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IoT based Health Monitoring using Fuzzy logic

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Abstract

The field of Health Monitoring is gaining popularity at present. With the reason that every family member will be employed and busy, the health monitoring of elderly people and patients has become very crucial. In this paper, we have developed a system where the caretakers can get the information of the temperature and the pulse rate of the people being monitored at home. We can also get the information about the air quality in the home so that the system will generate an alarm if any hazardous gas is detected. Here we have used a fuzzy logic approach for real time monitoring and analysis of the data collected from temperature sensor, Heart beat sensor and Gas sensor. Based on the trained data and the collected data from the sensors outliers will be detected. The collected data sent to the cloud can be downloaded using the Thingspeak platform. The future work has also been proposed and is planned to automate the message sending of the outliers detected to the caretakers and the doctors using deep learning.

Keywords: IoT, Fuzzy Logic, Health Monitoring, Node MCU, Sensors

1 INTRODUCTION

Future computing technology will be waving beyond our imagination, and beyond the traditional technology. IoT is among the top of the leading technologies, where object surrounding us will be equipped with IoT. With the help of RFID (radio frequency identification) and sensors it will create its own space where everything will be operated and communicated through internet. The devices will create its own environment. The resulting enormous amount of data will be stored, processed and presented efficiently, seamlessly, and will be easy to interpret. Cloud computing will provide us virtual

infrastructure for visualization platforms, utility computing, which will integrate the monitoring of the devices, storage devices, client delivery, analytics tools, and visualization. Cloud computing will provide us end-to-end service for users and businesses for on demand accessing the applications from anywhere. One of the most important applications of IoT is Healthcare application. In this project where we have built the health monitoring device to monitor and maintain the health status of human being like heart beat rate, temperature and air quality with existing low-cost sensors. We have used the Fuzzy logic approach. Fuzzy logic concept was introduced by Lotfi Zadeh in 1965. Fuzzy logic is a multivalued logic where truth values lies between any real numbers 0 and 1. Fuzzy logic handles the partial truth concept, in which the truth value range between completely false and completely true. Fuzzy logic approach includes: Fuzzification, Inference, Defuzzification.

- ***Fuzzification***.

Firstly, the crisp input data are gathered by the sensors and then using membership functions they are converted to a fuzzy input set, linguistic terms, and linguistic variables.

- ***Inference.***

By applying the rules, inference is done. The system is going to operate based on the set of rules like IF-THEN.

- ***Defuzzification.***

With the help of membership function the fuzzy output is finally mapped to crisp output.

The algorithm used for fuzzy logic is as follows:

1. Initialization of terms and linguistic variables
2. Construct MF (membership function)
3. Initialization of rule
4. Using membership functions convert crisp input to fuzzy input
5. Apply the rules for fuzzy input
6. Convert the fuzzy output to crisp output.

2 LITERATURE SURVEY

Healthcare for elderly people, who want to stay independently is explained in paper [1]. To maintain and monitor the health status, a person needs to wear a wearable device which will keep track of their health status and keep communicating with their caretakers, relatives and doctors. Sensors and wireless network are used for collecting

data and that data is stored in a database for communication purpose. In case of any emergency, message will be sent to registered caretaker and also to doctors. Doctor can advise the patient staying in remote location and also, he can prescribe medicine. This system can also be used as a medication remainder.

Paper [2] explains the use of fuzzy logic in industrial developments. To fill gap between the theoretical and mathematical operations, FL (Fuzzy Logic) is being used for linguistic control protocol for skilled operations. This method is being applied for practical situations in industries and also in pilot scale plants. Advantages of using Fuzzy logic are discussed in this paper. It also explains about the Fuzzy logic potential.

In paper [3], Alternation for Mamdani inference is discussed. This is used for time measurement of sports activities which covers advantages of combining the Takagi Sugano and Mamdani, which is advantageous than original system, where the response and also the complexity can be reduced, to get accurate results MF is tuned. This modified system can be used in various activities like sports and heavy exercise.

Paper [4] describes about how to monitor the health remotely. In this approach wearable device is used for measuring basic health status identifier like body temperature and pulse rate. Measuring these values regularly and storing them in cloud for reference and future use. If any variations in temperature or pulse rate or if temperature or pulse rate crosses the limit it will be notified immediately to their relatives or caretakers. It also gets the current location of person wearing the device. It will also generate the daily reports and data which will be uploaded to cloud. This helps the doctors to create the patient report on weekly or monthly basis to study patient details whenever required. Thingspeak [5] is an open source IoT platform, used to store the data and retrieve the data which is stored in cloud over the internet. This also which supports the MATLAB where we can analyse and visualize the Data, Data can be sent from Arduino, Beagle Bone Black, Raspberry Pi. With the help of Thingspeak we create login for sensor application, we can also track the location of the device. ThingSpeak is an IoT platform which will collect the data and analyse it. ThingSpeak will acts like a bridge between different type of sensors and software, which also acts as data collector which will collect data from different device and it will pull the data onto software environment. ThingSpeak will contain a Channel which is a primary element which contains location field, data field, and also status field. Channels are used to write the data, process and view with the help of MATLAB, and also respond to data by alerts and tweets.

In paper [6] Fuzzy Logic reasoning, implications and its applications are discussed. Implication is nothing but describing the fuzzy inputs which leads to linear relation between input and output. Also how the system is going to identify the input and outputs are also discussed. Applications of fuzzy logic in industrial plants are explained especially in cleaning the water and in the steel making process.

In paper [7] author has explained how best we can make use of body sensor network

for healthcare system. Developments in IoT and increasing demand for wearable devices create a lot of interest to designing and developing new things every day. Especially like smart objects, wearable device for healthcare system. In this paper "Body Sensor Network" BSN is proposed using some body sensors. Also, they concentrated on the security issues in IoT based health monitoring system. This system will be operated with the BSN system. By this robustness and efficiency can be achieved by using Crypto primitives for constructing the communication system with confidentially also authentication is done for the security purpose to smart objects and BSN, this system is implemented using Raspberry PI platform.

3 SYSTEM DESIGN AND IMPLEMENTATION

3.1 System Architecture

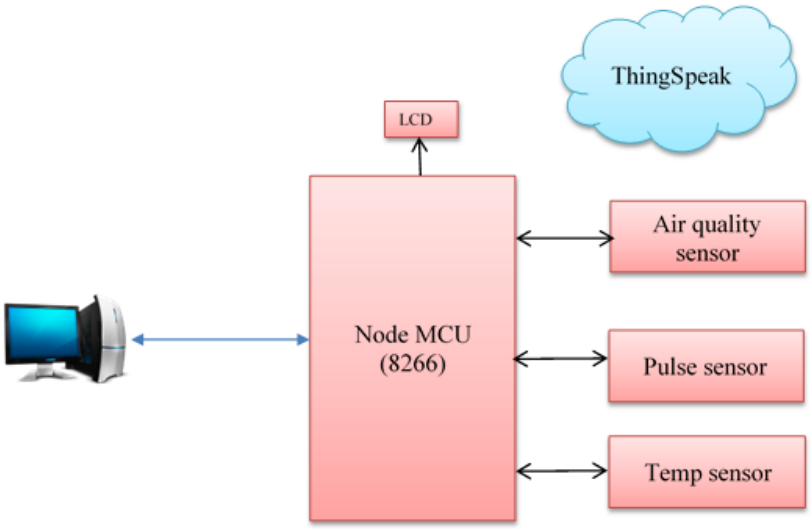

Fig. 3.1. System architecture

The system architecture for our IoT based health monitoring system using Fuzzy logic as shown in Fig 3.1. The system is designed to work in an IoT environment. Air quality sensor, temperature sensor and pulse sensor will be placed on and near to the patient. With the help of sensors placed on and around the patient, we can get the health condition of the patients and also the air quality which will be sent to the Target device through Node MCU 8266 Micro controller. The collected data from the microcontroller is sent to cloud using Wi-Fi for visualization and analysis of the data. We can also download previous data collected by sensors date wise and time wise. The collected data can be accessed through Thingspeak IoT platform.

We have used fuzzy logic to analyze the data collected from the sensors. We have also generated the graphs based on the inferences made using fuzzy logic. The advantage of using fuzzy logic is that we do not require many data sets to analyze the newly data collected. Another advantage of Fuzzy logic is its power of interpretability and simplicity

Here we have used the most commonly used Fuzzy methodology called the Mamdani Inference Method. Mamdani method is the simplest method because of its structure using min-max operations. We have also chosen the Mamdani fuzzy inference method because of its wide spread acceptance and it is well suited for human inputs. The output from the mamdani method can also be efficiently transferred to a linguistic form.

3.2 System Design

This device is having companion cloud storage-ThingSpeak as a platform for storing data onto cloud and retrieving the data from cloud. This system allows us to get real time data. Here we have used NodeMCU ESP 8266 as microcontroller, MAX30100 sensor used for measuring the pulse rate, DS18B20 sensor for measuring temperature and MQ-2 is used for measuring the air quality. The experimental setup of the health monitoring system including sensors and microcontroller is as shown in Fig 3.2.

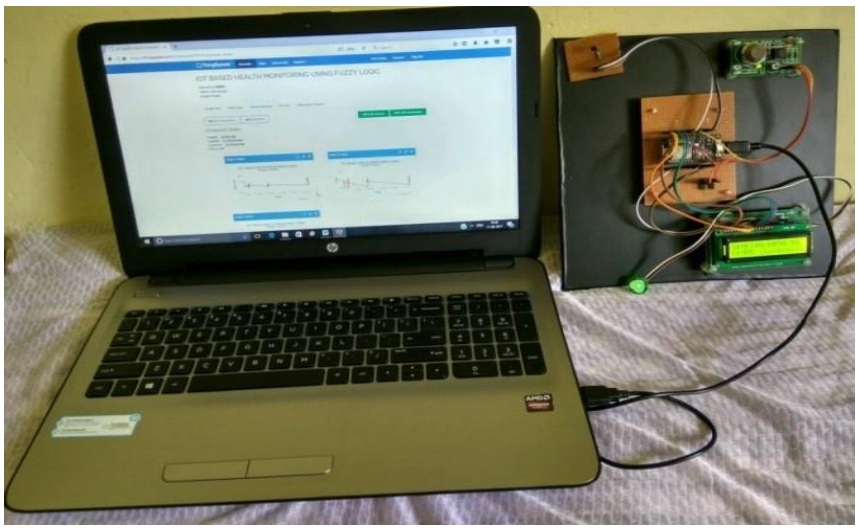

Fig. 3.2. System Design

3.3 ThingSpeak

IoT provides access to embedded devices and also to the web services. Thingspeak is an IoT application platform which provides wide range of functions such as analysis, monitoring and counter action capabilities. ThingSpeak is an open source IoT platform

used to store and retrieve the data stored in cloud over the internet. Thingspeak also supports the MATLAB where we can analyse and visualize the Data. Data can be sent from Arduino, Beagle Bone Black, Raspberry Pi. With the help of ThingSpeak we create login for sensor application and we can also track the location of the device. ThingSpeak is an IoT platform which will collect the data and analyse it. ThingSpeak will act like a bridge between different type of sensors and software, which also acts as data collector which will collect data from different device and it will pull the data onto software environment. ThingSpeak will contain a Channel which is a primary element which contains location field, data field, and also status field. Channels are used to write the data, process and view with the help of MATLAB, and also respond to data by alerts and tweets. The architecture of Thingspeak is as shown in Fig 3.3.

Key Features of Thingspeak.

- Using a MQTT or REST API it will send the data by configuring the devices.
- Data Aggregation from the devices and the third-party sources
- Data visualization for live data as well as historical data.
- Using MATLAB data Pre-processing and analysis of the collected data can be done.
- Based on schedules or events, run your IoT analytics automatically.
- Acts on the data
- Communicates using Twitter or Twilio.

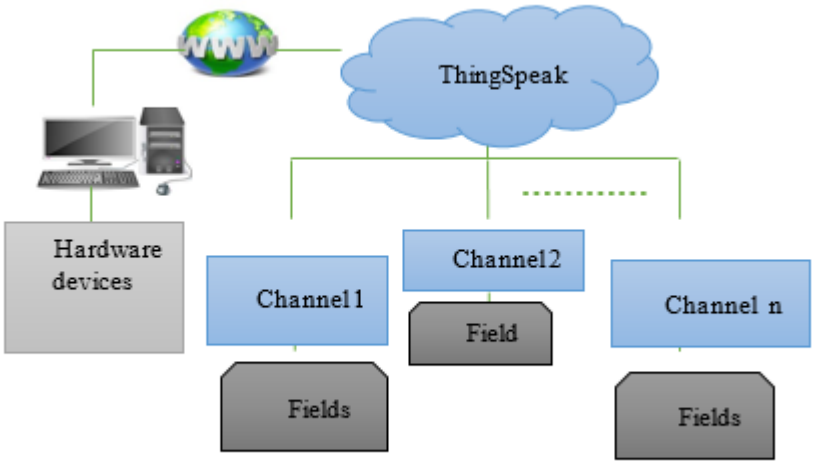

Fig. 3.3. Overview of ThingSpeak

Thingspeak Workflow.

- Channel creation and data collection
- Data Analysing and Visualizing
- Using apps, act on data

4 RESULTS AND ANALYSIS

4.1 Heart Beat Rate Measurement

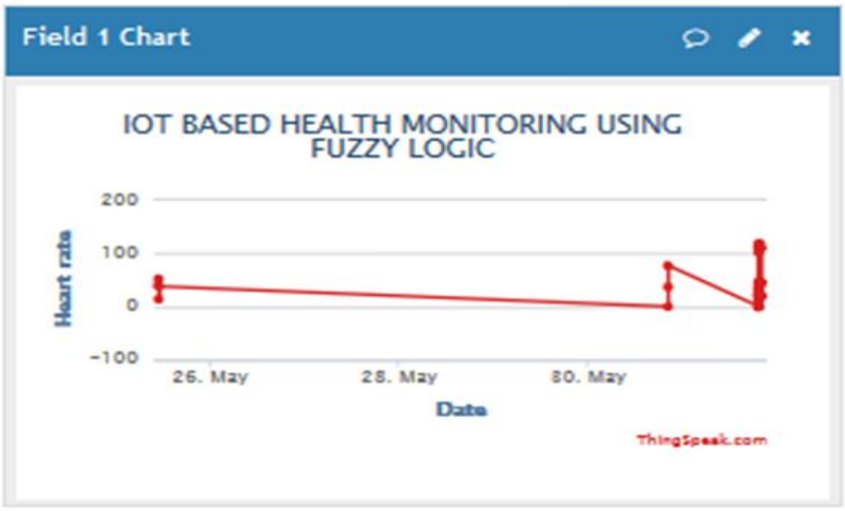

Fig. 4.1. Heart beat rate measurement

The MAX30100 is used as a pulse sensor. It consists of two LEDs optimized optics, photodetector, and a low noise analog signal processing for detecting heart-rate and pulse oximetry. This pulse sensor operates at a voltage range from 1.8V and 3.3V. MAX30100 ca be used as a fitness assessment device and also as a medical monitoring device. The heart beat measurements of a patient collected from the pulse sensor over a period of time and recorded in Thingspeak is as shown in Fig 4.1.

When Blood gets ejected from ventricles, pulse pressure is created and transmitted through the circulatory system. The pulse pressure when traversed through the vessels will cause displacement of vessel walls, which can be measurable at various points. Change in pulsatile of blood volume is detected by the photo electric method, in which photo conductors are being used. Photo resistors and photo transistors are used for amplification. LED is being used for emitting the light, which is transmitted through artery and photo resistors resistance is measured by the amount of light reaching. Each time the blood is forced, the volume of blood increases in the finger, optical density is altered which results in reducing the light transmission through finger. This will result

in increase in photo resister resistance accordingly. Photo resistors are connected as a voltage divider circuit which produces voltage that will vary with respect to the amount of blood in the finger.

4.2 Temperature Measurement

DS18B20 sensor used for measuring the temperature which will provide us 9 bit to 12 bit degree Celsius temperature measurements and also there is an alarm system. This sensor is an integrated-circuit, which will output the voltage linearly proportional to the Celsius temperature. ADC (Analog to digital converter) is used for the purpose of converting the analog values to digital. This sensor features with one wire communication. So there is only one data line and a ground to communicate with the microprocessor. There is no separate power supply cable, power supplied directly through the data line which is known as parasite power. The temperature measurement of the patient over a period of time is as shown in Fig 4.2.

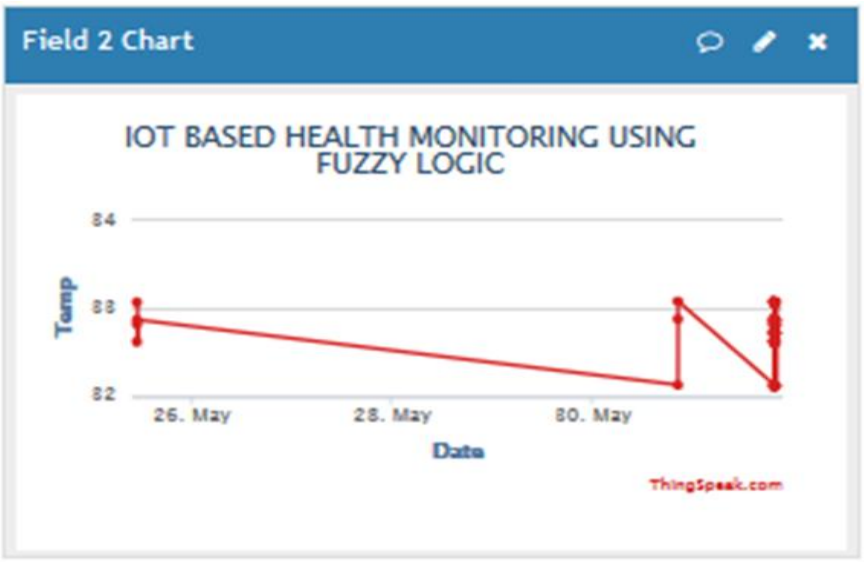

Fig. 4.2. Temperature measurement

4.3 Air Quality Measurement

MQ-2 gas sensor is composed of electrode, heater, micro AL2O3 ceramic tube, Tin Dioxide (SnO2), which are attached to the crust. Crust is made from plastic and stainless-steel net. The heater is the most important component which provides necessary conditions to the sensitive components work. MQ-2 sensor will have six pins, among those 4 are used for fetching signals, and 2 others are used as heating current provider

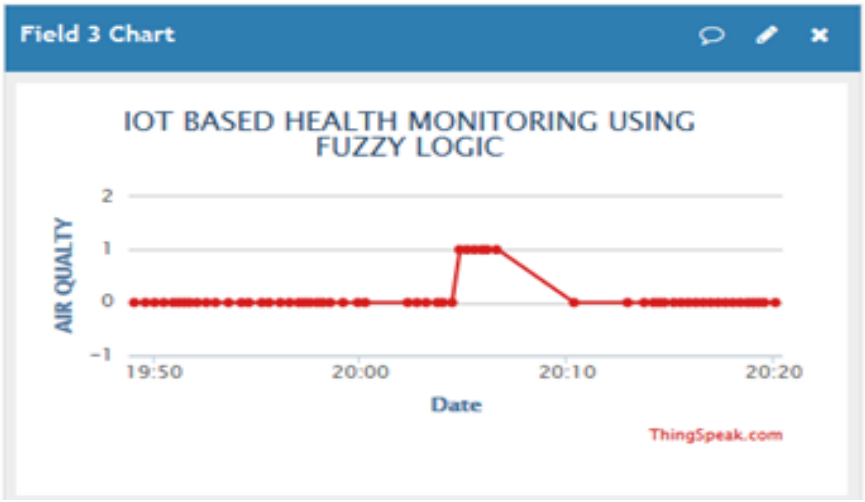

Fig.4.3. Air Quality Measurement

The air quality of the room in which the patient is monitored is as shown in Fig 4.3. MQ-2 sensor is used for measuring the air quality in the environment. The sensor detects any hazardous gas in the environment and suddenly it will be notified and alarm will be generated. This sensor will detect some of hazardous gases like Hydrogen, smoke, alcohol, methane, propane, i-butane and LPG. These sensors are used for the purpose of detecting gas leakages in the industries and also in houses. If any hazardous gas is detected then value measured and plotted in the graph will be raised to 1 otherwise it will stay in 0.

4.4 Importing Data from Cloud

The values of Heart beat rate, Temperature, and Air quality data values collected from relevant sensors will be sent to the cloud using Thingspeak channel. ThingSpeak will collect the data values from the different sensors used in the system. We write the Temperature, Heart beat rate and Air quality data into our IoT Based Health Monitoring using Fuzzy Logic channel. Channel will then allow us for visualizing the results. MATLAB Visualizations apps visualize the values that are measured and recorded.

Collected data will be stored in the cloud securely for future use and reference. We can import stored data at any time, from any place. Simply by clicking on the "import data" button will list out all heart rate, temperature and air quality combined with previous data recorded with date and time. The data collected from all the sensors which are stored in Thingspeak is as shown in Fig 4.4.

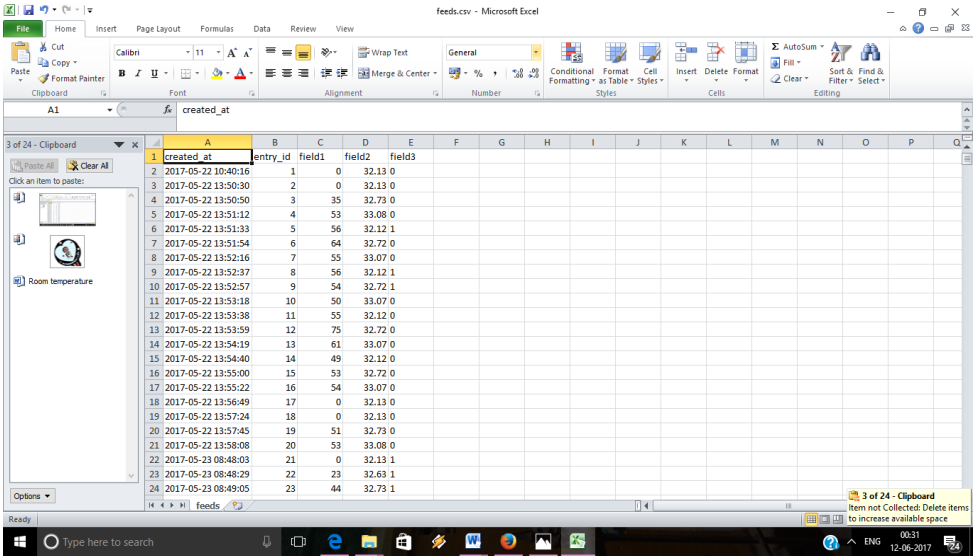

Fig. 4.4. Imported data from the cloud

5 FUTURE ENHANCEMENT

Here we have built a device that measures and analyze the three different values (heart beat rate, temperature, and air quality) using fuzzy logic approach. Also, we are able to import the data which is previously recorded and is securely stored in cloud.

In future, we have planned to automate the entire system. In the present system, we are downloading the details of the temperature, heart beat and air quality stored in the cloud and decision is made using the fuzzy logic approach. This can be completely automated and we can send the outlier messages to the caretakers and the doctors immediately. With this future work, we can leave the elderly people and the patients alone at home as they will be continuously monitored and the caretakers and the family members can lead a tension free life. This will also provide a better lifestyle to the elderly people as they can lead an independent life.

6 CONCLUSION

Now a day for busy scheduled life style this IOT Based Health Monitoring using Fuzzy Logic will help the people to maintain and monitor the health status of elderly people and the patients regularly to keep track of their health in good. This paper explains how best we can develop health monitoring system using IoT. We have applied the Fuzzy Logic approach to analyze the values recorded by the sensors. The core of device consists of NodeMCU8266 microcontroller with built in Wi-Fi to connect to internet, and the recorded values are analyzed with graphs in Thingspeak platform. We have

built the system with low cost health monitoring devices.

"The authors declare that there is no conflict of interest regarding the publication of this paper."

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