Refrence Paper 2

Automated IoT Based Healthcare System for Monitoring of Remotely Located Patients

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***Abstract*—Automated healthcare system is the need and future of healthcare in India. The challenges in implementation of healthcare systems in developing country like India are technology, infrastructure, trained doctors and connectivity among all stakeholders. Due the rapid growth in population providing the healthcare services is becoming difficult day by day specially in rural areas. The remotely located patients are the patients away from doctor but needs his constant monitoring and support. Such as patients in ICU, at home or may be at distant places. The problems also lies in updating doctors of the monitoring parameters and the history of patients time to time. This paper presents the implementation of automated IoT based helthcare system for remotely located patients which helps doctors and guide them accordingly. The system provides alerts by the means of E-mails in case of abnormal conditions observed in the monitoring parameters of the patient. It also takes care of supporting the decision making of severity of health conditions. An example of heart patient monitoring is taken for demonstration of the implemented system. The implemented system is successful to provide an interface among doctors, the nurses in hospitals and the relatives of the patient.**

Index Terms*— *Body temperature sensor; Classification machine learning techniques; Decision support system; Heart beat sensor; Heart dataset; Real time remote monitoring; Rule generation; Wi-Fi module

I. Introduction

The population of nation is exponentially increasing. The healthcare system constitutes of healthcare resources and people. Based on various demands of each person the healthcare system provide different services regarding healthcare. Currently medical expertise having massive knowledge of regarding treatments, analysis and diagnosis of diseases due to marvelous innovation and researches occur in the medical field. There is more need to give attention for elder people because senior population growing constantly.

The current healthcare systems placed in hospital premises give essential focus on treatment after disease diagnosis. The treatment cost and negative effect of medication increases because preventive healthcare services absence in hospitals. The increasing population causes challenges to existing healthcare systems. In this challenging era the major problem of death is heart disease due to stress problem and also patients dont get healthcare services on time[2]. People dont get time for healthcare because they are busier in their career making. There is need to continuously monitor elder people living independently by reason of single family lifestyle. For getting systematic and proper health services on time is possible with real time health monitoring of person remotely.

The advancements in digital technologies increasing day by day. The wireless and mobile communication technologies possesses advantages alike availability, flexibility, high speed, reduce cost of wiring and simple use of technologies. The system having decision support system which perform data analysis on trained heart dataset, patient history with real time input to predict heart problem earlier. The essential cause of deaths is heart disease. Therefore the system focuses on predicting heart problem. The system generate alerts if result of data analysis is serious health issue of patient health. After surveying existing healthcare systems with drawbacks and benefits of emerging technologies we are going to propose an automated IoT based healthcare system for remote patient, doctors and caretakers remotely for patient.

A. Areas of Improvement In Existing Healthcare Systems

After surveying various healthcare systems which presently available at hospitals in India possess few drawbacks. There is requirement for improving areas in healthcare system for overcoming drawbacks.

- System should be provide services in real time.
- Connectivity among remote places should be enable.
- Generic digital devices should be used.
- System should be helping doctors to remember treatment and diagnosis.

II. Review of Literature

The patient do not get accurate and timely health services in emergency case because of limitations of existing system. Since remote patient healthcare monitoring is necessary in real time. For this purpose following literature survey is done. In paper [1], with enhancements in newly emerging digital and communication technologies, increased use of internet and wireless sensor network is possible to build system for remote health monitoring is described.

The authors explain how android application is developed and use for healthcare monitoring in paper [3]. In paper [4], fully software based system is developed as a real time activity and mobility monitoring framework. This ROAMM system proposed by IEEE members. Above papers describes systems which are using both hardware as well as software module for

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development of system. The Samsung Gear S smart watch is use for collecting input parameters of persons activities in this system.

The software platform weka as a data analysis tool use to compare different classification techniques on heart dataset by authors in paper [5]. The authors use training method and 10 cross fold method for finding better result with comparing these two methods. The authors conclude that the SVM algorithm with training method satisfy the better performance criteria. The ensemble learning method is use in paper [8]. The bagging, boosting and stacking methods are type of ensemble learning method. The paper describes stacking method for combination of SVM and MLP algorithm give best accuracy.

III. System Architecture

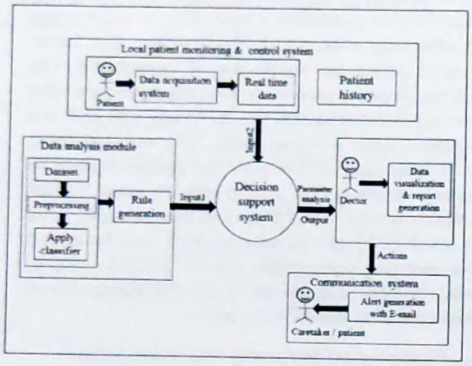

Fig. 1. Block Diagram of System

The architecture of system is illustrated in Fig. 1. The system having two major purposes. In real time remotely monitor health status of patient is the main purpose of system. The doctor or caretaker of patient can monitor health parameters at any time and at any place remotely with this system. Synchronously alerts are generated if health status goes in abnormal condition. Another purpose of system is perform data analysis on training heart dataset, patients history with real time parameters. Based on those input parameters system makes prediction of the disease. The system generates alert when result of decision support system is shows the critical condition of health status of patient.

A. Working of System Modules

The local monitoring and control system module is useful to take inputs for system. At patients' site this module is kept. The data acquisition module captured input readings from sensors. The Wi-Fi module is used for transferring input data to the web server. Also the patient history parameters are recorded for patients. At doctors' site the data analysis module is useful for generating rules on training datset by applying decision tree classifier. Then all inputs are passed to the decision support system. Then all three inputs i.e. training dataset and patient history with real time parameters are forwarded to the decision support system. For prediction of disease this system perform machine learning with applying decision tree C4.5 classification algorithm on those data. If result generated by decision support system is critical health status of patient then alert in form of E-mail is generated. With this facility the doctor can take immediate action to emergency condition related to patients' abnormal health status.

1) Software Design Specification: The WEKA 3.8 data analysis tool is use for selecting classification algorithms based on accuracy performance measure parameter. The input readings from sensors capture with the Arduino software(IDE). The ASP.NET web site is developed in visual studio 2013 software. For storing data into database the Microsoft SQL server 2012.

2) Hardware Design Specification:

- Body Temperature Sensor:
  The body temperature of person is measure with DS18B20 body temperature sensor. For measuring body temperature DS18B20 is place under arms, keep in finger or place on forehead. The range for measuring body temperature with DS18B20 is -55°C to 125°C. The one wire protocol mechanism use for working of DS18B20 sensor.

- Heart Beat Sensor
  The heart beat sensor is use to measure real time heart beat rate continuously for one minute. The heart rate is crucial parameter for predicting heart problem. The proposed system is going to predict the heart problem since heart beat sensor is use.

- Wi-Fi Module
  The heart rate and body temperature parameters capture by sensors are forwarded to the web server with ESP8266 Wi-Fi module. This module contains system on chip since Wi-Fi network is accessible by any microcontroller.

- Microcontroller: Arduino Mega 2560
  The hardware module use microcontroller Arduino Mega. This controller have 16 analog inputs, 54 digital input/output pins, USB cable connection, reset button and port for power. USB cable is attach to laptop through Arduino and give power with adapter.

3) Algorithm for Data Analytics: The C4.5 decision tree supervised classification algorithm is used for the data analysis. The rules are generated from UCI heart dataset with C4.5 classifier. This algorithm is developed in 1993 by Ross Quinlan[15]. The J-48 in weka is the implementation of C4.5 algorithm. The C4.5 algorithm is the extension of ID3 classifier. The C4.5 algorithm use Gain ratio as metrics. The splitting attribute is selected for attribute whose gain ratio is maximum.

$$GainRatio(A) = \frac{Gain(A)}{SplitInfo(A)} [9] \quad (1)$$

$$SplitInfo_A(D) = -\sum_{j=1}^{v} \frac{|D_j|}{D} \times log_2 \frac{|D_j|}{D} [9] \quad (2)$$

C4.5 algorithm advantages[10]

- It handles both discrete and continuous data.
- It handles missing data.
- It supports pruning.

4) System Design: In system design section, shows design flow of my proposed system with an use case diagram. The use case is behavior diagram which type of Unified Modelling Language (UML) diagram. It shows dynamic behavior of proposed system.The use case diagram depicts the interactions of users with the system.

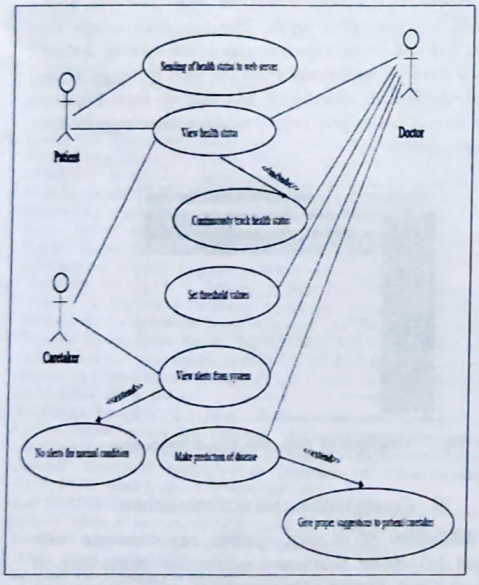

Fig. 2. Use Case Diagram For Proposed System

IV. Mathematical Model

The mathematical model for proposed system is as follows:

- Let S be a system. S = {I, D, H, A, P, O}
- Identify inputs as, I = {i_1, i_2}
  Where, I is set of sensors' inputs
- D = {d_1, d_2, d_3,.....,d_{14}}, where D is set of attributes of dataset
- H = {h_1,h_2,h_3,.....,h_7}, where H is set of history attributes
- A = {a_1, a_2, a_3, a_4}, where A is set of classification algorithms
- Identify system output is O, O = {o_1 , o_2}
  Where, o_1 = generation of alerts and o_2 = prediction of disease
- Identify processes as P. P = {p_1, p_2, p_3}
- $p_1 = f(I) \rightarrow o_1$, If (I > threshold value)
- $p_2 = f(H, I, D) \rightarrow r$
- $p_3 = f(r, a_1) \rightarrow o_2$

V. Results of Experiment and Implementation

1) Result of Weka Experiment: In weka experiment, Hungarian, Statlog and Cleveland UCI these three heart datasets taken for selecting one heart dataset among those three datasets. The remove percentage filter applied on datasets for partitioning dataset into 70% training and 30% testing dataset. Then applying J-48, Naive bayes, random forest and KNN classification algorithms on datasets and getting performance comparison results shown in Fig. 4. The Cleveland UCI heart dataset with naive bayes and J-48 decision tree algorithm having more accuracy than another algorithms.

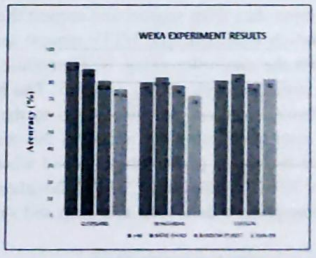

Fig. 3. Performance Comparison of Classification Algorithms Based on Accuracy

TABLE I
PERFORMANCE COMPARISON OF CLASSIFICATION ALGORITHM ON CLEVELAND DATASET

CLASSIFIER	ACCURACY(%)	PRECISION	RECALL
J-48	92.07	0.908	0.952
Naive Bayes	87.93	0.824	0.966
Random Forest	80.66	0.805	0.841
KNN-Ibk	75.71	0.778	0.757

Depend upon accuracy, precision and recall performance measures comparing performance of algorithms shown in Table I. Table I shows the values for J- 48 and Naive bayes algorithms having greater performance criteria after applying on Cleveland UCI dataset. The accuracy is measured with following formula.

$$Accuracy = \frac{(TP + TN)}{(TP + FP + FN + TN)} [12] \quad (3)$$

2) Hardware Module: Following Fig. 4 illustrate the connection of DS18B20 body temperature and heart beat sensor with Aduino microcontroller to laptop. The connection is possible with attaching one end of sensors to microcontroller and another end is attach to patient. With USB cable hardware module is attach to laptop. The hardware module connection is use for real time health monitoring of person.

Fig. 4. Hardware Module Connection With Laptop

3) Software Module: The ASP.NET website is developed for remotely monitoring patients health status. The microcontroller capture the input data from sensors and request the web URL for website which is hosted. The HTTP request send to the web server from the controller using Wi-Fi module. The forwarded data is stored on web server database. The health readings capture through sensors are displaying on the web page continuously after one minute. By accessing this website on laptop, computer or mobile phone wherever and whenever caretaker or doctor need to monitoring patient healthcare in real time from remote place is done with this proposed system.

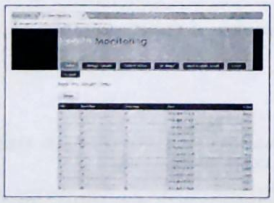

Fig. 5. Real Time Health Parameters Reading on Website

The final result is produce by the decision support system. The critical health status result generated by decision support system then alert in form of E-mail is generated. The doctor can take immediate action to this emergency condition when getting alert. The following figures shows the final result and alert generation.

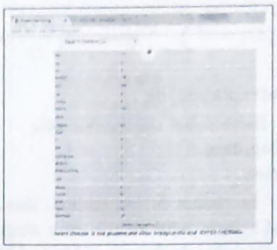

Fig. 6. Real Time Health Parameters Reading on Website

4) Generating Alert: The proposed system generate alert through E-mail in abnormal condition of health status. The medical expert set threshold values for heart rate and body temperature for generating alerts. The threshold values for heart beat and body temperature are set at run time by doctor. The Fig. 6 shows E-mail notification for alert message to the registered user E-mail address for first reading from Fig The real time alert is use to give proper health related suggestions to caretaker/patient.

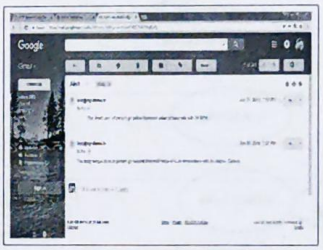

Fig. 7. Generation of Alert With E-mail Notification

VI. Conclusion and Future Scope

The limitations of existing systems are overcome with automated IoT based healthcare system for monitoring of remotely located patient. The result of weka experiment conclude that the higher performance accuracy achieved by decision tree classification algorithm applying on cleveland UCI heart dataset. The remote patient healthcare monitoring is achieved with developing website and storing real time health parameters on web servers database with IoT. The system is generating alerts in form of E-mails when health status is not in normal condition. The second module of system provide prediction of heart disease with supervised machine learning classification techniques in the decision support system. The probability of predicting heart problem will be increasing with generating rules from UCI heart database with decision tree algorithm. Also the rules are generated manually for different conditions of heart rate and body temperature values. Finally, based on both rules prediction of heart disease is achieved.

The alert is generated when health status result of decision support system in risk condition.

The system will be useful for predicting other diseases with changing sensors requirements like ECG, EEG, activity monitoring sensors etc. The tracking of person with GPS will be possible in emergency help condition. The ensemble learning method i.e. stacking for combining more than one classification algorithm of different type will be helpful to enhancing performance of algorithms for prediction of disease. To achieve high accuracy the ensemble learning method will be use with proposed system.

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