiratory rate, ECG, EEG, live video tracking for old age people and sensor fusion.
- Cloud based data analysis for Real time data.
- Using Different neural network **Architecture** for edge ML
- Real time telemedicine video calling app with wearable monitoring system

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