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Real-Time Health Diagnosis And Wound Analysis Using Machine Learning

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Abstract: The advancement of smart healthcare systems has led to innovative solutions for real-time patient monitoring and disease detection. This project introduces an IoT-based Health Monitoring System designed to track vital health parameters and detect potential diseases using multiple biosensors and machine learning techniques. The system integrates PPG, DHT11, gas sensors, piezoelectric sensors, flex sensors, MAX30100, and an ESP32 camera module to collect physiological data such as heart rate, temperature, oxygen saturation, sweat analysis, bone health conditions and detects wound.

***Index Terms* - IoT-based healthcare, machine learning, disease detection, biosensors, remote health monitoring, KNN, CNN, Adam optimizer, ThingSpeak, real-time diagnostics.**

I. INTRODUCTION

The integration of embedded systems with healthcare technologies has significantly transformed how patient data is monitored, analyzed, and interpreted. This project focuses on designing a smart health monitoring system that collects various physiological parameters using biomedical sensors and applies machine learning techniques to diagnose potential health conditions. With the rising prevalence of lifestyle-related diseases and the growing need for remote healthcare—particularly in rural or underserved areas—this system aims to provide an affordable and efficient solution for real-time health tracking.The proposed system employs multiple sensors to detect parameters such as heart rate, body temperature, oxygen saturation, sweat levels, bone health, and wound conditions. These values are captured using microcontrollers like ESP32 and NodeMCU and analyzed through classification algorithms such as K-Nearest Neighbors (KNN) and Convolutional Neural Networks (CNN) for disease detection and wound assessment. Additionally, the system is integrated with IoT platforms to enable cloud-based monitoring via ThingSpeak, facilitating telemedicine applications where healthcare professionals can remotely monitor and respond to patient conditions.

II. LITERATURE SURVEY

Sonner, Z. et al., 2022 – Research on Noninvasive Multiplexed Sweat Sensor Platform for Simultaneous Monitoring of Metabolic Markers
Developed a wearable sensor patch capable of detecting multiple metabolic markers in sweat, including **glucose and lactate**, using electrochemical sensing. Demonstrated the feasibility of continuous monitoring for health and fitness applications.

Bandodkar, A.J. et al., 2022 – Development of Machine Learning-enabled Wearable Sensing for Personalized Health and Disease Management
Presented a wearable sweat-sensing platform integrated with **machine learning algorithms** for real-time

detection and prediction of physiological and pathological conditions. Highlighted the potential of personalized health monitoring and disease management.

Jia, W. et al., 2021 – Sweat-based Wearable Chemical Sensing Systems: A Review Provided a comprehensive review of sweat-based chemical sensing systems, focusing on sensor technologies, integration strategies, and disease detection applications. Emphasized the critical role of **machine learning** in data analysis and interpretation.

Lee, H. et al., 2018 – A Wearable and Highly Sensitive Pressure Sensor with Ultrathin Gold Nanowires Developed a flexible and highly sensitive pressure sensor for sweat analysis, capable of detecting subtle compositional changes related to health conditions. Demonstrated potential applications in early disease detection, such as **diabetes** and **dehydration**.

Kim, J. et al., 2017 – Deep Learning-enabled Smart Garment for Wearable Physiological Monitoring Proposed a smart garment integrated with **deep learning algorithms** for continuous monitoring of physiological parameters, including sweat composition. Showcased the effectiveness of AI in identifying disease-related patterns for early detection and preventive care

III. PROPOSED METHODOLOGY

Our project envisions the development of a smart, non-invasive health monitoring system that utilizes a fusion of multiple biomedical sensors and embedded systems to detect wound conditions and multiple disease markers from sweat and vital parameters. The system is designed to monitor parameters such as glucose levels, sodium levels, body temperature, oxygen saturation, heart rate, sweat pH, joint movement, pressure/stress, and wound condition — all without the need for invasive procedures

BLOCK DIAGRAM

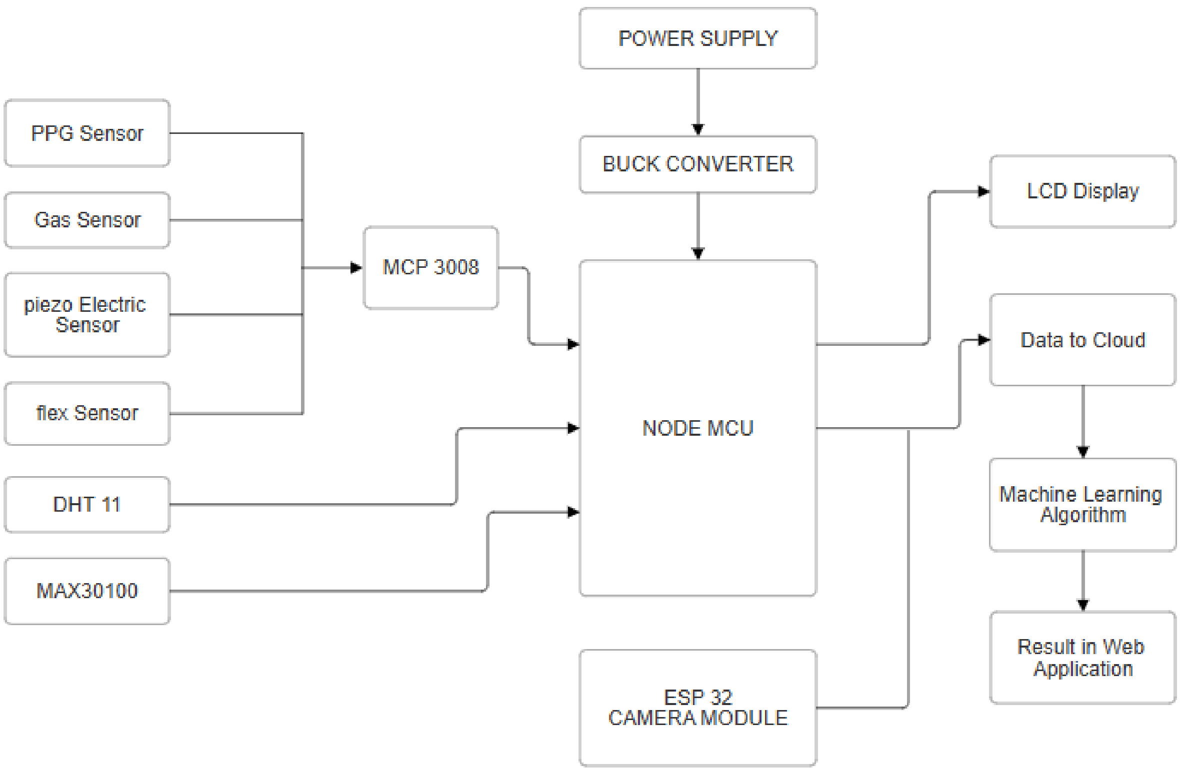

Fig 1. Block diagram

BLOCK DIAGRAM EXPLANATION

1. The core of our system will be an embedded computing platform that seamlessly collects data from these sensors in real-time, ensuring continuous and accurate measurements of glucose, hemoglobin, and sodium levels. Advanced signal processing and data analysis algorithms will be employed to provide users with precise health insights.
2. User interaction will be facilitated through an intuitive and user-friendly interface, allowing individuals to view real-time data, historical trends, and receive personalized alerts and recommendations. Moreover, machine learning techniques will be integrated to adapt the system to individual user profiles, enhancing measurement accuracy over time.
3. The system collects real-time data from multiple biomedical sensors including MAX30100, DHT11, pH sensor, gas sensor, flex sensor, piezoelectric sensor, and IR sensor.
4. The ESP32-CAM captures wound images to analyze healing stages using convolutional neural networks (CNN).
5. The NodeMCU microcontroller acts as the central processing unit, gathering data from all sensors and performing initial processing.
6. MCP3008 ADC is used to convert analog signals from sensors like pH and piezoelectric into digital form for the microcontroller to process.
7. The collected data is sent to a local machine or cloud where it undergoes preprocessing and feature extraction.
8. Machine learning models like KNN are used for classifying health conditions based on sensor data.
9. CNN is used for wound detection and classification based on images from the ESP32-CAM.
10. The system displays real-time vital signs and diagnostic results on an LCD display.
11. Wi-Fi connectivity via NodeMCU enables real-time data upload to the ThingSpeak cloud platform.
12. Users and medical professionals can remotely access health reports and trends through cloud visualization.
13. The system ensures continuous health monitoring with a user-friendly design and non-invasive method.
14. It helps in early detection of diseases such as diabetes, dehydration, infection, and skin-related issues.
15. The integration of sensors, embedded hardware, and machine learning enables accurate and personalized health monitoring.

ESP8266 MICROCONTROLLER

The ESP8266 is a popular and widely used microcontroller developed by Espress if Systems.It is known for its low cost, low power consumption and built in wi-fi connectivity making it ideal for IoT projects. The ESP8266 Microcontroller integratesa powerful 32 bit tensilica.L106 RISC processor which works at clock speed of 80MHz.

HARDWARE REQUIREMENTS

Microcontroller :

It is powered by a 32-bit Tensilica L106 microcontroller running at80 MHz (or higher speeds, depending on the version).

Wi-Fi Connectivity: The ESP8266 has built-in Wi-Fi capabilities, allowing it toconnect to wireless networks and communicate with other devices over the internet. GPIO Pins: It has several General-Purpose Input/Output (GPIO) pins, which can beused to interface with various sensors, actuators, and other electronic components.

Serial Communication :

The ESP8266 supports serial communication, which enablesit to communicate with other devices using protocols such as UART, SPI, and I2C.

Programming :

The ESP8266 can be programmed using a variety of programminglanguages and frameworks, including Arduino IDE, Micro Python, and Lua.

MAX 30100 Sensor :

The MAX30100 sensor is a small, low-cost, integrated pulse oximetry and heart-rate monitor module. It's commonly used in wearable devices for health monitoring and fitness tracking. The MAX30100 sensor can measure blood oxygen saturation (SpO2) levels non-invasively by shining red and infrared light into the skin and measuring the amount of light absorbed by oxygenated Fig 2.1 shows the picture of MAX 30100 sensor.

DHT11 (Humidity and Temperature) Sensor :

The **DHT11** is a low-cost digital sensor used to measure **temperature** and **humidity**. It is commonly used in hobby electronics, weather monitoring systems, and embedded system projects like your health monitoring system.

Photolethysmography Sensor :

PPG stands for photoplethysmography, which is a non-invasive method used to detect blood volume changes in the microvascular bed of tissue. PPG sensors are commonly used in wearable devices like fitness trackers and smartwatches to monitor heart rate. They work by shining light into the skin and measuring the amount of light that is absorbed or reflected by blood vessels. This data can then be used to calculate heart rate, blood oxygen levels, and other health-related metrics Fig 2.2 shows the picture of PPG Sensor.

pH Sensor :

The hardware specifications of a pH electrode, which is a critical component in pH measurement systems, are crucial for ensuring accurate and reliable pH measurements. Below, I provide a detailed breakdown of the hardware specifications typically associated with pH electrodes Fig 4.6 shows the Diagram of pH sensor.

Triple Accelerometer:

A triple-axis accelerometer is a MEMS-based sensor that measures acceleration along three perpendicular axes—X, Y, and Z. It works by detecting changes in capacitance caused by the movement of a tiny internal mass when the device experiences motion or gravity. These changes are converted into analog or digital signals representing acceleration in each axis, typically in units of g (gravitational force). The sensor outputs this data through interfaces like I2C or SPI to a microcontroller, enabling applications such as orientation detection, fall detection, motion tracking, and vibration monitoring in embedded systems, smartphones, wearables, and health monitoring devices.

Gas Sensor:

Gas sensors operate on the principle that specific gases or volatile organic compounds (VOCs) are emitted by the human body as a result of metabolic processes. These gases can include acetone, ammonia, nitric oxide, hydrogen, methane, and others, each of which can serve as an indicator of specific health conditions.

Flex Sensor

A flex sensor is a type of sensor that measures the amount of bending or flexing. It is made of a resistive material that changes its resistance value based on how much it is bent. The greater the bend, the higher the resistance. This change can be read by a microcontroller and used to determine the angle of flex.

Piezoelectric Sensors :

Piezoelectric sensors, when integrated with machine learning, provide powerful tools for real-time health monitoring and wound analysis. They allow for non-invasive, continuous tracking of physiological signals such as heartbeat, respiration, and wound status. Machine learning models further enhance these sensors by analyzing complex sensor data to provide actionable insights, such as early detection of infections, predicting wound healing progress, and monitoring overall health. As technology improves, the combination of piezoelectric sensors and machine learning has the potential to revolutionize personalized healthcare and wound management.

SOFTWARE REQUIREMENTS

ARDUINO IDE

Writing, building, and uploading code to practically all Arduino Modules are theprimary uses of the open-source Arduino IDE programme, which was created byArduino.cc. Because it's official Arduino software, code compilation is so simplethat even the average person with no prior technical expertise can get started. Integrated Development Environment, or IDE for short, is a piece of authorised software created by Arduino.cc that is primarily used for authoring, building, anduploading the code in practically all Arduino modules. The official website of Arduino offers an easy way to download and install the open-source software known as the Arduino IDE.

THONNY

Thonny is a new Python IDE for learning and teaching programming that can make program visualization a natural part of the beginners' workflow. Among its prominent features are different ways of stepping through the code, step-by- step expression evaluation, intuitive visualization of the call stack and mode for explaining the concepts of references and heap. It supports educational research by logging user actions for replaying or analyzing the programming process. It is free to use and open for extension.

Thonny IDE is an integrated development environment that brings together the best of both worlds in terms of quality and editability for 3D-aware facial generation. It consists of a 3D-semantics-aware generative model that produces view-consistent, disentangled face images and semantic masks The system also includes a hybrid GAN inversion approach that optimizes latent codes for faithful reconstruction Additionally, Thonny IDE features a canonical editor that enables efficient manipulation of semantic masks and produces high-quality editing results.

Notifications: Users can receive push notifications or emails based on events or sensor readings from their IoT devices.

FLOWCHART SETUP FOR MONITORING OF DISEASE DETECTION AND WOUND ANALYSIS

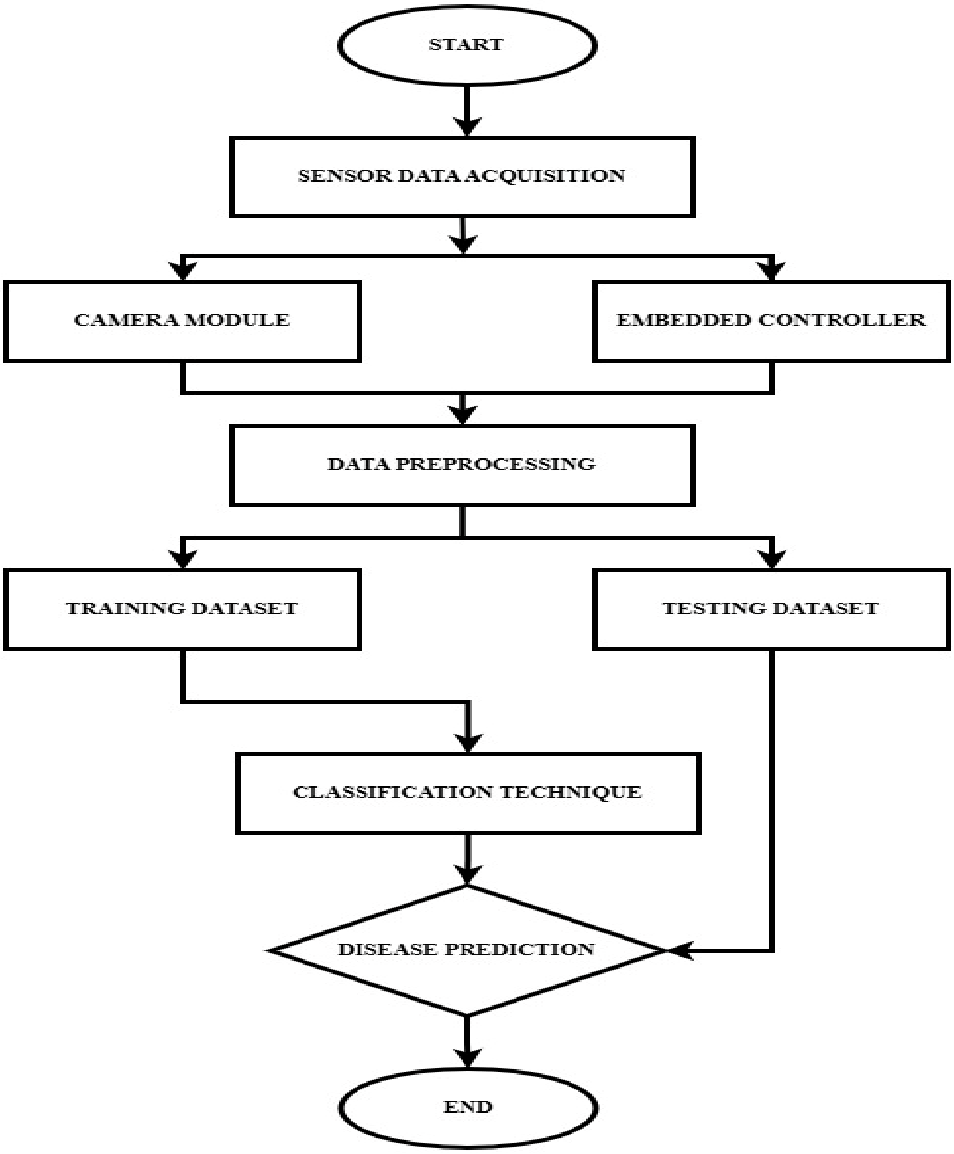

Fig 2.Flow chart for Monitoring Of Disease Detection And Wound Analysis

FLOWCHART EXPLANATION:

1. The flow diagram of the proposed system represents the sequence of operations from data acquisition through biomedical sensors to the classification and display of health conditions using machine learning.
2. It outlines how sensor data is collected, preprocessed, and interpreted by the microcontroller and then analyzed using machine learning models like KNN and CNN for accurate disease prediction and wound detection.
3. The final output is visualized locally on an LCD and remotely on a cloud platform like ThingSpeak.

HARDWARE SETUP:

1. At the core of the system is the ESP8266 Wi-Fi module, which facilitates seamless wireless communication between the hardware and the web application.
2. The MAX30100 sensor is used for measuring blood oxygen saturation (SpO2) and heart rate (BPM), while the DHT11 sensor monitors body temperature and humidity.
3. A PPG (Photoplethysmography) sensor is incorporated to detect blood volume changes.

4. The piezoelectric sensor is used to capture pressure-related variations, and the flex sensor measures joint or limb movements.
5. A gas sensor detects the presence of harmful gases, contributing to environmental health assessment.
6. These components are connected via a microcontroller, with analog values converted using the MCP3008 ADC for compatibility.
7. The ESP8266 transmits the sensor data in real time to the web interface, allowing users to monitor their vital signs continuously and remotely.

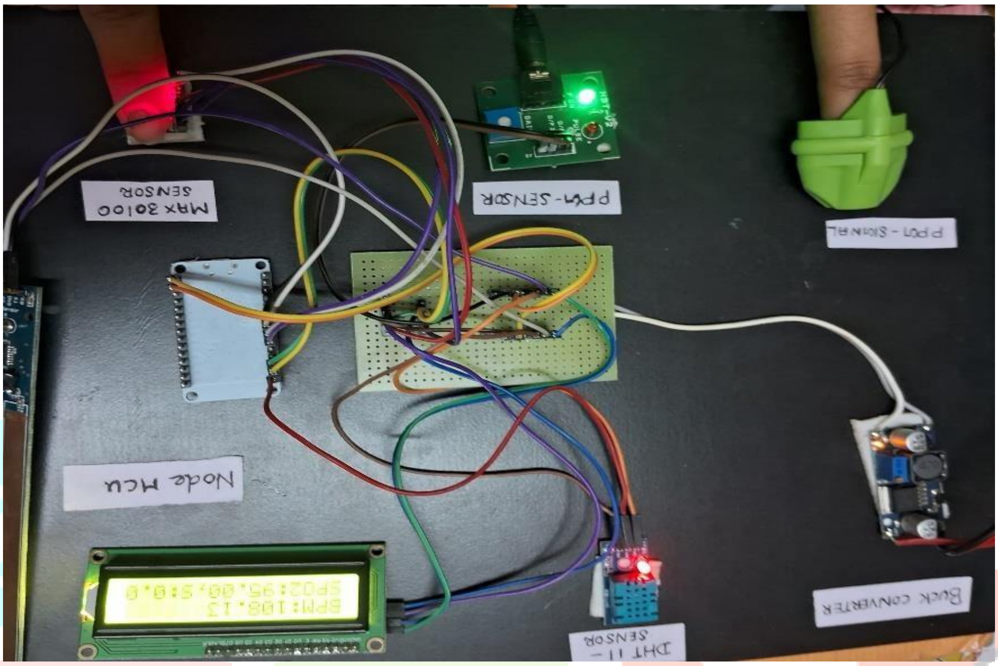

Fig 3. Health Monitoring Setup

RESULT IN WEB APPLICATION:

Thus the Result in Web Application Shows the smart health monitoring system is designed to collect and display real-time physiological data from multiple sensors connected through the ESP8266 and ESP32-CAM modules.

The sensors include a pulse sensor or MAX30100 for measuring BPM (heart rate) and SpO2 (oxygen saturation), DHT11 for temperature monitoring, a PPG sensor for capturing photoplethysmographic signals, a piezoelectric sensor for detecting pressure or vibration, a flex sensor for measuring bending or joint movement, and a gas sensor like MQ-2 for detecting harmful gases

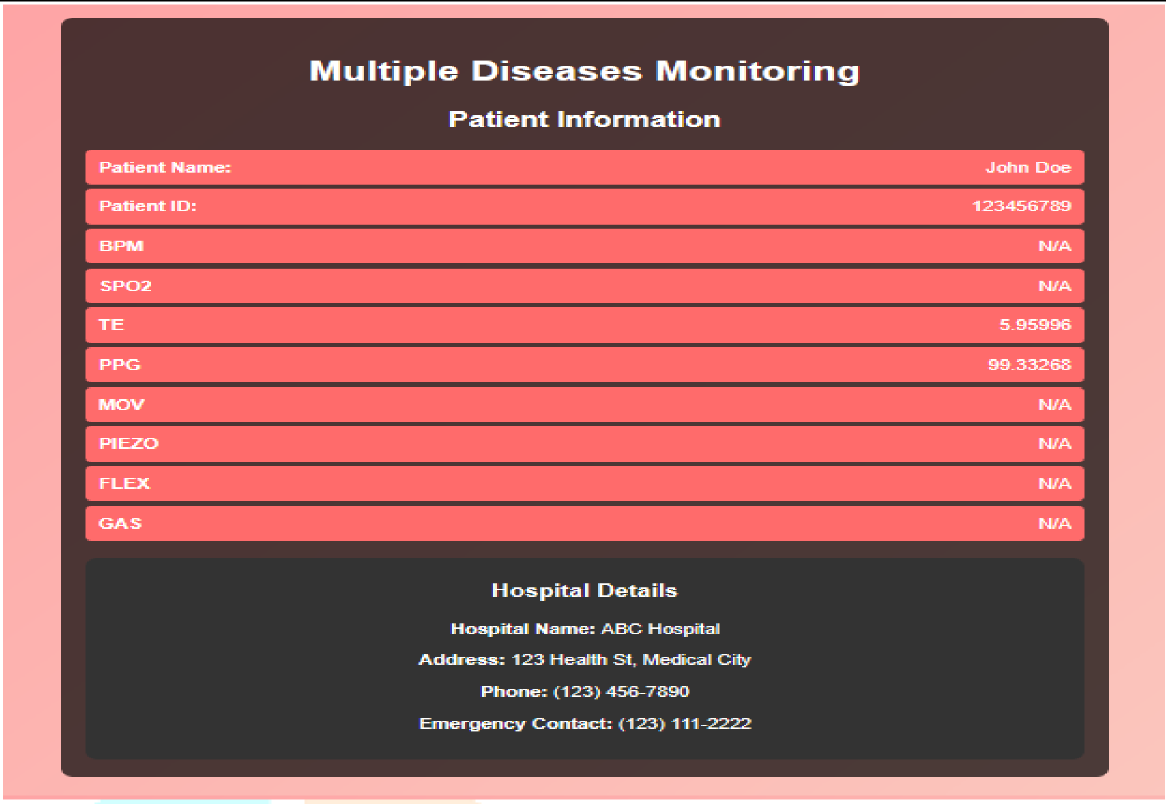

Fig 4.Web Application

IV. CONCLUSION AND FUTURESCOPE

The integration of machine learning with advanced sensing technologies, such as gas sensors, piezoelectric sensors, and other health-monitoring devices, has the potential to revolutionize real-time health diagnosis and wound analysis. The use of these sensors allows for non-invasive, continuous, and accurate monitoring of physiological conditions, enabling early detection of health issues and aiding in the timely intervention required to improve patient outcomes.

Health diagnosis, sensors can monitor respiration, heartbeat, and blood flow, providing critical data for conditions like cardiovascular diseases, respiratory disorders, diabetes, Varicose and Arthritis. Wound analysis applications, on the other hand, leverage sensors to detect pressure changes, vibrations, and chemical changes, which are key indicators of infection, healing progress, or complications like chronic wounds or pressure ulcers. The integration of machine learning algorithms facilitates the analysis of these sensor signals, enabling the prediction of disease onset, the detection of abnormal changes, and the monitoring of recovery. Despite the tremendous advancements, there are still challenges, including sensor sensitivity, data noise, the complexity of model interpretation, and issues related to device comfort, especially in long-term monitoring. Nevertheless, the successful application of ML-based sensor systems for health diagnosis and wound analysis demonstrates a promising future for personalized healthcare and proactive medical care.

EXPECTED DELIVERABLES AND EXPECTED BENEFITS

1. The disease is detected using sweat through machine learning
2. The obtained data will be stored in the cloud
3. Through the graph the parameters were taken and the output is resulted through an Thonny IDE .
4. The patrameters is sensed by an different se3nsors like MAX 30100 and PPG sensors.
5. Manual monitoring of the patient's performance will detected
6. Accurate measurement is obtained

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