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Healthcare Monitoring and Analytic System Based Internet of Thing

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Abstract
In this work, a healthcare monitoring system-based Internet of Medical Things (IoMT) is proposed, implemented, analyze it by artificial intelligence using fuzzy logic. Atmega microcontroller was used to achieve the function of the proposed work and provide the area for monitoring and Analytic(decision) to the caretakers or doctors through putting the results in the platform. In this paper, the heart rate pulse sensor and infrared temperature sensor are chosen, which give skin temperature and room temperature to provide their results to the caretaker. The decision that gives the patient is in a normal state, or the fuzzy logic does an abnormal state or risk state. The fuzzy logic is used for it accurate and fast in processing data and gives a result very closer to the reality in smart health services. IoMT enables the doctors and caretakers to monitor the patient easily at any time and any place by using their intelligent laptops, tablets, and phones. Finally, the proposed system can contribute to the construction of a wide healthcare monitoring system in the unit or in the department that follows on for the hospital. Therefore, Doctors can improve the accuracy of the diagnosis, as they receive all the patient data necessary.
KEYWORDS: Atmega microcontroller board; Cloud Computing; Internet of Things; Pulse rate; Temperature sensor.

I. INTRODUCTION

Increasing mortality cases for the patient, elderly, and people with chronic diseases because it don't exist for enough healthcare monitoring, thus, the attention of researchers towards the benefits of the internet especially after appear supposedly Internet of Things (IoT) and specifically the Internet of Medical Things (IoMT). In the last decade, the large expansion of IoT makes all things to be correlated. Some of IoT's applications include smart city, home automation, intelligent climate, smart shopping, automated transportation, and health care. IoMT allows for sustained development in the health care sector, in the field of patient treatment and communication. The major benefits of IoMT in health-care organizations are improved outcomes of treatment, Reduced costs, enhanced patient care, better risk control, better disease detection, and reduced errors. The key feature of the health care system is checking vital signs of the patient, such as skin temperature, Electrogradigram (ECG), respiration, percentage of oxygen saturation, blood pressure, motion and heart rate [1].
On the subject of IoMT, several studies have been proposed, analyzed, and investigated (related work), for example, Healthcare Monitoring System Based on Pulse Sensor [2],

Healthcare based on IoT using Raspberry Pi [3], An Intelligent Sensor Based System for Real Time Heart Rate

Monitoring (HRM)[4], Neuro Fuzzy based Healthcare System using IoT [5], A SMART PATIENT HEALTH MONITORING SYSTEM USING IOT [6], Healthcare IoT-Based Affective State Mining Using a Deep Convolutional Neural Network[7] and Fuzzy-based Driver Monitoring System (FDMS): Implementation of two intelligent FDMSs and a testbed for safe driving in VANETs [8]. Each study in the previous works has a different way to realize the function of the IoMT, a different number of sensors, different types of vital signs, different types of machine learning used, different microcontrollers used, different ages of patient, and different platforms.
In this paper, the skin temperature, room temperature, heartbeat rate is measured, then analyze it by using fuzzy logic with many rules to decide the degree of risk, and put the results of measurements and decision in the platform. The microcontroller that uses in this paper is Atmega microcontroller.
In the future, the proposed system could lead to the development of a comprehensive healthcare monitoring system in the hospital unit or department. This project would also support ICU patients, and It can also facilitate the monitoring of the elderly in nursing homes.
The organization of this paper is as follows: Sec.2 internet of things and cloud (upidots). Sec.3contains the designed system, theoretical operation concepts, and implementation.

In Sec. 4, the results of the developed system are presented, demonstrated, and discussed. Finally, the conclusion of the proposed system is presented in Sec. 5.

II. INTERNET OF THINGS (IOT)

The Internet of Things (IoT) refers to the process of using computer networks to build and shape Internet-connected objects. IoT means that, rather than have a few numbers of efficient electronic devices such as computers, laptops and tablets, it is easier to have a vast number of low-powered gadgets such as air conditioners, wristbands, fridges and umbrellas. Such objects mesmerize in IoT have the power of creative reasoning to perform the assigned task without the need for a personality and a name [9].

The "Thing" or entity present in the physical world, for data collection and processing, will obtain data from person or a living thing and turn those inputs into the Internet. This is made possible by using sensors to save during the specified time the value provided by the thought. "Actuators" may be used by linking items in the universe to show the outputs to the human body. Some of these outputs are triggered by the collected data and are processed with the Internet [9, 10].

IoT and cloud computing, by integrating two technologies, are equally involved in similar ways. The tracking system that is advanced by integrating these two systems to accurately monitor patient records even at the remote site, which is helpful to doctors. IoT technology is continuously sponsored to boost the performance of the Cloud in terms of high resource availability, usage, energy computational capability and energy. In addition, cloud computing is gaining support from IoT technology by improving the domain to manage the real environment and dynamically and distributed transition of the many new services. However, the IoT-based cloud platform should be comprehensive to build new technologies and applications in the smart world [9, 11]. The combination of IoT and cloud based online applications works well in terms of performance as opposed to ordinary web-based applications. Those combinations can be used by emerging applications such as military, banking, and medical applications. The cloud-based IoT technique in particular would support the efficient provision of services in medical applications for monitoring and remotely accessing the records. IoT Based Healthcare systems use the requisite data to capture on time such as regular adjustments in health parameters and update the risk of medical parameters within a standard time period. Additionally, IoT apps and the sensor readings relevant to medical parameters can be used effectively to detect the disease in good time before the dangerous state is reached [9, 11].

The essential advantages of IoT in healthcare systems are [12]:

1) Treatment outcomes: As the tracking is constant, reliable and automatic, all data is processed in the cloud and sent to the doctor in an orderly manner; the care processes have moved correctly. Using this technique will ensure prompt medical attention for estimating recovery.

2) Costs reduction: With the opportunity to meet patients and view them remotely, the cost of inpatient visits can be reduced. In addition, many patients may be treated and stabilized at their homes with the introduction of home care equipment.

3) Errors reduction: Comprehensive and reliable data obtained automatically and without human error will significantly reduce the incidence of medical errors and the associated financial and vital costs.

4) Disease management: If signs of a patient's health are registered and documented, the disease can be detected and treated prior to its progression.

5) Medication management: IoT allows people to avoid drug abuse through the exact use of medications as well as hospitals and health centers.

6) Patient's satisfaction: The focus on patient needs, prompt care, accuracy of data, reduction of frequent visits, cost savings, recording of recovery processes, and the most importantly is the active participation of patients in the treatment process, all of which have a positive effect on them.

III. SYSTEM DESIGN, THEORETICAL CONCEPTS AND IMPLEMENTATION

A. System Architecture

The designed system architecture for the proposed IoMT based healthcare monitoring system using Fuzzy logic as shown in Fig 1. The designed system works in an IoMT environment. Room temperature sensor, skin temperature sensor and heart rate sensor will be putted on and near to the patient. With the aid of the sensors that placed on and about the patient, healthcare condition for the patients can be gotten and then can be transfer the information of these sensors records to the target device through ethernet shield that connect on the Atmega microcontroller. The collected data from the microcontroller is sent to cloud using cable in ethernet shield for visualization the analysis data. The collected data can be accessed through upidots IoMT platform.
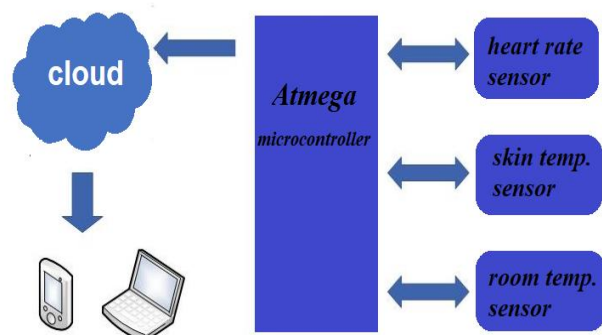

Fig1. System architecture

B. Theoretical concepts

1. Fuzzy logic basics

The Fuzzy logic (FL) approach have utilized. It was introduced by Lotfi Zadeh in 1965. The (FL)-based methodology focuses on the decision-making purpose. It is mainly used to get deficient data to take decision with the concepts called true or false and degrees of truth. The fuzzy set fully include the classical set. The membership function property is utilized for implementing the fuzziness of elements in the set that will have the solution based on the experiment in spite of knowledge. The weighted rate methodology is used to implement the membership function inside the fuzzy interference system[13-14].

In our work, the collected data form the sensors is analyzed by fuzzy logic. The graphs based on the inferences made using fuzzy logic is generated. 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 [15]. Mamdani Inference Method is used as a Fuzzy methodology that is a commonly used methodology and simplest method because its structure depending on min-max operations. The Mamdani fuzzy inference method have also chosen because of its wide spread acceptance and it is well suited for human inputs. The output from the Mamdani method can also be sufficiently transferred to a linguistic form[14].

The fuzzy rule base system is utilized to produce the outputs according to the offered input for the system. In this paper, 2 input parameters will be entered to the system. The first (skin temperature) consist of 2 membership functions and the second (heart rate) consist of 3 membership functions. The output (degree of risk) consist of 3 membership functions. The number of rules is calculated based on each given parameter's membership function. The whole number of rules framed is 6 as shown in (Table **1**). The membership function values and the fuzzy rules are introduced by researcher's proposition based on the fuzzy inference concept.

	Input		Output
	Skin temperature	Heart pulse rate	Degree of risk
1	Hyper thermal	Normal	Low
2	Hypo thermal	Normal	Low
3	Hyper thermal	Tacky cardia	Med
4	Hypo thermal	Tacky cardia	High
5	Hyper thermal	Brady cardia	High
6	Hypo thermal	Brady cardia	High

Table 1. The fuzzy rule table with different categories of the input and output parameters

Fig. **2** demonstrates the Fuzzy Inference System in which the heart pulse rate and skin temperature are the input values.

After finish Fuzzification, Defuzzification methodology is used for producing the output for degree of risk.
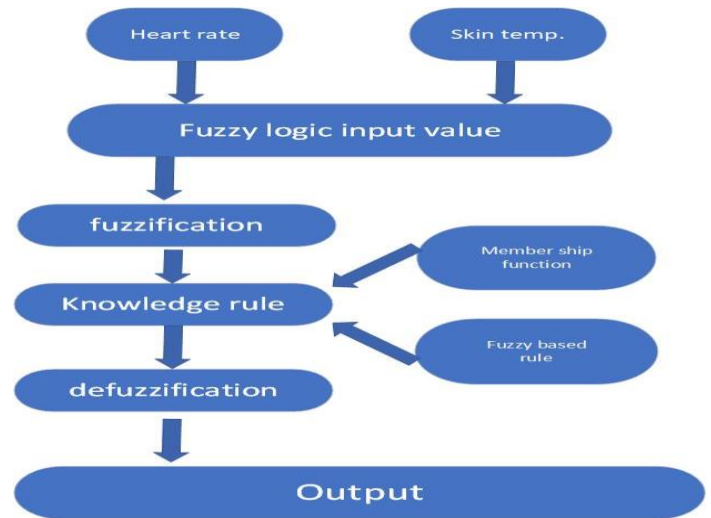

Fig. 2. Fuzzy Inference System

The input membership functions are formulated using the trapezoidal function, and the output

membership function is formulated using the trapezoidal membership function. Fig. **3**

demonstrates the membership function for heart rate whose parameters for analyzing heart rate are brady, normal and tacky.

Fig. **4** show the membership function for skin temperature whose parameters for analyzing skin temperature are hypo and hyper.

Fig. **5** show the membership function for output whose parameters for analyzing output are low, medium and high.
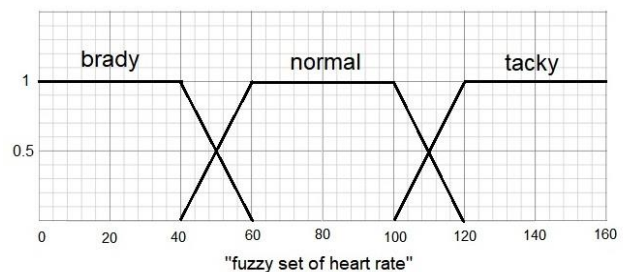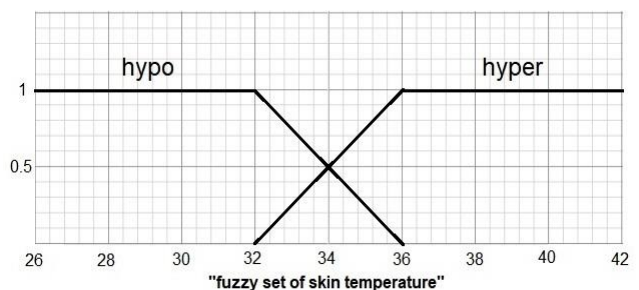

Fig.3 membership function for heart rate

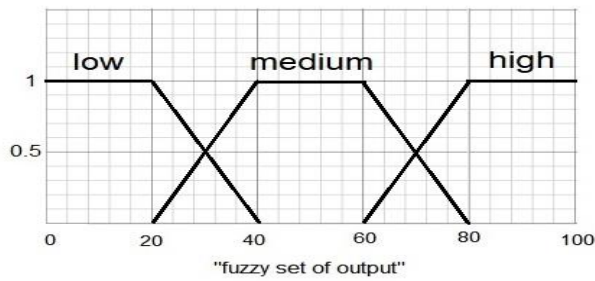Fig.4 membership function for skin temperature

Fig.5 membership function for output

2. Arduino Uno

It is a microcontroller board which used the 8-bit ATmega328P microcontroller from Atmel. It has 6 analog inputs,14 digital input/output, a 16 MHz crystal, a power jack, reset button and a USB connection. easy connecting it to a computer with a USB cable or battery is enough to get it started or powering it with an AC-to-DC adapter. Uno Software (IDE) gives simply application development on windows platform [16-17].
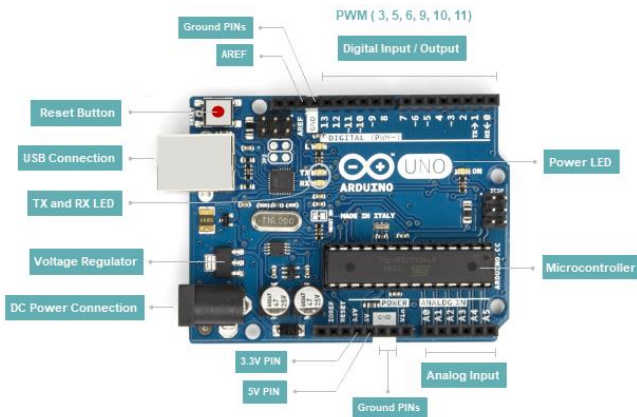

Fig 6. Arduino Uno

3- Temperature IR Sensor

The MLX90614 is an Infra-Red Thermometer which is non-contact temperature monitoring. The MLX90614 integrates a low-noise amplifier, 17-bit ADC and an effective DSP package while achieving high thermometer accuracy and resolution.

The thermometer comes in a factory fitted with a digital SMBus output that gives full access to the temperature measured in the 0.02 ° C maximum temperature range(s).

Fig 7. Temperature IR Sensor

4-Grove - Ear-clip Heart Rate Sensor

Heart rate ear clip kit includes an ear clip and a module receiver. The system to calculate heart rate can be used to track patient and athlete heart rate. The whole device is highly adaptive, low power consumption and very portable.

Fig 8. Ear-clip Heart Rate Sensor

C. Implementation

The following figures show the installation of the Ethernet Shield directly on the Atmega microcontroller board through the corresponding blocks, and also shows how to supply the sensors connected to the power (5v) by red wire and ground by black wire through mini board. Where the information transfer wire of the heartbeat sensor was connected to one of the analog blocks and the information wire of the skin temperature sensor was connected by green wire to the two blocks, or lines are called Serial Clock (or SCL) and Serial Data (or SDA).

The power of the microcontroller can be supplied in several ways, the first by laptop from the USB port and the second by an external adapter that connects to its power jack in the controller and the third by batteries that connect to the port (Vin).

The shield provides a standard RJ45 ethernet jack, reset button on the shield resets both the shield and the Atmega microcontroller, and the number of informational LEDs.
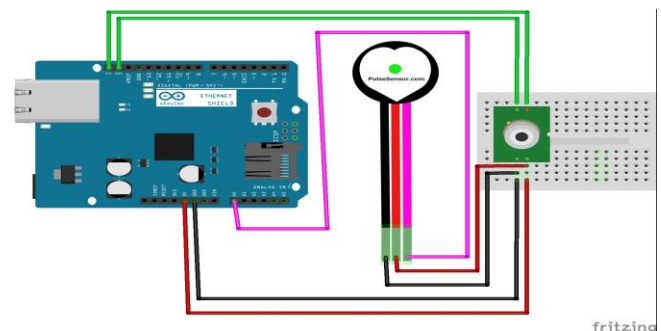

Fig 9. Installation of circuit

IV. RESULTS AND DISCUSSION

A. Mechanism Operating

The department's connections to the installation and testing phase of the smart health metering system are shown as in the following figure after mentioning the steps of installing the device.

STEP.1: The sensor Pulse is set at the patient's ear. This involves an IR-sensor. Get pulse from the sensor in every pumping. This sensor output from the signal conditioning unit for amplification is provided to the Atmega microcontroller.

STEP 2: The patient places his finger over the opening underneath the skin temperature sensor, so the sensor takes the value of the skin temperature through the IR and then goes to the Arduino Uno.

Figure 10. Experimental environment

B. Testing and findings health care unit

The developed Patient Health Monitoring System is checked to use different people from normal to uncommon states of health. The different tests and results give minimum error rate and the findings are described below.

Fig 11. Screenshot: degree of risk

Through the tests that I conducted on several people, especially the elderly and shown in the photos above, I notice when the vital signs of the body (heartbeat and skin temperature) are within the normal range, the smart system gives a low risk ratio, unlike if one of the vital signs out of the normal range, the smart system It will give a risk ratio that is appropriate to these data, so caregivers will be able to know how dangerous the observer is, with ease and speed, to take the necessary measures.

In the Fig 12 graph of the green heart rate sensor signal repeats every 15 seconds and the red skin temperature sensor signal repeats every two seconds depending on the delay specified in the program. Whereas, the x axis represents the time and the y axis represents the amplitude.

In addition, the system gives room temperature in order to prevent the influence of temperature changes on the health condition of the observer.

C. Data display in the cloud

Regular vital parameters such as heart rate, body temperature, EEG signals can be shown in a laptop or cell phone and the same can be sent to the doctor in emergencies. In the above picture, the information of the person watching is shown on the cloud, where the skin temperature, room temperature, and the number of heartbeats appeared. The Fuzzy logic system gave the patient's risk level directly. It was high because the skin temperature was lower than the normal limit, and the number of heartbeats was lower than the normal limit, and this condition is considered Very dangerous from a medical point of view.

This can be achieved using our program, the results of which are put online and can be seen from anywhere in the world. Since this is a concept model, our framework displays the almost real-time values of various health parameters.
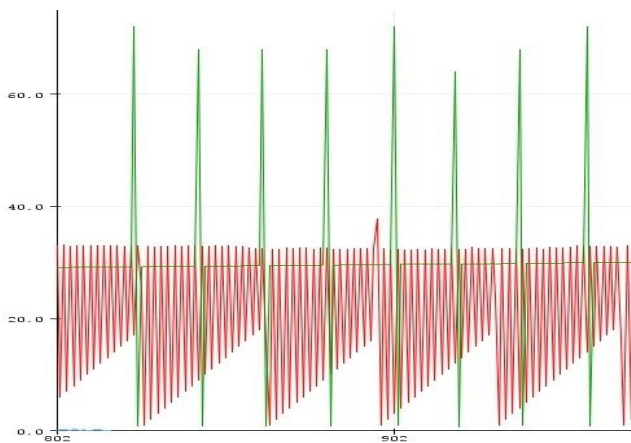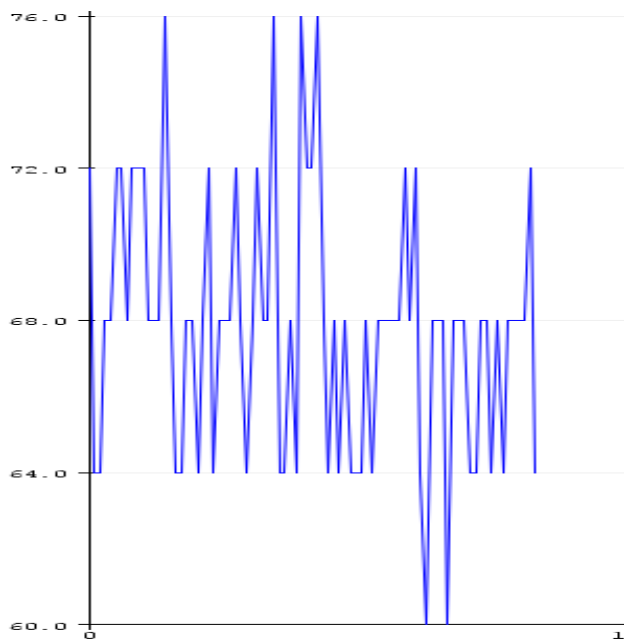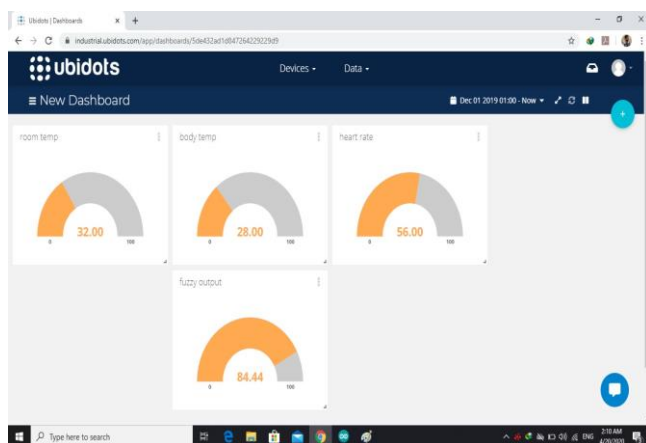
Fig 12. Screenshot: sensing signals in plotter

Fig 13. Screenshot: parameter on cloud

V Conclusion and Future Work

The Use of Internet of Things technology in healthcare with an intelligent system (fuzzy logic) can reduce the need for hospitals, and thus fewer deaths, especially among the elderly. IoT protocols enable easy integration with caregiver devices and applications and make the solution very much scalable. This paper proposes and explains a very easy-to-use device and uses the fuzzy logic system found in the Arduino libraries to analyze the recorded values from the sensors, and then give the risks ratio directly. It found through the experiment that using this system provides good results that can be relied upon easily, quickly, and accurately, even though some of the components used are not original. As for using an original and well-made component company, this system can be used throughout the day for monitoring without any problems, as it is easy to use and suitable for the elderly.

The IOT platform will be paired with cloud computing in the future so that the information can be accessible for diagnosis and intensive care in all hospitals.

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