IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

SMART HEALTH CARE USING IOT & ML: A REVIEW

Vinutha M S[1], Prajwal M R[2]
[1]Assistant Professor, Department of CSE,
Dr Ambedkar Institute of Technology, Bangalore, India
[2] UG student, Department of Civil Engineering, BMSCE, Bangalore, India

ABSTRACT: Smart health is a new revolution in health industry where information and technology are integrated to improve patient outcomes. The goal of smart health care system is to integrate innovative technologies such as the Internet of Health Things (IoHT), medical Cyber-Physical Systems (medical CPS), health cloud, health fog, big data analytics, machine learning, blockchain, and smart algorithms to deliver improved, value-added and cost-effective healthcare services and enhance the effectiveness and efficiency. The Internet of Things (IoT) can be described as network of physical objects that are embedded with sensors, software, and other technologies that interact and communicate with each other. The branch of IoT termed as Healthcare Internet of Things (H-IoT) is dedicated towards medical science for rapid automation of the healthcare sector. Due to the large amount of complex heterogenous data involved in healthcare there is need for the integration of machine learning (ML) algorithms into IoT to enhance the performance of system.

Keywords: IoT, IoHT, Machine Learning, Smart Health, sensors.

INTRODUCTION:

The inclusion of new health care models based on cutting edge technology and communication technology has arisen because health care system is facing several real time challenges. The issues like increasingly high costs of healthcare services, professionals and equipment, shortages in skilled healthcare professionals, rising demand for high-quality healthcare services, size and complexity of the healthcare value chain are to be addressed as about 10% of global domestic product (GDP) is spent on healthcare annually. The solution to these issues is integration of IoT and ML algorithms which results a smart health care model. In recent decades the vast array of data generated in medical sciences stemming from different sources such as sensors, medical imaging, personal health records, and public health organizations is a massive. With the emerging technology, smart health care systems provide reliable and secure means of offering various services by extracting valuable information from acquired data and draw useful inferences which helps in early diagnosis, treatment and recovery. [1][2][3]

IoT Architectures & Communication Protocols:

Due to the advancements in communication technologies and data transfer speed, the ability to transmit large amounts of data has grown drastically with the use of IoT. The integration of smart sensors, actuators, and data analytics in an IoT environment for real-time sensing and monitoring brings great potential to the healthcare industry. With the advancement in the field of technology and the demand for applications, IoT is receiving increased attention in the field of health services. IoHT is an important branch of IoT that mainly aimed at bringing change in health service model and there by promote the development of the health service industry. [4][5]

In IoT real time data transfer is possible by means of interconnecting the healthcare resources like doctors, hospitals, rehabilitation centres and all medical devices and sensors along with the patients. An IoT system shown in fig 1 comprises of an end-to-end network typically consisting of following major stages. [6][7]

1. **Devices:** These includes sensors, actuators, monitors, detectors, accelerometers, cameras, smart watches, smart locks, global positioning systems (GPSs), and LED lights etc which are deployed and interconnected to collect data from the human body to determine the state of the body. IoT devices use internet and transmit data to other devices and applications or they can retrieve data from other interconnected devices. and process it locally or on a cloud server after sending it to centralized servers. An IoT device can use both wired and wireless modes of communication involving multiple interfaces. The common interfaces are I/O interfaces for sensors, Internet connectivity interfaces, memory and storage interfaces, and audio/video interfaces. The table below outlines the IoT device capabilities for both hardware and software platform. [8]

IoT Device Capabilities		
Hardware Systems	**Software Systems**	
Raspberry Pi, Arduino, ESP8266	**Operating System**: Contiki, Mbed, RIOT, Embedded Linux, Windows10 IoT	**Built-in Tools**: AWS IoT, Goggle Cloud IoT, Things Board, Kaa, Device Hive

2. **Data Acquisition & Pre-Processing**: The layer is responsible for gathering analog signal and converting raw data into required format that help in analysis.
3. **Data Storage**: This layer stores the processed data in data centre or cloud and then transfer this to next layer for analysis.
4. **Data Analysis**: This layer generates requires response through the application of different algorithms.

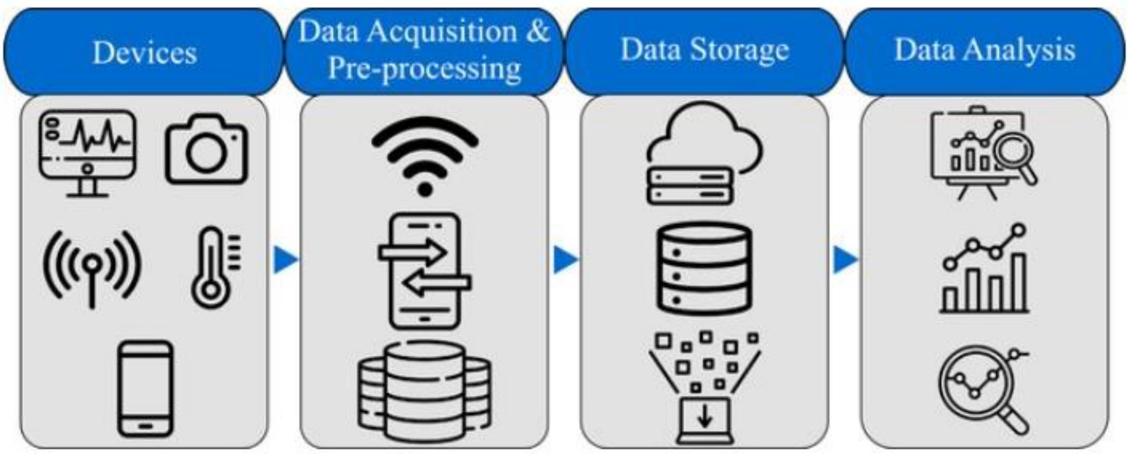

Fig 1: Stages of IoT Healthcare

The IoT network is one of the important elements of smart health care system. This network is the foundational infrastructure for transmission and reception of medical data and enables the use of healthcare-tailored communications. Most common and frequently used IoT architectures are as shown in fig 2.[9]

- **Three-layer architecture**: Involving perception layer at the base, network layer in middle and application layer at the top.
- **SOA**: A new layer named the service layer is added between the network layer and application layer that ensures sufficient services to assist the application layer in extending the three-layer architecture in the SOA framework
- **Middleware-based architecture**: it is also known as a five-layer architecture. The middleware-based architecture plays a vital role by providing links among the applications, users, and data. To ensure performance factors like reliability, scalability, and QoS in contemporary applications, the middleware-based architecture is most suitable approach.

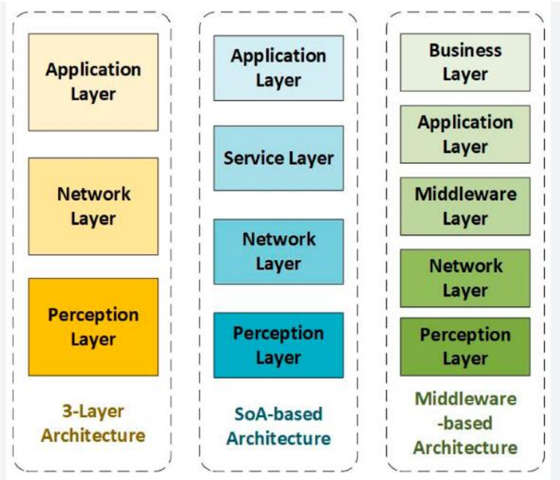

Fig 2: IoT ARCHITECTURES

IoT protocols: Based on the nature of application the IoT protocols are chosen. Multiple protocols have been developed as single protocol cannot be used for all application. the following table 1lists some IoT Communication Protocols [10]

Protocol Name	Network Standard	Latest Version (Year)	Transport Protocol
CoAP	IETF, Eclipse Foundation	RFC 8323 (2018)	UDP
MQTT	OASIS, Eclipse Foundations	MQTT version 5.0 (2018)	TCP
XMPP	(RFC 3920-RFC 3923) RFC 4622, RFC 4854, RFC 4979, RFC 6122	XMPP v 1.0.1, XEP-0128 (2019)	TCP
AMQP	OASIS, ISO/IEC	AMQP v 2.5.0 (2019)	TCP
DDS	OMG	DDS v.1.4 (2015)	TCP/UDP
LoWPAN	IEEE 802.15.4	6Lo-BLEMesh (2019)	TCP
BLE	802.15.1	6Lo-BLEMesh (2019), MRT-BLE (2018)	TCP/UDP
Zigbee	IEEE 802.15.4	Zigbee 3.0 (2018)	UDP

Table 1: IoT Communication Protocols

The quality of life, patient outcomes, management of real-time diseases and the user experience has enhanced by use of IoT. The medical applications of IoT are classified into two categories such as

- **Services**: The popularly used IoT services are Ambient Assisted Living (AAL), Internet of m-health, Community healthcare, Indirect emergency healthcare, Embedded Gateway Configuration (EGC),
- **Applications**: The applications of the IoT are classified into two types such as single condition and clustered condition. The single condition applications are meant for a particular disease like Sensing the Glucose level, Monitoring the ECG, Monitoring the blood pressure. Handling multiple diseases together comes under clustered condition applications. Rehabilitation system, Medication management, Wheelchair management are classified uber cluster condition.

There are mainly two kinds of attack in Health environment involving IoT such as

- **Routing Attack**: Include router attack, select and forwarding attack and replay attack. In routing attack intruders targets the route of data to send or drop data packets.
- **Location Based Attack**: Include denial of service attack, finger and timing-based snooping attack and sensor attack. In this attack mostly the intruder's attacks on the destination node to deny the services of the system.

Security Challenges of IoT: Confidentiality, Authentication, Access control, Privacy, Trust and Policy enforcement are some of the security challenges. The existing countermeasures for addressing the IoT security challenges are classified into two approaches cryptographic algorithms where AES, DES and RAS algorithms are used and in anonymization technique the main objective is preserving the privacy of the data.[11]

Machine Learning

The term "Machine Learning (ML)" refers to a subfield of artificial intelligence which includes various statistical techniques that allow computers to learn from experience without being explicitly programmed. For physicians, predicting and identifying illness has always been a challenging and time-consuming task. Early disease identification will help people all around the globe since it will enable them to get the proper care before it worsens. Machine learning techniques can be used by medical professionals to develop better diagnostic tools to analyse medical images. Healthcare is constantly changing due to the constant development of new technology and communication. ML could assist medical professionals in elicit insights from unstructured text which was previously challenging to generate and deploy on a large scale. With this new technique of ML-derived intelligence, physicians and administrators can make timely decisions about patient care and operational programmes that affect millions of lives.[12]

The potential of ML models for healthcare applications is also benefitting from the progress in technologies. Integration of Internet of Things, cloud/edge computing, mobile communication, and big data technology has bought a revolution in health industry. Together with these technologies ML is capable of producing highly accurate predictive outcomes and can facilitate the human-cantered intelligent solutions. Benefits like enabling remote healthcare services for rural and low-income zones is possible by using these technologies which play a vital role in revitalizing the healthcare industry. A large amount of medical data requires effective extraction and processing methods for correct diagnosis of diseases through machine learning technology. [13]

Major types of ML that can be used in healthcare applications are briefly described next.[14]
Unsupervised Learning: Utilizing unlabelled data is the method involved in unsupervised learning. Methods like clustering of data points using a similarity metric and dimensionality reduction to project high dimensional data to lower dimensional subspaces are widely used examples of unsupervised learning. The classical examples of unsupervised learning methods in healthcare encompass the prediction of heart diseases through clustering and prediction of hepatitis disease using principal component analysis (PCA) which is a technique for dimensionality reduction.

Supervised Learning: Mapping the association between the inputs and outputs using labelled training data are characterized as supervised learning methods. The task is called classification if the output is discrete and for a continuous value output, the task is called regression. classification of different types of lung diseases (nodules) and recognition of different body organs from medical images are some classical examples of supervised learning methods. Sometimes, semi-supervised learning methods ML can be used i.e., where the training data contains both labelled and unlabelled samples.

Semi-Supervised Learning: If labelled and unlabelled samples are available for training then Semi-supervised learning methods are useful. Typically, a small amount of labelled data and a large amount of unlabelled data are involved. Semi-supervised learning techniques are valuable across a variety of healthcare applications were acquiring a sufficient amount of labelled data for model training is very difficult and challenging.

Reinforcement Learning: Reinforcement Learning is a feedback-based Machine learning technique in which a policy function given a set of observations, actions, and rewards in response to actions performed over time. An agent learns to behave in an environment by performing the actions and getting rewards in response to that. RL holds a great potential to revolutionizing many healthcare applications by applying context-aware symptoms checking for disease diagnosis which is a recent advancement in smart health care system.

Machine learning algorithms are computational models that allow computers to forecast or make judgments based on data or by understanding the patterns without the need for explicit programming. The general workflow of machine learning algorithms used in healthcare can explained with the help of following steps. [15]

Step 1: Data Collection: Gather relevant data from various sources, in form of EHRs, Medical imaging, Lab results, wearable devices, Demographics, Life style factors and more.

Step 2: Data Processing: Raw data collected in previous step cannot be directly used for analysis as there may be missing values, noise, outliers. The issue of inconsistent data can be addressed by preprocessing which may include normalization, feature scaling, feature extraction and Cropping.

Step 3: Feature Extraction & Selection: Relevant feature is extracted from data processing step based on task being handled. Based on problem being solved and data being handled the technique for feature extraction will vary. In health care techniques like

- static feature extraction: mean, median, mode, Standard deviation, min, max, Kurtosis and many more being used.
- Frequency Domain Analysis: FFT, DFT, Wavelet transformation
- Time Frequency Analysis: Short Time Fourier transformation, Continuous wavelet transformation and Stockwell transformation.
- Signal processing Techniques: Filtering, Convolution
- Dimensionality Reduction: PCA, LDA
- Image Processing Techniques: CNNs, LBP, HOG
- Graph based Techniques: GNNs, Subgraph mining
- Knowledge based feature Engineering
- Deep Learning based Techniques.

Step 4: Model Selection & Training: Based on nature of the problem and available data the model selection and training will happen. Logistic regression, Decision tree, SVM, Neural network and deep learning architectures are common models used and then training of the model using data will happen subsequently.

Step 5: Model Evaluation: Evaluation metrics and cross validation are used to asses the performance of the model after training. The metric varies based on task but often accuracy, precision, recall, Specificity, F1-score, Area under the ROC curve, Confusion Matrix and many more.

Step 6: Model Deployment: Deployment in to the real world will be done after the evaluation is satisfactory. Deployment may be integration of a new model to existing system with regulatory standards and data privacy regulation.

Step 7: Monitoring & Maintenance: Health care model cannot be static so periodic updates and retraining of model are necessary to maintain accuracy and reliability as healthcare environment and patient population are changing

Step 8: Feedback Loop: For improving performance and usability of model, feedback from stakeholders like patients and health care professions is essential. A new feature, addressing issue or limitation encountered in deployment can be refine with the help of feedback.

Conclusion

The purpose of this survey was to offer context of IoT and machine learning for smart health care. The necessary transformation from the current, fragmented healthcare system to comprehensive, responsive and ubiquitous future healthcare is unimaginable without the support of technology. Smart health care system is expected to provide early detection and early treatment which are key to reducing the cost of treating most diseases. Researchers globally started to explore various technological solutions to augment healthcare delivery in a manner that complements existing services by harnessing the potential of the IoT and Machine learning Algorithms.

References:

[1] J. Al-Jaroodi, N. Mohamed and E. Abukhousa, "Health 4.0: On the Way to Realizing the Healthcare of the Future," in *IEEE Access*, vol. 8, pp. 211189-211210, 2020, doi: 10.1109/ACCESS.2020.3038858.

[2] Rodrigues, Joel & Segundo, Dante & Arantes Junqueira, Heres & Sabino, Murilo & Prince, Rafael & Al-Muhtadi, Jalal & Albuquerque, Victor. (2018). “Enabling Technologies for the Internet of Health Things”. IEEE Access. PP. 1-1. 10.1109/ACCESS.2017.2789329.

[3] H. K. Bharadwaj et al., "A Review on the Role of Machine Learning in Enabling IoT Based Healthcare Applications," in IEEE Access, vol. 9, pp. 38859-38890, 2021, doi: 10.1109/ACCESS.2021.3059858.

[4] M. Moutaib, T. Ahajjam, M. Fattah, Y. Farhaoui, B. Aghoutane and M. El Bekkali, "Application of Internet of Things in the Health Sector: Toward Minimizing Energy Consumption," in *Big Data Mining and Analytics*, vol. 5, no. 4, pp. 302-308, December 2022, doi: 10.26599/BDMA.2021.9020031
[5] Alshehri, Fatima & Muhammad, Ghulam. (2020). "A Comprehensive Survey of the Internet of Things (IoT) and Edge Computing in Healthcare". IEEE Access. PP. 1-1. 10.1109/ACCESS.2020.3047960.
[6] Alizadehsani, Roohallah & Roshanzamir, Mohamad & Hoseini Izadi, Navid & Gravina, Raffaele & Kabir, H M Dipu & Nahavandi, Darius & Alinejad-Rokny, Hamid & Khosravi, Abbas & Acharya, U Rajendra & Nahavandi, Saeid & Fortino, Giancarlo. (2023). Swarm Intelligence in Internet of Medical Things: A Review. Sensors. 23. 1466. 10.3390/s23031466.
[7] Nasr, Mahmoud & Islam, Md & Shehata, Shady & Karray, Fakhri & Quintana, Yuri. (2021). "Smart Healthcare in the Age of AI: Recent Advances, Challenges, and Future Prospects".
[8] Yang, Yilin & Wang, Haocong & Jiang, Ruizhe & Guo, Xiaonan & Cheng, Jerry & Chen, Yingying. (2022). "A Review of IoT-Enabled Mobile Healthcare: Technologies, Challenges, and Future Trends". IEEE Internet of Things Journal. 9. 1-1. 10.1109/JIOT.2022.3144400.
[9] Islam, S. M. Riazul & Kwak, Daehan & Kabir, Md. Humaun & Hossain, Mahmud & Kwak, Kyung. (2015). "The Internet of Things for Health Care: A Comprehensive Survey". IEEE Access. 3. 678-708. 10.1109/ACCESS.2015.2437951.
[10] Islam, Md & Nooruddin, Sheikh & Karray, Fakhri & Muhammad, Ghulam. (2022). "Internet of Things Device Capabilities, Architectures, Protocols, and Smart Applications in Healthcare Domain: A Review".
[11] A. B. Pawar and S. Ghumbre, "A survey on IoT applications, security challenges and counter measures," *2016 International Conference on Computing, Analytics and Security Trends (CAST)*, Pune, India, 2016, pp. 294-299, doi: 10.1109/CAST.2016.7914983
[12] Javaid, Mohd & Haleem, Abid & Singh, Ravi & Suman, Rajiv & Rab, Shanay. (2022). Significance of machine learning in healthcare: Features, pillars and applications. International Journal of Intelligent Networks. 3. 10.1016/j.ijin.2022.05.002.
[13] Rathore, Deepak & Mannepalli, Praveen. (2021). "A Review of Machine Learning Techniques and Applications for Health Care". 4-8. 10.1109/ICATME50232.2021.9732761.
[14] A. Qayyum, J. Qadir, M. Bilal and A. Al-Fuqaha, "Secure and Robust Machine Learning for Healthcare: A Survey," in IEEE Reviews in Biomedical Engineering, vol. 14, pp. 156-180, 2021, doi: 10.1109/RBME.2020.3013489
[15] N. Mohamed, V. K. Singh, A. Ul Islam, P. Saraswat, D. Sivashankar and K. Pant, "Role of Machine Learning In Health Care System for The Prediction of Different Diseases," *2022 Fourth International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT)*, Mandya, India, 2022, pp. 1-4, doi: 10.1109/ICERECT56837.2022.10060494.