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A Framework on Health Smart Home Using IoT and Machine Learning for Disabled People

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Abstract--- *The creation of accessible environments that promote independence, participation has been and remains a point of argument by and for disabled people. People with disabilities face large amount of hurdles and problems while trying to get help in the field of healthcare. In looking after disabled people the amount of services are limited, the treatment may be cost-effective and face many physical barriers. The paper presents a generic framework for an intelligent health smart home making the possibility for a person with disability to live in the comforts of home and be provided with healthcare services. The proposal of system is to develop an IoT based mobile gateway solution for Interactive Home wireless system, monitoring and control system and data acquisition system to display on mobile phone using S MS and email alert. The IOT applications developed in healthcare domain in smart home include mobile based control system, monitoring system and decision making system. Machine Learning is being employed to enable the IoT system to analyze sensor data, look for correlations and determine the best response to take. By detecting the values of the sensors, the temperature, smoke and presence of fire are found out in the environment and assuring the disabled person to handle any situation through IoT. Moreover information about patient's heart rate, ECG and body temperature is collected and sent to a decision making system which contains fuzzy rules which calculates how frequently patient data are classified as normal and critical and also decides whether to store the data in database or forwarding to a caretaker to take immediate actions so that critical situations can be avoided.*

Keywords--- *Smart Environment, IoT, Machine Learning, Fuzzy Logic.*

I. INTRODUCTION

Health promotion activities around the world do not consider disabled people. Contemporary studies indicate that health care which includes many programs for pro motion of health and prevention of diseases and services does not reach the people with disabilities and face many problems trying to access.

Providing health care services from the comfort of the patient's home is an efficient way. The healthcare domain playing significant role needs multimedia through the development of monitoring system. Smart Environment involves Information acquisition from sensor networks, re mote control and communication of devices, predictive

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and decision making capabilities to self-organize, to provide services and manipulate complex data to make the inhabitant's lives more comfortable. IoT is a means of interconnecting many devices over a network and enabling to observe, identify and understand the surrounding or situation in an effective manner. IoT involves convergence of data, processing and exchange of data within the devices connected over a network ma king effective management of surrounding.

Machine Learning, a technique related to statistical analysis and data mining is one of the efficient methods of teaching computers to make effective predictions based on some data and is the semi-automated extraction of knowledge from data. Fuzzy logic is a methodology useful for arriving at a precise and explicit conclusion in a faster and simpler manner based on ambivalent and imprecise input information.

The rest of the paper includes the following sections. The following section includes related works based on smart health home for disabled people.

II. RELATED WORKS

Ruijiao Li et, al [1] focuses on various problems faced by the elderly and the struggles to live a life by themselves and uses communication and information technology to provide solutions to those problems and to improve the style of living. Alexandre Santos et.al [2] presents an architecture based on IOT for monitoring the patient's health and establishes an assisted living by making use of mobile communication, embedded sensors and security systems.

M. Wcislik et. al [3] explains the ideas behind Wireless Health Monitoring System, the base station being a smart phone.

J.Vanus et. al [4] proposes a model for saving energy by making use of artificial lighting and combining with daylight and ma king sure to be of great help for the patient in need of assistance.

J. Vanus et. al [5] describes how to technically control all the appliances and other technologies in a building inbuilt with wireless connections and other technologies that would satisfy the comfort and needs of elderly and disabled people.

Anne Hakansson et.al [6] presents a model for ma king use of internet of things in a home embedded with sensors to take appropriate decisions in the time of need and the security. Sarah N. Abdulkader et.al [7] discusses the application areas that could benefit from brain waves and the challenges that would be faced by utilizing brain signals. The solutions that aim to decrease the effects have also been reviewed.

Anthony Fleury et.al [8] presented a classified the daily activities of living in a home embedded with sensors based on various machines. Sensors were used to locate the presence and motion, speech and sound were recognized by making use of microphones and accelerometers were used to sense the motion and all these were installed after which the efficiency was measured.

Samaneh Zolfaghari et.al [9] presented various methods identify day to day activities of the inhabitant in a home with sensors by making use of ontological methods. Various techniques were applied and the framework was proposed.

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Pinar Kirci et.al [10] proposed a system which gathered patient's heart beat rates with wearable sensor system which are then transmitted to the nearby device. Thus monitoring of patient's health was provided from their homes. Hospitals, doctors in charge and relatives were informed at times of emergency. The proposed system is a user friendly application and was easy for disabled and old people to use it.

Lin Yang et.al [11] proposed an architecture which made use of internet of things technologies and included sensors to be used for wireless networking and thus extending a home that would be efficient enough to accommodate disabled people especially for those who use wheelchairs and to make a affordable healthcare system at home .

Maruthalingam Pirapinthan et.al [12] focused on helping the elderly and disabled people to carry on with the daily activities without being interrupted meanwhile monitoring the health conditions and tracking the health status by making use of sensors and other sensible devices that are to be embedded within the ho me and on the individual's body.

JukkaOjasaloet.al [13] explained about how the development of technology have helped disabled people to enjoy the comfort of the home and yet be provided with healthcare services and this study specifies ideas for designing a better system that would be of greater help to the physically challenged people.

Wang Xian mei et.al [14] presented a smart ho me control system which uses the head and mouth movements to control household appliances. The system uses RS232 serial communication for sending operation commands to appliances.

Michael Marschollek et.al [15] focused on monitoring the health conditions of the elderly people at home by acquiring data from various wearable sensors and devices. The acquired data is analyzed and activity patterns are determined.

Diulie J. Freitas et.al [16] presented a system that would focus on monitoring rooms and detecting any problems and to notify a warning message whenever a problem is encountered.

Loren zo Scalise et.al [17] presented a candidate implementation of home automat ion system describing the software architecture and the selected components, and a test bed of the architecture and thus monitoring the user's status within the home environment.

III. SYSTEM ARCHITECTURE

IoT has greater potential in gathering information from different sensors and making valid decisions out of the information acquired. The system architecture for intelligent health smart home is presented in fig.1. The three main sections of the architecture are monitoring system, controlling system and decision ma king system. Here the main sections are described in brief.

3.1 Smart Home Health Monitoring

The aim of the model is to observe and examine the health status of the critical patients for accurate medical monitoring and patients with conditions that must be accurately measured for an ulterior professional diagnosis. The

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monitoring model include heart beat rate, ECG report, body temperature and fall detection report. The data is acquired real time using Data Acquisition using wireless sensor networks (WSNs) and is sent to the decision making element. The monitoring model is briefly explained in the application interface in the subsequent section.

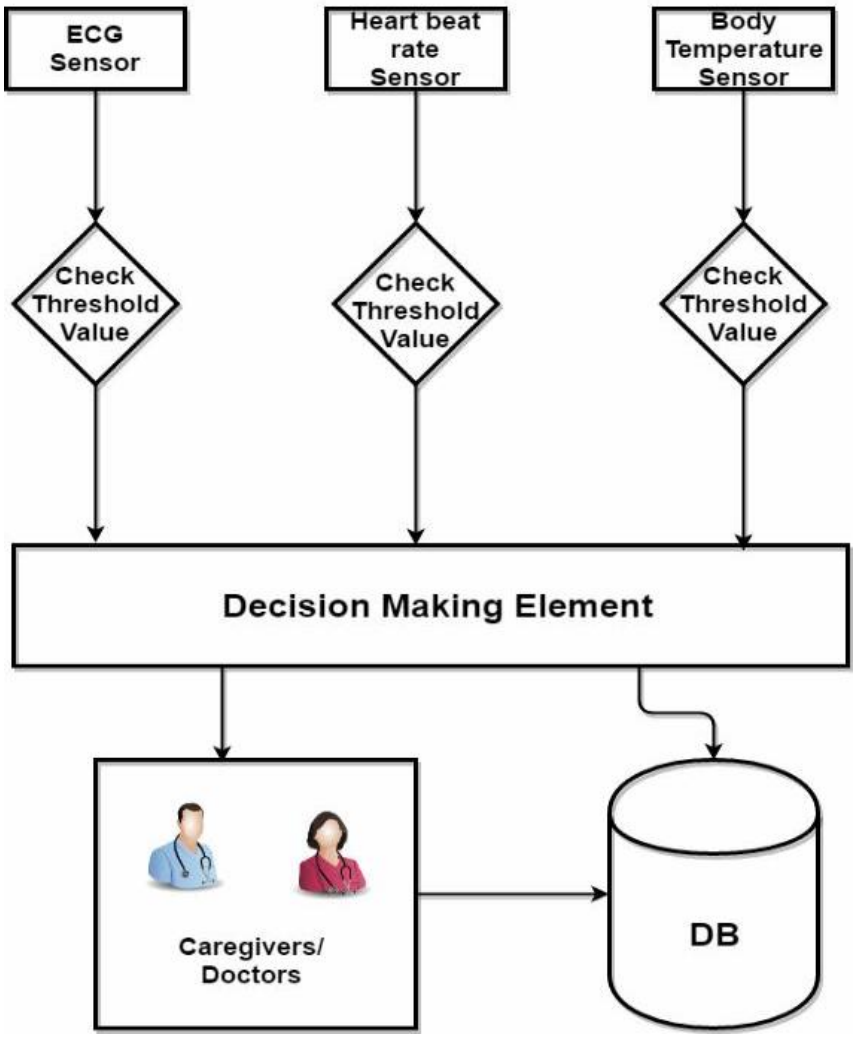

Figure 3.1: Block Diagram of Health Monitoring

Smart Home Appliances Controlling

The aim of the model is to increase the independence of the disabled patients to a great extent. It provides access and control of the house anytime anywhere within the surroundings to the inhabitant. The monitoring model includes Temperature report, Fire detection report, Smoke detection report and light dependence rate. The controlling model includes the control over fan, light devices, door and windows. The data is acquired using wireless sensor networks (WSNs) and controlled using Global System for Mobile (GSM) communication. The model is briefly explained in the subsequent section.

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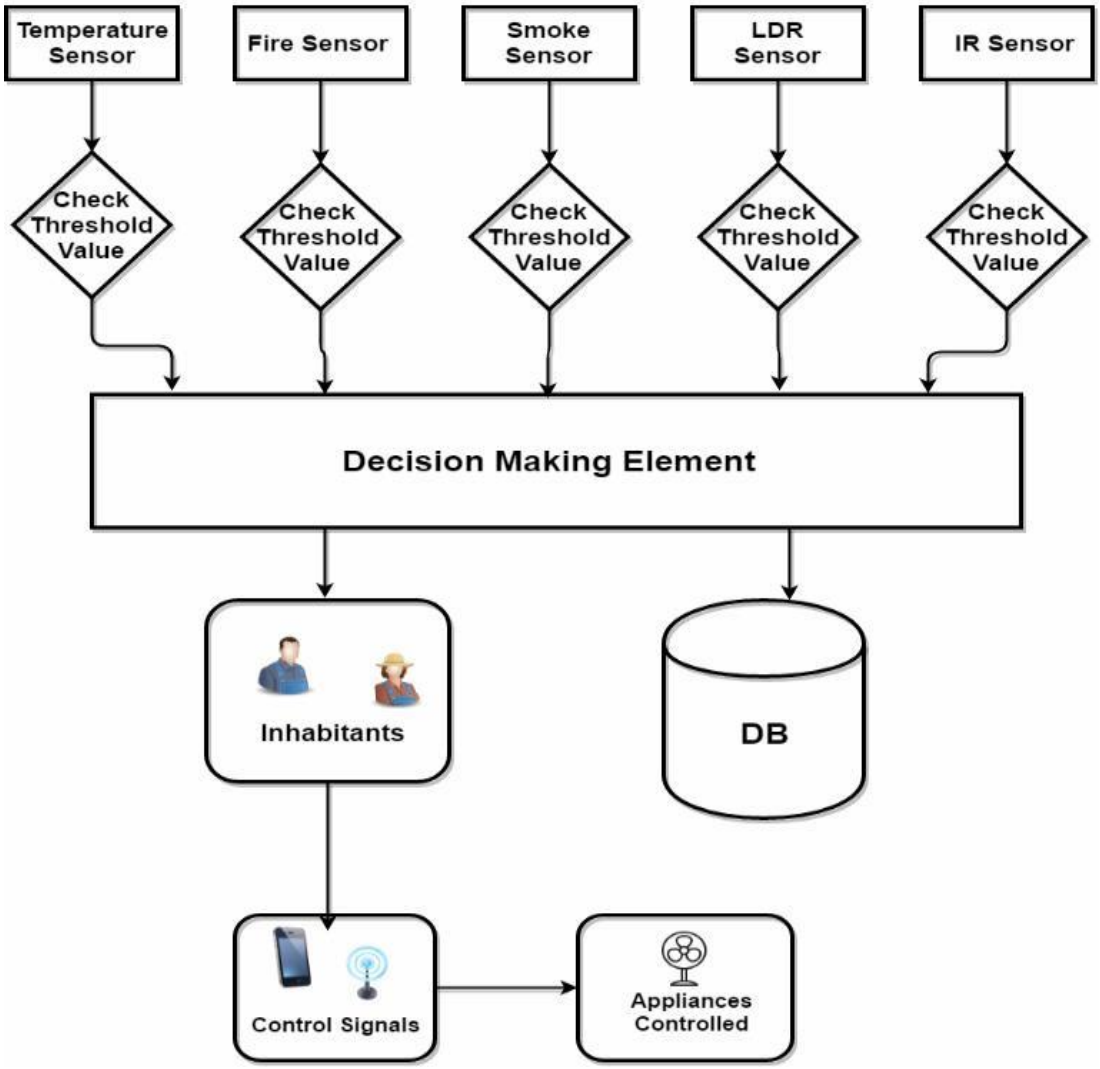

Figure 3.2: Block Diagram of Appliances Controlling

1. Decision Making Element

Here solution is derived by presenting a model integrating disabled patients, Healthcare specialist, and caregiver and healthcare institutions. In the proposed model Healthcare specialist and caregiver will be provided with all the information regarding the patient's health status to make decisions on whether to take immediate actions to treat the patient or to save the information in database for future reference. The system uses Machine Learning to determine what constitutes normal health status and sends alerts to caregivers when not so. Moreover fuzzy rules are employed to calculate the frequency of classification of patient data as normal and critical. The acquired values from the sensors are compared with a threshold value. If the value is less than the threshold value then the data is updated in the database which already contains the patient's profile. This helps the doctors to track the health status of the patient's health on a regular basis. If the acquired value is greater than the threshold value then alert messages are sent to both the caretakers and doctor so as to take immediate actions when necessary.

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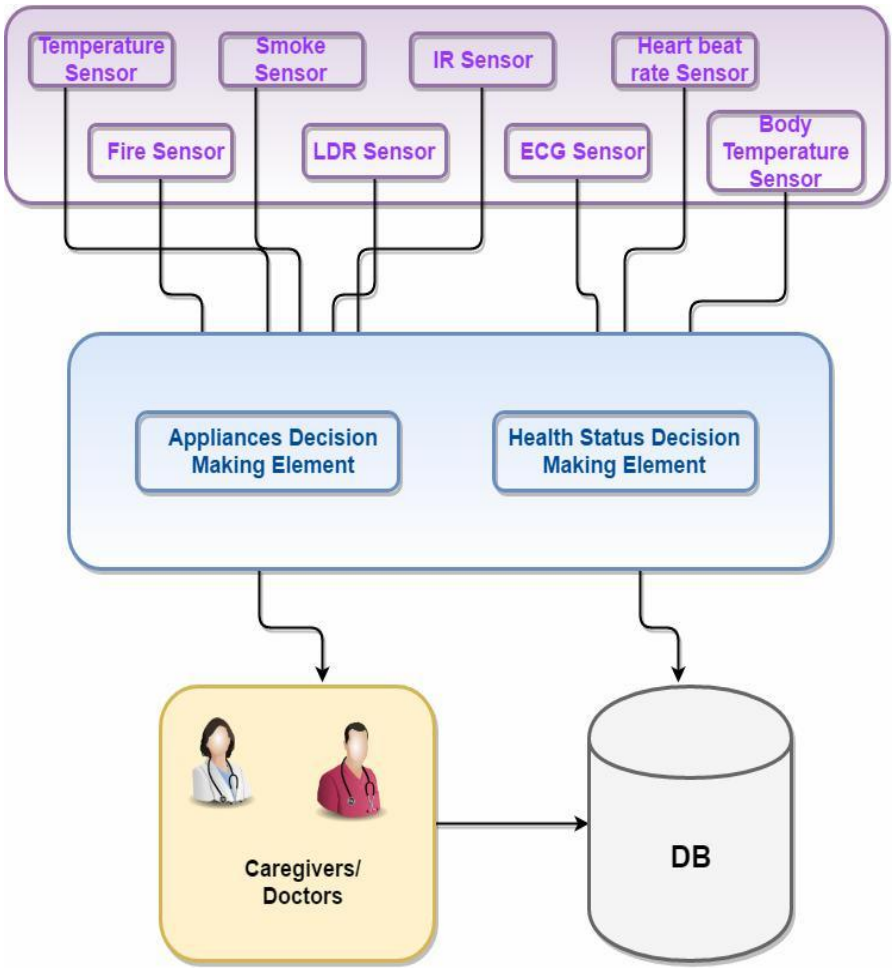

Figure 3.3: Framework for Health Smart Home System

IV. APPLICATION INTERFACE

Sensors are connected to Raspberry pi with ARM processor. The GSM SIM 900 is also connected to the pi so that communication can be established.

LM 35 sensor for temperature detection, Fire sensor, LDR sensor for light dependency detection, PIR sensor for motion detection, IR sensor for heat detection and MQ2 sensor for smoke detection are used to collect information within the smart home to analyze the smart environment. If the collected value of each exceeds a particular threshold which is already defined, an SMS alert and an e mail is sent to the inhabiting patient's mobile phone. A patient who is dumb can react by sending a message again to control the respective appliance and take immediate and appropriate actions. Patient with hearing impairment has to be notified through visual or vibratory signal in the mobile phone and will react in the same way as before mentioned. In case of a visually impaired patient, voice commands are recognized and converted to text and the appropriate message is sent to control and take actions. Moreover in the case of a physically challenged person, Brain Computing Interface is implemented using Neurochips to understand, analyze and interpret the commands and connected to a mobile device to send the required message to control the surrounding for effective living. The above mentioned methods for each type of

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disabled people can also be used to control the appliances sending controls through mobile communication.

In case of health monitoring, ECG sensor, heart beat sensor and body temperature sensor are used to collect information from the patient about the health status and are sent to the decision ma king element which are all connected to the Raspberry pi. The collected values from each sensor are compared with the defined threshold value. In case of emergencies, alert messages are sent through the GSM SIM 900 to the registered mobile phones and the registered email id. In other cases the information are stored in database for future reference.

Machine Learning is performed on the obtained health details and based on the already present fuzzy rules inside the decision making element we categorize data and we analyze how frequently patient data is classified as normal to be stored in database and as critical to take immediate actions.

The Machine Learning classifiers were implemented and the following results were obtained:

Table 4.1: Performance Measure (Accuracy) of the Machine Learning Ensemble Methods

ML Ensemble Methods	Observed Accuracy (%)
Random Forest classifier	86.88
Bagging-meta Estimator	80.32
AdaBoost	86.88
GBM(Gradient Boosting	83.60
classifier)	
XGBoost	83.60

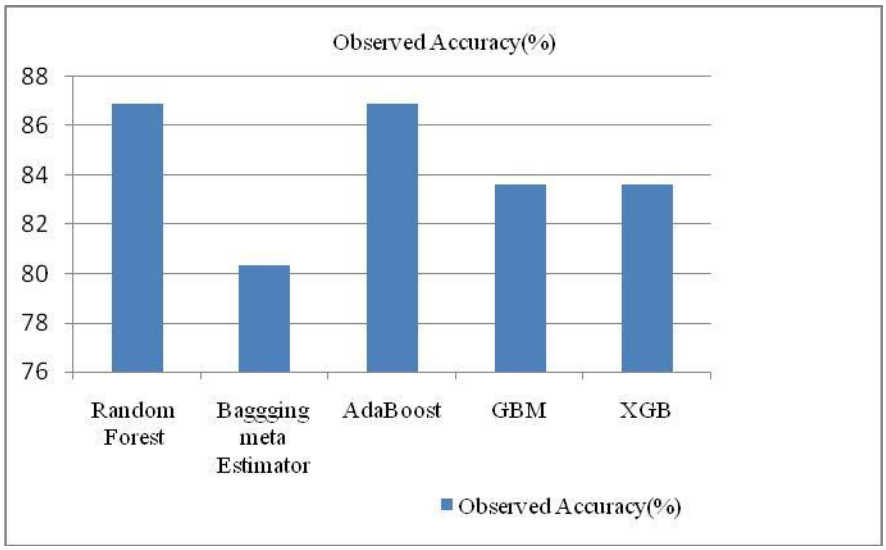

Figure 4.1: Chart Representing Observed Accuracies of the Algorithms for this Use-case

4.1 Inference

The performance of each ML ensemble algorithms was shown in the Table 4.1. From the above graph it was understood the Ensemble methods produced a very good accuracy levels. Random Forest being the best followed by AdaBoost classifier. AdaBoost and Random Forest outperformed bagging-meta estimator, GBM and XGBoost.

Simple ensemble model was created from the two boosting-based classifiers, where the average of each of the boosting models' prediction probabilities was used to make a final prediction [18].

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Ensemble of decision trees: random forest fit multiple decision trees to bootstrap-resampled versions of the data, then either a) average the resulting trees (for regression) or b) take majority vote (for classification) [19]. Hence a better performance is obtained over other classifiers.

V. CONCLUSION AND FUTURE WORK

The paper presents an architectural frame work for intelligent health smart home. The framework is well illustrated and presented to assist disabled patients to improve the quality of living and ease of providing healthcare services. Different sources of information are identified and integration of information to make decisions based on patient's health status is illustrated. Data acquisition from wireless sensors and interpretation to monitor the surrounding is also identified and various methods to control the surrounding by disabled patients are discussed. The framework can be of major impact in smart environment in Healthcare domain due to its adaptability and convenience. The future work is to carry out real time implementation of the architecture and to benefit the disabled people around the world.

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