Health Monitoring System using IoT with Machine Learning

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***Abstract*—The Internet of Things (IoT) is a young technology that continues to grow with numerous new advancements in the medical and health sectors. Health care is an important part of human life. It helps prevent diseases and improve the quality of life. Today, people don't have the time to visit the hospital for routine checkups and maintain a medical record of their health status. To overcome this, we introduced a system called the Health Monitoring System. It is an IoT framework for ML-integrated healthcare monitoring systems that enables routine and periodic monitoring of patients' health conditions. The patient's data are collected using an IR and blood pressure sensor, compared using the machine learning SVM algorithm, and then it is determined if the patient has diabetes or not.**

***Index Terms*—IoT, ML, SVM Algorithm, IR sensor**

I. Introduction

Human lifestyle is based on several elements, including inconsistent eating patterns, a diet lacking in nutrition, environmental pollution, inadequate exercise, employment that lasts for an extended period, restlessness, and elevated stress levels, all of which contribute to a worsening of human health. The goal of contemporary healthcare visionaries is to deliver superior medical treatment in a more affordable and patient-friendly way to patients everywhere in the world. It is therefore necessary to enhance patient monitoring technologies to increase the effectiveness of patient care. The Internet of Things (IoT) is a young technology that is always evolving and getting better thanks to several new developments in the medical and health fields. Human lifestyle is founded on several elements, such as inconsistent eating patterns, a diet lacking in nutrition, environmental pollution, inadequate exercise, employment that lasts for an extended period of time, restlessness, and elevated stress levels, all of which contribute to a worsening of human health. The goal of contemporary healthcare visionaries is to deliver better treatment to patients anywhere in the world in a more affordable and patient-friendly way. Therefore, it is necessary to enhance patient monitoring equipment in order to increase the effectiveness of patient care. The Internet of Things (IoT) is a network of physical items, or "things," that have been outfitted with sensors, software, and other technologies to enable Internet-based data communication and exchange.

The Internet of Things (IoT) is a young technology that is rapidly developing thanks to several new advancements in the medical and health fields. We have greatly benefited from the development of modern medicine thanks to the IoT health-monitoring platform. The medical industry uses IoT devices extensively. By utilizing cutting-edge technology and resources, IoT Health wearables are tackling new difficulties. Health wearables can be used to occasionally and routinely check on patients who are in or out of the hospital. The objective of this project is to develop an advanced automation system employing machine learning (ML) methods and the E-Healthcare Monitoring System, an IoT Architecture.

II. Problem Definition

Since it is impossible for us to visit the doctor every day for a checkup as well as maintain a proper health record or keep track of our health, inconsistent eating patterns, a diet deficient in nutrition, environmental pollution, a lack of adequate exercise, and other factors all contribute to the current unhealthy human lifestyle. prolonged work, and since it is impossible for us to go to the doctor every day for a checkup. We developed the EHMS system to enable us to monitor our health using an IoT wearable device from any location. The burden of finding time to visit a doctor every day to monitor their health and maintain a healthy lifestyle is also lessened when people use this approach.

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In some cases, people with early signs of diabetes Mellitus cannot go to the hospital for a checkup because of their busy schedules and do not recognize the symptoms. As a result, the person may die silently from kidney disease brought on by uncontrolled diabetes. Therefore, in the suggested system, we do a diabetes prediction to see if the user has diabetes or not. This will assist the person in taking prompt action if they have diabetes and in taking preventative measures before their uncontrolled diabetes results in any serious kidney damage.

III. Existing System

In the existing system, It is much simpler for doctors to identify the underlying causes of sickness and gauge its severity utilizing contemporary algorithms when they employ modern technology tools like the Internet of Things (IoT), machine learning, and Artificial Intelligence in combination with Big Data. The human health problems are tracked in this study project using machine learning techniques. The UCI dataset is used for the machine learning algorithm's initial training and validation.

Utilizing an IoT setup, the testing step involves taking the subject's temperature, blood pressure, and heart rate. In the testing phase, anomalies in the health state are predicted using sensor data gathered using an IoT framework. To calculate the accuracy in prediction %, statistical analysis is done on data gathered into the cloud from IoT devices. The K-Nearest Neighbour surpasses other traditional classifiers according to the findings collected.

IV. Related Works

Before beginning a new study, a literature review establishes familiarity with and understanding of current research on a certain topic. It includes information on current projects, such as their characteristics, problems, and solutions. We picked four articles for the survey: IoT-based Health Monitoring & Automated Predictive System to Confront COVID-19 [1]. Smart-monitor: patient monitoring system for IoT-based healthcare system using deep learning [2]. An Efficient Health Monitoring System with Temperature and Heart Rate Sensors Using IOT [3]. E-Healthcare Monitoring System using IoT with Machine Learning Approaches [4].

A. IoT based Health Monitoring & Automated Predictive System to Confront COVID-19 [1]

The COVID-19 pandemic was initially discovered in December 2019 and was formally recognized as such in March 2020. By September 2020, the virus had spread to 213 nations, infected more than 29,095,917 people, and claimed the lives of 926,824 people. To stop the spread of the infection and deliver medical care remotely, this initiative suggests leveraging the Internet of Medical Things (IoMT). Additionally, AI has been used to identify possible COVID-19 instances in humans. The article suggests a COVID-19 patient health monitoring system based on the Internet of Things (IoT) that can offer real-time biological data and create a communication channel between patients and medical professionals while keeping a physical barrier.

It combines a machine learning (ML) strategy to forecast the severity of the patients, gathers data using Internet of Things (IoT) devices, and validates the approach using real-time data processed on the cloud platform. Pandemic prevention models have been developed, but they underestimate the randomness of getting sick, getting better, and dying.

B. Smart-monitor: patient monitoring system for IoT-based healthcare system using deep learning [2]

The monitoring system based on the Body Sensor Network (BSN) is intended to create a protected healthcare system with prompt support. Monitoring and foreseeing the signal divergence is also crucial. In order to gather a crucial human physiological signal, the suggested IoT-based healthcare system combined a deep learning algorithm with an intelligent sensor network. The central cloud server and the gathered signal have shared a wireless medium for processing and visualization. The system has an intelligent sensor that automatically and continuously collects physiological signals. Wireless data transmission to a cloud server is accomplished by coordinating a Wi-Fi module with a National Instruments myRIO processor. Four main modules make up the suggested learning architecture.

C. An Efficient Health Monitoring System with Temperature and Heart Rate Sensors using IOT [3]

The Internet of Things (IoT) is a technology that makes it possible for objects all around the world to communicate with one another online. Three layers make up this system: Control, Device, and Transport. The Transport layer offers features like high dependability, congestion avoidance, and ensuring packets are received in the order they were delivered, while the Control layer is a security approach. The Device layer is made up of various devices, sensors, and controllers.

D. E-Healthcare Monitoring System using IoT with Machine Learning Approaches [4]

The Internet of Things (IoT) is a young technology that has seen significant advancements in the fields of medicine and health. It is a network of physical objects that have been given software, sensors, and other technological components to allow them to communicate with other systems and devices over the Internet and share data with them. IoT devices are increasingly employed in the medical field, and wearable health devices are rising to the occasion by using new resources and cutting-edge technology. In order to provide patients with better healthcare wherever in the globe in a more practical and patient-friendly way, E-Healthcare Monitoring is an IoT application framework that is being introduced by this project. It proposes an IoT application framework called the E-Healthcare Monitoring solution (EHMS) linked with Machine Learning (ML) techniques in order to construct an innovative automation solution.

The Health Monitoring System, an Internet of Things (IoT) application, can coordinate ongoing examinations for a variety of chronic conditions as well as online patient health monitoring. Patients' data is gathered through IoT health devices in a range of locations, including offices, homes, and hospitals. On the local EHMS server, the instantly saved data are used for data visualization, review analysis, prediction, and decision-making. It can be shared by doctors, inpatients, outpatients, and patient carers. EHMS is capable of providing a range of high-quality and secure services, such as continuing observation, data collection that is helpful, accurate diagnosis analysis, and quick patient care.

V. Proposed System

EHMS is an IoT application that can control periodic checkups and online patient health monitoring for a number of chronic conditions. It employs Internet of Things (IoT) sensors to gather data from patients in a variety of living settings, including hospitals, residences, and workplaces. The server stores the acquired data, and training models are subsequently constructed using machine learning classification methods. The information on the patients that has been gathered is utilized to forecast diabetes as well as the likelihood that uncontrolled diabetes would result in kidney failure.

A. Architecture

The architecture diagram of the system is shown below:

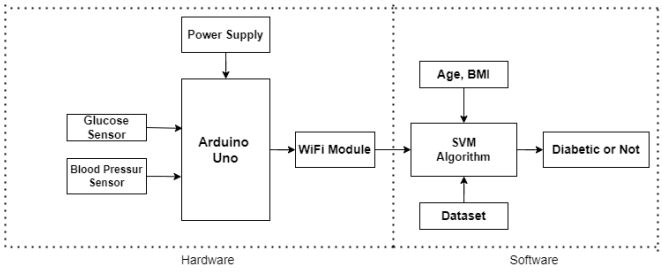

Fig. 1. Architecture

It consists of nine main components, which include a Glucose sensor, Blood pressure sensor, Power supply, Arduino Uno, Wi-Fi module, SVM Algorithm, Age, BMI, Dataset and Diabetic or Not, with 2 main blocks: Hardware and Software.

1) Glucose:- To prevent diabetes complications and organ damage, it's crucial to monitor blood glucose levels. An alternative to the unpleasant and nerve-damaging intrusive way of measuring blood sugar is the non-invasive approach. The primary goal of this endeavor is to create a straightforward, trustworthy, painless, cost-efficient, and portable glucose measuring instrument.
Biological tissues absorb and scatter a light beam as it passes through them. Light scattering occurs in biological tissues because the extracellular fluid's refraction index and the cell membranes' refraction index are out of whack. The amount of light scattered by the tissue varies depending on blood glucose levels. Beer-Lambert The length of the light ray's path and the law stating that the absorbance of light through any solution is inversely proportional to the solution's concentration are both key factors in measuring the absorbance. According to the light transport theory, light attenuation is [5]

$$I = I_0 e^{-\mu}_{eff} L \quad .....(1)$$

where L is the optical path length within the tissue, I_0 is the intensity of incoming light, and I is the intensity of reflected light. The coefficient known as the effective attenuation coefficient, or (μ_{eff}), is what determines how much light is attenuated inside the tissue. which is given by

$$\mu_{eff} = [3\mu_s (\mu_s + \mu_s)]^{1/2} \quad .....(2)$$

The chance of photons being absorbed inside the tissue per unit path length, which is given by, is the definition of the absorption coefficient (μ_a)

$$\mu_a = 2.303 \in C \quad .....(3)$$

Equation 4 provides the reduced scattering coefficient, where (μ_s) is the reduced scattering coefficient, $\in$ is the molar extinction coefficient, and C is the tissue chromophore concentration.

$$\mu_s = \mu_s(1 - g) \quad .....(4)$$

where (μ_s) is the scattering coefficient and g is anisotropy. Therefore, it can be inferred from equations (1) to (4) that (μ_a) relies on the blood glucose level. Thus, the dispersion characteristic of blood reduces as blood glucose content rises.

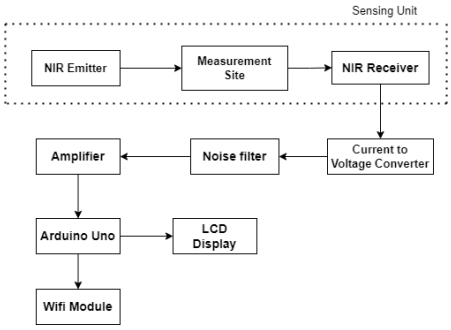

Fig. 2. Block Diagram of Glucose Measuring

2) Blood Pressure:- The MAX30100 from Analogue Devices is an integrated pulse oximeter and heart rate sensor that uses two LEDs, a photodetector, better optics, low-noise analog signal processing, and two LEDs to detect SpO2 and HR readings.
3) Power supply:- Arduino boards require 5V DC voltage from the USB port, which may be obtained from a computer, wall socket adaptor, or mobile battery bank.
4) Arduino Uno:- The ATmega328P serves as the foundation for the Arduino UNO microcontroller board. It

contains a USB port, a power connector, an ICSP header, a 16 MHz ceramic resonator, six analog inputs, fourteen digital input/output pins, and a reset button. It includes 14 optical pins for input and output and 32 kB of flash memory for code storage.

5) Wifi Module:- A Wi-Fi chip that has TCP/IP capability is the ESP8266. Along with other functions, it supports Wi-Fi 802.11 b/g/n at 2.4 GHz. The ESP8266 SDK was used to construct the ESP8266 Wi-Fi library. This module is used to upload the network's cloud with the acquired data.
6) SVM Algorithm:- The support vector machine (SVM) is a data classification technique for predictive analysis that places new data pieces into one of the labeled categories. When it comes to detecting certain diseases or choosing the best course of action, the Support Vector Machine (SVM) algorithm helps to increase accuracy. The tri-sensor system used in the project model measures the patient's heartbeat, pulse rate, and oxygen saturation level.
7) Age:- Age is a basic factor for any disease prediction. In this system, age is used as an input factor for diabetes prediction. In older people recovery from diabetes is quite difficult.
8) BMI:- body mass index is a measure of body fat based on height and weight that applies to adults.BMI in this system is used as an input factor for diabetes prediction. BMI is obtained from $height/(weight)^2$ which is converted into BMI using machine learning algorithms.

B. Data Collection

The daily readings are submitted to doctors, who can then recommend the medications and fitness program that will help the patient live a better life and beat the ailment. In order to improve people's quality of life, the health sector is using the Internet of Things more frequently when it comes to monitoring and caring for patients. A programmable gadget that can perceive and respond to its surroundings is called an Arduino. The innovative method of integrating the Internet of Things into patient monitoring systems is to combine Arduino and the Internet of Things.

The Internet of Things (IoT) concept as a whole is based on wireless networks, gateways, and sensors that change how people connect and access information. The data transmission in this system is handled by a microcontroller. It is interconnected with IoT, which gives doctors and carers information. The patient's health information is kept in the cloud. A doctor can quickly access a patient's health at any time and from any location.

C. Training

It is common practice to separate the original dataset into training and test sets. A piece of the original dataset is used to train our model, which is then evaluated for generalizability to another dataset, commonly referred to as the test set. The training dataset and the test dataset are the two core concepts in machine learning. The test dataset is used to evaluate the model after it has been fitted using the training dataset. There are around 700 datasets used. The remaining 20% is used for testing, leaving 80% for training.

The overall description of the dataset is presented in Table 1. It is produced utilizing a dataset. The more than 700 data sets in the dataset determine the worth of the data.

TABLE I
DESCRIPTION OF DIABETICS DATASET

item name	Normal	Low	Critical
Pregnancies	3 - 5	1 <3	= >6
Glucose	70mg/dL	<70mg/dL	= >70mg/dL
BP	<80mmHg	80mmHg<=100	=>100mmHg
BMI	18.50<25	25<=30	=>30
Age	21-28	28-34	35-50

D. Softwares Used

1) NumPy:-
It is a library for programming languages that provides support for large, multi-dimensional arrays and matrices, as well as a substantial amount of high-level mathematical operations that may be carried out on these arrays. It offers a sizable library of sophisticated mathematical functions that can be used to these arrays and matrices as well as robust data structures that guarantee effective use of arrays and matrices in computations.
2) Pandas:-
It is a Python-based software library with specialized data structures and operations for dealing with time series and mathematical tables that are intended for data manipulation and analysis. Merging is one of the data manipulation methods supported by Pandas.
3) Scikit-learn:-
Python programming language, is a free machine learning library that is used to create statistical and machine learning models. Scikit-learn gives us the ability to create various machine-learning models for clustering, classification, and regression as well as statistical tools for evaluating these models.
4) Flask:- Flask is a well-liked microweb platform for creating Python APIs. It is a basic yet powerful web framework with the ability to scale up to complex applications, making it perfect for getting started quickly. Python is used to create web apps with Flask. A quick debugger is offered, and there is an integrated development server.
5) Pickle:- Pickle allows for flexibility when deserializing objects. You can easily save different variables into a Pickle file and load them back in a different Python session, recovering your data exactly the way it was without having to edit your code.
6) MySQL:- An interface for connecting from Python to a MySQL database server is called MySQL Python/Connector. It is constructed on top of MySQL and implements the Python Database API. The MySQL

server will offer all the services needed to manage your database. Once the server is operational, you may use MySQL Connector/Python to link your Python program to it.

VI. Result

This health monitoring system model consists of a dataset that is trained and tested to give the best results. There are over 700 data points in the dataset. The system used various machine learning algorithms for training and classification, but it gave the best results using the SVM algorithm. This model has an accuracy of around 78%. The trained model is later used to predict if the user has diabetes or not. The predictions on the test dataset are computed by calculating the precision and recall in Table II.

Using basic inputs like age, BMI, and the input that is obtained through the health monitoring device, we can predict the diabetes of a patient. We can say that the persona accuracy measure for a given data set when a person is diabetic is when precision is 0.78 and recall is 0.68. When the person is not diabetic, the precision is 0.84 and the recall is 0.92. This model can make more accurate predictions with visual analysis.

TABLE II
Accuracy measure of SVM Algorithm for a given dataset

	Precision	Recall	Support	F1 Score
Diabetic	0.78	0.68	56	0.72
No Diabetic	0.84	0.92	100	0.88

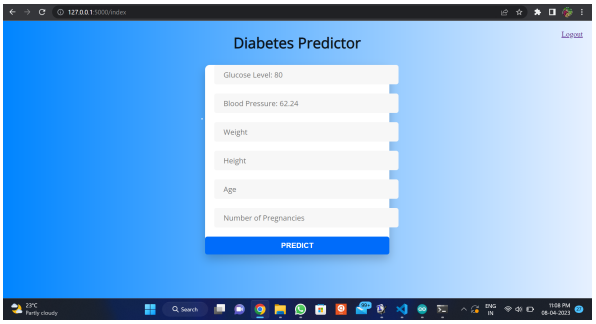

Fig. 3. prediction

Fig.3 Users can often input different personal and health data, such as glucose level, blood pressure, weight, height, age, and number of pregnancies, into a prediction page for a diabetic predictor to determine the likelihood of acquiring diabetes. Users might be asked to enter data into particular fields, and they might need to fill out every field before the prediction can be made. The predictor algorithm will run when all the data has been entered, and based on the user's input, it will reveal the anticipated likelihood of having diabetes. A bigger percentage may be used to represent this data, with a lower percentage suggesting a lower risk of acquiring diabetes.

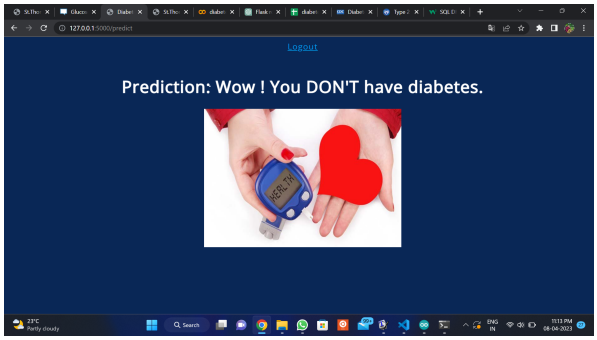

Fig. 4. Result: No diabetic

Fig.4 is a page of results for a diabetic predictor that displays a message but no diabetic prognosis. It is the project's last output page.

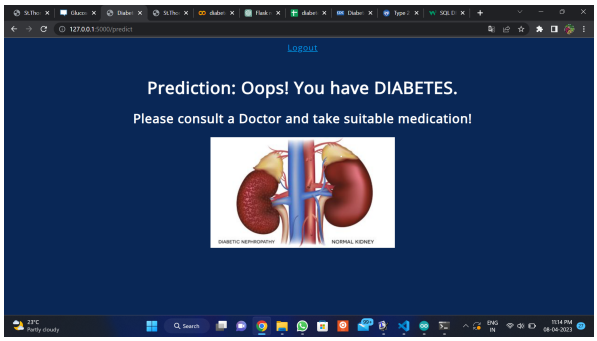

Fig. 5. Result:Diabetic

Fig 5 result page for a diabetic predictor that shows a prediction of diabetes along with an image or icon to encourage the user to seek medical attention and take suitable medication.

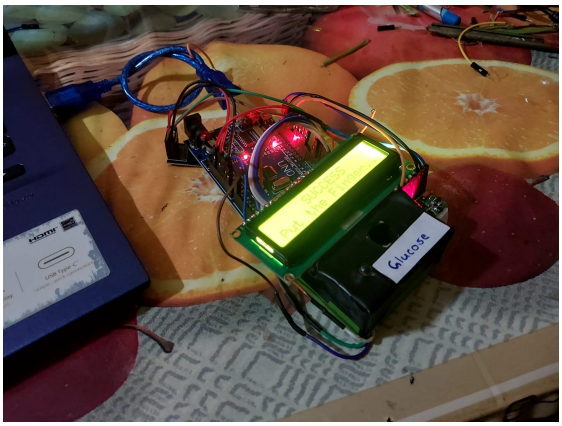

Fig. 6. Hardware Part

In the hardware part Fig.6, We have a glucose sensor, a blood pressure sensor, an Arduino UNO, Wifi module. To measure the glucose level, we have two in-built IR sensors, and to measure blood pressure, we have a Max30100 sensor. Using

an Arduino UNO, we process the data. The WiFi module sends the data that we obtain from the sensors to the website for further prediction.

VII. Conclusion

Most people in this fast-paced culture suffer from a wide range of chronic and nonchronic illnesses. Over a long period, people like academic students, research scholars, doctors, pharmacy chemists, and scientists also found improved solutions to medical problems. The wearable gadget makes it simple for the concerned doctor to track and confirm patient information, which serves as the foundation for studying treatment outcomes. In the event that the patient's abnormal state is discovered during EHMS analysis, the doctor has the option to make the proper judgments in light of the aberrant findings. It is possible to begin treatment right away and to provide the patient with the appropriate medicine settings in an ambulance in a short amount of time.

The Health Management system has difficulties with a variety of health-related services, including daily health alerts, medical appointments, nutrition recommendations, E-Health check-up reports, and many more via SMS services. In order to offer the best possible E-Health services, hospitals can completely customize. Future upgrades will be supported by Health Monitoring systems. We have gathered a collection of diabetes data for a proposed approach from web resources. It is expected that the dataset obtained is identical to the dataset obtained using wearable IoT-based technology. The dataset was run via the SVM machine learning algorithm, which produced an accurate result.

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