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Patient health monitoring using IoT with machine learning

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Abstract - *Health aspects of human being need to be monitored with utmost care and must be treated with appropriate drugs. Several diseases can be reduced by proactive monitoring of one's health. In the recent decades, technological development is at its peak due to which several wearable devices and health monitoring gadgets are available at the market. Even expert doctors find it challenging to estimate the health issues from the symptoms observed from the diseased. Using modern technological tools such as Internet of Things (IoT), machine learning and Artificial Intelligence along with Big data makes the job of physicians much easier in digging out the root cause of disease and predicting its seriousness using modern algorithms. In this research work, the machine learning algorithms are used to monitor the health conditions of the humans. Initial training and validation of machine learning algorithms are performed using the UCI dataset. Testing phase is carried out by collecting heart rate, blood pressure and temperature of the person using IoT setup. Testing phase estimates the prediction of any abnormalities in the health condition from the sensor data collected through the IoT framework. Statistical analysis is performed from data accumulated into the cloud from IoT device to estimate the accuracy in prediction percentage. Also, from the results obtained from the K-Nearest Neighbor outperforms other conventional classifiers.*

Key Words: **Raspberry Pi, Cloud, IoT**

1.INTRODUCTION

The essential part of the life is healthcare. Health care is the maintenance and improvement of health via prevention and diagnosis of diseases. Any ruptures or abnormalities that are present deep beneath the skin can be diagnosed with the help of the diagnostic equipment like CT, MRI, PET, SPECT etc. Also, certain abnormal conditions like heart attack, epilepsy can be detected even before they occur The steady increase in the population and also a unpredictable spread of chronic illness among masses have created a strain on modern health care systems [1], and the demand for resources from hospital beds to doctors and nurses is extremely high [2].Obviously, a solution is required to reduce the pressure on healthcare systems while the maintaining the standard and quality of the health care provided at its optimum level. The Internet of Things (IoT) is a potential solution to curb the pressures on healthcare systems, and has thus been the focus of much recent research [3–7].the occasional monitoring of patients with diabetics is detailed in [5] and also monitoring of patients with specific disease such as Perkinson disease is described in [6]. Further research looks to serve specific purposes, such as aiding rehabilitation through constant monitoring of a patient's progress [7]. Emergency healthcare has also been identified as a possibility by related works [8, 9], but has not yet been widely researched. Several related works have previously surveyed specific areas and technologies related to IoT healthcare. An extensive survey is presented in [10], with focus placed on commercially available solutions, possible applications, and

remaining problems. Each topic is considered separately, rather than as part of an overarching system. In [11], data mining, storage, and analysis are considered, with little mention of integration of these into a system. RFIDs were used in American hospitals to advance care and to reduce the costs of treatment [12]. The cardiac impulses of the patient can be monitored by the doctor using healthcare monitoring system and, it helps the doctor to provide proper diagnosis. A number of wearable systems have been proposed to provide reliable wireless transmission of data [13]. Although there are many benefits of the internet of things in health care, they are not without any challenges. Both the hospital executives and IT are concerned about data security and IoT device management [14].

Machine Learning is a field which is elevated out of Artificial Intelligence (AI). Applying artificial intelligence, we can build better and shrewd machines. Machine Learning is a plan to gain from precedents and experience, without being expressly modified. Instead of writing code, the data is fed to the generic algorithm, and logic is built based on the data given. Machine learning is used in web searches, spam filtering, ad placement, stock trading and so on [15]. Machine Learning gains equal importance and recognition as that of big data and cloud computing by analyzing those big chunks and simplifying the task of data scientists in an automated process. Expansive scale informational collections are gathered and examined in various areas, from designing sciences to interpersonal organizations, business, bio molecular research, and security [16]. Most traditional machine learning algorithms are intended for data that would be entirely loaded into memory [17]. Even though learning from these plentiful data is expected to bring substantial science and engineering advances along with enhancements in quality of our life [18], it brings tremendous encounters at the same time. Machine learning techniques have been widely adopted in a number of massive and complex data-intensive fields such as medicine, astronomy, biology, and so on, for these techniques provide possible solutions to mine the information hidden in the data [19]. A report from McKinsey Global Institute proclaims that machine learning will be the driver of the subsequent big wave of innovation [20].

2.IOT ARCHITECTURE FOR DISEASE DETECTION

This system provides a platform for monitoring and sup ervising patients by the usage sensor networks. The design consists of both hardware and software sections. The hardware section includes Heart rate sensor, Temperature sensor, Blood Pressure sensor and Raspberry Pi board. The stages of the process are as follows: collection of sensor values, storage of data in the cloud and the analysis of the data stored in the cloud to check for abnormalities in the health condition.

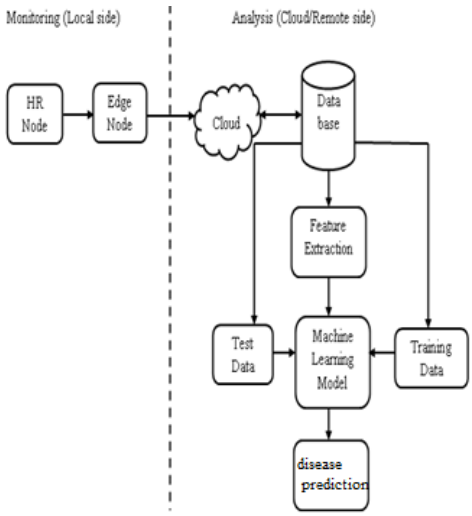

Fig. 1. Block Diagram

The abnormalities usually occur when there is an unrecognized activity in the body parts. The occurrence of seizures in the brain can increase the rate of heartbeat. The heart rate can be measured by using heart rate sensor. The rate of the heart at every instant can be measured. The sensor is interfaced with Raspberry Pi board in order to visualize the resultant values. The values can be visualized by using either serial monitor or by interfacing an LCD display. Since

the volume of data is large, all the data collected are sent to the cloud. The data send to the cloud are analyzed in the local side. In general, the rate of heart beat tends to increase gradually for any abnormal conditions.

Several open source cloud platforms support Raspberry Pi board and Raspbian jessi is one among them. It is an open source platform and the data collected are uploaded in the cloud by registering the physical address. The analysis of the values collected for the presence of any abnormalities is done by using machine learning algorithms. The values collected in the cloud are then imported for the purpose of analysis. The system should be trained using sample values for making predictions. In order to get accurate predictions, large amount data should be trained. Larger the data trained, higher the accuracy. The dataset that is to be trained should consist of the data collected from multiple persons under multiple circumstances. Also, the dataset should have the data collected from persons of different age and it should possess the data of both healthy and unhealthy persons.

The data that is tested till the previous session should be included in the training dataset and the data that is collected at the instantaneous moment is the data to be tested. By the usage of the data trained initially and the practical data that is included, prediction is made.

3.PROPOSED SYSTEM

The proposed system is that the data from the sensor network are collected and processed by the microntroller. The proposed results are stored in the cloud. From the cloud the processed data can be retrieved for analysis. The analyzed data is again stored in the cloud which can be retrieved by the doctors. The values obtained and the state of the person is made available in the hospital webpage. The block diagram of the entire setup is depicted in Fig 2. The entire system can be sectored into three major parts. Health monitoring system, Health state prediction system and Emergency alert system are the three major sectors of the proposal. Since the approach is dealing with health related issues, the data collected and processes has to be kept confidentially. To ensure confidentiality and security, encryption mechanisms are used which adds credit to the drafted system.

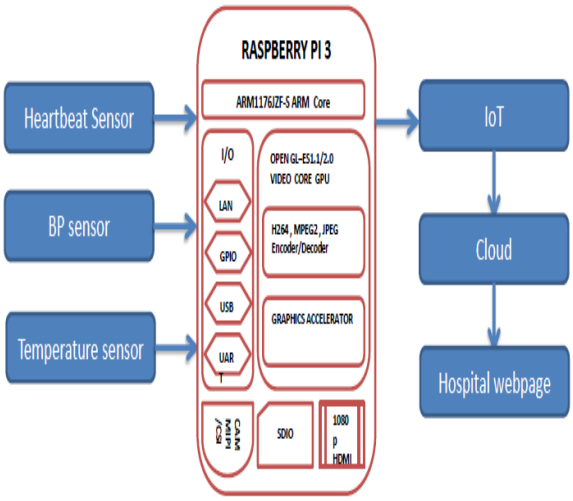

Fig 2: Block diagram

The health monitoring module comprises of the hardware components of the system that makes it IoT enabled and is used to record the health parameters of the patient using various sensors. Here, Raspberry pi acts as a central server to which all the sensors are connected through the GPIO pins or using MCP3008 analog-to-digital convertor if their output is in the analog form as Raspberry pi works only on digital signals.

Health state prediction is one of the most promising modules of the proposed system. In this module, the patients' health data are collected from the sensory nodes and stored in the database. The data stored in the database is subjected to be tested in the KNN classifier which classifies various states of the person's health. The accurate classification is made by the classifier which hardly needs manual rechecking.

The concept of including machine learning algorithm drives the scope of this module to a larger extent. Machine learning algorithms helps the proposed system to mimic the potential of scholarly doctors in terms of disease prediction data mining techniques do justice to the prediction methodology.

4.MACHINE LEARNING ALGORITHMS FOR HEALTH STATE PREDICTION

Analysis of the dataset can be done by using machine learning approach. A classification technique (or classifier) is a systematic approach for building classification models from an input data set. Few examples for machine learning algorithms include decision tree classifiers, rule-based classifiers, adaboost classifiers, neural networks, support vector machines, least squares regression, Knn classifier and Naive Bayes classifiers. Each technique provides a learning algorithm to recognize a model that best fits the bond between the attribute set and class label of the given input data. The model generated by a learning algorithm should be able to fit the input data well and also correctly foretell the class labels of records it has never seen before. The key objective of each learning algorithms is to build models with good generalization capability. Using the machine learning algorithms, the dataset for health monitoring is trained and analysis is done based on the training. The classifier used in this approach is K-Nearest Neighbor classifier

A. K-Nearest Neighbour (KNN) classifier:

Knn is a non-parametric supervised learning technique in which the data is classified to a given category with the help of training set. Predictions are made for a new instance (x) by searching through the entire training set for the K most similar cases (neighbors) and summarizing the output variables for those K cases. In the classification, this is the mode class value. Its purpose is to use a database in which the data points are separated into several classes to predict the classification of a new sample point. The steps of classification are as follows:

1. Training phase: a model is constructed from the training instances. The classification algorithm finds relationships between predictors and targets. The relationships are summarized in a model.
2. Testing phase: test the model on a test sample whose class labels are known but not used for training the model.
3. Usage phase: use the model for classification on new data whose class labels are unknown.

The flow of the Knn classifier is shown in Fig 3.

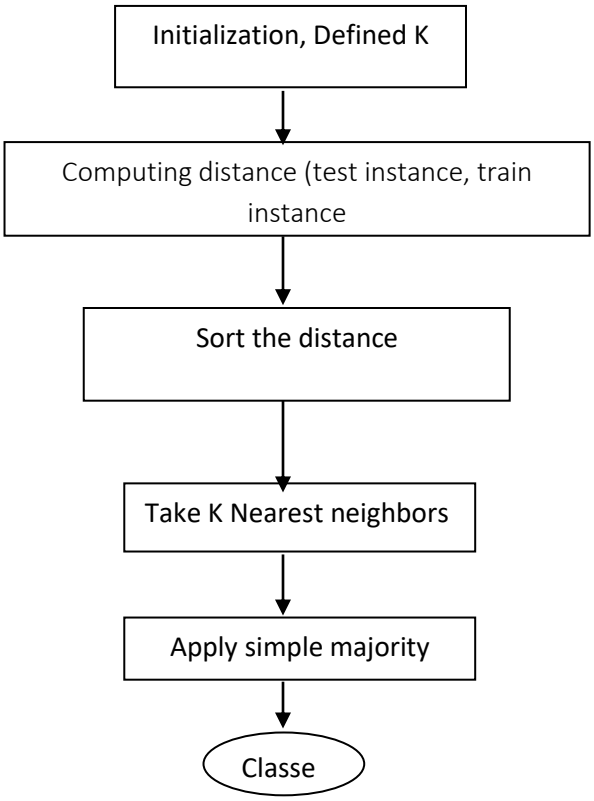

Fig 3: Flow of the classifier

B. K- Nearest neighbour algorithm:

The algorithm of Knn classifier is explained with an example. Consider Fig 4, there are two different target classes, white and orange circles. Totally there are 26 training samples. The prediction has to be done for blue circles. Considering K value as three, the similarity in the distance is calculated using similarity measures like Euclidean distance.

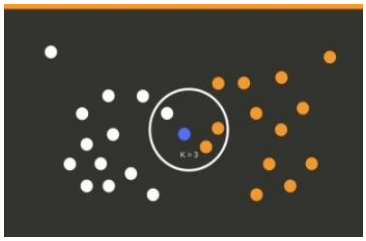

Fig 4: sample daigram

If the similarity score is less which means the classes are close. From the image, the distance is calculated and less distance circles are placed inside the Big circle.

Let's consider a setup with "n" training samples, where x_i is the training data point. The training data points are categorized into "c" classes. Using KNN, the aim is to predict class for the new data point. So, the first step is to calculate the distance (Euclidean) between the new data point and all the training data points.

To arrange all the distances in non-decreasing order. Assuming a positive value of "K" and filtering "K" least values from the sorted list. Now, the K top distances are available.

Nearest neighbor is a special case of k-nearest neighbor class. Where k value is 1 (k = 1). In this case, new data point target class will be assigned to the 1st closest neighbor.

Selecting the value of **K** in K-nearest neighbor is the most critical problem. A small value of K means that noise will have a higher influence on the result i.e., the probability of over fitting is very high. A large value of K makes it computationally expensive and defeats the basic idea behind KNN (that points that are near might have similar classes). A simple approach to select k is

k = n^ (1/2).

To optimize the results, we can use Cross Validation. Using the cross-validation technique, we can test KNN algorithm with different values of K. The model which gives good accuracy can be considered to be an optimal choice.

It depends on individual cases, at times best process is to run through each possible value of k and test our result.

The classification techniques can be classified into the following three groups:

1. Parametric
2. Semi parametric
3. Non-Parametric

Parametric & Semi parametric classifiers need specific information about the structure of data in training set. It is difficult to fulfill this requirement in many cases. So, non-parametric classifier like KNN was considered.

Data was randomly split into training, cross-validation & testing data. Experimentation was done with the value of K from K = 1 to 15. 98.02%. The best performance was obtained when K is 1.

C. Advantages of K-nearest neighbours algorithm:

- Knn is simple to implement.
- Knn executes quickly for small training data sets.
- Performance asymptotically approaches the performance of the Bayes Classifier.
- Don't need any prior knowledge about the structure of data in the training set.
- No retraining is required if the new training pattern is added to the existing training set.

D. Limitation to K-nearest neighbours algorithm:

- When the training set is large, it may take a lot of space.
- For every test data, the distance should be computed between test data and all the training data. Thus a lot of time may be needed for the testing.

PERFORMANCE ANALYSIS & DISCUSSION

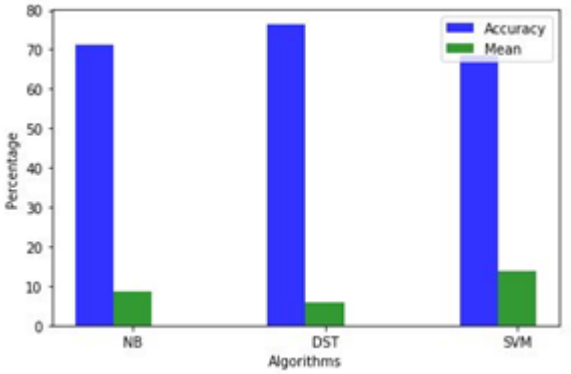

Fig 5: Performance of various machine learning algorithms for Epilepsy detection using train and test ratio of 8:2

The performance of various machine learning algorithms depends on the nature of the dataset. The given dataset is analyzed using three algorithms viz., decision tree algorithm, naïve bayes algorithm and support vector machine algorithm. As per the analysis represented in Fig., it is observed that the accuracy is greater for decision tree algorithm than the others. Accuracy is the ratio of number of accurate predictions of the total number of the given input samples. Several major factors affect the accuracy of algorithm and mean is one among those factors. If any value is found inappropriate in the dataset, those values can be replaced by the mean values. Mean is inversely proportional to accuracy. In order to get increased accuracy, mean value should be low. Fig. shows the relation between accuracy and mean. Also, the nature of dataset is more reliable with the decision tree algorithm which makes the accuracy higher. The accuracy of decision tree algorithm is obtained as 76.4% which is 5.3% greater than naïve bayes algorithm and 7.83 % greater than support vector machine.

5. CONCLUSIONS

Health factors of human if left unnoticed will result in serious issues and even cause danger to their life. Automating the continuous monitoring of heath parameters through IoT is discussed as novel solution. Technology plays the major role in health care not only for sensory devices but also in communication, recording and display device. It is very important to monitor various medical parameter sand post operational days. Hence the latest trend in Healthcare communication method using IOT and Machine learning techniques. Internet of things serves as a catalyst for the health care and plays prominent role in wide range of health care applications. Initial training and validation of machine learning algorithms are performed using the UCI dataset. Testing phase estimates the prediction of abnormalities from the sensor data collected through the IoT framework. Statistical analysis is performed from data accumulated into the cloud from IoT device to estimate the accuracy in prediction percentage. For this kind of IoT platform based continuous monitoring of human heath parameters, machine learning algorithms had played a significant role.

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