



Automated Patient Data Monitoring System using IoT Enabled Wearable Device

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ABSTRACT

The project introduces all-inclusive system of real-time monitoring and prediction of health safety levels of human beings. Sensors are provided in the wristband that sense body parameters such as body temperature, oxygen saturation levels, pulse rate, blood pressure. These collected data streams into a central server that stores and analyses the data. This will help predict health safety levels using various machine learning algorithms and XGBoost, Logistic Regression, K-Nearest Neighbors, etc. It makes use of a database management system for the efficient organization and retrieval of data. The body parameter recordings are stored safely as a database for reference in the future. It uses a microcontroller - Node MCU and Arduino Uno- giving it real time predictions of how the case may look in the days ahead. Furthermore, using the Android application, gives preview prediction as well monitor health levels safety over some periods for both users and doctors. This holistic approach avails insight into causes or triggers of the abnormal health situation and allows a person suffering from the health problem to be in control

1 Problem Statement

This is a health management system seeking to transform the world into a better place by coupling wearable technology with sensor networks and machine learning algorithms based on real-time monitoring and forecasting by mobile applications. In itself, it forms a wristband made up of sensors to make observations of body parameters, which include body temperature, percent oxygen saturation in blood, and pulse rate, and thus all these supply real-time data they forward to a central server for storage and further analysis. Machine learning algorithms include XGBoost, Logistic Regression, and K-Nearest Neighbors. It processes data for predicting the levels of safety from based on historical patterns and correlations. A database management system allows data to be stored and retrieved effectively for the smooth operation of the predictive models. In the microcontroller-based system, Node MCU along with Arduino Uno, real-time predictions are made that give instant feedback regarding levels of health safety. Additionally, an Android application is available for users to and track safety levels over time,



Objective

1. Design a wristband equipped with sensors for measuring physiological parameters, for example, temperature, saturation of oxygen, pulse rate.
2. Real-time collection system of sensor data that collect data by means of wearable bands which are then uploaded to a central server for later storing and analysis
3. Predictive safety levels of health on the collected data using Historic data through - XGBoost; Logistic regression algorithm; K-Nearest Neighbours algorithms
4. Design a database management system of the data which is used to train the machine learning algorithm and real time storage of sensor data.
5. Design microcontroller-based systems, for instance, Node MCU and Arduino Uno, with real-time prediction from the health status safety levels that are provided by the machine learning.
6. Design and implement an Android application for easy viewing and tracking of health safety levels at different times with a comfortable interface for proactive health.
7. Performance and correctness of the proposed system in predicting the health safety levels and actionable insights for a patient and the healthcare provider.
8. Improves the system usability and accessibility so that the affected person can be empowered in taking appropriate steps toward proper management of his/her health issue and quality of life.

2 Existing System

The traditional management system depends on the monitoring of symptoms, clinic visits, and follow-up on treatment medication. Such an approach is neither live patient monitoring nor does it consider the dynamic nature for the safety. The prevailing management systems currently include:

1. Tracking Symptoms: They are usually advised to conduct self-tracking of symptoms and document all flare-ups or changes in their condition by hand. All such data should be submitted to the care providers at follow-up visits.
2. External Triggers: The usual heart patients are made aware of allergens, air pollution, smoke, and weather changes. However, the current monitoring of the environmental parameters is not an easy task.
3. Clinic Visit and Monitoring: A regular visit to the clinic will track the status .health care providers will follow a patient's assessment, revising treatment plans according to a patient's reported symptoms and results from lung function tests. However, they will not occur as often as needed to identify a change in the status.

The current health management depends on self-reporting of patients, regular visits to clinics, and adherence to drugs that provide no real-time insight into the causes of the heart and also do not support a proactive management approach. Therefore, there is an urgent need for innovative solutions that would encompass real-time monitoring, predictive analytics, and intervention based on personalization, which can increase control over the quality of life



3 Proposed System

This new system transforms management in the health sector. It utilizes wearable technology integrated with sensor networks, algorithms of machine learning, mobile applications, and real-time monitoring as well as predicting health safety levels. These parameters monitor several body measures such as body temperature, oxygen saturation levels, pulse rates. The central server receives the real-time data collected from sensors for storage and analysis. Machine learning algorithms used in the system are XGBoost, Logistic Regression, and K-Nearest Neighbors with historical patterns and correlations to predict the safety levels. For this purpose, a database management system has been designed to efficiently organize and retrieve data so that predictive models work effectively. These types of microcontroller-based systems, such as Node MCU and Arduino Uno, make real-time prediction. Through this microcontroller-based system, health safety levels can be viewed real-time. Furthermore, running application support on an android device is provided with prediction visualization together with safety level.

System Requirements

Software Requirements

- Operating System: Windows 10/11
- Programming Language: Python 3.8.x
- IDE : Jupyter Notebook, Arduino IDE

Hardware Requirements

- DTH
- MAX30100
- NODE MCU
- Arduino Uno
- Processor: Intel Family
- Version: Core i5 and Higher
- Hard Disk: 500GB and more
- RAM: 8GB

Hardware Description

DHT

DHT temperature and humidity sensors. DHT sensors are generally finding application in measuring the temperature and humidity levels in the environment. These sensors possess a capacitive humidity sensor and a thermistor for temperature measurement, all compacted into One single chipset with a digital output. Referring to the system that is proposed earlier, stated that there are going to be two DHT sensors placed: one for environmental temperature and humidity; another one, for body temperature. These specific sensors are essential for most applications, where temperature and humidity levels are measured in real time, both indoor and



outdoor where they can affect and more severe symptoms as well. When temperatures and humidity levels are controlled and monitored using DHT sensors, the system will also help patients appreciate situations which could be conducive to attacks and how they can avoid them. They will benefit the most in terms of treatment since they will know the right conditions when they are supposed to manage. Constant body temperature monitoring will also allow managing some deviations of temperature that can signal changes in health which can be helpful for controlling and addressing general health issues.



Figure 1: *DHT Temperature and Humidity Sensor*

MAX30100

The MAX30100 is a highly integrated optical sensor module for heart rate and blood oxygen (SpO₂) measurements. It consists of two LEDs, a photo detector, and low-noise analog signal processing to determine heart rate and SpO₂ from any body part like fingers, wrist, earlobe, or others.

In your proposed system, the MAX30100 sensor is used to measure the oxygen saturation levels and pulse rate. This sensor performs an important function by providing physiological Information and making it possible to track the relevant signs of a patient on a continuous basis. By incorporating the MAX30100

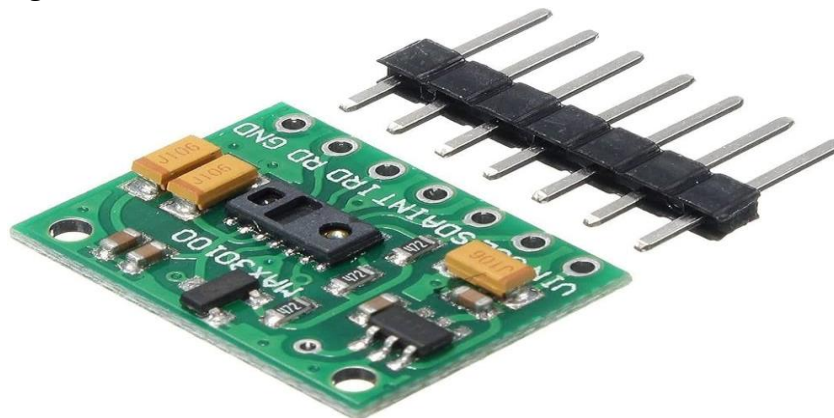


Figure 2: *MAX30100*



NodeMCU

NodeMCU is a well-known open-source hardware platform build around the ESP8266 Wi-Fi chip which permits the development of web-connected everyday devices. An ESP8266 chips is a Wi-Fi microcontroller unit that is integrated, and therefore, ideal for IoT design. NodeMCU boards are mostly used to prototype and manufacture IoT devices as they are quite affordable, their support is quite good and they are easy to use.

In your proposed system NodeMCU microcontrollers are employed to provide an interface for displaying the machine learning prediction of safety levels in real time. These microcontrollers connect the display which is the users interface of the system and the central server where the predictions are made allowing the users to visualize the level of safety instantly.

The use of NodeMCU boards within your system design gives the opportunity to develop a simple and easy-to-use interface for exploring and presenting the primary results of predictive modeling performed with machine learning tools. In this way, patient will be able to control their illness in a timely manner and will be able to use all the tools available to maintain their health.

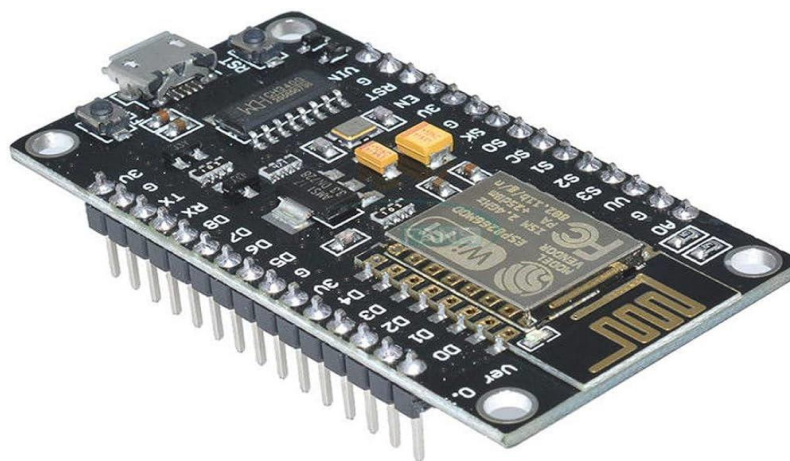


Figure 3: *NodeMCU*

Functional Requirements

- 1 Real-time Data Acquisition: The more wearable physiological sensors the system can obtain real time information with respect to parameters that can be measured such as body temperature and oxygen saturation.
- 2 Data Communication: In addition, in case of sensor data transmission to central processing and analysis server, security measures and protecting data in transit should be preserved.



- 3 Data Analysis: In addition, the system shall include machine learning capabilities that will assess the data obtained in order to formulate health safety levels related to health figures and their relationship from the past to present.
- 4 Feedback provision: In addition, the system should also be able to automatically provide the users with real time information feedback regarding the current health safety status using micro-controller systems or application along with an explanation of the triggers and level of safety health one is at.
- 5 All the data and relevant information must be documented in relation to this prediction system and operation as performed above and made available in a centralized server.
- 6 User Interface: Create intuitive and easy to use interfaces specifically web dashboard and mobile applications that would present sensor data, result of prediction, and history records of patient so that they can make informed decisions.
- 7 Alert Mechanisms: Create a system of alerts to the user in case there are changes in heart rate trigger or any danger level that would need action before the said level is reached.
- 8 Scalability: Construct the system in a way that in the long run once the system has been put in place and operating, more data and more users will be comfortably accommodated without having to down scale users and resources.
- 9 Recovery from Faults: Suggest appropriate ways of ensuring that loss of use of cherished available resources is minimized by identifying issues,

Methodology

The methodology is broken down into a number of stages in order to introduce the real-time monitoring and forecasting of health safety in different levels. Initially, the system comprises a wearable device manufactured in a form of a band with sensors for, inter alia, recording such body parameters as temperature, oxygen saturation level and pulse rate. The aforementioned sensors operate in real-time, as they measure the parameters and relay their readings to the central server where they are stored for future use. Following the acquisition of a clinician sensor's data, the relevant data will be dispatched to another designated central server for safe keeping. However, prior to that stage the data management system, better known as the central database, comes into play and slogs through the various processing steps of the raw data incorporated within (including, but not limited to, outliers detection and deletion, missing values imputation and data normalization) in order to ensure clean datasets that are ready for analysis without cross contamination.

Then, in the final step, advanced techniques such as XGBoost, logistic regression, k-nearest neighbor and others are applied for the analysis of the pre-processed data in order to determine the safety level. These algorithms are trained over historical data to identify the factors leading to certain attributes in the environment, and can do this very reliably and immediately. Also, by coming up with the database management system, it makes it easy for such information to be organized and retrieved, and this also enables easy linkage of the information from the machine



learning models to the data received. As a functional requirements, the user's Android application has been developed in order to enable easy browsing of the forecasts and monitoring the changes in the health safety level overtime.

Algorithm

We are using XGB, LR AND KNN Algorithms for this project

XGBoost (Extreme Gradient Boosting) One of the leading machine learning algorithms for efficiency and accuracy of tasks in predictive modeling makes it is suitable for the proposed safety level prediction system. XGBoost uses a gradient boosting framework iteratively to construct an ensemble of weak predictive models typically comprising decision trees, where at each step, emphasis is on the minimization of the residuals or errors of previous models. This cycle is repeated till a predefined stopping criterion to ensure that an ensemble robust model is achieved. Extensive regularization methods enhance further XGBoost's potential for keeping the complexity in control so as not to overfit, and more importantly, allow parallelization during training in large dataset conditions. In-built facilities in handling missing values coupled with feature importance scores have also made the model extremely flexible and easier to understand. Hence, in the suggested system, XGBoost would be in charge of sensor data analysis to predict the safety level. It will then help inform individuals to take precautionary measures early and to improve their quality of life.

Logistic Regression (LR)

LR is the most straightforward and widely used approach for the problem of two-class classification although, of course, one could apply it even in a multi-class problem. It is easy to apply and still remains a very good predictive model that makes this method worthwhile within the given safety prediction system.

It is a representation of one or more independent variables; that is, features which are related to a binary outcome variable with the logistic function. LR estimates the parameters of the logistic function with maximum likelihood estimation for predicting the probability that a particular observation belongs to a class.

In the context of the proposed system, LR forms the core algorithm for prediction of safety levels based on sensor data gathered from the wearable band. LR can be applied better for understanding the relations between environmental and physiological parameters. Because of its simplicity and interpretability, LR is very applicable to understand the underlying patterns of data and guide decision-making processes in proactive health management.

In that sense, although this algorithm does not capture complicated non-linear relationships well, this can be extremely efficient for computations and has an easy implementation, hence complementing other more advanced techniques in this proposed system, say XGBoost and K-Nearest Neighbors. Overall, the completeness of the approach to a safety prediction system is then contributed to by LR itself by providing for interpretable predictions and actionability toward healthcare professionals of the individuals in question.



K-Nearest Neighbors (KNN)

K-Nearest Neighbor is an extremely basic but highly efficient algorithm for classification and regression under machine learning. In other words, KNN can predict the new data point owing to the classification of its k nearest neighbors that fall mostly in the feature space and the mean of its neighboring data in case of regression.

According to the safety prediction system that is designed, KNN is the most suitable algorithm for predicting the levels of safety due to the analysis of data from the sensors. This will be a very simple yet efficient means of creating and employing models from data for estimation of values by assessing the closeness of the new data points to the existing measurements.

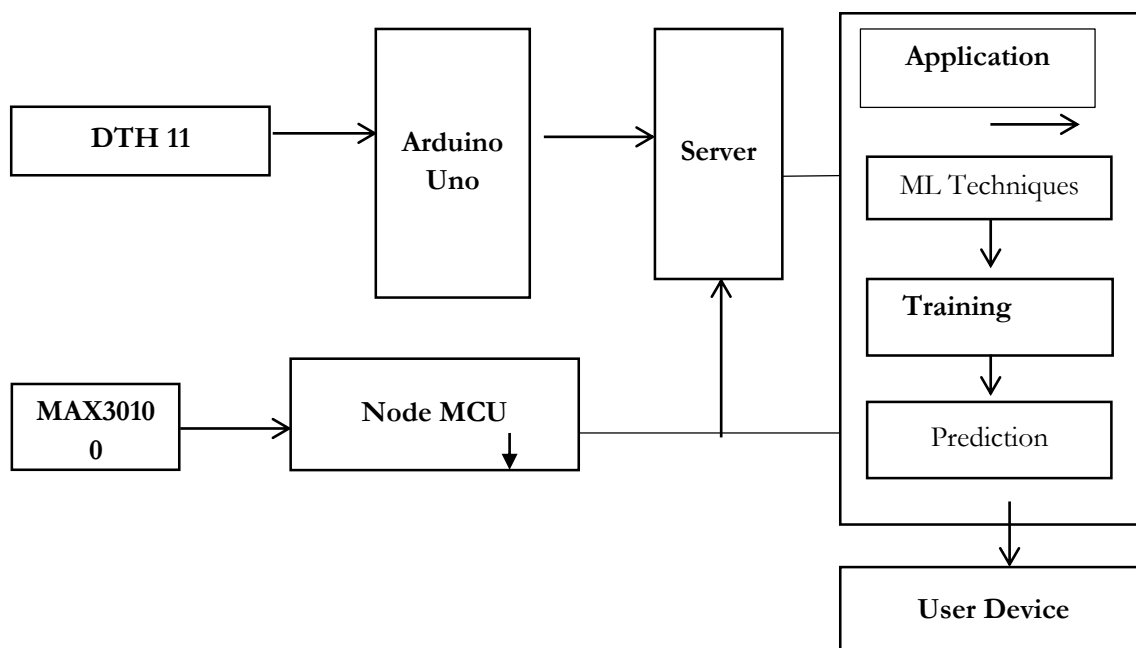
Another notable merit of KNN is that it can fork quite complex decision boundaries with ease. There may be a non-linear relationship within the sensor data outputted from the wearable band. KNN also has the advantage of being less restrictive on

This is particularly useful in a situation where one may not want to assume a parametric distribution for the data, or the distribution bears a lot of irregular features.

On the other hand, KNN is highly sensitive on the number of neighbors considered (k) and the distance measure used to compute the similarities between the points of interest. Because of this performance optimization of the KNN algorithm in the safety prediction system requires proper parameter tuning and adjusting the feature set carefully.

In addition to KNN, this system also explores the use of other algorithms like Logistic Regression and XGBoost which are more direct and intuitive for predicting levels of safety based on sensor outputs. Adding to the overall strategy for managing the conditions, this method is very flexible, quite easy and yet capable of dealing with complex activities.

Block Diagram





4 Results and Discussion

The major goal of this project is to create a health monitoring band that will be worn by patients and can transmit out to measure their vital health parameters once a week. Such data are measured by the smart band that has integrated sensors: temperature, oxygen saturation, blood pressure, and heart rate. Abnormalities are then reported along with the analysis using ML algorithms, which is sent to the patient's doctor by email without delay.

5 Conclusion

In remote healthcare applications, the use of the wearable sensor band provides a satisfactory answer as it enables the doctor to intervene on time and reduce the amount of time a patient has to stay in the hospital. The patient's data is collected, analysed weekly, emails are sent whenever intervention is needed and data is stored in a database

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