



Emerging Technologies for Healthcare

*Internet of Things and
Deep Learning Models*

Edited By

**Monika Mangla
Nonita Sharma
Poonam Mittal
Vaishali Mehta Wadhwa
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Preface

The use of computing technologies in the healthcare domain has been creating new avenues for facilitating the work of healthcare professionals. Several computing technologies, such as machine learning and virtual reality, have been flourishing and in turn creating new possibilities. Computing algorithms, methodologies and approaches are being used to provide accurate, stable and prompt results. Moreover, deep learning, an advanced learning technique, is striving to enable computing models to mimic the behavior of the human brain; and the Internet-of-Things (IoT), the computer network consisting of “things” or physical objects in addition to sensors, software or methods, is connecting to and exchanging data with other devices. Therefore, the primary focus of this book, *Emerging Technologies for Healthcare*, is to discuss the use and applications of these IoT and deep learning approaches for providing automated healthcare solutions.

Our motivation behind writing this book was to provide insight gained by analyzing data and information, and in the end provide feasible solutions through various machine learning approaches and apply them to disease analysis and prediction. An example of this is employing a three-dimensional matrix approach for treating chronic kidney disease, the diagnosis and prognostication of acquired demyelinating syndrome (ADS) and autism spectrum disorder, and the detection of pneumonia. In addition to this, providing healthcare solutions for post COVID-19 outbreaks through various suitable approaches is also highlighted. Furthermore, a detailed detection mechanism is discussed which is used to come up with solutions for predicting personality through handwriting recognition; and novel approaches for sentiment analysis are also discussed with sufficient data and its dimensions.

This book not only covers theoretical approaches and algorithms, but also contains the sequence of steps used to analyze problems with data, processes, reports, and optimization techniques. It will serve as a single source for solving various problems via machine learning algorithms.

In brief, this book starts with an IoT-based solution for the automated healthcare sector and extends to providing solutions with advanced deep learning techniques.

Here, we would like to take the opportunity to acknowledge the assistance and contributions of all those engaged in this project. We especially would like to thank our authors for contributing their valuable work, without which it would have been impossible to complete this book. We express our special and most sincere thanks to the reviewers involved in the review process who contributed their time and expertise to improving the quality, consistency, and arrangement of the chapters. We also would like to take the opportunity to express our thanks to the team at Scrivener Publishing for giving the book its final shape and introducing it to the public.

Editors

**Monika Mangla, Nonita Sharma,
Poonam Mittal, Vaishali Mehta Wadhwa,
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Part I

BASICS OF SMART HEALTHCARE

An Overview of IoT in Health Sectors

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Abstract

In the recent past, several technological developments have happened owing to the growing demand for connected devices. Applications of Internet of Things (IoT) are vast, and it is used in several fields including home-automation, automated machines, agriculture, finance sectors, and smart cities. Life style diseases are increasing among urban population and lot of money is spent for the diagnosis and treatment of diseases. Adaption of IoTs in health sectors enables real-time monitoring of the patients and alerts the patients for health checkups whenever required and communicate the information from time to time. During pandemic situations like Covid-19 which we are facing today, the need for IoT-enabled services in health sector is essential as the doctors have to treat the patients from remote locations. The connected devices can help in surveillance and disease control, keep track of nutritional needs, mental health, stress management, emergency services, etc., which will lead to an efficient health management system. This article gives an overview of applications of IoT in health sectors and how it can be used for sustainable development and also addresses various challenges involved in it. Efficient use of IoT in health sectors can benefit healthcare professionals, patients, insurance companies, etc.

Keywords: IoT, healthcare, smart gadgets, health monitoring

1.1 Introduction

Due to the increase in awareness of a healthy life style, the number of people depending on smart devices for monitoring their health is increasing day

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by day. IoT devices have become very essential to be the part of daily life in this technological advanced world. Various advancements are happening in the healthcare sectors from the recent past. With the advancement in technology in the use of IoTs integrated with Artificial Intelligence, a major digital transformation is happening in the healthcare sector. Various research is going on in this area which will add new dimensions to the healthcare system.

Wireless Body Area Networks (WBANs) have also been used extensively in healthcare services due to the advancement in technology. A survey on healthcare application based on WBAN is discussed in [1]. The paper also analyses the privacy and security features that arises by the use of IoTs in healthcare systems.

Use of RFID has become very common owing to the extensive applications of IoTs. A survey on RFID applications for gathering information about the living environment and body centric systems is discussed in [2]. The challenges and open research opportunities are also discussed in the article.

Various research is ongoing on to find the methods to improve the monitoring and tracking of the patients in an efficient manner. In [3], a novel IoT-aware smart architecture is proposed to monitor and track the patients. A smart hospital system is proposed which can collect real-time data and environmental factors by making use of ultra-low power hybrid sensing network.

A secure IoT-based healthcare system which operates with body sensor network architecture is introduced in [4]. Two communication mechanisms for authenticity and secured communication is addressed. The proposed method was implemented and tested using a Raspberry Pi platform.

In [5], authors address a survey paper on the IoT research and the discusses about the challenges, strengths and suitability of IoT healthcare devices and mentions about the future research directions.

One of the challenges faced by the IoT systems is regarding the security and privacy of data. In [6], the authors proposed a hybrid model for securing the medical images data. This model aims to hide the confidential patient data from the image while transmitting it.

Wireless body networks are becoming popular with the increased use of IoT smart devices. In [7], a solar energy powered wearable sensor node is addressed. At various positions of the body multiple sensors are deployed and a web-based application is used for displaying sensor data.

Experiment results achieved good results for autonomous operation for 24 hours.

Body sensor networks is the one of the significant technologies used to monitor the patients by means of tiny wireless sensor nodes in the body. Security of such IoT devices poses a major issue in privacy of the patients. A secure system for healthcare called BSN-care is addressed in [8].

Securing the privacy of patients is of utmost importance for IoT-based healthcare systems. Various research is going on this area. In [9], a big data storage system to secure the privacy of the patients is addressed. The medical data generated is encrypted before it is transferred to the data storage. This system is designed as a self-adaptive one where it can operate on emergency and normal conditions.

Various systems are developed to take care of the personal needs while traveling which can aid in travel and tourism. An intelligent travel recommender system called ProTrip is developed in [10]. This system helps travelers who are on strict diet and having long-term diseases in getting proper nutritional value foods according to the climatic conditions. This system supports the IoT healthcare system for food recommendation.

The issues in the security and privacy of IoT-based healthcare system are a major concern. Most of the system is based on cloud computing for IoT solutions which has certain limitations based on economic aspects, storage of data, geographical architecture, etc. To overcome this limitation, a Fog computing approach is addressed in [11] and authors explores the integration of traditional cloud-based structure and Cloud Fog services in interoperable healthcare solutions.

For IoT-based healthcare system efficient authorization and authentication is required for securing the data. Such a system is addressed in [12]. It was found that the proposed model is more secure than the centralized delegation-based architecture as it uses a secure key management between the smart gateway and sensor nodes.

Recent security attacks for the private data and integrity of data is a matter of concern for the IoT healthcare systems. Conventional methods of security solutions are for the protection of data during patient communication but it does not offer the security protection during the data conversion into the cipher. A secure data collection scheme for IoT healthcare system called SecureData scheme is proposed in [13], and the experimental results showed that this scheme is efficient in protecting security risks.

Life style diseases like diabetes are common nowadays. It is very important for such patients to follow a strict diet and most of the time it

is difficult for the healthcare professionals to get the precise physiological parameter of the patients. Without the knowledge of the current condition of the patients, it is difficult for the ontologies to recommend a proper diet for such patients. A fuzzy-based ontology recommendation system is proposed in [14] which can determine patient's conditions and risk factors by means of wearable sensors and accordingly can suggest the diet. The experimental results proved that the system is efficient for diabetes patients.

The data generated through IoT devices are prone to security threats. Maintaining the privacy of the patient data is of utmost importance. Traditional encryption schemes cannot be applied on healthcare data due to the limitations in the properties of digital data. A chaos-based encryption cryptosystem to preserve the privacy of patients is proposed in [15]. Random images are generated by the cryptosystem which ensures highest security level for the patient data. The performance of this model was found to be better than other encryption schemes.

The trends of IoT in healthcare sectors and the future scope for research is discussed in [16]. A sensor-based communication architecture and authentication scheme for IoT-based healthcare systems is addressed in [17]. Various research articles on big data analytics, and IoT in healthcare is addressed in [18].

With the enormous research happening in the field of IoT applications in healthcare sectors, new dimensions to the healthcare treatments and hospital services can be expected in the coming years.

1.2 Influence of IoT in Healthcare Systems

Due to the awareness about the importance of healthy life, people have become more health conscious nowadays. Humans are finding new ways to improve and track their health. Due to the implementation of emerging technologies like IoTs and Artificial Intelligence (AI), the healthcare systems have evolved as an entirely new system replacing the old system. Various stages of IoT system is shown in Figure 1.1.

Various developments have occurred in the healthcare systems in the recent past. Some of the advancements are discussed in this section.

1.2.1 Health Monitoring

Health monitoring on real-time basis became possible due to the invention of wearable smart gadgets. These devices continuously monitor various

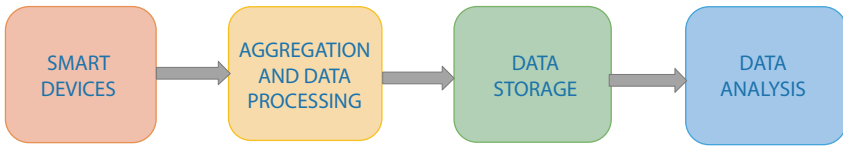


Figure 1.1 Stages of IoT.

parameters like blood pressure, heart rate, oxygen level, and calories burnt. Fitness bands help individuals to maintain their body healthy and fit by regularly alerting them about the steps taken per day and how much calories need to be burnt to stay healthy.

These devices can be interconnected by IoT devices so that the health-care workers and immediate family members can monitor the parameters and they will be alerted for any emergency situation. Such devices are very helpful for elderly persons who are living alone as they get immediate medical attention if there are variations in their body parameters.

1.2.2 Smart Hospitals

Smart hospitals mean all the equipment in the hospitals are connected through IoTs in addition to real-time monitoring systems for the patients. Managing the assets in the hospitals can be made in a smarter way by means of IoTs. The equipment like oxygen cylinders, wheelchairs, and nebulizers can be tracked on a real-time basis and made available when in need.

Now, in the current Covid-19 scenario, we have observed how the hospitals were managing the resources in a smarter way. The number of occupied beds and available bed status is updated on a real-time basis, and the data is made available in various digital platforms.

Cleanliness and hygiene also can be maintained in an efficient manner. Environmental conditions like humidity and temperature can be monitored continuously and the spread of diseases can be prevented efficiently.

1.2.3 Tracking Patients

Due to the advancement of technology, hospitals have become more patient friendly. The duration of hospital stay can be reduced due to the online real-time monitoring of the patient data through IoT devices. It is

easier for doctors to track the patient data at the comfort of sitting at a remote location. As the IoT devices are attached to the patients, continuous monitoring of the vital parameters is possible, and the doctors will be alerted for any variations in the parameters.

These smart devices not only track the patient's health parameters but also alert the patients for their consultation schedules. It also keeps the records of previous medications or medical history which aids the doctors in right diagnosis and treatments.

The availability of patient's data on IoT devices helps the hospitals to track the patients and provide quick medical attention in an efficient manner.

1.2.4 Transparent Insurance Claims

Healthcare insurance policy holders are increasing on a yearly basis. Due to the large number of policy holders who aims to get maximum profits by claiming the insurance, false claims are also increasing. Due to the presence of IoT devices which tracks the patient data, insurance companies can easily detect any fraud in the claims.

These devices not only help the patients to manage their insurance policies but also help the insurance companies to track the health of patients, underwriting, risk assessments, etc. Due to the IoT-enabled devices, the insurance claims became transparent and benefitting the genuine policy claims.

1.2.5 Healthier Cities

Population in cities are more compared to the rural areas as people prefer to have better quality and standards of living in cities with better facilities and infrastructures. Most of the cities are crowded and majority of the population use public and private transport for commuting. Vehicle densities in cities are more compared to villages which lead to more air pollution which, in turn, affect the health of the individuals and the environment.

Due to the advancement in technology in terms of usage of IoT devices, continuous real-time monitoring of the air quality is possible. The tracking of the air quality patterns helps the authorities to take appropriate actions to improve the air quality which, in turn, help to maintain a healthier city.

1.2.6 Research in Health Sector

Research in medical field is a continuous process which requires lot of time in gathering the patient data and analyzing it. Connected devices through IoTs generate large amount of real-time data which can be used

for research purposes in an efficient manner as data collection becomes much easier with less amount of time and money. Statistical and comparative study analysis is possible as these devices can be connected anywhere in the world and data can be generated which will aid in medical research.

Innovative methods of treatments can be introduced by doing proper research in an efficient and quick manner due to the presence of IoT devices. This also helps to improve the healthcare services.

Smart monitoring devices will monitor all the parameters inside a medical laboratory and alerts if there is an abnormality so that immediate action can be taken. Based on the data available, various research studies can be done with much ease.

1.3 Popular IoT Healthcare Devices

New devices are invented to match with the technological advancements. These new devices aim to make the life easier for humans. Some of the popular IoT devices for healthcare are as follows:

1.3.1 Hearables

Hearables are one of the popular IoT devices which are used by the people for hearing aid. With these devices, people who have difficulty in hearing or those who are hearing impaired can interact with the outside world. This device can be connected with other smart devices like mobile phones and data can be synchronized. Various types of filters and equalizers are used for better user experience to match with the real sounds.

1.3.2 Moodables

Moodables are devices which enhances the mood of a person by sending triggering signals to the brain. These devices must be worn on head which has inbuilt sensors to elevate the mood.

1.3.3 Ingestible Sensors

These are like small pills which can be ingested to monitor our body from inside and can give warning signals to the doctors in case of any abnormalities. This device is made up with sensors of pill size which can give warning for any underlying diseases. These sensors can detect whether the prescribed medicines are taken properly and also can help in drug management.

1.3.4 Computer Vision

Computer vision technology mimics the human vision by making use of Artificial Intelligence. This technology has been implemented in drones which help them to navigate and detect obstacles. Visually impaired people can make use of this technology to navigate easily.

1.3.5 Charting in Healthcare

IoT devices helps doctors to maintain the patient data in an efficient manner. Doctors can easily get the charting of various parameters like blood pressure and sugar level from the connected devices and it can be immediately reviewed and shared with the patient's devices. This saves huge amount of time that doctors spend in creating manual charts for individual patients.

1.4 Benefits of IoT

Various benefits of IoTs are discussed in this section.

1.4.1 Reduction in Cost

As the doctors can remotely monitor the patients using IoT-enabled devices, the cost in visiting the healthcare facilities and consultation can be drastically reduced. Since the real-time monitoring of the patients is possible with IoT devices, hospital admissions can also be reduced by providing timely treatments.

1.4.2 Quick Diagnosis and Improved Treatment

Doctors can easily diagnose the diseases as real-time monitoring is possible with IoT devices and can give appropriate treatment on time at an early stage. Patients can also be fully aware about their health conditions and the treatments provided. Hence, the transparency in treatment can also be maintained. Doctors can provide proactive treatment to the patients based on the real-time data collected.

The continuous monitoring of patients helps to save many lives during emergency medical situations which arise due to heart attacks, asthma attacks, high blood pressure, etc.