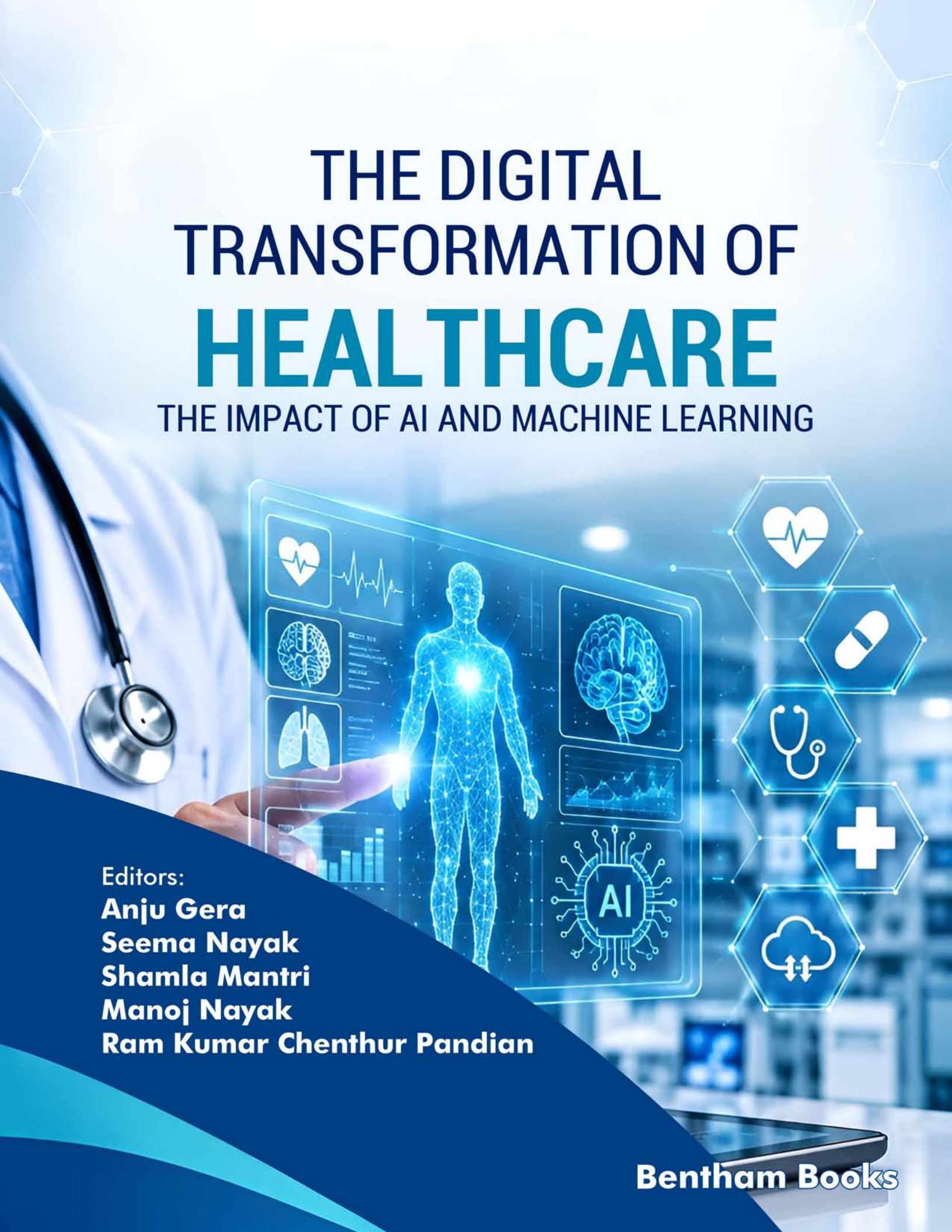
# THE DIGITAL TRANSFORMATION OF HEALTHCARE

## THE IMPACT OF AI AND MACHINE LEARNING




Editors:
**Anju Gera**
**Seema Nayak**
**Shamla Mantri**
**Manoj Nayak**
**Ram Kumar Chenthur Pandian**

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# The Digital Transformation of Healthcare: The Impact of AI and Machine Learning

Edited by

**Anju Gera**
*Department of Data Science*
*Galgotia College of Engineering and Technology*
*Greater Noida, Uttar Pradesh*
*India*

**Seema Nayak**
*Internal Quality Assurance Cell IIMT College of Engineering*
*Greater Noida, Uttar Pradesh, India*
*Department of Electronics and Communication Engineering*
*IIMT College of Engineering*
*Greater Noida, Uttar Pradesh, India*

**Shamla Mantri**
*Department of Computer Engineering and Technology*
*Dr. Vishwanath Karad MIT World Peace University*
*Pune, Maharashtra, India*

**Manoj Nayak**
*Department of Mechanical Engineering*
*Manav Rachna International Institute of Research and Studies*
*Faridabad, Haryana, India*

&

**Ram Kumar Chenthur Pandian**
*Department of Electronics and Communication Engineering*
*Sri Krishna College of Engineering and Technology*
*Coimbatore, Tamil Nadu, India*

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# PREFACE

Accelerated digital transformation of healthcare in the last half -decade offers a wide range of possibilities powered by Artificial Intelligence (AI), Data Science (DS), and Machine Learning (ML). Traditional methods in the health care system, like clinical history, diagnosis, examination, treatments, and patient care, have been revolutionized using these emerging technologies, offering operational efficiency and patient outcomes unlike any in its history. Telemedicine, remote care, electronic health records (EHRs), big data analytics, IoTs, and wearable devices are redefining how healthcare is offered and received by stakeholders with greater efficiency.

However, it presents greater challenges, including ethical issues, equity, the digital divide, integration and adoption, and data security concerns, and therefore requires a diligent regulatory framework.

Health Care's Digital Revolution: The AI/ML impact explores this profound shift, evaluation how AI/ML is re-shaping the medical healthcare system, redefining medicine, virtual health assistant, drug discovery, personalized treatment, administrative automation, remote patient monitoring, telemedicine, robotic surgery, predictive analytic and many more. This book is designed considering the moot points related to healthcare and can be handy for medical practitioners, healthcare professionals, policy makers, and anyone intrigued by the overlapping of medicine and cutting-edge innovations and technologies.

Inside, you will find:

● **The Foundations of AI/ML in Health Care** – Key concepts in AI/ML, data in health care AI, barriers and enablers, innovation driving the revolution.

● **Transforming Patient Care** – AI-based diagnostics, preventive care, drug discovery, and precision medicine.

● **Operational and Ethical Challenges** – Data privacy, algorithmic bias, and the human-AI collaboration dilemma.

● **The Future Landscape** – Emerging trends, regulatory framework, and the path toward equitable, AI-driven health care.

This book is not just a technical exploration but also gives an insight into the seismic shift of traditional practices, as well as a call to action to harness AI/ML responsibly, ensuring that innovation serves society for a better cause. We acknowledge the pioneers in technology/science/engineering/medicine whose work makes this evolution possible, and we invite readers to engage critically with the promises and perils of this new era.

The digital revolution in health care is here. The question is no longer if AI and ML will change medicine, but how we will steer that change for the greater good.

**Anju Gera**
Department of Data Science
Galgotia College of Engineering and Technology
Greater Noida, Uttar Pradesh
India

**Seema Nayak**
Internal Quality Assurance Cell IIMT College of Engineering
Greater Noida, Uttar Pradesh, India
Department of Electronics and Communication Engineering
IIMT College of Engineering
Greater Noida, Uttar Pradesh, India

**Shamla Mantri**
Department of Computer Engineering and Technology
Dr. Vishwanath Karad MIT World Peace University
Pune, Maharashtra, India

**Manoj Nayak**
Department of Mechanical Engineering
Manav Rachna International Institute of Research and Studies
Faridabad, Haryana, India

&

**Ram Kumar Chenthur Pandian**
Department of Electronics and Communication Engineering
Sri Krishna College of Engineering and Technology
Coimbatore, Tamil Nadu, India

# List of Contributors


| | |
|---|---|
| **Aparna U. Palekar** | Department of Conservative Dentistry and Endodontics, Rural Dental College, Pravara Institute of Medical Sciences, Loni, Maharashtra, India |
| **Asif Ibrahim Tamboli** | Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed To Be University), Karad Malkapur, Karad, Maharashtra, India |
| **Anand Gudur** | Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed To Be University), Karad Malkapur, Karad, Maharashtra, India |
| **Arunprasath Thiyagarajan** | Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India |
| **Akshaya A.V.R.** | School of Business and Management, CHRIST (Deemed to be University), Pune Lavasa Campus, Bengaluru, Karnataka, India |
| **Anshu Sharma** | School of Engineering and Technology, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India |
| **Aastha Budhiraja** | School of Computer Applications, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India |
| **Anju Gera** | Deparment of Data Science, Galgotias College of Engineering and Technology, Greater Noida, Uttar Pradesh, India |
| **Anshu Sharma** | School of Engineering and Technology, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India |
| **A. Priya** | Department of Computer Science and Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India |
| **Abinaya Inbamani** | Department of Electrical and Electronics Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India |
| **Amol Bhoite** | Department of Radio-Diagnosis, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India |
| **Basawaraj C. Biradar** | Department of Conservative Dentistry and Endodontics, Rural Dental College, Pravara Institute of Medical Sciences, Loni, Maharashtra, India |
| **Deepa R.** | Department of Computing Technologies, SRM Institute of Science and Technology, Kattankulathur Campus, Kattankulathur, Tamil Nadu, India |
| **D. Surendran** | Department of Information Technology, Karpagam College of Engineering, Coimbatore, Tamil Nadu, India |
| **Hemlata Sandip Oha** | Department of Computer Engineering and Technology, Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, India |
| **Kunjali Pawar** | Department of Computer Engineering and Technology, Dr. Vishwanath Karad, MIT World Peace University, Pune, Maharashtra, India |
| **Lakshmi Adhi** | Department of Electronics and Communication Engineering, Ramco Institute of Technology, Rajapalayam, Tamil Nadu, India |
| **L. K. Shoba** | Department of Computing Technologies, SRM Institute of Science and Technology, Kattankulathur Campus, Kattankulathur, Tamil Nadu, India |
| **Mukund V. Singh** | Department of Conservative Dentistry and Endodontics, Rural Dental College, Pravara Institute of Medical Sciences, Loni, Maharashtra, India |

| | |
|---|---|
| **Muthuvel Arumugam** | Department of Electronics and Communication Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India |
| **M. Pallikonda Rajasekaran** | School of Business and Management, CHRIST (Deemed to be University), Pune Lavasa Campus, Bengaluru, Karnataka, India |
| **M. Karthik** | SRM Madurai College for Engineering and Technology, Madurai, Tamil Nadu, India |
| **Nitin R. Nangare** | Department of Surgery, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India |
| **N. Rajasingam** | Department of Biomedical Engineering, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India |
| **Piyush T. Mantri** | Department of Conservative Dentistry and Endodontics, Rural Dental College, Pravara Institute of Medical Sciences, Loni, Maharashtra, India |
| **P. Mohan Kumar** | Department of Computer Science and Engineering, Hindustan Institute of Technology and Science, Chennai, Tamil Nadu, India |
| **Priyanka Sharma** | School of Computer Applications, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India |
| **P. Sivaranjani** | Department of Electronics and Communication Engineering, Kongu Engineering College, Erode, Tamil Nadu, India |
| **Rex Cyril B.** | Department of Computer Science, St. Joseph's College (Autonomous), Tiruchirappalli, Tamil Nadu, India |
| **Raji Sweethaa S.** | Department of Information Technology, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India |
| **Shamla Mantri** | Department of Computer Engineering and Technology, Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, India |
| **Satish V. Kakade** | Department of Community Medicine, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India |
| **S. Nithyadevi** | Department of Electronics and Communication Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India |
| **S. Birundha** | Department of Computer Science Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India |
| **Shilpa C. Patil** | Department of General Medicine, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed To Be University), Karad, Maharashtra, India |
| **S. Madumidha** | Department of Information Technology, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India |
| **T. Vijaya Kumar** | Department of Information Technology, Dr. N.G.P. Institute of Technology, Coimbatore, Tamil Nadu, India |
| **Tapas Kumar** | School of Engineering and Technology, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India |
| **Umesh G. Palekar** | Department of Conservative Dentistry and Endodontics, Rural Dental College, Pravara Institute of Medical Sciences, Loni, Maharashtra, India |

**V. Benhar Charles** Department of Computer Science, St. Joseph's College (Autonomous), Tiruchirappalli, Tamil Nadu, India

**V. Sangeetha** Department of Biomedical Engineering, Kalaignarkarunanidhi Institute of Technology, Coimbatore, Tamil Nadu, India

**V. Vasudevan** Department of Computer Science and Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India

**V. Janani** Department of Biomedical Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India

**V. Tharun** Department of Information Technology, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India

# CHAPTER 1

# Medical Diagnosis and Artificial Intelligence: A Harmonious Relationship

**Aparna U. Palekar[1], Piyush T. Mantri[1,*], Basawaraj C. Biradar[1], Mukund V. Singh[1]** and **Umesh G. Palekar[1]**

[1] *Department of Conservative Dentistry and Endodontics, Rural Dental College, Pravara Institute of Medical Sciences, Loni, Maharashtra, India*

**Abstract:** Medical diagnosis aims at determining the cause of a medical problem and reaching an accurate diagnosis in order to provide effective treatment for the patient. Various diagnostic tests are used not only to achieve an accurate diagnosis but also to predict the prognosis of a disease and the efficacy of the treatment.The recent advances in Artificial Intelligence (AI) and methods like Machine Learning (ML) and deep learning have helped the digitized healthcare system in reducing human error in detecting disease and improving the clinical outcomes and data collection over time. The applications of AI algorithms for medical diagnosis are numerous and are seen in various fields like medical imaging interpretation (*e.g.*, Computed Tomography, Magnetic Resonance Imaging, Ultrasound Imaging, DEXA, etc.), diagnosis of various diseases like diabetes, cancers, Alzheimer's disease, stroke, hypertension, chronic heart disease, disease classification, etc. The AI and MI algorithms are able to classify large amounts of patient data and identify patterns in symptoms and predict potential health risks for the individual. Thus, early intervention and risk monitoring greatly benefit the patient. AI-assisted diagnostic tools also help the healthcare provider to diagnose complex diseases more accurately. The early diagnosis provided by AI allows for early treatment and ultimately increases the longevity of the patient.

**Keywords:** Artificial intelligence, Deep learning, Diagnosis, Machine learning, Medical diagnosis, Neural networks.

## INTRODUCTION

The concept of "Artificial Intelligence" (AI) emerged in the 1950s, referring to the creation of machines designed to perform tasks usually carried out by humans. Machine Learning (ML) falls under the umbrella of AI, focusing on algorithms that discern inherent statistical patterns within data to make predictions for unseen

[*] **Corresponding author Piyush T. Mantri:** Department of Conservative Dentistry and Endodontics, Rural Dental College, Pravara Institute of Medical Sciences, Loni, Maharashtra, India; E-mail: ptmantri@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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data (Fig. **1**). Among ML models, neural networks (NNs) stand out, especially for complex data like imagery or language, outperforming traditional ML algorithms.

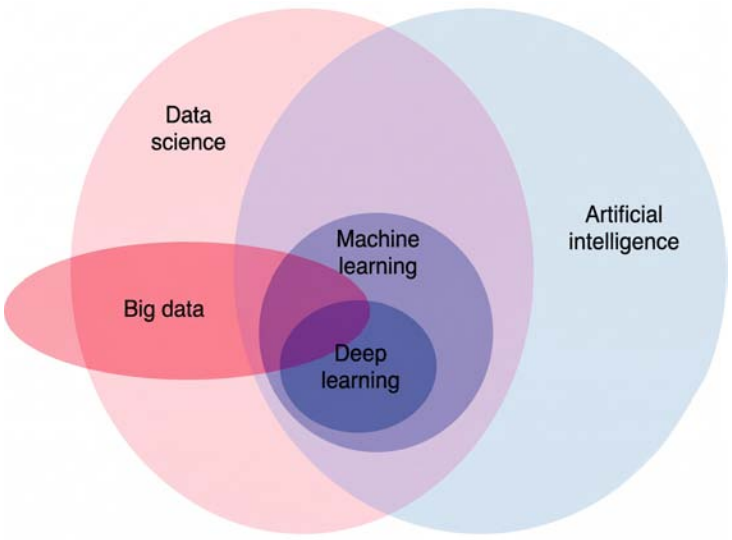


**Fig. (1).** Key components of artificial intelligent systems.

At the core of NNs lies the artificial neuron, a mathematical model inspired by human neurons. These neurons are stacked and interconnected using mathematical operations to form networks tailored to specific tasks such as image classification (*e.g.*, identifying a decayed tooth in a radiographic image as "yes" or "no").

"Deep learning" refers to neural network architectures with multiple layers, making them well-suited for handling complex data structures like images. Shapes, edges, corners, and bigger patterns are examples of hierarchical properties that these networks can depict. They are recognized as universal approximation machines, meaning they can approximate any function given certain mathematical constraints, mapping inputs (*e.g.*, a radiographic image) to outputs (*e.g.*, "decayed tooth"). These neural networks can be trained to recognize underlying statistical patterns given enough data and processing power. During training, labelled data points are repeatedly processed through the network, adjusting the connections (model weights) to minimize prediction errors [1].

AI, mimicking human intelligence, addresses various challenges globally. It facilitates the development of algorithms that provide predictions after learning from data. Neural networks are among the early AI algorithms. While shallow

learning neural networks have simpler structures with fewer layers, deep learning neural networks have intricate topologies with several layers [2, 3].

## KEY COMPONENTS OF ARTIFICIAL INTELLIGENT SYSTEMS

In machine learning, algorithms perform tasks by identifying patterns in data. Adjustments in machine learning encompass various elements, such as the neurons and layers in neural networks, and parameters like mutation rate, size of population, and crossover rate in genetic algorithms, which depend on the specific approach used. The artificial neuron is a key component of artificial neural networks (ANNs). Constructing artificial neurons and linking layers through various mathematical procedures generates networks capable of tasks like image classification. ANNs with complex multilayer structures are referred to as Deep Learning (DL). These systems can recognize more complicated macro patterns inside a hierarchical framework in addition to basic properties like lines, edges, and corners since they have many neurons and complex layers [4].

Over the past seven decades, AI and its implications have been seen as both beneficial and dangerous. Although this technology does not always live up to the hype, the last ten years have seen some impressive advances in artificial intelligence. It is becoming increasingly difficult for people to distinguish whether AI-generated content is authored by a human or a machine. Another significant advancement includes face recognition systems. Ultimately, AI-based technologies evolve from being seen as a threat to becoming recognized as a boon, impacting multiple facets of society, including domains such as healthcare and politics [5].

## MACHINE LEARNING IN IMAGE PROCESSING

Data undergoes pre-processing and manual labelling before being fed into the Machine Learning (ML) algorithm for training. ML algorithms are carefully chosen for data learning, followed by thorough model optimization and evaluation processes, culminating in the development of the final model. In medical image processing, the steps include image capture, preprocessing, analysis, and pattern identification. Pre-processed images from X-rays and MRI scans [6] are then processed using CNN models for image analysis. The extracted feature information is integrated into the modeling process. Based on the feedback received from the results, additional measures such as fine-tuning hyperparameters and further refining the model are undertaken [7]. The foundational machine learning technique is depicted in Fig. (**2**).

# CHAPTER 2

# Applications of AI and Machine Learning in Medical Imaging: Radiological and Nuclear Medicine

**Asif Ibrahim Tamboli**[1,*] and **Anand Gudur**[1]

[1] *Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed To Be University), Karad Malkapur, Karad, Maharashtra, India*

**Abstract:** Machine Learning (ML) and Artificial Intelligence (AI) have changed the way medical imaging is done, especially in radiology and nuclear medicine. This chapter gives a broad look at how AI can be used in radiological and nuclear medicine imaging. It talks about the progress, problems, and possible future directions in this field that is changing very quickly. The first part of the chapter talks about AI and machine learning technology used in medical images, centred on how they can help make diagnoses more accurately and quickly. Then it goes into the basics of medical imaging, giving a quick rundown of radiological and nuclear medicine imaging methods as well as important ideas in picture analysis. The main part of the chapter is about how AI can be used in a specific sector of radiology and nuclear medicine images. AI has made it possible for X-ray pictures to automatically find and classify problems. It has also made it possible for CT and MRI images to be reconstructed using AI. Computer-aided diagnosis (CAD) tools that use AI have also shown promise in making diagnoses more accurate. AI has made it easier to separate and quantify images in nuclear medicine imaging, which has improved the accuracy and speed of image analysis. Also, picture registration and merging methods based on AI have been created, which makes it easier to combine data from different types of imaging. Using AI to automate evaluation and treatment plans has shown promise for improving patient care in nuclear medicine. Although there have been big steps forward, this part also talks about the problems that come with using AI in radiological and nuclear medicine imaging. These include worries about data privacy, problems with regulations, and the need for strong testing of AI algorithms. Finally, the chapter ends with a discussion of possible future trends and improvements in AI for medical imaging. This shows how AI has completely changed the fields of radiology and nuclear medicine imaging.

[*] **Corresponding author Asif Ibrahim Tamboli:** Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed To Be University), Karad Malkapur, Karad, Maharashtra, India;
E-mail: drtamboliasif@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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**Keywords:** Artificial intelligence, Conventional neural network, Machine learning, Medical imaging, Radiological imaging, Support vector machine.

## INTRODUCTION

In the last half-decade, Artificial Intelligence (AI) and Machine Learning (ML) technologies have been used together to make huge strides in the area of medical imaging. These technologies have changed how medical pictures are taken, processed, and analyzed, which has led to better diagnosis, planning of treatment, and results for patients. In particular, AI and ML have had a huge effect [1] on nuclear medicine and radiology images, which helps doctors make better choices and give more personalized care. A lot of different medical problems need to be diagnosed and treated with the help of computed tomography (CT), X-rays, and magnetic resonance imaging (MRI). Radiologists [2] can read these pictures more quickly and correctly with the help of AI and machine learning tools. For instance, deep learning algorithms can automatically find and label problems in X-ray pictures, thus decreasing the time for analysis, leading to helping doctors. In the same way, ML models can look at CT and MRI pictures and find small changes that may show the presence of disease, like tumors or fractures, with a high level of accuracy. AI and ML improvements have also helped nuclear medicine imaging, which uses radioactive tracers to see and test how well organs and cells are working.

New image recording methods [3], such as Positron Emission Tomography (PET) and single-photon emission computed tomography (SPECT), have been enabled by using these technologies, as shown in Fig. (**1**). These methods give detailed information about metabolism and function. AI programs can look at these pictures and figure out how much tracer is being taken up, find strange trends, and guess how the patient will do. This assists doctors in diagnosing and treating conditions like cancer, heart disease, and neurological disorders. One of the best things about AI and ML in medical images is that they can quickly and correctly handle large amounts of data. In this way, doctors can look at pictures right away, make better choices, and act quickly when needed. AI systems can also learn from their mistakes and get better over time, which means that medical accuracy and clinical results are always getting better. This could change the area of radioactive and nuclear medicine imaging, making it faster, cheaper, and more focused on the patient [4]. This study will look at how AI and ML are used in radiology and nuclear medicine imaging, focusing on how they affect the accuracy of diagnoses, the planning of treatments, and the results for patients. We will talk about the different AI methods and techniques that have been developed for picture analysis, as well as the problems that this field is facing and where it might be going in the future. In general, AI and ML could change medical imaging for the

better by making it more accurate, specialized, and useful for providing healthcare.

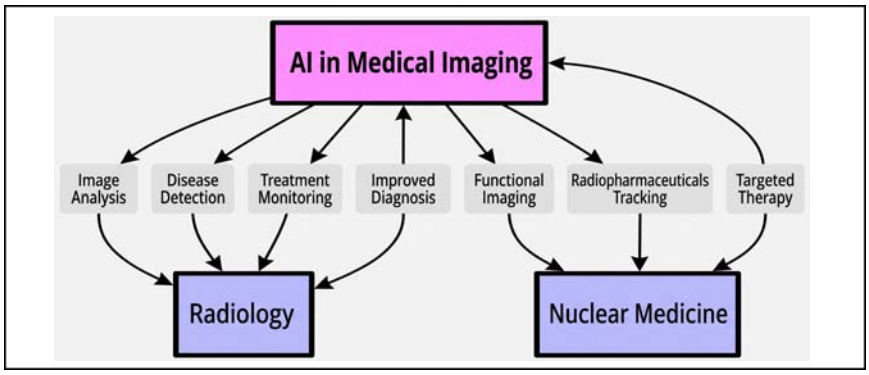


**Fig. (1).** Overview of radiological and nuclear medicine applications of AI in medical imaging.

## Overview of AI and ML in Medical Imaging

ML and AI have become game-changing tools in medical imaging, giving us new ways to look at, understand, and handle large amounts of imaging data. These tools could change everything about the field, making diagnoses more accurate, work more efficiently, and, in the end, improve patient care. AI is the study of how robots can mimic human intelligence, such as learning, thinking, and fixing mistakes on their own. ML is derived from AI, and a couple of applications of this technology include [5] prediction and decision-making. In medical imaging, AI and ML analyze large volumes of images, extract key details, and provide crucial information to doctors. One of the best things about AI and ML in medical imaging is that they can quickly process and understand pictures compared to older methods. One example of a machine learning algorithm is deep learning algorithms, which can accurately find and label problems in medical pictures without the doctors having to spend a lot of time and effort doing it by hand. This can help with faster evaluation and treatment, especially when acting quickly is very important. In medical images, AI and ML are also helpful because they can learn from their mistakes and get better over time. AI programs can find patterns and trends that humans might not notice by looking at huge sets of medical pictures and the results that were obtained from them. This can help doctors and other health care workers make better decisions about their patients' care and give them better care [6].

AI and ML can help healthcare workers handle the growing amount and complexity of medical imaging data, as well as make diagnoses more accurate and faster. As imaging techniques like CT, MRI, and PET become more popular, a huge amount of data is being created. This makes it harder for healthcare workers

# CHAPTER 3

# CNN-Based Classification of Brain Abnormalities in MRI Using Adaptive Deep Wavelet Autoencoder (ADWE)

**Muthuvel Arumugam[1,*], Arunprasath Thiyagarajan[2], Lakshmi Adhi[3], M. Pallikonda Rajasekaran[4]** and **Akshaya A.V.R.[4]**

*[1] Department of Electronics and Communication Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India*

*[2] Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India*

*[3] Department of Electronics and Communication Engineering, Ramco Institute of Technology, Rajapalayam, Tamil Nadu, India*

*[4] School of Business and Management, CHRIST (Deemed to be University), Pune Lavasa Campus, Bengaluru, Karnataka, India*

**Abstract:** The most dangerous issue nowadays is disorders of the brain. The objective of this chapter is to classify and identify brain abnormalities using brain MRI and CT images by applying the Convolution Deep Neural Network technique. Morphological and Vascular Abnormalities are the two categories of brain abnormalities. Morphological brain abnormalities refer to any abnormal element of brain functioning, anatomy, or metabolic levels. Morphological type classification is performed using CNN, and the procedure is compared to another prominent Deep machine learning technique. Using MRI and CT scans, the CNN, one of the Deep Learning architectures, is most likely used to diagnose brain disorders. A dataset is classified using a Deep Neural Network classifier.

**Keywords:** ADWE (Adaptive Deep Wavelet Auto Encoder), Deep learning (DL), Deep neural network, Image analysis, MRI, Wavelet.

## INTRODUCTION

Brain tumors are categorized into two types: benign and malignant tumors. The first form begins and ends in the brain, but the second type begins as cancer cells elsewhere in the body that progress to the brain. A tumor is a type of aberrant

* **Corresponding author Muthuvel Arumugam:** Department of Electronics and Communication Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India; E-mail:muthua21@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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tissue growth. A brain tumor is an uncontrollably growing mass of aberrant cells in the brain or central spinal canal. In the modern world, a growing number of tools and methods for analyzing tumors and their behavior are being used. Although no definitive therapy for brain tumors has been discovered, more researchers are incorporating various measures into clinical trials. High-quality images can be obtained using Magnetic Resonance Imaging (MRI), a form of medical imaging technique that is particularly useful for brain imaging due to its non-invasiveness and soft tissue contrast. An MRI scan is most frequently used to measure the size of a brain tumor. As a result, an automated and compatible tumor segmentation method would be advantageous. MRI produces a digital representation of tissue in any plane. The bulk of current conventional treatment approaches relies on human brain MRI scans, which increases the risk of inaccurate brain tumor diagnosis and identification. Thanks to digital image processing, brain tumors can now be recognized with accuracy and speed. MRI medical image information can be successfully retrieved using two of the most effective methods: segmentation and classification techniques.

## Domain Introduction

To create an image, square pixels, or picture elements, are arranged in rows and columns. In an 8-bit greyscale image, each picture element is given an intensity value between 0 and 255. Though the name suggests that it will have a range of gray tones, a gray-scale image is comparable to a black-and-white image. An image in greyscale typically has 256 greyscales, or 8 bits of color depth [1 - 4]. A "true color" picture has 160 lakh colors, or "8 x 8 x 8 bits = 256 x 256 x 256" colors, when the color depth is 24 bits. There are more greyscales in some greyscale images than in others; for example, a 16-bit = 65536 greyscales. It is theoretically possible to connect three greyscale images. It is theoretically possible to combine three greyscale images to create a single image with "281,474,976,710,656" greyscales [5 - 9]. Vector graphics (or line art) and bitmaps (pixel-based or "images") are the two fundamental types of "images." These are a few of the most common file types. GIF is an 8-bit (256-color) bitmap format that is non-destructive. The majority of its uses are online. The animated GIF is one example of these substandards. J. A Sample image in an array is shown in Fig. (**1**). PEG is a 24-bit (16 million color) destructively compressed bitmap format that is incredibly efficient (*i.e.*, includes a lot of information per byte). Frequently used, especially with online and Internet applications (bandwidth-limited) [10]. The industry uses TIFF, a 24-bit publishing bitmap format, extensively. One type of non-destructive compression is Lempel-Ziv-Welch (LZW) compression.

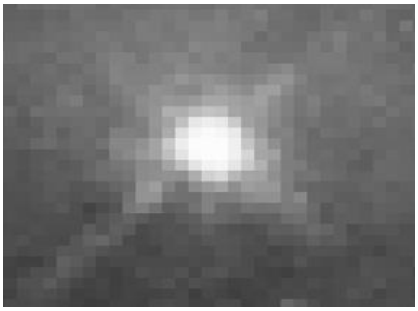

**Fig. (1).** A sample image in an array.

One popular vector format is PS, or PostScript which has a wide range of subpar features that make switching between platforms and operating systems difficult [11 - 13]. The Photoshop file type known as PSD stores every bit of data in an image, including all of the layers. Using visuals to convey or receive information is the most common and practical way to do so.

An 8-bit greyscale image has an intensity value for each image element that ranges from 0 to 255. Similar to a black and white image, a grey scale image will have a wide range of grey tones, as the name suggests [14 - 18]. Sample image for pixel and has a value from 0 (black) to 255 (white) for each pixel. The color depth of the image 8-bit = 256 grey scales, is shown in Fig. (**2**).

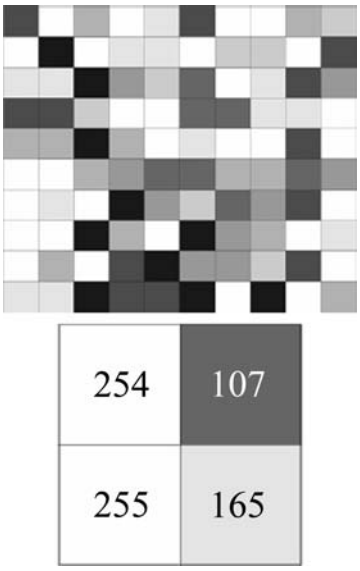


**Fig. (2).** Sample Image for pixel and has a value from 0 (black) to 255 (white) for each pixel. color depth of the image 8 bit = 256 grey scales.

# CHAPTER 4

# Analysis of Central Serous Chorioretinopathy (CSCR) Thickness in the Macula Using AI Techniques

**L. K. Shoba[1,*], P. Mohan Kumar[2], V. Sangeetha[3], T. Vijaya Kumar[4]** and **Deepa R.[1]**

[1] *Department of Computing Technologies, SRM Institute of Science and Technology, Kattankulathur Campus, Kattankulathur, Tamil Nadu, India*

[2] *Department of Computer Science and Engineering, Hindustan Institute of Technology and Science, Chennai, Tamil Nadu, India*

[3] *Department of Biomedical Engineering, Kalaignar Karunanidhi Institute of Technology, Coimbatore, Tamil Nadu, India*

[4] *Department of Information Technology, Dr. N.G.P. Institute of Technology, Coimbatore, Tamil Nadu, India*

**Abstract:** Currently, in the Medical Field, a medical imaging Technique (OCT) is notably employed in the diagnosis of retinal diseases. In this chapter, the CSCR image being analyzed at various stages is compared with the pre- and post-treatment CSCR images. Here, the image obtained first is preprocessed, and the given shaded picture is converted to a grayscale picture. The converted gray picture is then applied to the filtering technique by utilizing the improved Median Filtering Algorithm. Then, the image is extracted using feature extraction algorithms and edge detection algorithms to find the region of interest. By applying the threshold algorithm, the given image can be determined to be whether the defects are severe, moderate, or low, and the accuracy can be determined.

Here, the OCT image is obtained and analyzed for different stages to show how the thickness is varied and the accuracy is plotted in a graph. For analyzing images, it goes through different stages such as Image registration, preprocessing, and image segmentation. The result is plotted in a graph by showing the variation in corner point detection for different point feature extraction algorithms.

**Keywords:** CSCR, Fast extraction, Harris feature extraction, OCT, Retinal thickness, Registration, Segmentation, Threshold.

[*] **Corresponding author L. K. Shoba:** Department of Computing Technologies, SRM Institute of Science and Technology, Kattankulathur Campus, Kattankulathur, Tamil Nadu, India; E-mail: shobal@srmist.edu.in

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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## INTRODUCTION

Image processing techniques, such as Image segmentation, assume a significant role in numerous operations such as biomedical field applications, face recognition, computer vision, *etc*. But the prominent assignment in this processing is object detection and exploring the characteristics of a 3D image. Central Serous Chorioretinopathy implicates important information and helps the ophthalmologist in detecting and diagnosing a variety of abnormal variations in the Macula.

(Fig. **1**) illustrates the anatomy of an eye with the retina, macula, and fovea. The Macula is situated at the center of the retina. Since this layer is the most important, it provides the best color vision. CSCR is a disease that occurs mainly in the macula layer of the retina, which affects patients in the age range of 20-50. CSCR (central serous chorioretinopathy) is a disease that occurs due to the serous deposited in the macula layer. CSCR results in the leakage of retinal pigment epithelium with or without epithelium detachment, depending upon the thickness of CSCR. The main reasons for CSCR occurring are smoking, alcoholic consumption, obstructive sleep, strains, *etc*. The symptoms of CSCR are that objects may look blurred, normal objects may look like they are bent or irregular shapes, or objects may look smaller or farther away.

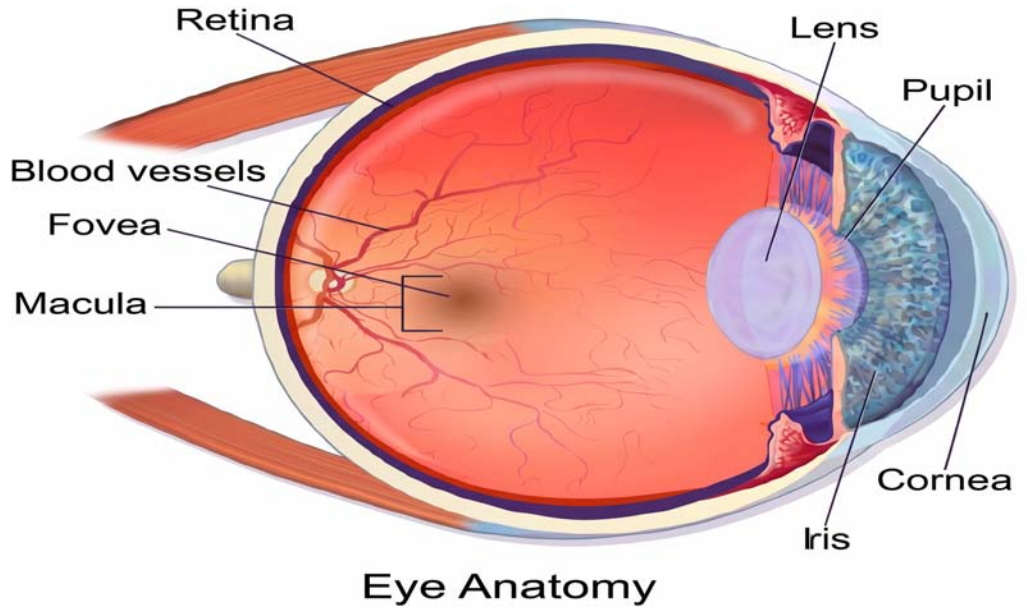


**Fig (1).** Anatomy of the eye.

Fig. (**2**) shows the Normal Person and CSCR syndrome person's vision.




**Fig (2).** a) Normal person's vision. b) CSCR syndrome vision.

Some of the basic techniques used in image processing are mathematical morphology, region growing, and region-based segmentation [1 - 3]. Morphological technique is mainly used in the implementation of image analysis, which deals with set theory. In set theory, a set is nothing but the objects in the image, consisting of foreground pixels and a structuring element, also known as a sub-image, which is used in the interaction of the image. The basic operations used here are erosion, dilation, opening, closing, *etc*. Erosion is defined as a process of shrinking an object by engraving its boundaries. Dilation is the opposite of erosion and is defined as a process of connecting disjoint objects and filling holes [4 - 6].

## PROPOSED METHODOLOGY

The proposed architecture diagram is laid out in Fig. (**3**). First, the input image that needs to be examined is given to the OCT machine. The scan image consists of multiple frames, where each frame is processed in isolation. *i.e*., F€ RA*B, where the variables, the number of rows and columns are depicted by the variables A and B. This frame is then passed through a tensor graph, which extracts the ILM and RPE layers by passing through different levels of thresholds. The proposed architecture diagram utilizes the idea of a 2D tensor chart, which utilizes the idea of taking the DAB (Difference of Asymmetric Bandpass) result of the fractional subsidiary of the OCT filter pictures. This input is given to the next process, which is used to identify the retinal thickness and the fluid deposit between the two layers. This procedure is rehashed for all the cases of the OCT info and examined pictures, which are utilized for 3D analysis. These results are further used to identify maculopathy diagnosis based on SVM classification of whether it is mild, normal, or severe CSCR.

CHAPTER 5

# Machine Learning-Based Alzheimer's Disease Detection Using EEG Data

**Hemlata Sandip Oha**[1,*] and **Shamla Mantri**[1]

[1] *Department of Computer Engineering and Technology, Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, India*

## Abstract

### Background

Alzheimer's Disease (AD) affects cognition and other day-to-day functions and is a progressive neurodegenerative disease. Early and accurate detection is crucial for early intervention. EEG is a non-invasive and inexpensive method to characterize the neurophysiological features associated with AD.

### Methods

EEG data from AD patients and healthy controls were pre-processed to limit noise and remove artifacts. Features were extracted, including absolute and relative power, mean, standard deviation, and spectral entropy, across frequency bands. Support Vector Machine (SVM) and K-Nearest Neighbors (KNN) classifiers were trained on extracted features from the EEG data, and an ensemble voting classifier was created to increase performance.

### Results

The KNN classifier was 96.2% accurate, the SVM classifier was 97.3%, but the ensemble voting classifier was more accurate at 98.46%. In addition, precision/recall/F1 score metrics were all strong, confirming that the ensemble voting classifier was robust in separating AD patients from healthy controls.

[*] **Corresponding author Hemlata Sandip:** Department of Computer Engineering and Technology, Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, India;
E-mail:hemaohalphd@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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**Discussion**

Results of this study indicate that machine learning methods, utilizing EEG, can detect AD, and that ensemble learning achieved improved performance.

**Conclusion**

This study presents a reliable framework using an EEG-based Machine Learning (ML) method, with the highest accuracy differentiating AD patients from healthy controls achieved by ensemble learning. In summary, the clinical decision-support tool we have proposed through our review is promising, but more work is required on larger datasets and models using other, more sophisticated algorithms.

**Keywords:** Alzheimer's Disease (AD), Ensemble techniques, K-Nearest neighbors, Machine Learning (ML) techniques, Support vector machine.

## INTRODUCTION

Alzheimer's disease (AD) is a progressive brain disorder characterized by the loss of memory and changes in behavior. Deterioration of cognitive function is a result of AD. Globally, AD is the most common cause of dementia. About 60–80% of dementia cases are brought on by it. More than 60% of the 55 million people who suffer from dementia globally live in low- or middle-income countries [1]. Every year, over 10 million new cases are recorded [1].

AD causes impaired neuronal communication and causes nerve cell death. As the condition progresses, people may encounter challenges with daily chores, language understanding, spatial orientation, and executive function. Although the onset and course of AD can differ greatly from person to person, it usually progresses slowly and irreversibly, eventually resulting in significant cognitive impairment and a need for care from others. To control symptoms, delaying the course of the disease is the only key factor.

This paper is structured with the following sections: Related Work, Materials and Methods, Results and Discussion, followed by Conclusion.

### Related Work

Previous work has looked into electroencephalogram (EEG) derived biomarkers to detect Alzheimer's disease (AD), and these investigations have demonstrated

the efficacy of detecting AD patients and distinguishing them from healthy individuals.

These investigations aim to enhance detection performance by examining distinct EEG properties in different frequency bands using analytical methodologies [2]. However, the study had a limitation of small dataset sizes and the requirement for longer-term studies to validate and improve EEG-based methods for AD detection [2].

Elias Mazrooei, *et al*. [3] proposed EEG signal analysis-based approach to detect mild Alzheimer's disease. Age and AD stages were found to have an impact on the P300 component in EEG recordings from 40 subjects in four different modes. Individuals with mild Alzheimer's disease exhibited reduced beta band activity while demonstrating increased theta band activity. For classification, convolutional neural networks, Elman, and Linear Discriminant Analysis (LDA) were used. Their results highlight the potential of EEG-based methods to improve AD diagnosis, indicating that proper feature extraction can lead to a notable improvement in classifier performance when it comes to identifying AD patients. The 40 participants in the study mean that it had a small size, which may limit how far we can apply its findings, so larger and more diverse datasets will need to be utilized to ensure solidity across a number of demographics and situations [3].

The research [4] employed EEG data and outlines a method for assessing dementia levels in Alzheimer's disease (AD) patients through EEG data. The study aimed to analyze the temporal dynamics of cognitive performance in AD patients by generating 14 instantaneous power indicators of their performance, based on rhythm waves, utilizing Hilbert marginal spectrum (HMS) analysis. The Gaussian mixture model (GMM) technique integrates innovative methods, including Treelet transform and WiGMM, representing a significant advancement towards the automated evaluation of dementia in individuals with AD. Complexity of Model Interpretability: In the proposed method, multiple complex techniques were implemented, like WiGMM and Treelet transform, making it potentially challenging to interpret the model results and utilize them in clinical practice without unique skills [4].

Chiang *et al.*, [5]. describe a new way of predicting and diagnosing early Alzheimer’s disease, utilizing EEG data and modern techniques. This study shows an objective and efficient method for identifying EEG rhythms related to Alzheimer’s disease using fuzzy logic and associative Petri net approaches. The process of diagnosing Alzheimer's disease includes feature extraction, building membership functions, and generating an associative Petri net model when filtering the EEG. In the process of detecting Alzheimer’s disease, deciding on

# CHAPTER 6

# Machine Learning-Based Mental State Prediction Using an EEG Brainwave Dataset

**Kunjali Pawar**[1,*] and **Shamla Mantri**[1]

[1] *Department of Computer Engineering and Technology, Dr. Vishwanath Karad, MIT World Peace University, Pune, Maharashtra, India*

**Abstract:** Electroencephalography (EEG) signals provide a rich source of information about the brain's electric activity. It enables the investigation of brain processes underlying cognition, emotion, consciousness, etc. Analyzing EEG signals is necessary for unlocking the mysteries of brain function, diagnosing and monitoring neurological disorders, advancing cognitive neuroscience research, developing innovative technologies like Brain-Computer Interfaces (BCIs), improving treatment and therapy options for patients, and developing cutting-edge technologies for Brain-Machine Interaction (BMI). This Research paper aims to provide a comprehensive overlook of EEG signal analysis, covering standard methodologies. The paper emphasizes the employment of Machine Learning algorithms to decode EEG signals, enabling the prediction of cognitive states. Research approach involves the use of datasets made available on the Kaggle website, where algorithms under consideration are like Logistics Regression, Ridge Logistics Regression, Lasso Logistics Regression, SVM (classifier), Random Forest (classifier), Naive Bayes, and XGBoost. Evaluation of the performance of the prediction process under each of the above models leads to the selection of the Random Forest model with the highest accuracy.

**Keywords:** Brain-machine interface, Data processing, Electroencephalogram (EEG), Machine learning, Regression, Support vector machine.

## INTRODUCTION

The World Health Organization (WHO) defines mental health as a state where each and every one can analyze health, handle daily stressors, work efficiently, and participate meaningfully in their communities [1]. The ability to independently identify the mental states, whether it is affective or cognitive, is helpful in a variety of fields, including neuroscience, education, robotics, and health care. Effective techniques for human-machine interaction become more crucial as real-world applications of smart devices, including self-governing

[*] **Corresponding author Kunjali Pawar:** Department of Computer Engineering and Technology, Dr. Vishwanath Karad, MIT World Peace University, Pune, Maharashtra, India; E-mail: kunjali555@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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robots, can be applied. Surface brain activity signals are just one of the various ways that humans can communicate with robots [2].

Electroencephalography (EEG) is a method that offers a fascinating glimpse into the inner workings of the brain, which includes the electrical activity of the brain from the cerebral cortex. Neurons are the source of this activity. The EEG signal can be recorded using either of two techniques: non-invasive or invasive. Thus, recordings can be cost-effective, and there is no possibility of negative effects [3]. A computer program that shows the voltage potential recordings processes the detected and amplified voltage differences between electrodes. The recorded Electroencephalography (EEG) data provides a continuous graphical display of the spatial distribution of changing voltage fields over time [4].

The resulting EEG recording resembles a complex symphony, with various rhythmic patterns such as frequency, amplitude, and temporal patterns of EEG waves that can provide information about different brain processes and states. EEG signals are categorized into five different bands, and every band has a corresponding relationship with a certain function of the brain [5]:

- **Gamma (γ) Waves (above 30 Hz):** The fastest brainwaves, associated with high-level cognitive processes such as intense focus, problem-solving, and learning.
- **Beta (β) Waves (13 to 30 Hz):** Detectable over the frontal and parietal lobes, these waves are linked to active thinking, concentration, and alertness.
- **Alpha (α) Waves (8 to 12 Hz):** Measured from the occipital region (back of the head), these waves occur in an awake person with closed eyes during relaxed wakefulness and daydreaming.
- **Theta (θ) Waves (4 to 8 Hz):** drowsiness, meditation, and memory processing.
- **Delta (δ) Waves (0.5 to 4 Hz):** The dominant and slowest brainwaves during deep sleep and unconsciousness.

However, interpreting the complex patterns of EEG signals can be challenging. Machine learning, as a methodology, involves training computers or machines explicitly. The application of diverse Machine Learning Techniques yields efficient results by training models over the gathered dataset, thereby accumulating knowledge.

This chapter focuses on accuracy and computational cost, against state-of-the-art classification algorithms for classifying EEG signals into various mental states. The application under consideration uses an EEG device to differentiate between three distinct mental states (such as neutral, intensely concentrated, and relaxed) of an individual. This collaboration between EEG and machine learning holds

immense promise for improving diagnoses of neurological conditions, while also paving the way for advancements in brain-computer interfaces and a deeper understanding of the human mind.

Literature works are summarized in Section II. Section III, where we elucidate the experimental design and data collection process. Section IV, where we delve into the various algorithms employed for signal processing and feature extraction.

## LITERATURE SURVEY

Renato Zanetti and Amir Aminifar proposed a data processing scheme along with a lightweight ML model based on the Random Forest (RF) classifier. The authors validate their approach and provide experimental results and discussions [6]. The researchers discussed the development of a Decision Support System (DSS) using Artificial Intelligence (AI) for predicting mental health conditions. The researchers involved in this study are Dr. Har Fouche, Ilker Yesilkaya, Esma Nur Ucar, and Tanalp Sengun. The DSS aims to provide accurate and efficient predictions by analyzing participants' responses to the SC 90-Revised (SCL-90-R) questionnaire [7].

A. Subasi and E. Erc¸elebi address the application of neural networks for classifying EEG data. The researchers proposed the use of a multi-layer perceptron neural network (MLPNN) for accurate classification of EEG signals, providing objectivity and automation in clinical studies [8]. Dr. Shamla Mantri, Vipul Patil, and Rachana Mitkar propose a novel method for detecting mental stress using EEG signals and present a survey on EEG-based emotional distress analysis. They discussed various techniques for analyzing EEG signals and suggested future improvements in identifying and addressing stressed conditions [9].

The researcher Dr. S. Mantri, V. Dukare, S. Yeole, D. Patil, and V. M. Wadhai provided an overview of EEG signals and their use in communication between humans and computers in their research. They discussed the recording and analysis of EEG signals, as well as the activation of different regions of the brain. A research paper by J. Yauri *et al*., proposes the use of EEG (electroencephalogram) for characterizing mental workload and demonstrates the ability of a neural network to generalize the model across a wider population [10]. The researchers, Omid Bazgir and team, developed an emotion recognition system that used techniques such as Discrete Wavelet Transform (DWT) and spectral features to analyze EEG signals and classify emotional state [11]. The paper [12] discussed various EEG analysis algorithms, including connectivity, power-spectral methods, temporal variations, and statistical measures, all implemented with machine learning techniques.

CHAPTER 7

# Case Studies and Applications of AI-Driven Health Monitoring Systems in Endocrinology and Cardiology

**Nitin R. Nangare**[1,*] and **Satish V. Kakade**[2]

[1] *Department of Surgery, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India*

[2] *Department of Community Medicine, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India*

**Abstract:** Artificial intelligence (AI)-based health tracking tools are changing the way healthcare is performed by giving doctors real-time information about their patients' health. This chapter gives two examples that show how useful AI-based health tracking tools can be in endocrinology and cardiology. The AI-powered system kept an eye on people with diabetes mellitus type 2 (DMT2) in the endocrinological case study. Continuous Glucose Monitoring (CGM) devices were used to get real-time glucose levels, and AI programs were built in to look at the data. The AI programs looked at the CGM data to guess what the glucose levels would be in the future and find trends that could mean someone has hypoglycemia or diabetes. The system also gave each patient specific advice on how to change their food and medications based on their glucose levels and other living factors. The data showed that people with DMT2 had better control of their blood sugar and a lower chance of problems. In the cardiology case study, the AI-powered system kept an eye on people who had Congestive Heart Failure (CHF). Wearable sensors were used by the system to measure things like heart rate, blood pressure, and the amount of exercise. AI programs were used to look at the data and find early signs of decompensation. The method lets healthcare workers know about possible flare-ups so they can act quickly. The data showed that people with CHF spent less time in the hospital and had a better quality of life. These case studies show how AI-powered health monitoring systems can make a big difference in how well people with endocrinological and cardiovascular problems do. Personalized and preventative healthcare is made possible by these systems, which use AI to provide constant tracking and quick solutions.

**Keywords:** Artificial intelligence, AI tracking, Cardio vascular disease, Diagnosis, Diabetes Management, Healthcare, Heart problem.

[*] **Corresponding author Nitin R. Nangare:** Department of Surgery, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India; E-mail: docnitiraj@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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## INTRODUCTION

In the past few years, Artificial Intelligence (AI) has become a major force in healthcare, changing how diseases are found, tracked, and treated. AI-driven health tracking systems that use machine learning algorithms and [1] big data analytics can make healthcare services more accurate, more efficient, and easier for more people to access. This part is mostly about how AI-powered health tracking systems can be used in diabetes and heart disease, which are two very important areas of medicine. Endocrinology is the study of hormones and diseases that affect them. It is very important for keeping people healthy and happy [2]. Disorders like diabetes, thyroid problems, and adrenal imbalance need to be managed and checked on a regular basis to avoid consequences. AI-powered health tracking systems have shown a lot of promise in this area. They can offer personalized and accurate monitoring solutions that can make a big difference in how well patients do. Another area where AI-powered health tracking tools are making a big difference is cardiology, the field [3, 4] of medicine that deals with heart problems. Cardiovascular diseases (CVDs) are one of the main reasons people die around the world. To effectively control these diseases, they need to be found early and constantly checked on. AI technologies, such as machine learning algorithms and deep learning models, are being used to create new ways to monitor patients that can find early signs of CVDs and provide care for those patients. Through a number of case studies, this chapter looks at how AI-powered health tracking tools can be used in diabetes and heart disease. These case studies show how AI technologies could change the way healthcare is provided, make it safer for patients, and lower its cost. This chapter's goal is to show how AI works in the real world so that you can understand the current state and future possibilities of AI-driven health tracking systems in endocrinology and heart disease. Using health tracking tools that are run by AI in hospital settings is not always easy [5]. Some of the problems that need to be solved are privacy issues, data security, compliance issues, and the need for healthcare workers to learn how to use new technologies. But the possible benefits of AI in healthcare are much greater than these problems. And because technology is changing so quickly, AI-powered health tracking systems will become more important in the future of medicine.

### Overview of AI-Driven Health Monitoring Systems

Health tracking systems that are powered by AI use [6] AI technologies like machine learning, deep learning, and natural language processing to look at health data and give you personalized insights, as shown in Fig. (**1**). These systems can look through huge amounts of data from different sources, like medical images, smart tech, and electronic health records, to find trends, guess what will happen,

and help doctors make decisions. AI-powered health tracking systems can learn from new data all the time, which makes them more accurate and better at what they do over time. Because they are flexible, they work especially well for keeping an eye on long-term conditions like diabetes, where treatment plans need to be changed often based on new health markers. Based [7] on health data and living factors, these systems can also improve preventive care by figuring out who is most likely to get certain diseases. AI-powered health tracking systems can help people make smart choices about their health and well-being by giving them early signs and personalized suggestions [8].

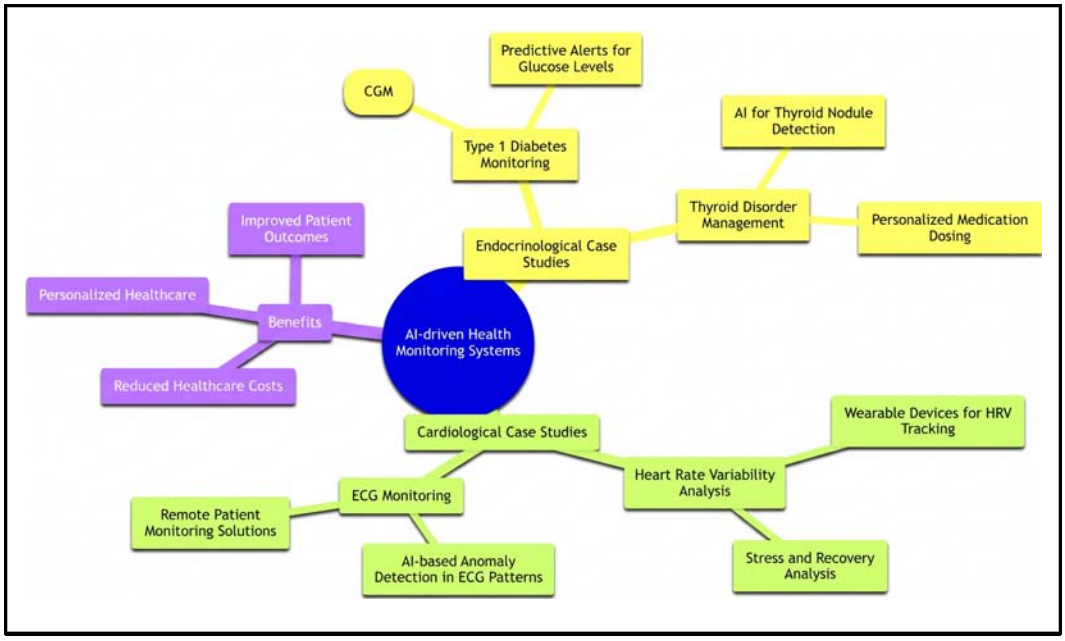


**Fig. (1).** Overview of endocrinological and cardiological case studies.

## Importance of AI in Healthcare Monitoring

It has the ability to completely change how healthcare is provided. One of the best things about AI is that it can quickly and correctly handle and examine large amounts of data. This lets doctors see patterns and trends that a person might not notice, which helps them make faster and more accurate decisions [9]. Health tracking systems that are run by AI can also help patients do better by making treatment plans that are specific to each person's health data. These systems can make recommendations for treatments that are more successful and have better results for each patient by taking into account things like genetics, habits, and the local surroundings. One of the best things about AI in healthcare monitoring is that it can make telemedicine and distant tracking better. Healthcare professionals

# CHAPTER 8

# IoT-Enabled Smart Health Monitoring System with Machine Learning for Real-Time Patient Supervision

**V. Benhar Charles[1,*], D. Surendran[2], V. Sangeetha[3], S. Nithyadevi[4]** and **Rex Cyril B.[1]**

[1] *Department of Computer Science, St. Joseph's College (Autonomous), Tiruchirappalli, Tamil Nadu, India*

[2] *Department of Information Technology, Karpagam College of Engineering, Coimbatore, Tamil Nadu, India*

[3] *Department of Biomedical Engineering, Kalaignar Karunanidhi Institute of Technology, Coimbatore, Tamil Nadu, India*

[4] *Department of Electronics and Communication Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India*

**Abstract:** It can be challenging to monitor patient health constantly in hospitals, especially those who are old or unconscious and require continuous observation. Not all manual health checks are feasible, and families want to know how the patient is doing instantaneously. In this context, an automatic health monitoring framework that provides timely alarms is proposed. Our system uses sensors such as the MAX30100 (heart beat and oxygen saturation), LM35 (temperature), or an ultrasonic sensor, which are connected to a NodeMCU connected to the Internet. The real-time notification will be sent to the family and health care workers through the BLYNK IoT Android app. The smartphone acts as a GUI for the patient's vital signs, so that it can be monitored remotely. Such a system makes it possible to constantly monitor the vital signs and trigger an alarm immediately in case of abnormalities, with life saving as a consequence. In addition, we also adopt several machine learning classification algorithms, including Regression Tree (RT), Support Vector Machine (SVM), and Random Forest (RF), to learn from patient health status. Of these methods, the Random Forest model performs better in terms of accuracy and error rate when compared with the Regression Tree or SVM. This model increases hospital monitoring effectiveness and makes proactive patient management possible.

**Keywords:** ESP8266, Internet of things, MAX30100, Saline bottle, Ultrasonic sensor, Wireless module.

[*] **Corresponding author V. Benhar Charles:** Department of Computer Science, St. Joseph's College (Autonomous), Tiruchirappalli, Tamil Nadu, India; E-mail: dbenharcharles1@live.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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## INTRODUCTION

The development of wearable sensors, as well as mobile computing, wireless communication, and the Internet of Things (IoT), has helped significantly in enabling the introduction of ubiquitous healthcare and remote patient monitoring systems. These technological advances may have led to the development of smart platforms that enable real-time measurement of a patient's physiological and behavioral signals with minimal human oversight. These solutions collect and analyze information in real-time from different sensors integrated into wearable devices and/or ambient appliances to measure signs such as heart rates, respiratory rates, temperature, ECG (ElectroCardioGram), oxygen saturation, or glucose levels. This technological advancement is transforming our current healthcare from reactive care to more proactive, convenient, and patient-centred care. In such a context, ubiquitous healthcare is characterized by the same unobtrusive systems seamlessly working in the background to provide medical services and allow patients, including elderly people, whose chronic health issues require daily examination or treatment routines, or the disabled, for whom home therapy is needed be regarded as an indispensable part of their lifestyle. Through real-time acquisition and dissemination of health information, the system would enable early identification of irregular patterns and swift reactions to emergencies that may prevent serious health deterioration or death. At the heart of that system is the Internet of Things, a technological architecture linking physical devices (each fitted with sensors and actuators as well as communication capabilities) to the internet. These are intelligent devices that communicate with their environment and with each other, sending data to cloud-based platforms or edge computing systems for processing and interpretation. Health IoT can bring both sensor and software applications together, allowing us not only to automatically monitor health but also to support the caregivers and healthcare professionals for decision-making from anywhere in the world. Those who have mobility or significant physical limitations realize a great advantage from systems of this type, as discreet health and environmental sensors can continuously monitor their status *via* the IoT. Vital signs of patients are monitored in real time thanks to sensors connected, and notifications are transmitted through mobile apps if values cross critical levels. For instance, when a patient's heart rate or body temperature increases beyond their safe range, an alert is automatically delivered to the caregiver *via* his or her smartphone or computer. And in the case that the main caretaker is not present, it may use loudspeakers to alert people nearby for immediate support. To this end, a NodeMCU ESP8266 microcontroller has been included for data acquisition and transmission. This board supports Wi-Fi communication and can directly upload health data to the cloud, a gateway, or a mobile phone app in real time. Heart Rate/Oxygen saturation and body temperature are measured using sensors MAX30100 and LM35, respectively.

These readings are also logged constantly, as well as output on a user-friendly Android app made with the BLYNK IoT platform. The mobile app is a graphical user interface for patients and caregivers to monitor their health status and provide alerts. Beyond that, a secure web interface enables healthcare providers to remotely access and analyze patient data for more distance diagnosis, therapy, and monitoring. Fig. (**1**) shows that the IoT-enabled architecture proves to be of great advantage in addressing the needs of patients in remote/rural areas where medical help is not easily available. Integration with real-time communication and automation allows caregivers to respond immediately (or even delegate to the nearest available caregiver) when patients are in need of an immediate response.

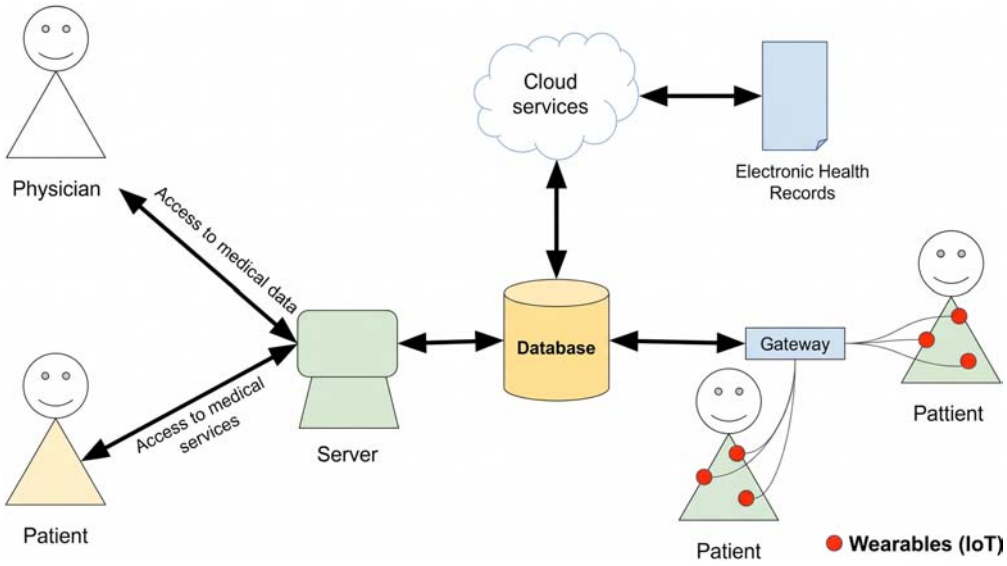


**Fig. (1).** IoT architecture of patient health database.

In addition, the health data is analyzed in a sophisticated way using machine learning techniques. Methods such as Regression Tree, Support Vector Machine (SVM), and Random Forest (RF) are used in the dataset to predict the likelihood of cardiac events or other health risks. In comparison, the Random Forest outperformed all other methods with a better prediction rate and error rate. This predictive capability improves the system because you can have an early intervention based on patterns where you noticed some inconsistency and irregularity. In conclusion, IoT technology integrated with mobile and web platforms offers an innovative, efficient, and scalable approach to monitoring the health status of individuals. By tapping smart sensors, fast communication, and advanced analytical tools such as machine learning, this technology can not only help your doctor decide when to send you to the hospital but also make that

CHAPTER 9

# Study of Healthcare Applications: Empowering Personalized Care

**Anshu Sharma[1,*], Priyanka Sharma[2], Aastha Budhiraja[2]** and **Anju Gera[3]**

[1] *School of Engineering and Technology, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India*

[2] *School of Computer Applications, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India*

[3] *Deparment of Data Science, Galgotias College of Engineering and Technology, Greater Noida, Uttar Pradesh, India*

**Abstract:** Mobile apps for healthcare are changing the way doctors and patients communicate, making medical services more readily available than ever. Patient engagement features, healthcare outcome enhancements, and healthcare delivery improvements are some of the benefits provided by these apps. There is access to information, virtual consultations, which allow patients to manage their personal data, book appointments, and consult with specialists remotely, all of which give patients more access to care and cut down on the need for in-person appointments. Many of these apps also have features that allow users to log symptoms, keep track of indicators, and monitor their health. Turning all that data over to medical professionals helps decision-making and gives them more to base a treatment plan on, and in many healthcare apps, you will also find information about medical conditions, surgeries, and healthy lifestyle choices. One more critical role is played by healthcare applications in supporting drug adherence. Medication monitoring tools and reminder systems help patients adhere to their regimens, which lowers the odds of complications and improves treatment outcomes. Taking a holistic approach to health, some apps also let users view their sleep patterns, activity levels, and overall wellness by connecting with gadgets and fitness trackers. The increasingly widespread utilization of healthcare apps means they will be able to affect the healthcare system, helping patients and providers share information more effectively, which benefits the standard and accessibility of healthcare services.

**Keywords:** Chronic disease, Healthcare, Sensor, Wearable.

[*] **Corresponding author Anshu Sharma:** School of Engineering and Technology, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India; E-mail: anshu.atri25@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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## INTRODUCTION

In today's era, the convergence of technology and medicine has produced what has come to be known as wearable healthcare technology, which is a burgeoning area of interest in healthcare.

We refer to this emerging stratum of technologies, which range from medical wearables and fitness trackers to health monitoring and comfort-enhancing devices, as they effortlessly integrate into our daily routine. The list of wearable devices for health purposes is rather long. Their samples are fitness trackers and smartwatches, biosensors, and remote patient monitoring systems. All these gadgets really change the health management and clinical care delivery paradigm [1].

The key force leading to the generation of wearable technology is its ability to obtain true-to-life continuous data without manipulation and analyze it in a timely manner so that proactive and personalized care can be provided. Through the implementation of sophisticated sensors, wirelessly covered areas, and data analytics, these devices give every patient the chance to be personally involved in the management of their health, while at the same time facilitating remote patient care and improving clinical decisions [2].

The chapter then precisely focuses on the variety of wearable health technologies, showing how it is progressing, being applied nowadays, what challenges it faces, and finally, its future assumptions. The first part of our class will be dedicated to types of wearables, their technological foundations, as well as their effect on various healthcare areas, such as chronic disease management, fitness, wellness, remote patient monitoring, and clinical research.

1. **Miniaturization of electronic components**: Microsensors, processors, and batteries have improved as technology has advanced, consequently becoming lightweight wearable devices that are able to track a variety of physical processes.
2. **Advancements in wireless communication**: The recent advent of wireless communication technologies creates a seamless pathway in which data from wearable devices is transmitted to smartphones, cloud platforms, and healthcare providers through communication channels such as Bluetooth, Wi-Fi, and cellular networks [3].
3. **Ubiquity of smartphones**: With smartphones making an appearance in almost everyone’s lives, smartwatches and other wearable technologies represent a powerful computing platform with potential for data processing, rendering dynamic charts and graphs, and integrating with various health applications.

4. **Increased consumer awareness**: The rise in people's concern about health and wellness, as well as the need for low-cost, continuous ad monitoring for growing consumer demand for wearable health technologies.
5. **Healthcare cost pressures**: To reduce healthcare costs and create efficiency, wearable devices are being used in remote patient monitoring and preventive care. As a result, hospital admissions are down, and care management is improving [4].

This chapter gives an overview of the near and far past, current, and potential wearables and underlying technologies by providing an extended and more detailed description of the relevant aspects introduced in the previous chapter. With respect to wearable devices, we will look into the ranges, technologies, and how the products are likely to revolutionize customized disease management, fitness and wellness, remote patient monitoring, and clinical research [5].

Through the dynamics of technology, mentality, and the concept of well-being, the wearable healthcare technology business segment has become enormous with the proliferation of various devices dedicated to healthcare.

## TYPES OF WEARABLE HEALTHCARE DEVICES

Wearable health technology covers a huge range of smart instruments made for exploring, controlling, and maintaining a well-groomed lifestyle in terms of health and physical activities. Such electronic devices can be broadly classified based on their utilitarian purposes and the parameters they measure [6].

### Activity Trackers and Fitness Wearables

Whether it is activity trackers or fitness wearables, these gadgets are the go-to devices that are used by the majority of people to get wellness information. These machines were created specifically to follow up on physical activity, exercise, sleep schedule, and all the other important fitness stats. Examples include:

1. **Fitness trackers**: Gadgets like Fitbit, Garmin, and Apple Watch that measure steps taken, distance covered, calorie usage, sleep quality, and many other similar cases may be considered a category.
2. **Smartwatches with fitness tracking capabilities**: There are plenty of smartwatches that provide fitness tracking features, such as the Apple Watch and Samsung Galaxy Watch; examples include heart rate monitoring, GPS tracking, and exercise tracking.
3. **Smart clothing and wearable sensors**: Sportswear associating sensors capable of tracking different physiological parameters, including heartbeat, breathing

CHAPTER 10

# Comparative Study of Healthcare Applications: User Experience, Development, and Functionality

**Priyanka Sharma[1,*], Tapas Kumar[2], Aastha Budhiraja[1]** and **Anshu Sharma[2]**

[1] *School of Computer Applications, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India*

[2] *School of Engineering and Technology, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India*

**Abstract:** Mobile apps for healthcare are changing the way doctors and patients communicate, making medical services more readily available than ever. Patient engagement features, healthcare outcome enhancements, and healthcare delivery improvements are some of the benefits provided by these apps. There is access to information, virtual consultations, which allow patients to manage their personal data, book appointments, and consult with specialists remotely, all of which give patients more access to care and cut down on the need for in-person appointments. Many of these apps also have features that allow users to log symptoms, keep track of indicators, and monitor their health. Turning all that data over to medical professionals helps decision-making and gives them more to base a treatment plan on, and in many healthcare apps, you will also find information about medical conditions, surgeries, and healthy lifestyle choices. One more critical role is played by healthcare applications in supporting drug adherence. Medication monitoring tools and reminder systems help patients adhere to their regimens, which lowers the odds of complications and improves treatment outcomes. Taking a holistic approach to health, some apps also let users view their sleep patterns, activity levels, and overall wellness by connecting with gadgets and fitness trackers. The increasingly widespread utilization of healthcare apps means they will be able to affect the healthcare system, helping patients and providers share information more effectively, which benefits the standard and accessibility of healthcare services.

**Keywords:** Authentication, Consultation, Healthcare, Prescription.

## INTRODUCTION

Utilizing technology to improve accessibility, convenience, and general well-being, a healthcare application is a digital platform created to completely transform how people engage with healthcare services.

[*] **Corresponding author Priyanka Sharma:** School of Computer Applications, Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India; E-mail: priyankasharmaiitd2@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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These apps function as all-inclusive tools that support patient involvement, health management, and healthcare delivery in many ways.

The many features that healthcare applications offer, such as appointment scheduling, telemedicine services, medication management, health data monitoring, integration with electronic health records, instructional materials, and secure communication channels, evidence their multidimensional quality. The scheduling of appointments is made easier by healthcare applications, which is one of their main purposes. Navigating a database of healthcare providers is simple for users, who can also make appointments at their leisure and filter results based on geography, availability, and specialization [1 - 4]. People may take proactive measures to manage their health and save time as a result of this. These applications often have reminder features that alert users before booked appointments, ensuring that users do not miss them. In terms of healthcare app functionality, telemedicine services are a major improvement. Through phone conversations, chat messages, or video calls, users may have remote consultations with medical experts. In instances when making in-person visits to healthcare institutions may be difficult, this function caters to the rising demand for prompt and easy medical consultations. Not only does telemedicine facilitate the provision of timely medical advice and treatments, but it also makes healthcare services more accessible.

Another important feature of healthcare applications is prescription management. In addition to receiving electronic prescriptions straight from healthcare professionals, users may examine their current drug list and request refills. Furthermore, in order to improve adherence and assist users in adhering to their recommended treatment regimens, these applications could have pill reminder functions.

The recording and management of health data is one of the elements that sets healthcare applications apart from simple appointment and prescription management. Heart rate, steps done, sleep patterns, and other health parameters may be entered and tracked by users. A thorough picture of an individual's health and well-being may be obtained *via* some programmes that easily interact with wearable devices, enabling real-time monitoring. Ensuring that healthcare applications may safely access and update pertinent patient information is made possible by integration with Electronic Health Records (EHR) [5 - 7]. In order to promote continuity of care, this integration expedites communication between patients and healthcare professionals. Healthcare practitioners may make better educated judgments and provide more individualized and successful healthcare treatments if they have access to the most recent medical records.

Medical education and information may also be found in great quantities *via* healthcare applications. Users get access to a wealth of information, such as guides, articles, and instructional materials on health, illness prevention, and medical issues. People may make better lifestyle choices and make more educated health decisions thanks to this educational component. Apps for healthcare offer secure channels of communication *via* which consumers may communicate, ask questions, and get critical information from healthcare practitioners. These applications take strong precautions to safeguard private health information, guaranteeing confidentiality and adherence to healthcare laws. Privacy and data security are critical in the healthcare industry. Certain healthcare applications further provide functionality for managing insurance and billing. Through the app, users may handle payments for healthcare services, keep track of insurance data, and manage their billing information [8 - 13]. Providing a centralized platform for handling healthcare-related finances, this function improves the user experience overall. These applications' community-driven assessment of healthcare services is made possible by features like feedback and review systems. Individuals may review, comment on, and share their experiences with healthcare professionals, establishing an open system that assists others in selecting their physicians wisely. Modern healthcare apps have developed into all-inclusive systems that include a wide range of features to enable people to efficiently manage their health. The healthcare industry is changing as a result of these applications, which do everything from make booking appointments easier and provide telemedicine services to managing prescriptions, recording health data, and providing instructional materials. Healthcare applications use technology to foster a more involved and knowledgeable approach to individual health and well-being, in addition to increasing accessibility and convenience. With further development, these apps might play a major role in changing healthcare delivery systems all around the world.

## HOW HEALTHCARE APPLICATION WORKS?

The purpose of apps for healthcare is to simplify and enhance many aspects of patient engagement, healthcare provision, and overall health. Depending on its features and objective, a healthcare app's specific operations may differ, but here is a general overview of how they usually work.

### User Registration and Authentication

Secure and personalized interactions are ensured by the basic procedures of User Registration and Authentication, which make it easier for users to integrate into healthcare applications. Users must install the healthcare app first, create an account as shown in Fig. (**1**), and then carry out further security measures,

CHAPTER 11

# Assistive Device for Tetraparesis Patients

**A. Priya**[1,*] and **V. Vasudevan**[1]

[1] *Department of Computer Science and Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India*

**Abstract:** Caring for disabled people carries a higher risk as it involves a computerized framework designed to assist physically challenged persons. This process involves an advanced technical system that records simple human actions using specialized equipment and programmed algorithms. The captured input is then converted into digital information. Once these digital signals are captured, the system executes the specific task requested by the patient. Previous research works mainly focused on acquiring input and enhancing its neural schema, without implementation techniques for the patients' requests. The proposed system operates in four different phases: observing iris movements, identifying the input operations, predicting the intended tasks, executing the output, and collecting user feedback after system use. Head movements are detected using IRB sensors.

**Keywords:** Cognitive system, Computer vision, Digital signal processing, IRB sensors.

## INTRODUCTION

Iris-based communication is one of the most advantageous assistive technologies, enabling paralyzed individuals to communicate their needs to caregivers. A wide range of techniques is integrated, and visual perceptions are interpreted using Computer Vision (CV). Real-world, high-dimensional data are converted into numerical or symbolic information for decision-making purposes. Computer Vision focuses on processes such as image identification and restoration, image storage, object detection, quality analysis, image reconstruction, feature extraction, and decision-making. Disentangling the images developed using geometry, statistics, and physics will help us understand images.

[*] **Corresponding author A. Priya:** Department of Computer Science and Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India; E-mail: priyankasharmaiitd2@gmail.com

**Anju Gera, Seema Nayak, Shamla Mantri, Manoj Nayak & Ram Kumar Chenthur Pandian (Eds.)**
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The routine activities of many people become complex due to the failure of a body part, various health factors, or injuries. The health factors may include paralysis, spinal cord injury, hemiplegia, or any brain injuries that disable the functions of the body parts. Rehabilitation is the only way to help them return to a normal lifestyle and regain their strength. When body parts lose their functionality, individuals face a high risk of being unable to perform daily activities independently. Hence, the proposed system can help overcome the difficulties faced by disabled and paralyzed individuals. This system aims to make daily activities easier and reduce the constant dependence on caregivers.

Through this system, disabled individuals will be able to communicate their needs to caregivers using only their eye movements.

Image acquisition is generally recommended for automated image processing, although optical and simple image processing techniques are also possible. This work presents a general overview of the methods being used. The acquisition of images (data in the form of pictures) is referred to as imaging. Closely related to image acquisition are computer graphics and computer vision. In computer graphics, physical models are used to produce images, conditions, and lighting, rather than obtaining them from real-world scenes, as in most animated films.

Iris identification is a fundamental module in an iris recognition system, as the performance of the system is highly dependent on this process, and errors may lead to misclassification during verification. This process involves extracting the structure of the iris from different components of an eye image, such as the pupil, eyelids, eyelashes, reflections, and sclera.

The proposed system focuses on capturing only the eye region and making decisions based on the current position of the iris. This eye region is typically extracted from the acquired facial image by segmenting the region of interest. The iris, when captured at a particular angle, is measured, and the corresponding decision is made, after which a message is sent to the caregiver.

IRB sensors provide greater accuracy in region segmentation, while CCD sensors are used for further decision-making to achieve more accurate results. This system is designed to create an interface between the user and the computer. The system can be controlled through eye movements, and the user can access the mouse *via* eye control. Thus, this system effectively assists paralyzed individuals in their daily activities.

## RELATED WORK

Ideal imaging conditions would result in a quality image, which would give more accurate iris segmentation as proposed in [1]. A non-ideal image can significantly affect iris recognition accuracy. This system proposes a novel way to segment a non-ideal image. In this system, two algorithms are applied for segmenting images that are taken under infrared or visible light. An active contour model is fused with expanding and shrinking active contour methods for a more accurate iris segmentation. The segmented iris is unwrapped effectively using a noncircular normalization schema [2 - 5]. The main methods used are as follows:

1. Active Contour Model
2. Gradient Vector Flow Active Contour

This system also puts into light a new method to detect a closed eye. This robust system will bring in a way to accurately isolate the iris from the image, even when the eyelids partially cover it. CASIA V4.0, UBIRIS V1, UBIRIS V2, and MMU2 result in a high-level accuracy with the proposed system. This gives considerably better output than the other methods used for iris segmentation, and the results are more accurate [6 - 8].

The proposed method [9] includes additional points that demonstrate the utility of webcams in the computer vision field, resulting in improved performance. Furthermore, it enhances the speed and sensitivity of eye movement study and tracking, especially in captured video [10]. The difficulties that occur at the stage of accuracy considerations are revealed and removed with the help of the models of eye movements that focus on five points in the eyes, also known as the center of the iris. For the detection of the iris center, a trained Convolutional Neural Network (CNN) is employed, providing a more precise description of eye movements. As a result, it is achieved with a more precise description of the eye movements. Moreover, dependency on a single iris center point can be minimized by creating six types of time-dependent eye movements. Another option used in training the CNN is the detection of the placement of eyes and their movements to minimize mistakes, such as the real and fake eye movements [11 - 13]. To detect the motion of the face, the proposed system developed a webcam-based visual activity, with a frame rate set to up to 0.50,000 rupees from over 30 subjects. Real and artificial eye movements will be distinguished by the system, which will allow them to employ techniques like:

1. Eye movement analysis and eye movement feature extraction
2. Point detection of eye features

CHAPTER 12

# Multidisciplinary Approach to the Relevance of AI in Cardiovascular Medicine and Its Implications for Implementation

**S. Birundha[1,*], M. Karthik[2], Abinaya Inbamani[3]** and **V. Janani[4]**

[1] *Department of Computer Science Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India*

[2] *SRM Madurai College for Engineering and Technology, Madurai, Tamil Nadu, India*

[3] *Department of Electrical and Electronics Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India*

[4] *Department of Biomedical Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India*

**Abstract:** Disease detection using Artificial Intelligence (AI) has become a major focus for many researchers, as stratified public health is a concern. Though many methods are available for detecting diseases, these techniques are expensive or inaccessible to the general public. As a result, it is possible to precisely forecast the onset and progression of a disease and identify the biomarkers associated with its processes. This chapter covers the foundations of AI algorithms for analysis and prediction in the cardiovascular system. It does this by emphasizing the need for deep learning and machine learning techniques, as well as by analyzing potential implementation challenges and roadblocks in the context of prediction used in cardiovascular medicine. The chapter will introduce algorithms which would be convenient, robust and in expensive and capable of running on suitable devices, so that the presence of diseases can be diagnosed from the color images provided, and necessary action can be taken.

**Keywords:** Artificial intelligence, Cardiovascular medicine, Deep learning, Disease detection, Echocardiography, Heart disease, LSTM.

## INTRODUCTION

Diseases are often construed as medical ailments that are related to specific symptoms and signs. Heart Diseases are listed as one of the leading causes of mortality, despite one-third of the disease being found to be preventable [1], with

[*] **Corresponding author S. Birundha:** Department of Computer Science Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India; E-mail: birundha.s@srec.ac.in

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a mortality rate of 30%. Cardiovascular disease (CV) or Heart disease is an abnormal condition branching out into various types of disease that negatively affect the structure or functioning of an organ. In this broader sense, these diseases are left undiagnosed or untreated as they are caused by lifestyle habits like smoking, alcohol, food habits, stress, and also due to medical conditions [2]. The clinical significance of the most common types of heart diseases is yet to be predicted in the early stage. As a result, these types of lifestyle-borne illnesses are becoming more prevalent, and the impact of time-consuming and physically demanding methods is severely impeding the ability of healthcare delivery systems to handle cases. Current advancements in the field and the availability of high-throughput, high-accuracy medical score Artificial Intelligence (AI) systems, however, may only make up a small portion of workable solutions to address this dilemma in clinical treatment [3]. These days, AI is receiving a lot of attention, mostly in relation to improving health and well-being. This revolutionary instrument can improve patient care by streamlining diagnosis, treatment, and patient welfare communication [4].

This requirement becomes the need for the healthcare providers, and those clinical assessments are linked to Digital platforms for point-of-care diagnosis [5]. An intuitive observation trial of a medical state that is based on an analysis of physiological data for the purpose of monitoring and evaluating heart functionality makes up a digital application-specific interface API. APIs afford individuals with transferable and up-front solutions to keep them up-to-date about their ailments. Machine learning is a subset of AI, while deep learning is an additional subset of machine learning in the AI pipeline. Algorithms learn to identify hierarchies among facts using a process called deep learning, which allows for truly multipart data evaluation. The field of machine learning in healthcare is rapidly expanding and attracting interest from both academia and industry. Though a pool of studies on cardiac disease forecasting is carried out, a precise analysis will give an added authentic data sharing [6]. Also, it is obligatory for clinicians to provide custom-made guidance about intrusions and ailment progression, using enhanced means of information sharing.

An AI model for decision making and prediction is depicted in Fig. (**1**). It assists in measuring the uniformity of the heartbeats as well as other conditions like mental tension. It also helps us search for diseased forms inside the heartbeats. As data for cardiovascular medicine is concerned, it is beneficial for its speed, transferability, and affordability [7]. However, in order to achieve accurate statistical interpretation, the data procurement technique is dependent on the user and requires intensive training [8].

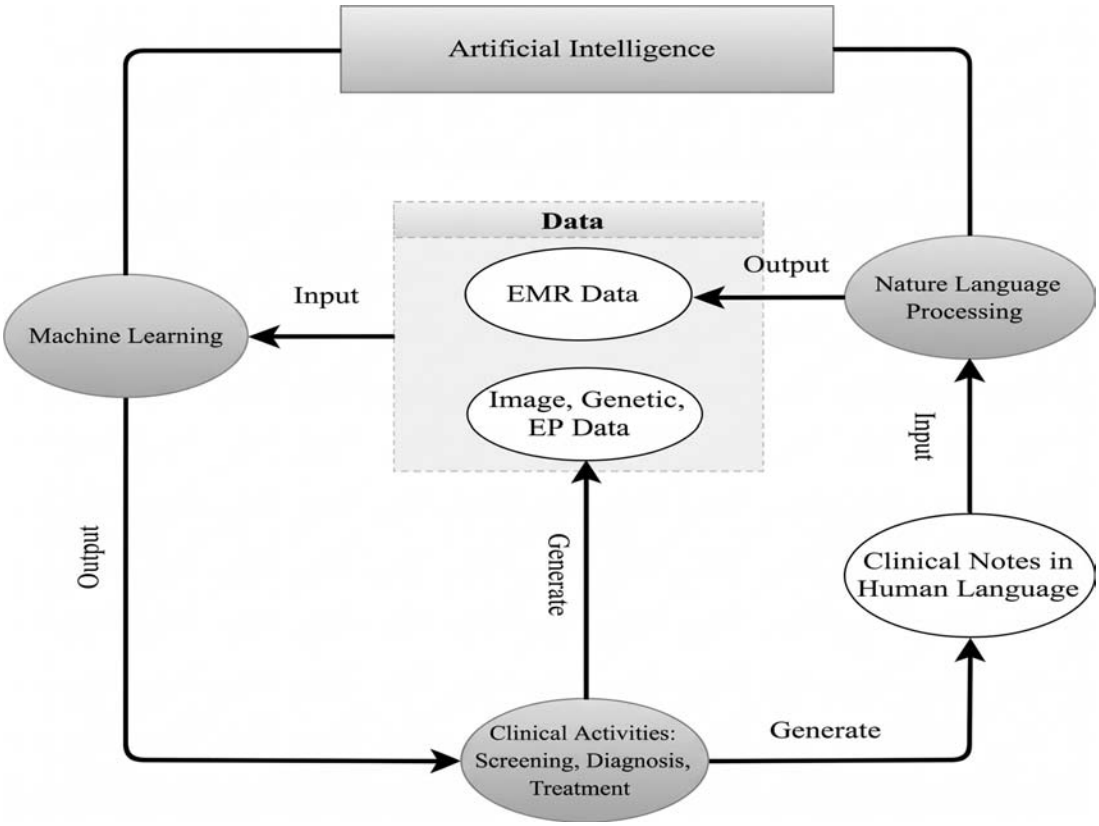


**Fig. (1).** AI model flow diagram for healthcare applications.

AI allows for an additional consistent analysis of the echocardiographic images, which helps to reduce this reliance on the user. Its potential to allow for the automatic development of noteworthy cardiac function activities in real-time, as well as the automatic categorization of echocardiographic interpretation in APIs.

## STUDY OBJECTIVE

The main objective of this study is to concentrate on a comprehensive series of AI subjects in cardiovascular medicine. In this view, the first discussed is a broad overview of echocardiography from a medical perspective, followed by different learning models described in various literature. The next part of the chapter focuses on tabular illustration to be discussed as a quick reference. The challenges and competence of AI algorithms in the healthcare sector and medicine are discussed at the end of the chapter.

# CHAPTER 13

# Understanding Blockchain Technology in Healthcare: Oncological Considerations in Implementation

**Amol Bhoite**[1,*] and **Shilpa C. Patil**[2]

[1] *Department of Radio-Diagnosis, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India*

[2] *Department of General Medicine, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth (Deemed To Be University), Karad, Maharashtra, India*

**Abstract:** Blockchain technology is getting a lot of attention because it could change healthcare systems by making them safer, more private, and more able to work with each other. Blockchain has the potential to change cancer care, especially in oncology, where data accuracy, security, and connectivity are very important. This summary talks about the possible pros, cons, and things to think about when using blockchain technology in cancer. In cancer, blockchain technology has a lot of important benefits, such as better data protection through cryptography, records that cannot be changed, and storage that is not controlled. These features make sure that private patient data, like genetic information and treatment records, stay safe and cannot be changed. Blockchain's open nature also makes it easy for healthcare workers, academics, and patients to share and exchange data, which makes it easier for everyone to work together on cancer care and study. Even with these advantages, there are some problems that need to be fixed before blockchain can be used successfully in cancer. These include following the rules, worries about data safety, problems with scaling, and connecting to other healthcare systems. Because cancer care is so complicated and uses interdisciplinary teams and a lot of different data sources, blockchain's role in making data handling and decision-making easier needs to be carefully thought through. Stakeholders need to work together to create strong control frameworks, standards, and communication methods that are specific to cancer in order to solve these problems. Combining blockchain with other new technologies, like AI and the Internet of Things, could also improve cancer care by letting data be analyzed in real time, individualized treatment plans be made, and cancer be found early.

**Keywords:** Blockchain, Data handling, Health care, Oncology, Remote monitoring, Telemedicine.

[*] **Corresponding author Amol Bhoite:** Department of Radio-Diagnosis, Krishna Vishwa Vidyapeeth (Deemed to Be University), Karad, Maharashtra, India; E-mail: amool0123@gmail.com

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## INTRODUCTION

In recent years, blockchain technology has become a new idea that could change many fields, including healthcare. Blockchain has a lot of potential in healthcare, where data protection, privacy, and being able to share data between systems are very important. Cancer research, which deals with a lot of complicated and private information, could gain a lot from using blockchain. This chapter talks about the basics of blockchain technology, how it can be used in healthcare, and the things that need to be thought about when using blockchain in cancer.

### The Basics of Blockchain

Blockchain is a global ledger system that lets people keep records in a way that is safe, open, and not controlled by a single entity. It is made up of a series of blocks, each with a list of events and a cryptographical link to the block before it. This chain keeps a record of all activities that cannot be changed. This keeps info safe and secure. Decentralization, immutability, openness, and digital security are some of the most important parts of blockchain [1]. Blockchain can be used in healthcare to make a safe and open system for handling trades, medical information, and patient data. Blockchain can make healthcare systems safer and more private by spreading out the keeping of data and making sure that it is correct.

### Applications of Blockchain in Healthcare

Blockchain technology can be used in many ways in healthcare, from managing supply chains to ensuring safe data sharing. When it comes to cancer, blockchain can be very helpful for keeping track of and protecting private data like genomics, treatment records, and data from clinical trials. One of the main uses of blockchain in cancer is to make it safe and easy to share medical information and patient data. Blockchain can make it easier for healthcare workers, academics, and patients to work together by setting up an open network for sharing data, as shown in Fig. (**1**). This can lead to better care management and treatment results [2].

Blockchain can also be used to keep track of where medicines and medical gadgets come from and make sure they are real. This protects the supply chain in cancer. This is especially important when it comes to fake drugs and the need for strict quality control in cancer care.

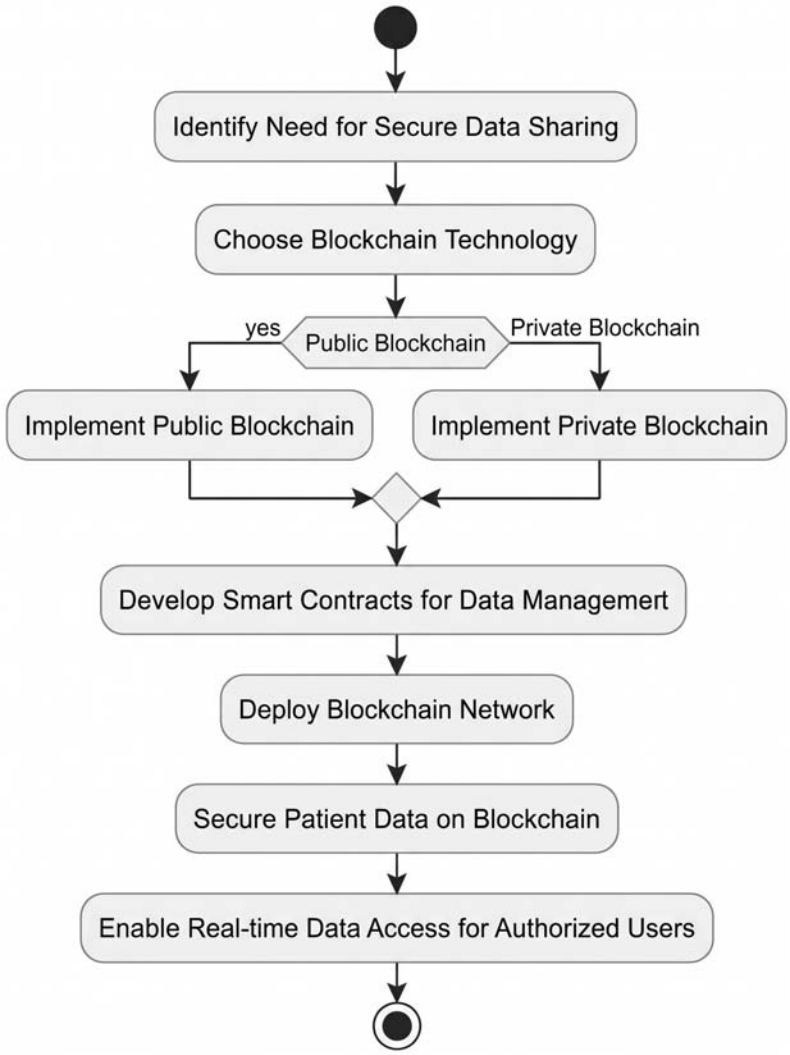


**Fig. (1).** Overview of the process of implementing blockchain technology in healthcare.

## Oncological Considerations for Blockchain Implementation

When putting blockchain to use in oncology, the specific problems and needs of cancer care must be carefully thought through. One of the most important things to think about is how sensitive oncological data is, which means that strong protection and security measures are needed. These worries can be put to rest by blockchain's digital security features, which keep data protected and impossible to change [3]. Another thing to think about is whether or not blockchain can work with current healthcare systems. Integrating electronic health records (EHRs) and

# CHAPTER 14

# Implementation of a Digital Healthcare System by Managing Patient Database Using Blockchain to Ensure Data Privacy and Security

**S. Madumidha[1,*], P. Sivaranjani[2], Raji Sweethaa S.[1], V. Tharun[1]** and **N. Rajasingam[3]**

[1] *Department of Information Technology, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India*

[2] *Department of Electronics and Communication Engineering, Kongu Engineering College, Erode, Tamil Nadu, India*

[3] *Department of Biomedical Engineering, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India*

**Abstract:** The change from pandemics to an endemic situation has become a reality, where many people have been affected by the disease and have shown adverse reactions. This highlights the need for a properly structured medical system. Proper medication can only be prescribed by doctors if they are aware of the patient's medical history. Therefore, a hospital consortium is designed using blockchain technology to securely monitor and manage medical history, named the Digital Healthcare System (DHCS). Blockchain technology ensures security from data theft and mass storage capacity over a large network. This blockchain network is built on the Ethereum platform. A Hospital Information System (HIS) is employed to track patient information and create a unique Patient ID (PID). This system allows easy management of patient medical history, assisting doctors in making proper diagnoses and prescribing proper medication. Techniques like MQTT and services like web agents and Key Management Systems (KMS) are employed to facilitate connectivity and communication in the network. Patients can access the blockchain and view their medical history through an application.

**Keywords:** Blockchain, Digital Healthcare System (DHCS), Digital Medical Record (DMR), Hospital Information System (HIS), patient ID.

## INTRODUCTION

Digital Healthcare Systems (DHCSs), or eHealth systems, are of great significance in the administration of public health. This idea was proposed by the

* **Corresponding author S. Madumidha:** Department of Information Technology, Sri Krishna College of Engineering and Technology, Coimbatore, Tamil Nadu, India; E-mail: madumidha.s@skct.edu.in

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Thai Ministry of Public Health in their cross-border national development project. Their aim was to develop a digital health information system by gathering data from different medical institutions participating *via* the web, all of which is linked through the Digital Medical Record (DMR). Patient information can only be viewed by authorized hospital administrators, thus maintaining privacy. The conventional paper-based documentation process has been replaced by digital systems, thus eliminating mistakes and making it simpler to retrieve information. In partnership with Naresuan University (NU), the Thai Ministry of Public Health has developed e-consultation systems for check-ups, surgeries, and responding to medical inquiries. These systems are also available in rural villages and medical centers. The system maintains the medical history of patients, which is accessible at any time and from anywhere, with security and protection from unauthorized access.

Three main factors are taken into account in this proposal:

1. The state of patient records at the moment.
2. The incorporation of documents into a data access interface that has been authorized.
3. Communication of research intentions across the country.

The Digital Healthcare System (DHCS) is responsible for managing all patients' medical records. Blockchain technology is applied to guarantee data security and immutability [1]. Web agents link the Hospital Information System (HIS) *via* Message Queuing Telemetry Transport (MQTT). Every hospital has its own HIS, which has different data structures and properties that are not visible to the common network at first. Data correctness and consistency are very critical in this area. Although cloud storage is a safer alternative, it is still vulnerable to risks [2]. If corrupted data is not detected, it cannot be recovered, which is a challenge with conventional cloud storage systems. The Key Management System (KMS) improves data security, and Application Programming Interfaces (APIs) are implemented in hospitals to facilitate reading and writing of patients' data to the blockchain. Blockchain technology makes it possible to recover past data and guarantees data immutability through a consensus algorithm signed by all parties involved. This proposal will address the issue of unauthorized access to data through blockchain-based centralized data storage systems. Web agents are front-end systems that link all information *via* the HIS

## RELATED WORK

Blockchain, also referred to as Distributed Ledger Technology (DLT), provides data security, privacy, immutability, and integrity. It is very efficient for long-

term data storage [3]. Patients in rural areas are generally monitored by IoT-based systems. However, data transmission and storage in these systems are not always secure, resulting in the possibility of data breaches. This problem can be overcome by combining IoT technology with blockchain technology, utilizing Hyperledger Fabric, along with a mobile application for data retrieval. A cloud-assisted DMR consortium was proposed using the Ethereum platform, where data is encrypted on a cloud server and retrieved with authorized proof [4]. If data has to be reverified or retrieved, user permission is required [5].

The InterPlanetary File System (IPFS) technology can potentially facilitate faster transactions than traditional blockchain networks, with high security. The DHCS intends to store patient data in a centralized system according to patient preferences. One of the major aims of the DHCS is to preserve the entire history of patients for future medical assessments. This helps healthcare professionals to access and analyze a patient's medical history efficiently, with less chance of unnecessary procedures and better quality care.

## PROPOSED WORK

### Design of the System

A decentralized Digital Healthcare System (DHCS) has been designed, which involves different hospitals as participants, with each hospital being accountable for managing the Digital Medical Records (DMRs) of their patients. This is made possible by web agents that send patient data packages and keep the system connected.

The use of blockchain technology has ensured that patient data is secure and cannot be altered, as mentioned in [6]. Although the patient data from different hospitals is accessible on the network, the details of the data are not known. The web agents control the accessibility of the data, which shows a limited view of the patient data history.

Each hospital collects and stores patient data [7]. A common interface, which is developed by using web agents, connects the servers of all the participating hospitals. Fig. (**1**) shows how the patient data is collected and stored locally in each hospital.

The Digital Medical Records (DMRs) in the Hospital Information System (HIS) are in different formats and are not accessible to the network. The DMRs are standardized by using Google's Database-as-a-Service (DBaaS) technology and are then stored in a central server [8]. Only authorized users have access to the data.

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## Anju Gera

Dr. Anju Gera is an Associate Professor in the Department of Computer Science (Data Science) at Galgotias College of Engineering and Technology, Greater Noida, India. She holds a B.Tech in Computer Science and Engineering, M.Tech, and Ph.D. from Banasthali University. With over 21 years of teaching and research experience, her areas of interest include Cryptography, Intelligent Systems, Machine Learning, Image Processing, and Data Analytics using R. Her research focuses on Machine Learning applications in Healthcare. She has published research papers in reputed national and international journals and conferences, with publications indexed in Scopus/WoS. She is also an ISTE and IAENG member and serves as a session chair and editorial board member.



## Seema Nayak

Prof. (Dr.) Seema Nayak is a Professor in ECE and Dean – IQAC at IIMT College of Engineering, Greater Noida, with 30 years of academic experience. She holds a Bachelor's degree in Electronics and Communication Engineering and a Ph.D. from MRIU, Faridabad. Her areas of expertise include Digital Signal Processing, Signals and Systems, Microprocessors, Digital Electronics, and VLSI, with research specialization in Digital Signal Processing. She has published/presented 82 research papers, authored three books, and holds six patents. She has guided research scholars, with two Ph.D. scholars awarded under her guidance, and has served as an editor and reviewer for reputed journals.



## Shamla Mantri

Dr. Shamla Mantri is an Associate Professor at Dr. Vishwanath Karad MIT World Peace University, Pune, India, with over 23 years of teaching experience. Her expertise includes Signal Processing, Artificial Intelligence/Machine Learning, Computer Networks, and Healthcare Technologies. Her research focuses on AI-enabled healthcare, biomedical signal processing, IoT, image processing, depression analysis, and intelligent systems for societal applications. She has authored 50+ research publications, with 587 citations and an H-index of 12 (Google Scholar). She also holds 9 patents/IPRs, including granted and published patents in India, South Africa, and the UK, reflecting her commitment to innovation and impactful research.



## Manoj Nayak

Prof. (Dr.) Manoj Nayak is a Professor and Head, Department of Mechanical Engineering, at Manav Rachna International Institute of Research and Studies (MRIIRS), where he has been serving since 2005. He holds a Ph.D. from NIT Hamirpur and an M.Tech in Manufacturing and Automation from YMCA Institute of Technology and Management. He has 31 years of total experience, including 21 years in academics and 9 years in industry. His expertise includes manufacturing, automation, automotive components, and quality management. He has guided 10 M.Tech scholars and 2 Ph.D. scholars, and has published 50 research papers, one book, and 10 book chapters in reputed peer-reviewed publications.



## Ram Kumar Chenthur Pandian

Dr. Ram Kumar Chenthur Pandian is the Director – IQAC and Professor in the Department of Electronics and Communication Engineering at Sri Krishna College of Engineering and Technology (SKCET), Coimbatore. He holds a B.E. in Electronics and Communication Engineering, an M.E. in Communication Systems, and a Ph.D. in Wireless Sensor Networks from Anna University. His research interests include Artificial Intelligence, Data Science, Biomedical Instrumentation, Sensor Networks, and Computer Networks. He has authored five technical books and one non-technical book, published 48 journal papers and 79 conference papers, and has received notable citations in Scopus and Web of Science-indexed publications.

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