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A Survey on Classification Algorithms Used in Healthcare Environment of the Internet of Things

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***Abstract* -** The Internet of Things evolved in various application areas that include medical care or health care. This technology helps the patients and doctors to predict the various diseases accurately and diagnose these diseases according to result. The important aspect of this survey is how data collected by sensor-enabled devices in healthcare or medical care environment of the Internet of Things is processed and classified. This survey paper provides a recent review of the different classification algorithms such as SVM, Naïve Byes, Decision Tree, KNN etc. which were used to classify the data collected from sensor-enabled devices of healthcare or medical care environment of the Internet of Things by the help of comparison table. This survey shows a brief review of how IoT gives their contribution in the field of healthcare by using different sensors and communication protocols. This paper also outlines the parameters of classification algorithms such as in terms of accuracy, true positive rate (TPR), precision, false positive rate (FPR) etc used to classify the healthcare data.

***Key Words* -** Internet of Things, Large Data Set, Healthcare, Medical care, Classification Algorithms, Smart Healthcare**.**

I INTRODUCTION

Medical care or health care is one of the major challenges of this world, it is estimated that approx 20-30 billion [1] population of this world suffer from different disease such as arthritis, asthma, cancer, COPD, diabetes [2], care for elderly people such as Heart Attack [3] detection, Activity and Movement Recognition of elderly people[4] and many more. The past few years have witnessed that Internet of Things (IoT) [5] has evolved a lot and continues to evolve in medical care and health care. This evolvement of IoT provides a platform to millions of people to get medical or health-related updates regularly for a smarter and healthier daily life. Internet of Things has evolved a lot over the past few years and continues to evolve in every field including Household, Industrial, Medical or healthcare, Defence, Automobile, Educational and many more. Figure 1, shows the different application areas of the Internet of Things. Nearly 50-60 billion of connected objects are expected by 2020 [6].

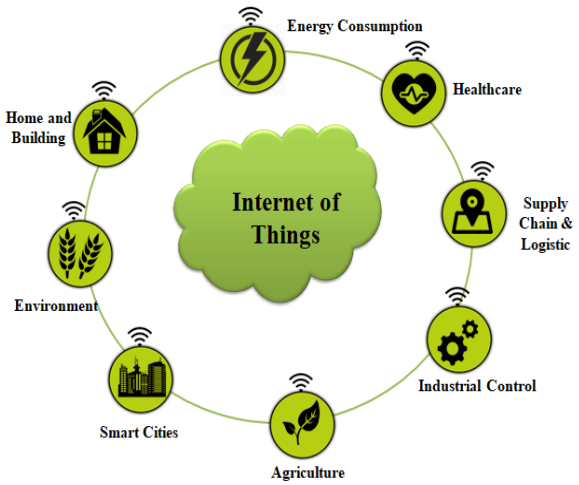

Figure 1:- Applications of the Internet of Things

As the internet of things [7] is a new idea for physical objects or things, called "smart devices" and is a very challenging area in the field of information technology and computer science. For scholars, the main challenges while deploying internet of things are to prepare and process data for classification because of an unprecedented increase in the amount and complexity of data collected by different types of sensors. The IOT permit the smart health objects for remotely managing and sensing the data of the smart health devices across the network infrastructure this will reduce human intervention and also increase efficiency, productivity, accuracy and economic benefit of the devices and also helps the patients in accessing the health services from a remote location.

The aim of this research survey is how data collected by sensor-enabled healthcare devices in a healthcare environment of the Internet of Things is processed and classified [7]. The aim will be achieved by surveying or studying different research papers on IoT based medical care or healthcare environment on which Classification Algorithms applied. The main contribution of this survey is the analysis of classification algorithms such as Support vector machine [8], Decision Tree [7] Random Forest [7] etc., with multiple parameters in a healthcare environment of the Internet of things.

The remainder of this paper is organized as follows. The contribution of the Internet of things in the healthcare area will be discussed in Section II and the work related to classification algorithms applied to IoT based healthcare data with comparison table will be discussed in Section III. In Section VI we will discuss the main conclusion of this paper.

II INTERNET OF THINGS IN HEALTHCARE AREA

Medical care or health care [1] is one of the most striking application areas for the IoT technology. The IoT technology helps to manage or monitor remote health services[1], personal fitness care at home, chronic diseases[1] such as arthritis, asthma, cancer, COPD, diabetes[4], care for elderly people such as Heart Attack[3] detection, Activity and Movement Recognition of elderly people[4] and many more. Figure 2, shows the different health-related services in which the Internet of things plays a significant role. With the help of the compounding of RFID [9] (radio frequency identification system), Bluetooth [9], Wi-Fi [9] technology together we can easily lead the health of a person. We can get information over the human's body temperature, heartbeat rate, blood pressure [10], etc by the use of sensors and compounding of RFID [9] and other technology. In case of an emergency, all the data collected by the use of sensors is notified to individual and their personal doctor.

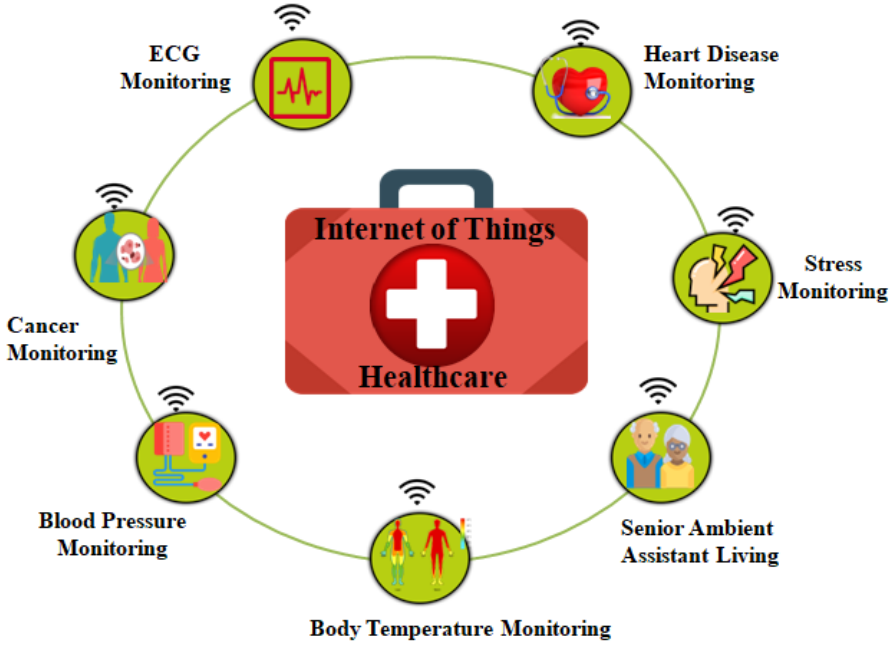

Figure 2:- Internet of Things in the field of Healthcare

III RELATED WORK

Liyakathunasia Syed et al [11] in 2018 presented a novel system using wavelets based image processes (WBIP) and ML for early detection of breast cancer. They used telemammography system to detect breast cancer from remote areas. They collected the patient's data that contains the mammogram images of the patients and other information related to patients that are taken by local

doctors and send it through IoT devices over the network, these images were preprocessed by using WBIP techniques and features were extracted from the preprocessed mammogram images. At last machine learning classification algorithm such as NN, KNN, J48 Decision tree, RF applied to classify the breast cancer tumor. The DT classifier has higher accuracy as compared to other classifiers.

Pravel Verma et al [12] designed a smart student health care system to analyze the healthcare of the students. They took 182 students health dataset to classify the waterborne diseases such as cholera, typhoid, hepatitis A etc. among the students. The waterborne diseases are transmitted in water and can be spread by washing, bathing or drinking infected water. In this research, the researchers first monitored the health of the students by using IoT devices and then applied data mining algorithm such as SVM, DT, NB and KNN to predict the waterborne diseases, out of these classifiers DT is the best model with 85.19% accuracy. The comparison of different classification algorithms along with different parameters used in different research papers [[8] [11] [12] [13] [14] in the field of healthcare is presented in Table 1.

Table 1 Comparison table of parameters used in different Classification Algorithms in Health Application of Internet of Things

Features	**Liyakathunisa Syed et al [11]**	**Prabal Verma et al [12]**	**Prabal Verma et al [8]**	**Sanjay Sareen et al [13]**	**N. Keshan et al [14]**
IoT Application Area	Health – Breast Cancer	Health – Waterborne Disease	Health- Infectious Disease, heart disease, Stress	Health – Ebola Virus	Health- Stress
IoT Data	Real time Data	Real time Data	Real time Data	Real time Data	Real Time Data
Environment Used	WEKA	WEKA	WEKA	WEKA 3.6	WEKA
Classifier used	J48, RF, KNN, Multi-Layer Perceptron Neural Networks,	SVM, KNN, DT, NB	SVM, KNN, DT, NB	J48 tree, Random Tree, Naïve Bayes, REP Tree	Naïve Bayes, LR, MP, SMO, IB1, 1BK, ZeroR, J48, Random Forest, Random Tree
Sensor Used	Wireless Sensors	Wearable sensors	Medical Sensors	Wearable sensors	Wearable sensors
Cross Validation	10 - fold	10 - fold	4-fold cross validation	10-fold cross validation	2 fold Cross Validation, 10 fold Cross Validation
True Positive Rate)	98.13%	77.74%	DT -90.4% (For infection)	J48 tree 0.941	NA
False Positive Rate (FPR)	98.42%	76.06%	DT -93.3% (For infection)	J48 tree 0.054	NA
Recall	98.13%	7.74%	DT -90.4% (For infection)	J48 tree 0.912	NA
Precision	98.75%	NA	NA	J48 tree 0.901	NA
F-Measure	NA	NA	DT -96% (For infection)	J48 tree 0.880	NA
Accuracy	96.93%	85.19%	DT -92.8% (For infection) SVM- 87.4 % (For Stress Level) k-NN – 92.3% (For Heart Disease)	J48 tree 94%	100% (High) 88.24% (Low, Medium, High)

Pravel Verma et al [8] proposed a healthcare system based on cloud and Internet of Things that accurately predict the level of disease among the patients. They collect data from m healthcare applications and medical sensors and then applied classification algorithms such as SVM, KNN, DT, NB to diagnose the diseases. Sanjay Sareen et al [13] also

proposed an architecture based on Internet of Things, cloud computing and RFID for prediction and detection of symptoms of Ebola virus in patients. They applied classification algorithms such as J48 tree, Random Tree, Naïve Bayes, REP Tree on large data stored in the cloud and predict the disease with 94% accuracy. N. keshan et al [14], monitor the ECG signals of the automobile drivers to analyze the stress in three levels low, medium & high. In their research they apply machine learning classification methods to analyze the stress conditions among the drivers while driving, they achieved the accuracy of 88.24% by using random tree classifier.

Psychological stress or pain is a feeling of pressure or strain. Whenever human is nervous, the heartbeat of human is increasing due to stress. P.S. Pandey [14] in his research paper predicted whether a particular person is fit or not, is he under stress or not? By using internet of things and classification algorithms such as Logistic Regression, SVM, Naïve Bayes(NB), he predicted and classified this with 100% accuracy. In his research paper the author use heartbeat rate as an important parameter to detect a person is under stress or not. The machine learning is used to predict the patient's condition and IoT is used to communicate with patients about their stress conditions.

Research related to personalized healthcare by Amit Walinjkar [16], in which they collected and combined the wearable ECG device data with real-time arrhythmia data to predict the irregular heartbeat with 99.47% accuracy. Dimitia Azariadi et al [27] developed an algorithm or software infrastructure that supports ECG signals and analyses these signals to diagnose the disease arrhythmia. In this algorithmrithm, discrete wave transform (DWT) is used for feature extraction and support vector machine classifier for classification. The overall accuracy achieved by this algorithm is 98.9%. Table 2 shows the comparison of [14, 15, 16, 17] with different classification algorithms on classification algorithms.

Table 2 Comparison table of parameters used in different Classification Algorithms in Health Application of Internet of Things

Features	**P. S. Pandey [14]**	**Amit et al [15]**	**Ani R et al [16]**	**Dimitra Azariadi et al [17]**
IoT Application Area	Health - Stress	Health- Arrhythmia	Health- Chronic Disease	Health - Arrhythmia
IoT Data	Real Time data	Real Time Data	Real Time data	Real Time data
Environment Used	Scikit-Learn	MATLAB	Bagging technique	MATLAB
Classifier used	Logistic Regression, SVM, VF – 15, Naive Bayes, VF - 15 with weights to features	KNN, Bagged Tree, Decision Tree	Naïve Bayes, Random Forest, K-Nearest Neighbor, Decision Tree	SVM
Sensor Used	Pulse Sensor	Wireless sensor	Sugar sensor, Blood Pressure Monitor with Pulse rate	Wearable sensors
Cross Validation	NA	10 Fold Cross Validation	NA	NA
Accuracy	100 % (test Accuracy) & 66% (Train Accuracy)	99.4%	93%	98.9%

IV CONCLUSION

With the evolvement of IoT in healthcare or medical care environment, the diagnosis process can be made more effective and reliable. The main aim of this survey was to provide an overview of classification algorithms applied to sensor data in an Internet of Things healthcare or medical care environment. This article has endeavored to clarify how certain classification algorithms have been applied by various researchers in healthcare or medical care environment of IoT. In this paper, we have identified which sensors combinations, techniques, and algorithms can detect the disease accurately and quickly This paper survey several solutions provided for classifying the sensor data of the Internet of thing's healthcare environment by considering different parameters. This paper includes classification algorithms approaches and also identified which classification algorithm performance is better in terms of accuracy, true positive rate (TPR), precision, false positive rate (FPR) etc. in a particular Internet of things healthcare

environment also it includes dataset and its properties of the healthcare environment.

Conflict of Interest

It is certified that there is no conflict of interest among authors

References

[1] S. M. R. Islam, D. Kwak, M. H. Kabir, M. Hossain and K. S. Kwak, "The Internet of Things for Health Care: A Comprehensive Survey," in IEEE Access, vol. 3, pp. 678-708, 2015.

[2] K. Chui, W. Alhalabi, S. Pang, P. Pablos, R. Liu, and M. Zhao, "Disease Diagnosis in Smart Healthcare: Innovation, Technologies and Applications," Sustainability, vol. 9, no. 12, p. 2309, Dec. 2017.

[3] Gowrishankar S., Prachita M Y. and Arvind Prakash, "IoT based Heart Attack Detection, Heart Rate and Temperature Monitor". International Journal of Computer Applications (IJCA) 170(5):26-30, July 2017

[4] I. Bisio, A. Delfino, F. Lavagetto and A. Sciarrone, "Enabling IoT for In-Home Rehabilitation: Accelerometer Signals Classification Methods for Activity and Movement Recognition," in IEEE Internet of Things Journal, vol. 4, no. 1, pp. 135-146, Feb. 2017.

[5] Marimuthu Palaniswami, Rajkumar Buyya, Jayavardhana Guddi, Slaven, Marusic, "Internet of Things (IOT): A Vision, Architectural Elements, And Future Directions," Elsevier, Future Generation Computer Systems, vol.29, pp. 1645-1660, Feb. 2013.

[6] Furqan Alam, Rashid Mehmood, Iyad Katib, Aiiad Albeshri, "Analysis of Eight Data Mining Algorithms for Smarter Internet of Things (IoT)", Procedia Computer Science, Volume 98, 2016, Pages 437-442, ISSN 1877-0509.

[7] Feng Chen, , Pan Deng, Jiafu Wan, Daqiang Zhang, Athanasios V. Vasilakos, Xiaohui Rong, "Data Mining for the Internet of Things: Literature Review and Challenges", International Journal of Distributed Sensor Networks(IJDSN), 2015, Volume 2015.

[8] Prabal Verma, Sandeep K. Sood, "Cloud-Centric Iot Based Disease Diagnosis Healthcare Framework", Journal of Parallel and Distributed Computing (JPDC), 2017.

[9] Bagadhi Sateesh, "Introduction to Internet of Things", International Journal of Computer Sciences and Engineering, Vol.6, Issue.6, pp.1086-1090, 2018.

[10] Mantripatjit Kaur, Anjum Mohd Aslam, "Big Data Analytics on IOT: Challenges, Open Research Issues and Tools", International Journal of Scientific Research in Computer Science and Engineering, Vol.6, Issue.3, pp.81-85, 2018

[11] Syed L., Jabeen S., Manimala S., "Telemammography: A Novel Approach for Early Detection of Breast Cancer through Wavelets Based Image Processing and Machine Learning Techniques". Advances in Soft Computing and Machine Learning in Image Processing. Studies in Computational Intelligence, vol 730. Springer, Cham, 2018.

[12] Verma, P., Sood, S.K. & Kalra, S., "Cloud‑Centric IoT Based Student Healthcare Monitoring Framework", Journal of Ambient Intelligence and Humanized Computing (JAIHC), (2017).

[13] Sanjay Sareen, Sandeep K. Sood, Sunil Kumar Gupta, "IoT-based cloud framework to control Ebola virus outbreak", Journal of Ambient Intelligence and Humanized Computing, Springer 2016.

[14] N. Keshan, P. V. Parimi and I. Bichindaritz, "Machine learning for stress detection from ECG signals in automobile drivers," 2015 IEEE International Conference on Big Data (Big Data), Santa Clara, CA, 2015, pp. 2661-2669.

[15] P. S. Pandey, "Machine Learning and IoT for prediction and detection of stress," 2017 17th International Conference on Computational Science and Its Applications (ICCSA), Trieste, 2017, pp. 1-5.

[16] A. Walinjkar and J. Woods, "ECG classification and prognostic approach towards personalized healthcare," 2017 International Conference On Social Media, Wearable And Web Analytics (Social Media) (ICWWA), London, 2017, pp. 1-8.

[17] Ani R, Krishna S, Anju N, Sona Aslam M,O.S Deepa, "IoT Based Patient Monitoring and Diagnostic Prediction Tool using Ensemble Classifier", International Conference on .

[18] D. Azariadi, V. Tsoutsouras, S. Xydis and D. Soudris, "ECG signal analysis and arrhythmia detection on IoT wearable medical devices," 2016 5th International Conference on Modern Circuits and Systems Technologies (MOCAST), Thessaloniki, 2016, pp. 1-4.

