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Survey on Fog Computing in Healthcare Monitoring

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***Abstract*— At this moment in time, the requirement for medical assistance has been increasing. With a lot of patients coming in and a lesser ratio of doctors present there is a need to manage patient data in an organized manner and notify the doctor as and when required. The problem arises when a single doctor would have to monitor a patient's standard test results. It will render to be a tedious process even if the patients test results are normal.**

IoT plays a major role in healthcare as IoT devices can be tagged with sensors and used for real-time remote monitoring of patients. IoT generates bulk of data that can be refined using the cloud but for instantaneous monitoring, delays are caused when the data is to be transferred from the cloud to the application which is not admissible. Hence we have come up with a simple and affordable response that will possibly provide good insight into the patient's test results by using FOG as a median. Notification systems and machine learning algorithms are used to reduce the difficulties that emerge. These algorithms aim to improve the prediction process by relying on various inputs.

Keywords—Health monitoring, FOG, IoT, Machine Learning, Sensors, Body Area Network.

I. INTRODUCTION

Fog Computing is a devolved computing infrastructure or process in which computing resources are located between the data source and cloud or any other data center. The term fog computing, originated by CISCO, also refers to fogging.

As in nature how fog is nearer to the earth than clouds, it is just the same in the technological world, fog is near to end users, introducing cloud capabilities nearer to the ground. Fog is the enhancement of cloud computing, that comprises of several edge nodes directly connected to a physical device.[1] The major distinction between cloud computing and fog computing is geographical distribution, flexibility, latency, and security [1].

Body Area Network (BAN) is a bustling field of research and development as it offers the potential for a great implementation in the health monitoring system. By using BAN technology, doctors can check all the vital factors of a patient from faraway and they can stipulate acceptable solutions. The main motive supporting this technology is to deteriorate the workload at doctor's facilitates and give appropriate medical care [4]. BAN has been widely used in the medical healthcare field. It does the physiological monitoring of the patients much easier and cheaper when compared to hospitals. The main advantage of using BAN in the health monitoring system is that we can get emergency services from the doctor.

Machine Learning (ML) is an application of AI, where the expression cites to the power of IT systems to alone discover solutions to the problem by identifying the patterns in the database. Generally, ML allows IT systems to acknowledge patterns on the idea of existent datasets and algorithms also to originate the competent solution approach. So artificial knowledge is developed in the idea of experience[8]. The aim of every learning algorithm is to create models with acceptable generalization capability. By applying machine learning algorithms on the datasets of health monitoring the model is trained and analysis is finished with the support of the training.

II. RELATED WORK

IoT, the network of physical entities that transfer data over the internet. A device can be built using this IOT keeping the main objective to focus on monitoring patients. The professionals can advise and diagnose the patient before arriving to the emergency. This model constitutes the system that monitors the patient 24/7. The features mentioned in this model grants the user to monitor patients from distance without the need of physical interaction [12]. The influence of IoT in health care is yet to take wing due to various issues. The main features are to improve outcomes, fasten the response and enhance service levels, along with ensuring, high levels of safety and privacy on data being the key feature of this project.

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Network edge data processing, will provide shorter response time, which pave the path in saving a life and enhancing security.

A level of digital intelligence is added to the device by connecting different entities to them as in the project sensors are used. The prime cause following this change is to lessen the workload of doctor and accomplish patient care. The motive of using various body sensors to detect the physical parameters like ECG, body temperature, BP and heartrate of the patient[3].

Which can be achieved using Body Area Network, a simple WSN placed over or inside the body[3]. In the proposed system WBAN has various body sensors and a core which acts as a sink or gateway which gathers patients health data from sensors. Hub act as energy resource and storage. The Health monitoring system is mainly used for patients who need uninterrupted monitoring of their health condition. The sensors which are used are small wearable equipment and they can also be integrated into patient's clothing. BAN's consist of actuators and sensors around the body to monitor the patient's condition [3]. The sensors can select, monitor, operate, and transfer the vital signs. Sensors that are fixed to patients body are used for gathering biomedical data. They accumulate the data by physical stimuli and process the data. Theses sensors maybe implanted as node type or as body surface node. The data sent by sensors will be received by the actuators s and then interacts with the user [4] [6]. The data obtained is immediately notified to the medical personnel and caretakers. WBAN systems also require some data security measures to guarantee the privacy, data integrity, and confidentiality of patient's records all time. “Singcryption Certificateless protocol” is used for security in WBAN[2].

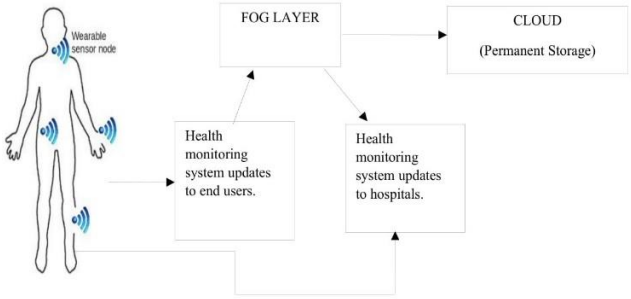

Fig 1 BAN Architecture

A Cloud is generally used to store the data is retrieved using sensors, due to many drawbacks which is faced during the processing and transferring of this data to the user-end a FOG technology is used as a medium between end user and the cloud.

Achieving real-time automation requires live data capture and examining, without having to deal with lateral restrictions that occur during processing of networked data. Fog computing provides efficient communication and safety connecting local assets, which gives it an upper- hand over cloud computing, even though cloud computing is proven to be scalable and flexible [2]. The fog computing acts as a facilitator for IoT and over comes some constraints of Cloud Computing. The interplay of IoT-Fog-Cloud is also mentioned, involving fog computing model architecture[5].

IoT devices can be deployed with fog computing in order to multiply, the permitting computing to happen adjacent to the user as possible. In the means of necessitating IoT to be reactive enough to use, a system can be proposed consisting of Fog computing will complement with cloud computing but fog will not replace cloud computing. The model of P2P Fog computing was put forward to upgrade the bandwidth throughput of fog computing, so as to meet the raising demands of IoT devices. Introduction of chord mechanism between fog layers by extending fog computing architecture in P2P fog model [7]. Data security being one of the major concerns is solved as most of the data filtering take place provincially at the extremity of network in fog pen even though the cloud servers are assaulted the data remains secured since the data persists provincially[2]. In cloud computing, the request sent must covers a huge number of in between hops to get to the central data for the action, which in turn expands possibility of data being compromised [2]. Fog computing balances data security and integrity and hence reduces the traversal of data over the network.

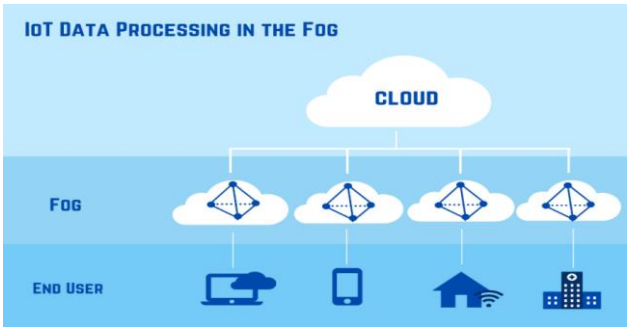

Fig 2 Distribution using FOG

A classification technique (or classifier) should be a structured outlook for raising classification models from feed in field set. Few of the ML algorithm includes decision tree classifiers, neural networks, Adaboost classifiers, support vector machines, rule-based classifiers, method of least squares regression [7][9]. Learning algorithms is provided by each technique to acknowledge which model satisfies the bond interleaving the attribute set and the advanced set of the given input file. The prototype produced by a learning algorithm should be ready being apt to the input file and also to foresee the category tags of reports which it has never seen before.

Some of the inputs can be driven for training and validation of ML algorithms, which are executed. Testing phase approximates the prognosis of abnormalities from the sensors data which is gathered through the IoT framework. Statistical analysis is implemented from data gathered into the cloud from IoT devices to approximate the accuracy in prediction percentage. Machine learning algorithm have played a remarkable role, for this kind of IoT platform based continual monitoring of human health parameters[14]. The prior action should be given to individuals, such that it allows the software to autonomously spawn the results. For example, data and the specified algorithm must be delivered to the system beforehand and therefore the appropriate analysis rules for the popularity of patterns within the data stock must be define [9]

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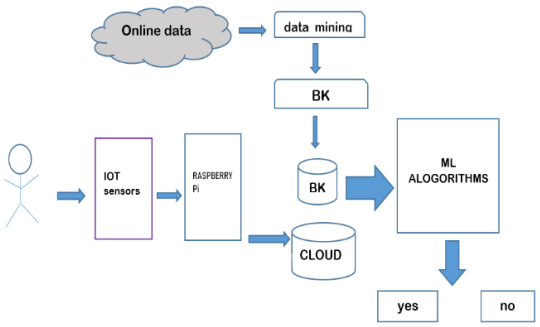

Fig 3 Working of ML algorithm

TABLE I . LITERATURE SURVEY

No	Source	Problem defined	Approach Used	Results	Implications
1	Fog Computing with P2P(Peer-to-Peer) : enhancing fog computing with bandwidth IoT scenarios[9].	A architecture model known as P2P fog introduces a P2P network mechanism into three layered client, fog and cloud model hence enhancing the functionalities.	The introduced P2P fog model increases fog computing by appending P2P mechanism between the fog layers, which permits the fog nodesto ally and hence meets the client needs.	The system minimizes the requests which traverse to cloud and fulfil most of the proximity of the user. The proposed model enhances the bandwidth throughput of fog computing, so as to meet the evolving demands of IoT devices.	As it reduces the number of requests sent, but still the device fetches all the required data in a more rapid course of action this can be implemented.
2	Fog Assisted – IoT Enabled Patient Monitoring in Smart Homes[10].	A health monitoring architecture model which is IoT based system with fog computing	The proposed model is a layered approach for distant health surveillance which is made of five layers DAL,ECL,IML, DML,CSL namely: 1. Data Acquisition Layer 2. Event Classification Layer. 3. Information Mining Layer. 4. Decision Making Layer 5. Cloud Storage Layer	1. A health care system with fog computing. 2. A health monitoring IoT based system.	From the proposed system we can draw a conclusion that IoT based fog computing model are more efficient in passing sensitive patient information to end users which helps in accurate monitoring.
3	From Cloud Computing to Fog Computing: Platforms for Internet of Things[2].	Unleash the ability of end devices and edge computing	Fog Computing shoves the computing power, applications and data at borderline network, far-off the centralized computing nodes.	Real time interaction enhances data processing performance, minimum communicationlatency, fast response.	Since this approach is favourable to our project it can be implemented.
4	Blood Pressure Monitoring on the Cloud System in Elderly Community Centres[8].	A design platform to lessen the possibility of cardiovascular disease amidst of elderly when they have BP uncontrolled.	i) Baseline characteristic and wellbeing survey. ii) Electronic health records(EHR). iii) BP, blood glucose level and BMI readings.Call logs from nurses.	In this work, theBP telemonitoring platform will help to apprehend and upload BP readings wirelessly to the cloud platform and compilation with other data, data mining on the long term BP records will help to understand the best way of highBP control.	The approach used can be taken in order to monitor the blood pressure in patients.
5	IoT-Fog based Healthcare Framework to identify and control Hypertension[1].	This paper presents about the usage of suitable algorithm and sensors for identifying and controlling hypertension attack.	Artificial neural network algorithm is used. Sensors for detecting the location diet, heart rate monitoring . Health monitoring system comprises of several components such as	In this paper, BP is continuously monitored and also other parameters of health to identify stages of hyper tension is achieved by IoT fog based health monitoring system.	This paper gives the insight about the sensors which can be used and algorithm which can be used to train and test the given data set and also reveals that the proposed framework

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			• Stage classification • Temporal data granulation • Risk assessment of hypertension attacks • Alert generation		attains bandwidth efficiency, minimum delay and higher accuracy in response time.
6	Machine Learning methods for Real time Blood pressure measurement based on Photoplephysmography[7].	The work presents BP calculation procedures based on PPG signal.	i) Ridge Linear Regression. ii) Artificial Neural Network. iii) Decision Tree Regression. iv) Bagging Regression. v) Random Forest.	All algorithms are analyzed on an eagle-view level to see how different machine learning techniques can help in blood measurement.	This paper gives a head start in knowing what algorithms can be used for our project.
7	Fog –Assisted wIoT : A Smart Fog Gateway for End- to-End Analytics in Wearable Internet of Things[5].	This paper presents an end- to-end architecture that performs data conditioning and intelligent filtering for generating smart analytics from wearable data.	Spectra Symbol flex Sensors are integrated in Smart Glove	This proposed system monitors the motion of hand.(Parkinson 's disease, stroke can be rectified)	This proposed system develops and validates asmart fog gateway that could perform end-to-end analytics for internet-connected wearables. A comparison is given between Intel Edison and Raspberry Pi is provided which forms the evidence for selecting the embedded boards that could match demands of the application
8	Internet of Things Based Wireless Patient Body Area Monitoring Network[4].	This paper presents the usage of IoT in coexistence of WSN(Wireless sensor network).	Sensors for detecting heart rate, ECG, temperature, BP. The protocols which can be used for alerting hospitals or care takers is also discussed here.	This system uses physical parameters of patient for monitoring their health.	The proposed system designs and implements a simple health monitoring system which considers patients physical parameters. These accumulated data is sent to doctors computer by applying technologies which are based upon IoT and WSN.
9	Wireless ECG Monitoring System: Design, Construction and Analysis[11].	The fundamental aspects for identifying different heart functioning disorder are accurate ECG result and Heart rate information. But this is difficult to collect from patient who has been in an accident in remote places for his/her immediate diagnosis.	i) Real time ECG signal data of a patient even from remote place is collected via using ECG sensors. ii) Signal Conditioning. iii) GPRS communication.	This system uses Wireless ECG monitoring system which is successfully designed, constructed and tested on the subjects. ECG waveforms are seen using Digital Storage Oscilloscope.	The proposed system gives accurate real-time data of ECG which is important and thus data is collected. The obtained data can be reviewed by doctors in a very short period of time.
10	Patient health monitoring using IoT with machine learning[12].	This paper presents how the patients health details must be kept in track and how they can be treated with proper medication.	i) IoT architecture for disease detection. ii) Machine Learning algorithms for health care prediction.	Automating the continuous monitoring of health parameters through IoT is discussed as novel solution.	The proposed system develops an IoT architecture on which ML algorithms are applied which helps in predicting the symptoms of certain diseases.
11	Fog Computing in Healthcare	This paper presents drawbacks that prevail in health monitoring	i) Medical sensor node	The system presented in this paper gives an insight	This proposed system gives

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	Internet- of-Things: A Case study on ECG Feature Extraction[13].	system such as distance supervision and unsupported portability which give rise to inconvenience for patient and doctor.	ii) Embedded operating system iii) Fog computing service	about how fog computing is implemented as an archway for intensifying healthcare monitoring systems. The paper also gives insight about various services provided by fog computing like interoperability, distributed database, real-time notification system.	location awareness and GUI with access management and introduces adaptable, superficial arrangement for extracting the attributes of ECG.
12	Machine Learning Algorithms for Disease Prediction Using IoT Environment[14].	Health issues are growing gradually everyday. As we have been engaged with the hectic life schedule, approaching medical consultant or hospital regularly becomes tedious.	i)Training :Model is trained by gathering the synthetic data as well as real time data of the patient from online repositories. After that implement approaches like data pre-processing, data cleaning, data acquisition. ii) Testing : By using less sensors in wearable devices an IoT environment is designed.	The system gives average performance.	This system helps in predicting the diseases and also gives insight about real-time health monitoring which can be implemented in our project.
13	Health Monitoring and tracking system for soldiers using Internet of Things[6].	This paper presents the easy tracking of injured soldiers in the border who will be suffering from some damage, if this is information is not available it may cause permanent disability or death.	An algorithm is applied to know the correct location of the injured soldier.	In the proposed system, sensors are placed on the soldiers body to keep track of their health condition and location by using GPS.	Usage of GPS in our system helps in calculating the distance of the patient.
14	IoT based Emergency Health Monitoring System[3].	How can the patient be monitored without interruption in patient's health monitoring system.	i) Principle of Photoplethysmography. ii) Coding algorithms	Operating cost of the hospitals are reduced by using wireless communication. By using wireless application the risk of infection can be reduced and mobility can be enhanced. By using these wireless systems many patients can be monitored simultaneously.	The proposed system gives the idea about using fog computing and ML. It also tells that using Arduino is a disadvantage.
15	A Secure and Energy Efficient Resource Allocation Scheme for Wireless Body Area Network[15].	How to increase the efficiency of the smart healthcare	Star Topology SigncryptionCertificteless Algorithm	Packets which are in queue buffer state are queued and transmitted to the hub. Sensors are energy efficient.	The proposed system gives an insight about how and why Body Area Network

III. EXPERIMENTAL SETUP AND PERFORMANCE EVALUATION

As of the literature survey conducted we can infer the following usage of the sensors and its accuracies.

A. Temperature Sensor :

TABLE II . Temperature sensor accuracy

Sensors	**Accuracy**
BME680	99
LM35	97
DALLAS DS18B20	98
DHT22	96

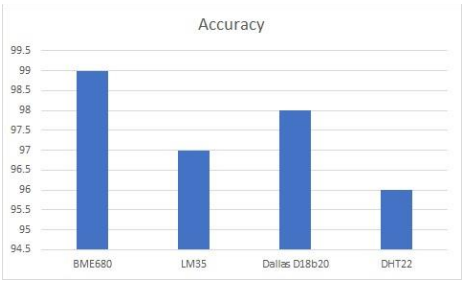

Fig 4 Accuracy graph of temperature sensors

B. Heart rate Sensor :

TABLE III. *Heart rate accuracy*

Sensors	**Accuracy**
XCLUMA MAX30102	98
Grove finger clip heartrate sensor	97
Techleads pulse heartrate sensor	93
Mikroe Heartrate sensor	95

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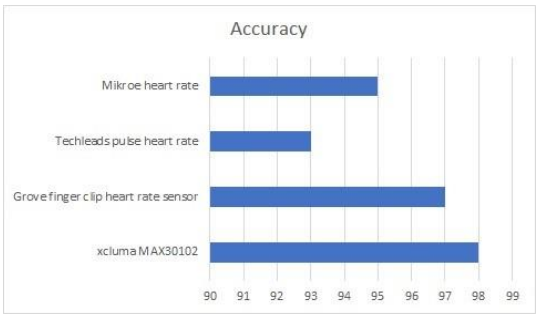

Fig 5 Accuracy graph of Heart Rate Sensor

V. CONCLUSION

Health monitoring and prediction of disease in real-time is provided by this system through internet services. The best outcome can be achieved using LM35 sensor which is accuracy integrated-circuit temperature sensor which measures temperature more accurately than thermostat and free of oxidation. The XCLUMA MAX30102 sensor which is heartrate bio sensor module with high accuracy. By using the sensors we take the inputs in the form of analog signals. We also use BP sensors of good accuracy. Prediction accuracy of Random Forest (RF) is positive than learning approaches with finest accuracy and minimal time complexity. A recommendation system is an additional feature which predicts the hypertension, heart attack, fever are implemented in our project.

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