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# AI, IOT and Wearable Technology for Smart Healthcare –A Review

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***Abstract*— Now a days healthcare industry is no longer an isolated zone untouched by technological innovation. Technology drives healthcare more than any other force and in the future it will continue to develop in dramatic ways. Top healthcare technologies such as AI, IOT, Big Data, Cloud computing, Smart Wearables and many other technological innovations have turned the traditional healthcare into smart healthcare. In last few years, technology has enabled us to closely monitor our health. From wristbands that track heart-rate and steps to personal blood pressure checkers to body fat measuring weighing scales, Wearable technology has changed the way we process our biology. This paper focuses on Smart healthcare technologies which have added the element of "smartness" in the healthcare industry. It also introduces the usage of Wearable technologies which track user lifestyle behaviours and seek to provide tools for better personal health management. In addition, we shall consider the major applications of AI and IOT in the field of healthcare . Furthermore we review various machine learning algorithms which are used for developing efficient decision support for healthcare applications.**

***Keywords*— Artificial Intelligence (AI), Machine learning, Internet of Things (IOT), Smart healthcare, Wearable devices.**

## I. INTRODUCTION

HEALTHCARE is an essential part of life. In the current era of healthcare, everyone wants to be facilitated with the economical rates and great comfort by deploying the technologies .Unfortunately, the steadily aging population and the related rise in chronic illness is placing significant strain on modern health- care systems and the demand for resources from hospital beds to doctors and nurses is extremely high [1][2]. Luckily, Continuous Chronological developments are helping to improve some medical processes, ease the workflow of healthcare practitioners, and ultimately, to improve the situation in an overloaded hospital so we can say that healthcare is changing from reactive and hospital-centered to preventive and personalized, from disease-focused to wellbeing-centered. In essence, the healthcare system as well as fundamental medicine research are becoming smarter.

According to Blue Stream Consultancy, "Smart healthcare is defined by the technology that leads to better diagnostic tools, better treatment for patients, and devices that improve the quality of life for anyone and everyone [2]. Today's healthcare system has also recognized the advantages of using Information and Communication Technology (ICT) to improve the quality of healthcare, turning traditional into smart healthcare. Healthcare practitioners will be able to interpret and leverage the plethora of big data from connected systems to make informed patient care decisions as well as understand and predict current and future health trends with the help of Machine learning. .ML is an approach to achieve artificial intelligence (AI). In this algorithms are utilized to analyze data, learn from it, and identify patterns, then makes decisions with minimal human intervention.

The presented paper is structured as follows: Section II explains various types of technologies used in healthcare; Section III deals with major applications of AI and IOT in IOT franework, Section IV gives the detailed description of wearable Technology and its benefits; Section V describes the usage of machine learning Algorithms with IoT.

## II. VARIOUS TYPES OF TECHNOLOGIES FOR HEALTHCARE

### *1) IoT in Healthcare*

The IoT (internet of Things) is a combination of ubiquitous communication, connectivity and computing along with ambient intelligence. IoT in healthcare technologies is also popularly known as IoMT (Internet of Medical Things). The Number of connected medical devices is expected to increase from 10 billion to 50 billion over the next decade.

Cisco estimates that by 2021, the total amount of data created by any IoT device will reach 847 Zettabytes (ZB) per year. At some point, IoT will become the biggest source of data on Earth. Along with identifying, monitoring, and informing caregivers about the patient's vitals – it also provides the much-needed critical data to the health care providers so that issues can be identified at an early stage leading to better delivery of care services [3].

### *2) AI in Healthcare*

AI in healthcare has the potential to improve patient care and staff efficiency by assisting with medical image analysis and diagnosis. One of the most popular uses of AI in healthcare is in IBM's smart cloud, where Watson lives. Personalized care has been the hallmark of smart healthcare solutions, which can be easily gained through machine learning. Especially in maintaining smart electronic health records, machine learning enables major stakeholders in the healthcare industry to gain advantage and speed up the care delivery curve [4].

### *3) Big Data in Healthcare*

Using big data can help healthcare sector players to provide more efficient operations and insights into the patients and their health. With the vast amount of data available in the healthcare sector like financial, clinical, R&D, administration and operational data, big data can derive meaningful insights to improve the operational efficiency of the industry. By the

 

year 2019, the market value of Big Data spending on healthcare is expected to be around USD 14.33 billion.

***4) Cloud Computing in Healthcare***

After Big Data, if anything has made the healthcare technologies way smarter, then it is the cloud computing technology. As it is cloud computing encourages cost savings, scalability, and system flexibility; now with the increased use of cloud-assisted medical collaboration, the demand for cloud computed healthcare solutions has grown exponentially.

***5) Smart Wearables in Healthcare***

Recently, smart wearables, typically as wearable electrocardiogram (ECG), blood pressure (BP), electroencephalography (EEG), electromyography (EMG), blood pressure (BP), photoplethysmography (PPG), heart sound, respiration, sleep, and motion monitoring, have been gaining a significant role in the field of healthcare and are looking to be a big and promising market in the technology industry.

***6) 3D Printing in Healthcare***

As 3D printing technology continues to develop, doctors are hoping to use 3D printing to create more complex implants for ailing patients. Similarly, doctors want to eventually utilize 3D printing to create new hands, feet, legs, noses, and eyes for people [15].

## III. MAJOR APPLICATIONS OF AI ND IOT IN SMART HEALTHCARE

The Internet of Things is a vision, in which objects become part of the Internet, where every object is uniquely identifiable and accessible on the Web. These objects may directly or indirectly collect, process or exchange data via data communications network but the next step is to add the artificial intelligence to Internet of Things systems. So, IoT (Internet of Things) is a framework that uses technologies like sensors, network communication, artificial intelligence, cloud computing and bigdata to provide real life solution as shown in figure 1. These solutions and systems are designed for optimal control and performance[3][6].

Now a days, Healthcare providers and device makers are integrating AI and IoT to create advanced medical applications and devices that can provide person-centric care for individuals, from initial diagnosis to ongoing treatment options, while solving a variety of problems for patients, hospitals and the healthcare industry. At the same time, these AI-enabled medical IoT devices will make healthcare treatments more proactive rather than preventive [5].

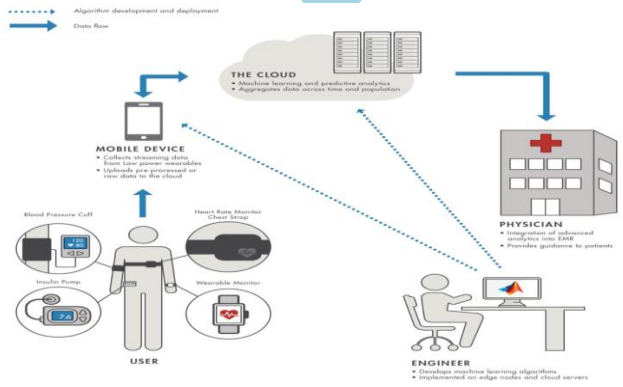


**Figure 1: IOT Framework that consists of Artificial Intelligence**

### *IOT Applications in Healthcare*

***1) Location-Based Real-Time Services***

Through IoT, healthcare professionals can track patient whereabouts. This is particularly useful when an injured person is coming in for urgent medical assistance.. IoT devices help in real-time environmental monitoring as well – such as checking room temperature[7].

***2) Improve Patient Experience***

IoT devices help in improving the patient experience. Due to their seamless connection between devices, patients can control the room temperate and lighting, communicate with their friends and family via video calling, and call nurses via intercom. IoT also allows for easy access to patient information from the cloud by medical staff, provided they are stored therein to begin with[8].

***3) Hygiene Compliance***

Practicing hand hygiene is one of the best ways of preventing infections. Hand hygiene monitoring systems help in setting and detecting a degree of cleanliness among healthcare and medical staff. The simplest function of hand hygiene IoT devices is to beep whenever medical staff comes in close proximity of a patient bed without washing their hands.

***4) Remote Monitoring***

Remote monitoring of health is a crucial application of IoT. Constant monitoring helps in giving adequate healthcare to patients. Globally, many individuals die as they do not receive timely medical attention. IoT can help solve this. IoT devices can apply complex algorithms and analyze them. This helps in providing better medical attention and care to patients in remote areas – usually places where doctors cannot physically go.

### *B. Current Applications of AI in Medical Diagnostics*

AI in healthcare has the potential to improve patient care and staff efficiency by assisting with medical image analysis and diagnosis.[9]

***1) Disease Identification/Diagnosis***

Identifying and diagnosing diseases and other medical issues is one of the many healthcare challenges machine learning is a being applied to. IBM Watson Genomics, a joint venture between IBM Watson Health and Quest Diagnostics, is looking to integrate cognitive computing with genomic tumor sequencing in order to help advance precision medicine.

***2) Personalized Treatment /Behavioral Modification***

Personalized medicine, or more effective treatment based on individual health data paired with predictive analytics, is also a hot research area and closely related to better disease assessment. The domain is presently ruled by supervised learning, which allows physicians to select from more limited sets of diagnoses, for example, or estimate patient risk based on symptoms and genetic information.

***3) Drug Discovery & Development***

From next generation sequencing to applications in precision medicine, machine learning has various roles to play with drug discovery and development both now and in the future. The initial screening of drugs in early stage and preliminary testing could utilize machine learning systems as could the methods used to predict a drugs success rate when taking into account a plethora of biological factors

Both MIT and Microsoft have projects using machine learning algorithms to enhance and improve both our understanding

 

and treatment of diseases and similar efforts focused on cancers and leukemia are also ongoing.

***4) Creating Electronic Smart Records***

With the huge volumes of medical and healthcare data now available, the implementation of smart electronic healthcare records has become essential machine learning applications in the creation of electronic smart records involve using records with built-in artificial intelligence or machine learning so as to assist with keeping medical records, interpreting health conditions and suggesting treatment plans.

***5) Automation***

Machine learning systems within robotic surgeons are one way in which automation could find itself integrated into healthcare systems of the future.Using techniques such as machine and deep learning, robotic surgeons could eventually be fully automated and remove humans from surgical procedures altogether.

***6 ) Radiation Treatments***

An artificial intelligence (AI) system that could help to plan radiotherapy treatment for head and neck cancer patients has shown promising early results.

## IV. WEARABLES TECHNOLOGY

After the invention of smartphones, wearable electronics are the next big innovation in the world of technology. Wearable technology is a blanket term for electronics so Wearables are electronic technology or devices incorporated into items that can be comfortably worn on a body[12]. These wearable devices are used for tracking information on real time basis. They have motion sensors that take the snapshot of your day to day activity and sync them with mobile devices or laptop computers. There are many types of wearable technology but some of the most popular devices are activity trackers and Smartwatches. Examples include Fitbit, Apple Watch, and Samsung Galaxy Gear as shown in figure 2.


**figure 2: Different types of Wearable devices**

Wearable devices provide output and connect to the Web in various ways. Some enable wearers to monitor their own readings using a mobile phone and a special website. Others allow data to be downloaded and viewed by third parties such as healthcare managers, or clinicians who are watching for disturbing trends that merit medical intervention. Some devices simply encourage wearers to share their fitness progress with work-out buddies and friends via social media sites A wearable medical device can quickly catch any changes in the patient's body[12].

A fine example is shown in figure 3, consider a person has been through congestive heart failure and is convalescing at home. Now the device would know if his weight, respiration rate or pulse oxygen level changed and the linked app would alert someone if his health might be deteriorating.

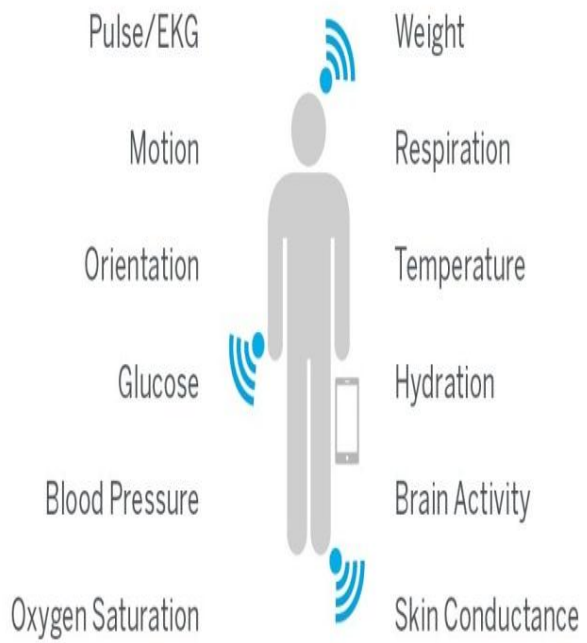


**figure 3: Wearable device can predict health problem**

Wearable technology has touched multiple areas but healthcare has been the major benefiter of this technology [14]. By deploying Wearables technologies, hospitals and clinics can achieve benefits across multiple levels and roles. Some such benefits can be enumerated as

***1)Encourages Proactive Healthcare***

With wearable tech, there is potential for a more proactive approach to healthcare. This is because wearables can be used to take action in the early stages instead of reacting to health issues after they begin causing problems. For people that are already prone to health problems, irregularities can be detected before they become problems.

***2) Keeps Patients Engaged***

People will become much more engaged with their own health if they are able to use wearable tech to monitor themselves. Users will be able to stay informed about their health condition by getting access to real-time data which is continuously collected from a wearable device.

***3) Monitors Vulnerable Patients***

Healthcare providers can also use wearable tech to monitor vulnerable patients who are prone to medical issues. If they are at risk but not seriously ill enough to be in the hospital, wearable tech can be used to monitor them at home to ensure no problems occur.

***4) Improve Patient Care and Satisfaction***

 

Provide surgeons and physicians with critical information to improve decision-making process while increasing opportunities for patient connection. Examples include using smart glasses to view patient vitals and relevant information during surgical procedures without taking eyes off the patient.

***5) Benefits Healthcare Providers and Employers***

Wearable technology has the potential to provide enormous benefits to healthcare providers. By using wearable devices to monitor patient data over a long period of time, medical professionals can get a better view of the issues that are affecting their patient. They can then use the data to make a more accurate diagnosis than they would have been able to without using the device.

## V. MACHINE LEARNING ALGORITHM IMPLEMENTED IN IOT

Machine learning is a field of computer science, probability theory, and optimization theory which allows tedious tasks to be solved for which a procedural or the logical approach would not be possible or feasible. In other words it is a method of training computers to improve predictions or features based on some input data. Input data depends entirely on the problem. It could be information obtained from the machines like computers connected to the same network or the different network, results obtained from the program as an input to the other program[10].

Machine learning models determine a set of rules using vast amounts of computing power that a human brain would be incapable of processing. The more data a machine learning model is fed, the more complex the rules – and the more accurate the predictions

***1) Artificial Neural Networks***

This type of learning technique is also called neural networking. It is basically a learning algorithm inspired by the structure and functional aspects of biological neural networks. It is basically used to model the complex relationships between inputs and outputs, to find the patterns in the data. ANNs help to provide the predictions in healthcare that doctors and surgeons simply couldn't address alone.

ANNs can be used to detect heart and cancer problems. ANNs are used to analyze urine and blood samples, as well as tracking glucose levels in diabetics, determining ion levels in fluids, and detecting various pathological conditions [11].

***2) Inductive logic programming (ILP)***

This is a method used to rule the learning system with the help of logical programming as its representation for different input examples, background knowledge and the hypotheses. If we have the encoding of any known background knowledge with specific sets of examples that represent a logical database of the facts, then a hypothesied logic program can be derived using an ILP system. This entails all the positive and no negative instances, and accepts any programming language for representing the hypotheses.

***3) Clustering:***

This is a technique used for the assignment of different observations into various clusters (sets) so that all the observations present within the same cluster are similar according to some pre-designated criteria. It is an unsupervised learning method. It provide benefits to a healthcare organization for grouping patients having similar type of diseases or health issues so that the organization can provide them with effective treatments. This approach is mainly used to find similarities between data points.

***4) Bayesian networks:***

This is a kind of probabilistic graphical model that represents a set of random variables with all their conditional independencies by making use of a directed acyclic graph. For instance, it can represent the probabilistic relationships present between various diseases and their symptoms. If we know the symptoms, then this network can easily calculate the probability of the presence of various diseases.

***5) Decision tree learning:***

Decision tree learning is a type of ML technique that uses a decision tree as its predictive model. This model maps the observations about an item to different conclusions about the target value of the item. Decision tree analysis in healthcare can be applied when choices or outcomes of treatment are uncertain, and when such choices and outcomes are significant (wellness, sickness, or death). This approach allows physicians to better identify the most favorable option for patients

***7) Association rule learning:***

Association rules are if-then rules, which help to uncover the vast relationship between seemingly unrelated data This is actually a method used for discovering different interesting relations between all the variables present in large databases.

## VI. CONCLUSION

The healthcare landscape has changed and is still changing. Patients are starting to embrace the change, using medical IoT devices to manage their health requirements. Healthcare providers are starting to incorporate connected healthcare to drive excellence, be competitive and improve treatment outcomes to give patients better healthcare experience, while medical device makers are developing solutions that are more accurate, intelligent, and personalized. From a medical standpoint, wearable technology also offers exciting possibilities for the digital healthcare industry. The wearable hardware developers, wearable app developers along with regulators and healthcare service providers, must embrace the potential of wearable technology in providing better patient outcomes. Ultimately, leveraging technologies in an effort to improve treatment outcomes, the management of drugs and diseases, and the patient experience, will lead to a more efficient hospital.

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