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## Patient health monitoring system

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### ABSTRACT

*Health is one of the primary capabilities that a human need to go on with his life. That is the main reason the healthcare provided to the human must be bestowed in ample means and effective ways to ensure his health based on health monitoring parameters and the medical assistance being provided directly. The new technological development and its implementation now involve the internet and the sensors often known as the Internet of Things (IoT), which enables the worldwide approach to the health care base system development. This steers to the health system management that in a real-time approach it supplies a set of particulars relevant to the patient being monitored. In all the countries the death rates are becoming high due to the absence of well-timed medical treatments. These can be shut out through standard health care. The paper puts forward an IoT approach for a superior health monitoring system, by involving the sensors where they sense the body temperature plus the heartbeat and tells the doctor or the attending staff of the patient about the state of the patient. The project uses the KNN algorithm to predict the shape and condition of the sufferer to prevent them from going into further bad state. When the bad condition of the patient is predicted and detected by the system, it sends mail to the doctor in a most emergency situation or else in other cases it keeps on updating the sensed values in the web page created. The system also includes a buzzer beeping situation, where the beeping occurs when the nurse has to be notified of the state of the patient. Whereas, the previous systems developed did not do the predicting part, which plays the most important role in taking care of the patient. Thus, the project results in taking the greatest possible measure in helping the patients improve their situation.*

**Keywords**— IoT, Machine learning, KNN, Emergency

### 1. INTRODUCTION

The objective of IoT is the unification and integration of all communication systems [3] that surround us. Hence, the systems can get control and access to all other systems that provide ubiquitous communication and computing with the purpose of defining a new generation of assistance services [6]. IoT is complemented by the application of machine learning, to learn user behaviour patterns, gain knowledge of the context, define action rules for each scenario in relation to the user's behaviour etc. Specifically, the field from machine learning that works with the Internet of things to define services for the assistance of people is ambient intelligence and particularly when dealing with healthcare of admitted people with the critical condition [2]. The main goal of this paper is to define a model based on IoT to reduce the tedious process of the nurses and duty doctors to check the admitted patients during emergency situations. Our proposal for the Internet of things in medical environments is based on three pillars: [14] Firstly, to read the temperature and pulse value of the patient using sensors embedded with the patients. Secondly, the buzzer buzzes to indicate that the patient is in an emergency situation to the nurse present in that particular ward. Also, the nurse is given a webpage to monitor the patient's condition at a regular interval. Thirdly, a message is sent to the duty doctor's phone in case of any critical emergency where the presence of a nurse is insufficient to treat the patient [1]. The values collected from the sensors are stored in a cloud [5] [10]. The prediction and analysis are done in the cloud and accordingly, the buzzer or message alert is sent to train [11].

### 2. RELATED WORK

Nilanjan Dey, (2017) proposed that the internet of things can be converged with the healthcare sector to transform into more advanced and efficient services. The conjunction of the Internet of things technology and medical field makes a great impact in the healthcare sector. IoT has physical devices network, embedded system, sensor, servers, software and network connectivity to communicate remotely and collect data from the system components. IoT integrates the automation, sensor networks, embedded system, these facilities makes IoT a great convenience. He also mentioned the healthcare application supported with IoT system can be connected and used anywhere, anytime and at any place of our convenience which leads to the smart healthcare usage. [3]

Sreekanth K U, (2016) addressed about the effectiveness and scope of Internet of things in healthcare unit, he also explained about the gradual improvement in the status of healthcare with the help of Internet of things. The wearable healthcare gadgets such as

watches, bracelets, rings, hair laces, health monitor, pedometer, activity tracker, virtual reality headsets brought a new way continuous monitorization of our personal health. They can monitor the health parameters such as heartbeat, blood pressure, body temperature, Oxygen saturation level in blood with the help of the wearable devices and their families can regularly check their health report [2].

Luca Catarinucci, (2015) proposed the designing of health care system which collects the patient's health condition and environmental conditions at real-time and sends to the control centre where it is analysed and sent an alert based on the emergency condition. The main advantage of the system is it reduces the monitoring of nursing staff in the hospital .he used three important features such as RFID enhanced wireless sensor network called hybrid sensing system, IoT Smart gateway, a User interface for monitoring the medical report [12].

B. Prasath, (2016) introduced the desktop application for monitoring the health status of the patient themselves and he developed the application user-friendly for the usage of the patient. He senses the blood glucose sensing through a generic IoT based medical acquisition detector, Electrocardiogram monitoring is done by portable wireless acquisition transmitter and wireless receiving transmitter, Blood pressure monitoring is implemented by the BP apparatus with the communication module with the patient's body, Body temperature monitoring is done by home gateway which transmits the temperature with the help of infrared detector [7].

Prosanta Gope, (2015) ensured the security aspects of the healthcare system in hospitals, the data security is done in six aspects, the aspect are Data integrity, Data freshness, Authentication, Anomaly, Secure localization and this system has body sensor network which allows the connection of all the body sensor attached to the patient ,they monitor the patient periodically and collects the data and sends the data to the server. The system gets parameters such as Electrocardiogram, Electromyography, and Blood pressure [8]. Punit Gupta,(2016)introduced a robust IoT system that monitors the patient automatically in a specific interval of time and sends the health record to the duty doctor, it reduces the importance of the availability of doctor all the time in hospital and doctor can remotely get access to the health record of the patients. It collects the health parameter such as blood pressure, body temperature, patients heart rate. This system uses the smart sensor network and it is later analysed by the medical experts and at the same time maintaining a database for the health record also gives a better track of the patient's health condition and improved examining of patients [4].

Moeen Hassanalieregh, Alex Page, Tolga Soyata, Gaurav Sharma, Mehmet Aktas, Gonzalo Mateos Burak Kantarci, Silvana Andreescu in the 2015 IEEE paper proposed that smart health care systems enabled by the internet of things are the most important one. Here, the physical and mental health status is collected by various embedded or environmental sensors. These data are processed and analysed and made available always. This practice may bring about an evolution in the practice of medicine. It also enables personalized treatments and other management options for the patients. It also aids in reducing the cost of healthcare simultaneously improving the quality of services [5].

Sarfraz Fayaz Khan, in the year 2017, proposed that Information and Communication Technologies are being adopted widely for the efficiency of healthcare treatments and its overall administration. Researches have been initiated and started in various fields with the introduction of the Internet of Things. In the healthcare environment, the staffs and doctors are given a chance to improve and adopt new services by the usage of Wi-Fi. This is done by using the internet of things hardware which is fused with the Wi-Fi module of the RFID, NFC tags and some small sensor nodes. The different ways in which IoT can be implemented in healthcare institutions are widely discussed in this paper. In addition, the combination of microcontrollers with the sensors is added to improve efficiency. The result includes robust output against medical emergencies [13].

Riitta Mieronkoskia, Iman Azimi, Amir M. Rahmani, Riku Aantaa, Virpi Terava, Pasi Liljeberg, Sanna Salantera, in 2017 international journal of nursing studies said that the most promising quality of advanced technology in medicine and nursing is the patient care and safety. In addition to the software applications developed, the embedded systems and hardware can play a wide role. A few are wearable sensors, medical equipment and implantable devices. Numerous papers proposed on nursing care are of the basic level and the innovations are yet to developed and used. The internet of things concept is widely used in the technological fields and is not much developed in the nursing areas, which ought to be done in the nearing future. It is mentioned that modern technology can be extensively used to overcome the challenges faced in the medical and nursing areas [14].

Megha Koshti, Prof. Dr Sanjay Ganorkar, in 2016, proposed that their main objective is to monitor the heart rate of the patient, i.e., monitoring of the ECG signal. They have used a prototype model with a steering wheel to monitor the ECG of the patient. As the internet and World Wide Web play an important role in all the technologies developed, the embedded web server is used here which is a combination of internet and embedded devices. This is primarily used to access the equipment remotely. A heart rate detection algorithm based on continuous wavelet transform has been used. In addition, skin electrodes have also been used to monitor the nerve voltages of the heart pulses. Analog to digital converter is used to convert the obtained analog values into readable digital values [11].

Amir-Mohammad Rahmani, Nanda Kumar Thanigaivelan, Tuan Nguyen Gia, Jose Granados, Behailu Negash, Pasi Liljeberg, and Hannu Tenhunen, said that there is demand for new health care technologies though with lots of improvement in the internet of things field. Basically, there exists a connection between the sensor networks and the internet in the development of any health monitoring system using the internet of things. This connection is usually made for translating the protocols that are used in the networks and the sensors. They also have the entire control on the amount of data that is being transferred and its security. So, they introduce a smart e-health gateway by providing local storage, data processing, data mining and more. The energy efficiency, scalability, and reliability are some basic challenges faced and can be overcome shortly. A successful implementation of the high-level above-mentioned system can bring about numerous changes and benefits in the health care systems [6].

Antonio J. Jara, Miguel A. Zamora and Antonio F. G. Skarmeta, said in their paper that it is more important to provide proper health care to elderly people with the wide increase in the whole population problems related to health. Their aim is to focus on new medical advancements and technologies. To achieve global connectivity between the hospital, doctors and the patients is to include internet of things approach to the advancements. This is done mostly to improve the effectiveness of the patient's records. So, they have developed an architecture that provides flexibility of communications, control and monitoring. These are done by the usage of 6LoWPAN and RFID/NFC for secure communications. Also, these are carried using high specifications with low power consumption to improve security standards. Here in addition to these cryptographic sim cards are being used for authentication and encryption to communicate with the medical devices. As future works mentioned they are going to analyse the power consumption and introduce various other algorithms [1].

Yuehong YIN, Yan Zeng, Xing Chen, Yuanjie Fan mentioned in their publication that various exploration is done in technologies especial one those of the medical field ones. This is mainly done to improve and strengthen the existing technologies of health care services. They feel that among various techniques internet of things have played a vital role to interconnect the available medical resources and provide smart health care services which are more effective and reliable especially to the elderly patients. They have discussed the various applications of technologies in IoT supporting medical fields. Also, the challenges and prospects of these developments are also discussed. Their future enhancements include self-learning and self-improvement to enable faster researches. Also new and different required hardware and standardization with improved privacy and security could be included [9].

M Shamim Hossaina, Ghulam Muhammad proposed that quality health care and services are provided with the improvement and advances in the internet of things ideology where technological developments are tremendously increasing day by day. With the high number of increases in the elderly and disabled people, there is a demand for efficient infrastructure for analysing the patient's record so that preventable deaths could be avoided. HealthIoT is basically the combination of protocols, sensors, and equipment that aid in the process. This system collects the ECG through mobile devices and sent to cloud for security reasons. Watermarking, signal enhancements and other analytics are enhanced to identify thefts in the processes. The future work will include testing the proposed framework for data security and notification functions and including test trials with patients and health professionals [10].

### **3. EXISTING SYSTEM**

All the related works that have been done by different researchers that are related to the current research are as follows,

- A Health-IoT Platform Based on the integration of sensing and displaying the data from the sensors [4] [1].
- RFID Technology for IoT-Based Personal Healthcare [13].

#### **3.1 A health-IoT platform based on the integration of sensing and displaying the data from the sensors**

The health monitoring systems developed until now only take care of the part of sensing the desirable values through the sensors and displaying them in their respective hosting page. Someone has to be present there to constantly view the patients and take care of their conditions [1]. The continuous checking of the value from the sensors and the relative hosting page in one of the most tedious works to do [4]. Man is always intended to do mistakes, so if the concentration the person checking the patient diverts, some mishappenings may occur [7] [8].

The disadvantages are:

- Continuous manual work even though, the system is automated.
- Only the latest values from the sensors will be present so that no prediction can be done with the values.

#### **3.2 RFID Technology for IoT-Based Personal Healthcare**

The RFID technology is now mature to provide part of the IoT physical layer for personal healthcare in smart environments through low-cost and disposable sensors. It is here presented a survey that RFID for application to body-centric systems and for gathering information (temperature, humidity, and other gases) about the patients' living environment [3]. Many available options are marked out up to the application level with some examples of RFID systems able to collect and process multichannel data about human behaviour in compliance with the power exposure and sanitary regulations.

The disadvantage is:

- In this paper for the wireless communication is established in RFID technology that covers the only short area.

### **4. PROPOSED SYSTEM**

This work aims at designing and implementing a hospital management system using a machine learning algorithm. The physiological parameters of the patients in collected in real time by the sensor network in normal environmental conditions and stores the data in the server where it is predicted by the prediction algorithm, it displays the current data in the webpage and it sends signal according to the prediction in case of emergency. It is composed of three main parts i) Sensing system ii) Health status prediction system iii) Emergency alert system.

#### **4.1 Sensing system**

**4.1.1 Body temperature sensing:** Body temperature is one of the most essential parts of health care services that can say a patient is normal or abnormal. Body temperature is the decisive vital sign in the maintenance in homeostasis. The temperature measurement system is implemented by the sensor (LM35) and the value is converted to the form of Celsius by the analog to digital converter setup. The sensor is attached to the bed of the patient as a probe and the temperature is collected periodically. The converted value is stored in the server in the raspberry pie and further used later. The main components for body temperature detection are a sensor and the analog to digital convertor setup.

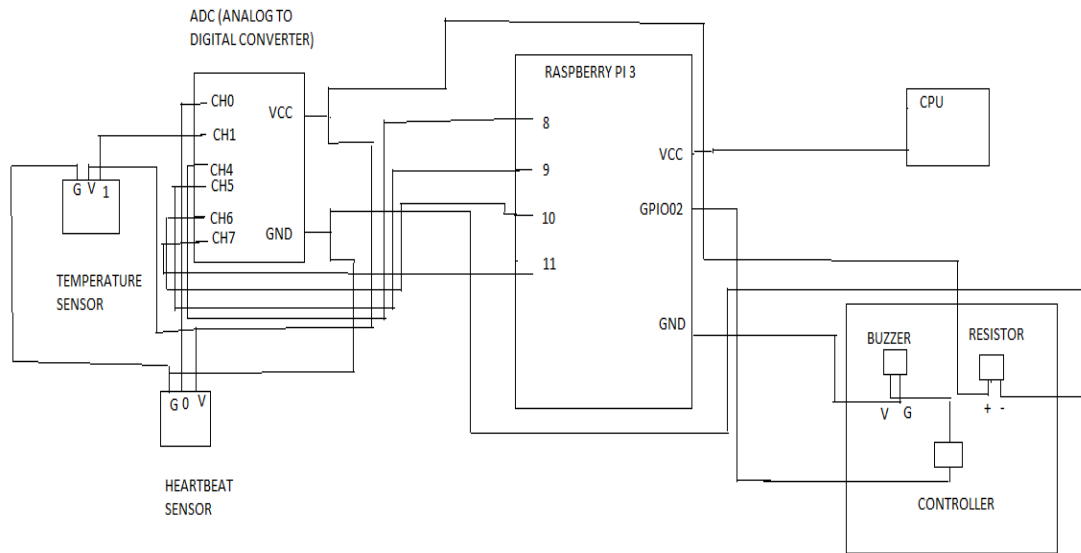


Fig. 1: Circuit diagram

**4.1.2 Heartbeat sensing:** Heartbeat is the vital requirement for the good health of a human being. The monitoring of the electrical activity of the heart and rhythm of the heartbeat is very important. The heartbeat sensing is implemented by the heartbeat sensor and the value has converted the analog to digital converter. The value is collected periodically and stored in the server which is inbuilt available in the raspberry pie. The heartbeat sensor is attached to the bed as a probe to the patient in an intensive care unit. The components which are essential in the heartbeat sensing is sensor and analog to digital converter.

**4.1.3 Interfacing of Sensors to raspberry pie:** The interfacing of sensors with the raspberry pie starts with analog to digital convertor. The MCP3008 which is a transistor which acts as a convertor, it has four analog pins for reading the value and converting it into digital form, similarly, it has four ground pins and four power supply pins and the pins which is meant for connecting the sensors. The temperature sensor should be always connected to the 0th pin of analog to digital convertor and the heart beat sensor should be connected to the 1st pin in the convertor. The four analog pins from the pins are connected to the four digital pins in the raspberry pie for getting the value from the sensors. Each sensor has three pins, they are ground, power and value pins which is connected accordingly to the convertor.

#### 4.2 Health status prediction system

Even Though the value collected from the sensor is displayed on the webpage, it will be even more efficient when the system predicts the abnormality of the patient and gives an alert. This is where machine learning becomes more effective in action. KNN algorithm has been used for the prediction of the sensor values collected. KNN (K-Nearest Neighbour) algorithm is a simple algorithm and works well in practice. KNN algorithm is a classification supervised algorithm. KNN uses data and classifies the new data points based on the similarity measure i.e. (distance function). The data is assigned to the class which has the nearest neighbour. It does not have specific training phase because it uses all the training data set. KNN is non-parametric lazy algorithm which means it works quite well in the real-world data because most of the real-time data does not obey the typical theoretical assumptions. KNN algorithm uses all the training data set to predict the result based on the best subset of the training data set. The algorithm is implemented in python which has several methods.

#### 4.3 Emergency alert system

The predicted data gives the signal to the raspberry pie where a buzzer is connected to it the buzzer cannot work alone it should be connected to a resistor and a controller. The buzzer has three pins ground, power supply and a value pin, the value pin is connected to the controller and the power supply should be given through the resistor which has 1k resistance and the ground is given to the negative pin in the resistor and the controller power supply is given through the raspberry pi and when it gets the signal from the raspberry pi it turns on the buzzer and gives signal to the duty nurse available. If the condition gets even worse it also sends the email through SMTP protocol from the registered mail to the current duty doctor mail.

### 5. PERFORMANCE METRICS

Some samples were performed to analyse the proposed IoT based health monitoring system. They are described in detail in the following explanations.

#### 5.1 Confusion matrix

The confusion matrix is a matrix that describes the complete performance of the model. It is also known as the error matrix. The rows in the matrix represent the instances in a predicted class and the columns represent the actual class. It is a type of contingency table, a type of table in a matrix format that displays the frequency distribution of the variables, with two dimensions ("actual", "predicted"). In the model proposed here the classification system has been trained to distinguished between "normal, abnormal (buzzer), abnormal (mail)". Considering a sample of 150 datasets – 50 normal, 50 abnormal (buzzer), 50 abnormal (mail), the prepared confusion matrix would look like the below. In the confusion matrix depicted above, the system predicted the number of normal datasets as 49 but 1 was categorized into abnormal (buzzer) where instead of normal condition the nurse has to be there, which is actually not necessary. The same is done with abnormal (buzzer) and abnormal (mail).

There are 4 terms used here, namely:

1. TRUE POSITIVES: The cases in which the prediction is YES and the actual output is also YES
2. TRUE NEGATIVES: The cases in which the prediction is NO and the actual output is also NO.
3. FALSE POSITIVES: The cases in which the prediction is YES and the actual output was NO.
4. FALSE NEGATIVES: The cases in which the prediction is NO and the actual output was YES.

**Table 1: Samples**

	ACTUAL CLASS			
	Normal	Abnormal (buzzer)	Abnormal (mail)	
PREDICTED CLASS	Normal	49	0	0
	Abnormal (buzzer)	1	48	3
	Abnormal (mail)	0	2	47

**Table 2: Prediction**

n=150	PREDICTED: NO	PREDICTED: YES
ACTUAL: NO	3	6
ACTUAL: YES	0	141

$$\begin{aligned} \text{Error rate} &= \text{True positives} + \text{False negatives} / \text{Total samples} \\ \text{Error-rate} &= 141+6 / 150 \\ &= 0.98 \end{aligned}$$

Thus, the error-rate in the model predicted here is very less as shown from the above steps.

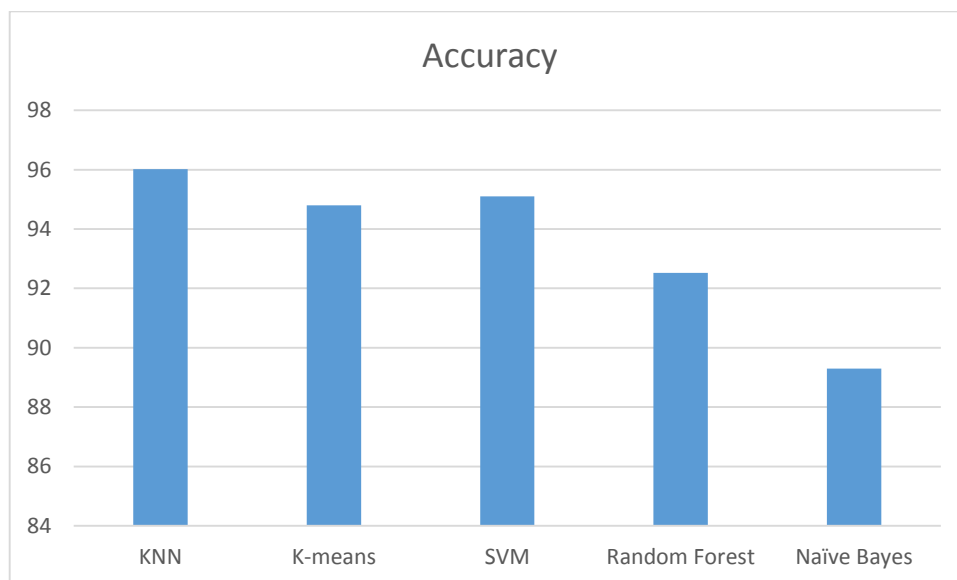
**5.2 Classification accuracy**

Classification accuracy is the percentage of correct predictions. It is for evaluating the classification models. Accuracy is the fraction of predictions the model got right.

$$\text{Accuracy} = \text{Number of correct predictions} / \text{Total number of predictions}$$

**Table 3: Accuracy comparison values**

Algorithms	Accuracy
KNN	96.02
K-means	94.8
SVM	95.1
Random Forest	92.52
Naïve Bayes	89.3



**Fig. 2:Accuracy comparison depiction**

Thus, the algorithm used is comparatively better than the other algorithms used. It also works best for real-time data processing and analysing of data.

**6. CONCLUSION AND FUTURE ENHANCEMENT**

The conclusion can be put together that rapidly advancing IoT and machine learning technologies have provided great opportunities for developing the healthcare department. Regardless of all these advancements, there are also some challenges that are to be overcome in the future. Some areas for future upgrades are listed as follows.

- **Security:** The main requisite for the IoT system is providing safety for its users. The privacy of patients should be made certain to prevent unauthorized identification and tracing. From this point of view, the higher the level of autonomy and intelligence of the things, the more challenges the protection of identities and privacy would arise. Furthermore, IoT-based applications are extremely vulnerable due to two basic factors: (1) most of the communications are wireless, which makes spying on the information extremely simple; (2) most of the IoT components are characterized by low energy and low computing capabilities, thus they can hardly implement complex stratagem on their own to ensure security. Thus, to overcome this cloud facilities can be used.
- **Hardware:** In the development of wearable devices, the question of how to achieve discreetness still poses a big challenge, because comfort is naturally the main concern. This requires a lot of manual time and power to make the embedded system.
- **App:** the Android application has to be developed so that every time the doctor or the attending staff need not log in to the mail or the website to check for the patients' state.

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