APPLIED COMPUTER VISION AND SOFT COMPUTING WITH INTERPRETABLE AI

Edited by
Swati V. Shinde
Darshan V. Medhane
Oscar Castillo

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Applied Computer Vision and Soft Computing with Interpretable AI

This reference text presents the knowledge base of computer vision and soft computing techniques with their applications for sustainable developments.

Features:

- Covers a variety of deep learning architectures useful for computer vision tasks.
- Demonstrates the use of different soft computing techniques and their applications for different computer vision tasks.
- Highlights the unified strengths of hybrid techniques based on deep learning and soft computing taken together that give the interpretable, adaptive, and optimized solution to a given problem.
- Addresses the different issues and further research opportunities in computer vision and soft computing.
- Describes all the concepts with practical examples and case studies with appropriate performance measures that validate the applicability of the respective technique to a certain domain.
- Considers recent real word problems and the prospective solutions to these problems.

This book will be useful to researchers, students, faculty, and industry personnel who are eager to explore the power of deep learning and soft computing for different computer vision tasks.

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Preface

Computer Vision is the field of studying and developing technology that enables computers to process, analyze, and interpret digital images. Today, Computer Vision applications can be found in several industries, such as industrial robots, medical imaging, and surveillance. On the other hand, soft computing is being used to reduce the limitations caused by problems in data analytics. Moreover, soft computing is emerging as an innovative technological approach with the ability to allow a broad range of applications which can transform human lives in excellent ways.

The diverse perspectives of soft computing involve numerous aspects of interpretable artificial intelligence. Interpretable artificial intelligence incorporates theories, concepts, and techniques of science, internet technology, computer technology, neuroscience, and so on in a highly multidisciplinary way. It also offers a high computational dynamism. In view of the importance of an interpretable artificial intelligence as an emerging trend and technological approach to be followed in multidisciplinary research areas, we are pleased to present a book titled *Applied Computer Vision and Soft Computing with Interpretable AI*.

Researchers and practitioners have contributed to this book by means of chapters that illustrate research results, projects, surveying works, and industrial experiences that describe significant advances in the areas of computer vision, soft computing, and interpretable artificial intelligence. This book is organized in 20 chapters.

It is intended to be a major reference tool for scientists and engineers interested in applying new computational and mathematical concepts to design applications based on interpretable AI. We consider that this book can also be used to obtain novel ideas for new lines of research, or to continue the lines of research proposed by the authors here. We compliment the contributors for writing their comprehensive chapters which not only introduce the several concepts of interpretable AI in a broad context but also help us in understanding the complex applications of it.

We thank all the people who have helped or encouraged us during the production of this book. We would like to thank our colleagues working in Soft Computing and Computer Vision who are too many to mention individually by name. Of course, we need to thank our supporting agencies for their help during this project and thank our institutions for always supporting our work. Finally, we thank our families for their continuous support during the time that we have spent on this project.

Swati V. Shinde
Pune, Maharashtra, India

Darshan V. Medhane
Nashik, Maharashtra, India

Oscar Castillo
Tijuana, Mexico

Editors

Swati V. Shinde earned her PhD in Computer Science and Engineering at Swami Ramanand Teertha Marathwada University, Nanded. She has 22 years teaching experience and is currently Dean of R&D and Professor of Computer Engineering, Pimpri Chinchwad College of Engineering (PCCoE), Pune. She worked as a HOD-IT for seven years at PCCoE. Her research interests include Machine Learning, Deep Learning, Soft Computing, Artificial Neural Networks, and Fuzzy Logic. She has published more than a hundred research papers in reputed journals. She received six Best Paper Awards at different IEEE conferences and has filed seven research patents. She received a DST research project grant of almost Rs 3,700,000. She also received a research grant from SPPU University, Pune, an International FDP grant from SPPU, and a conference grant from AICTE. She is a certified trainer and ambassador of NVDIA's Deep Learning Institute. She received the Dr. APJ Abdul Kalam Women Achievers Award from IITech Bangalore. She was awarded the Indo Global Engineering Excellence Award by the Indo Global Chamber of Commerce Industries and Agriculture. She also received first prize for her prototype from SERB at IIT Kanpur.

Darshan V. Medhane is Associate Professor and Head of Department of Computer Engineering at Maratha Vidya Prasarak Samaj's KBT College of Engineering, Nashik. Formerly he was Assistant Professor in Computer Science and Engineering at the Indian Institute of Information Technology, Pune (established by MHRD, India). He holds a doctorate from the Vellore Institute of Technology, Vellore. He has 12 years of teaching experience. He has published several research works in reputed peer reviewed journals like *IEEE Transactions* and has many SCI and Scopus indexed papers to his credit. He has published more than twenty books and a number of book chapters. He completed a funded research project sanctioned by BCUD, University of Pune, and another by SEED, Ministry of Science and Technology. He received the Best Student Award for Engineering. He is a reviewer for various journals. He is a member of IEEE and IET. His research interests include Cyber Physical Systems, Computational Intelligence, Evolutionary Multi Objective Optimization, Position Monitoring Systems, Automata Theory, and Distributed Computing Systems.

Oscar Castillo earned a Doctor of Science degree (Doctor Habilitatus) in Computer Science from the Polish Academy of Sciences (with the dissertation "Soft Computing and Fractal Theory for Intelligent Manufacturing"). He is Professor of Computer Science in the Graduate Division, Tijuana Institute of Technology, Tijuana, Mexico. In addition, he serves as Research Director of Computer Science and head of the research group on Hybrid Fuzzy Intelligent Systems. Currently, he is President of the Hispanic American Fuzzy Systems Association and is a past president of the International Fuzzy Systems Association. Professor Castillo is also Chair of the Mexican Chapter of the Computational Intelligence Society (IEEE). He also belongs to the Technical Committee on Fuzzy Systems of IEEE and to the Task Force on "Extensions to Type-1 Fuzzy Systems". He is also a member of NAFIPS,

IFSA, and IEEE. He belongs to the Mexican Research System (SNI Level 3). His research interests are Type-2 Fuzzy Logic, Fuzzy Control, Neuro-Fuzzy, and Genetic-Fuzzy hybrid approaches. He has published over 300 journal papers, 10 authored books, 90 edited books, 300 papers at conference proceedings, and more than 300 chapters in edited books, in total more than 1000 publications (according to Scopus) with an h index of 89, and more than 26,000 citations according to Google Scholar. He has been Guest Editor of several successful special issues in journals such as *Applied Soft Computing*, *Intelligent Systems*, *Information Sciences*, *Soft Computing*, *Non-Linear Studies*, *Fuzzy Sets and Systems*, *JAMRIS*, and *Engineering Letters*. He is currently Associate Editor of *Information Sciences*, the *Journal of Engineering Applications on Artificial Intelligence*, the *International Journal of Fuzzy Systems*, the *Journal of Complex Intelligent Systems*, *Granular Computing*, and *Intelligent Systems*. He was Associate Editor of the *Journal of Applied Soft Computing* and *IEEE Transactions on Fuzzy Systems*. He was elected IFSA Fellow in 2015 and MICAI Fellow in 2016. Finally, he recently received recognition as Highly Cited Researcher in 2017 and 2018 by Clarivate Analytics and Web of Science.

Contributors

Pratik Adhav
Pimpri Chinchwad College of Engineering
Pune, India

Taymaz Akan
Louisiana State University Health Sciences Center
Shreveport, LA, USA
and
Istanbul Topkapi University
Istanbul, Turkey

Avadhoot Autade
Pimpri Chinchwad College of Engineering
Pune, India

Mohammad Ali Balafar
University of Tabriz
Tabriz, Iran

Anjali Manish Bari
Bharati Vidyapeeth's College of Engineering for Women
Pune, India

Amol Bhawarthi
Cognizant Technology Solutions
Pune, India

Sajal Ranjan Chakravarty
National Institute of Technology Raipur
Raipur, India

Saroj Kumar Chandra
Jindal University
Raigarh, India

Rishabh Dadsena
National Institute of Technology Raipur
Raipur, India

Leena Deshpande
Vishwakarma Institute of Information Technology
Pune, India

Satish R. Devane
Savitribai Phule Pune University, MVPS's KBT College of Engineering
Nashik, India

Aditya Dhumal
Pimpri Chinchwad College of Engineering
Pune, India

Gavin Dsouza
University of Mumbai, St. Francis Institute of Technology
Mumbai, India

Aaishwarya Ashish Gaikwad
Pimpri Chinchwad College of Engineering
Pune, India

Uma R. Godse
MIT Art, Design and Technology University
Pune, India

J. G. Gujar
Sinhgad College of Engineering
Pune, India

Kavita Jatwar
National Institute of Technology Raipur
Raipur, India

Sangita M. Jaybhaye
Vishwakarma Institute of Technology
Pune, India

Deepa A. Joshi
Savitribai Phule Pune University, Dr. D.Y. Patil Institute of Technology, Pimpri
Pune, India

Sonali Kadam
Bharati Vidyapeeth's College of Engineering for Women
Pune, India

Shreya Kakade
University of Mumbai, Thakur College of Engineering and Technology
Mumbai, India

Apeksha Kamath
University of Mumbai, Thakur College of Engineering and Technology
Mumbai, India

R. Karthikeyan
Vardhaman College of Engineering Hyderabad
Hyderabad, India

Yumna Khan
University of Mumbai, Thakur College of Engineering and Technology
Mumbai, India

Anand Khandare
University of Mumbai, Thakur College of Engineering and Technology
Mumbai, India

Ratnesh Kumar
University of Kalyani
Kalyani, Nadia, India

Payal Kunwar
University of Mumbai, Thakur College of Engineering and Technology
Mumbai, India

Sagar Lahade
Pimpri Chinchwad College of Engineering
Pune, India

Maheshwar D. Jaybhaye
COEP Technological University
Pune, India

Kalyani Mali
University of Kalyani
Kalyani, Nadia, India

Darshan V. Medhane
Savitribai Phule Pune University, MVPS's KBT College of Engineering
Nashik, India

Radhika Menon
Savitribai Phule Pune University, Dr. D.Y. Patil Institute of Technology
Pimpri, Pune, India

K. Jairam Naik
National Institute of Technology Raipur
Raipur, India

Amin Golzari Oskouei
Azarbaijan Shahid Madani University
Tabriz, Iran
and
University of Tabriz
Tabriz, Iran

Abhimanyu Babar Patil
Pimpri Chinchwad College of Engineering
Pune, India

Niraj Patil
Vishwakarma Institute of Information Technology
Pune, India

Tejas Patil
Vishwakarma Institute of Information Technology
Pune, India

K. Rajeswari
Pimpri Chinchwad College of Engineering
Pune, India

Yash U. Ringe
Savitribai Phule Pune University, MVPS's KBT College of Engineering
Nashik, India

Rohan Sawant
Savitribai Phule Pune University, Dr. D.Y. Patil Institute of Technology
Pimpri, Pune, India

Aakanksha Sharaff
National Institute of Technology Raipur
Raipur, India

Amruta Sudhakar Shinde
Bharati Vidyapeeth's College of Engineering for Women
Pune, India

Ankita Shinde
Vishwakarma Institute of Information Technology
Pune, India

Sandeep R. Shinde
Vishwakarma Institute of Technology
Pune, India

Swati V. Shinde
Pimpri Chinchwad College of Engineering
Pune, India

Pratik R. Sonar
Savitribai Phule Pune University, MVPS's KBT College of Engineering
Nashik, India

Kavita Sonawane
University of Mumbai, St. Francis Institute of Technology
Mumbai, India

Ulligaddala Srinivasarao
Vardhaman College of Engineering Hyderabad
Hyderabad, India

Masood Ismail Tamboli
Vishwakarma Institute of Information Technology
Pune, India

Deepali Ujalambkar
Savitribai Phule Pune University, AISSMS College of Engineering
Pune, India

Vedmani A. Vaidya
Vishwakarma Institute of Technology
Pune, India

B. Vasavi
Vardhaman College of Engineering
Hyderabad, India

Sushma Vispute
Pimpri Chinchwad College of Engineering
Pune, India

N. Yogeesh
Government First Grade College
Tumkur, India

1 Improved Healthcare Systems Using Artificial Intelligence
Technology and Challenges

Anand Khandare, Apeksha Kamath, Shreya Kakade, Yumna Khan, and Payal Kunwar
University of Mumbai, Mumbai, India

CONTENTS

1.1 INTRODUCTION

Artificial intelligence (AI) is a comprehensive branch of computer science which is concerned with the automation and performing of processes that simulate the human brain. AI has transfigured the entire healthcare industry. The significant development of computational power and infrastructure, big data, and various machine learning (ML) and deep learning algorithms has resuscitated interest in AI technology and accelerated its incorporation in various sectors [1]. Surveys conducted suggest that the market size of AI in healthcare was globally valued at USD 10.4 billion in 2021 and is expected to scale up at a compound annual growth rate of 38.4% from 2022 to 2030. According to All The Research, this market value is expected to rise to USD 36.25 billion by the year 2026. In India too there has been an increasing involvement towards research to explore the potential applications of AI in healthcare. Investment in AI research is expected to rise to USD 11.78 billion by 2025

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and to generate an additional USD 1 trillion by 2023, thereby boosting India's economy. AI and ML have begun to attract attention due to their success in being able to accurately predict diseases in their nascent stage based on historical health datasets. AI and automation in health care using AI have developed rapidly, particularly for early discovery and problem-solving applications [2].

Though the COVID-19 pandemic has caused extensive social and economic disruption, it has disinterred the potential of AI technologies and positively influenced the demand for it. Appen's State of AI 2020 Report has shown that 41% of companies accelerated their AI strategies and use during COVID-19 [3]. As per the study conducted by the National Center for Biotechnology Information in 2020, AI-based algorithms have been able to accurately detect 68% of COVID-19 positive cases in a dataset of patients who had been diagnosed as negative cases by professionals [4].

For fatal diseases such as cancer, heart related diseases, and diabetes, as well as computed tomography, AI can be utilized to find accurate and effective innovations which will result in enhanced cures of patients who are going through adversity with these diseases. It can also search for possible remedies for such problems. The old methodologies of analysis and deducing critical clinical diagnostics have been superseded by switching to AI technology. Algorithms in AI help to manifest systems which are precise enough by gradually learning from data. This proves fruitful as unknown patterns can be recognized which help to produce a variety of treatments and accurate diagnostic results. Implementation of AI/ML technologies in enhancing patient care, reducing machine runtime, and minimizing care expenses have given an impetus to the growth of AI in the healthcare industry. When it comes to this industry, especially in the matter of life and death, the promise of AI to improve health outcomes is interesting and fascinating. As noted by the global tech market advisory firm ABI Research, the AI market in the healthcare and pharmaceutical industries is expected to increase from USD 463 million in 2019 to more than USD 2 billion over the following five years [5]. AI is developing drastically in the healthcare sector and its uses are becoming a reality in many medical fields and specialties (Figure 1.1).

Though there has been commendable progress in the field of AI research, a plethora of lacunas still exist when it comes to actually implementing this technology in healthcare. Some of the factors include lack of awareness, lack of trust in technology, lack of infrastructure, and lack of medical

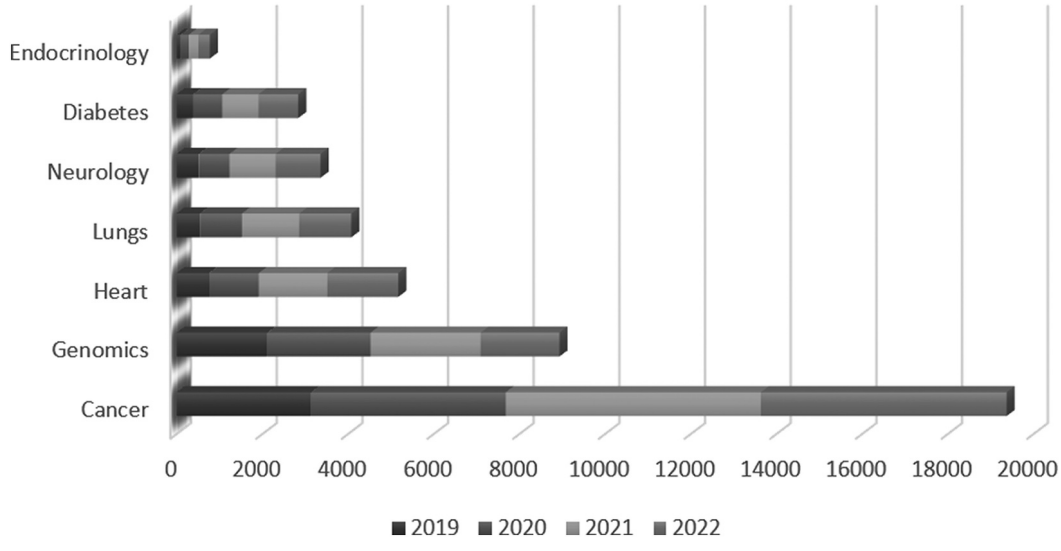

FIGURE 1.1 Research papers published on healthcare in the AI literature. The comparison has been made based on the number of different papers available on the PubMed database.

professionals who are comfortable with technology. This chapter analyzes recent inventions in the domain of AI in healthcare and is aimed at understanding its potential and the risks involved in trying to find solutions to the challenges.

1.2 MOTIVATION

A perfect alliance of increased computer processing speed, a large AI talent pool, and larger data collection libraries has enabled the expeditious development of AI tools and technology within the healthcare sector. AI can use futuristic advanced algorithms to learn features from a large volume of healthcare data, and then utilize the obtained insights to be of service to clinical practice. Also, it can be equipped with learning and self-correcting abilities to improve its accuracy based on feedback. An AI system is capable of assisting physicians by providing up-to-date medical information from journals, textbooks, and clinical practices to inform about proper patient care. Additionally, an AI system can help to reduce diagnostic and therapeutic errors that are inevitable in human clinical practice. Furthermore, an AI system brings out useful information from a large patient population to assist in making real-time inferences for health risk alerts and health outcome prediction.

1.3 LITERATURE REVIEW

Recently, a lot of progress has been made in the field of AI, especially in the healthcare sector, to the point where there have been debates going on as to whether AI will replace medical physicians in the future. AI has great potential in any field owing to its ability to adapt and learn from past mistakes, improvise, and its ability to predict the future when complemented with features like the ability to work in hazardous conditions, perform redundant tasks without fatigue, and all with precision. Currently, the USA is the leading country using AI in healthcare, followed by China and India. In this section, we survey the current AI technologies being used in healthcare or which have the potential for being incorporated in it.

In [6], the authors review the use of AI in healthcare and discuss two major AI categories – ML and natural language processing (NLP) – for performing various healthcare related operations, followed by a survey of applications of AI in stroke care. ML can be used for finding patterns between data and analyzing medical images and other structured data like genetic and electrophysiological (EP) data. NLP can be used for understanding unstructured data primarily in the form of notes and prescriptions to extract information from texts and convert it into a format that can be used by machines ultimately performing ML techniques to gain insights to predict results. For ML, the authors discuss its two major categories: supervised leaning models that include those like support vector machine (SVMs), neural networks (NNs), logistic regression, decision trees, and random forest; and unsupervised learning that works on methods like clustering and principal component analysis (PCA).

In [7], the authors discuss the application of Explainable AI (XAI) methods for elaborating the rationale behind the techniques of AI and the predictions made by it for people, characterized by its increased transparency of processes, liability to stakeholders, result tracing, and overall assistance in improving the performance of models. Nowadays, various AI models exist that are self-explainable and perform predictions quite well, but the challenge with such models is that they put a limit on the models that could be explored and could have otherwise provided better results if not for the lack of explainability of those models. This emphasizes the need for methods like XAI that can explain any AI model. Based on predictions made by a particular AI model, XAI can be used to explain the results and compare them using a clinician's logic. In the case of contradiction, errors can be traced and used for improving the AI model.

In [8], the authors discuss the applications of deep learning in the fields of bioinformatics, medical sensing, imaging, and so on. Unlike traditional NNs, deep learning uses many hidden neurons, which account for its higher quality of abstraction of raw data that helps to perform

better operations especially in the field of healthcare by generating features that are usually difficult to elucidate, such as determining DNA or RNA nucleotide sequences and identifying irregularities in cells and tissues. Further, the authors conduct a comparative study of various deep learning architectures along with their pros and cons and discuss the applications of the architecture in healthcare. Though deep learning extensively helps to overcome various complex issues in healthcare, it has some challenges, such as the extensive requirement of data, is highly time-consuming, and can be complex due to its requirement of the optimal estimation of parameters, amongst other things.

In [9], the authors discuss AI in the field of healthcare. They have a particular focus on the healthcare system in India. They discuss the usefulness of AI in helping during the COVID-19 pandemic, which proved to be very useful for contact tracing. It easily assisted in screening the symptoms to identify whether a person was COVID positive or negative. In India there are various healthcare systems. But there is a lack of technology used to enhance the growth of medical treatment. There is a need for proper and accurate data to train AI systems so that they can easily carry out the tasks which are critical for normal human doctors and other medical staff. The government should formulate policies which will be useful for collecting information from patients and the population and to use it to develop a better medical system.

1.4 TECHNOLOGY IN HEALTHCARE

Many industries have been advanced and made efficient using AI, especially healthcare. A previously only imagined industry has now become a truth of everyday life. It is being used by mankind in all possible ways to make life easier. The IT industry is radically evolving and standing out because of AI. The essential division portraying the focus of AI consists in processing detailed facts for managing health systems, automated health records, and the active direction of doctors in their health verdicts [10]. The emerging benefit of AI systems provides a facility to support health professionals, mainly in diagnosis, and which has received mainstream consideration from a research perspective. In the coming years, AI will detect numerous other advanced ailments when it is reorganized with more skill and furnished with more comprehensive facts.

Advancements in healthcare have clear advantages, such as enabling patients to improve their choices and results, and also possible subordinate advantages, such as fewer referrals, cost reduction, and time saving. These could also allow remote data access and endorse employment and maintenance in rural areas [11], in order that this provides a more unbiased scheme of worldwide healthcare in poor-resource situations in high and low-income nations. Some of the technologies of AI that are progressively changing the healthcare industry are mentioned below.

1.4.1 Accurate Cancer Diagnosis

There are AI libraries which are helpful for pathologists. They can precisely diagnose their patients using such tools. The AI library which is useful for them is PathAI. During the diagnosis of a disease like cancer errors are not tolerable; AI helps to overcome such errors and it also provides techniques which can be used in treatment. As a result of advancements taking place in the field of AI, cancer can be detected at an early stage; before the disease becomes established, it can be traced and cured, saving precious life.

1.4.2 Premature Detection of Lethal Blood Diseases

Use of AI to diagnose blood-related diseases which are lethal is of utmost importance, as when done at an early stage enables a timely cure. *Staphylococcus* and other bacteria like *E. coli* in the blood can be easily scanned at a rate which is comparatively faster than manual scanning. This is possible with the use of microscopes which are AI-enhanced [12]. To train the AI to scan and find the harmful

bacteria, images of over 25,000 blood samples were used. This helped the model to detect bacteria that were harmful to humans [12]. Machines augmented with the power of AI enabled the identification of the bacteria in samples of blood and, when new samples were provided, the existence of such bacteria was accurately predicted. The accuracy was 95% which helped to reduce the rate of fatality on a large scale.

1.4.3 Customer Service Chatbots

Chatbots are made by using computer technologies like NLP. These chatbots permit patients to raise their doubts regarding appointments, services, payments, etc. Chatbots can help patients with their ailments, medications, and recognize symptoms. This is achievable by the communicating power of chatbots which in turn helps to lower the burden on healthcare professionals.

Chatbots assist in providing solutions of some basic problems, thus allowing healthcare experts to focus on other tasks which are crucial. This use of AI in healthcare is attractive to patients and enables improved cures and treatment, resulting in better outcomes.

1.4.4 Treatment of Odd Diseases

BERG is an AI-based platform founded on biotechnology that works on portraying diseases to increase the pace of developing and producing innovative and advanced vaccines as well as medicines, thus showing a new way forward for healthcare. Interrogative biology and research and development (R&D) are used to enable professionals to innovate and produce robust medical treatments for patients who suffer from rare diseases.

BERG has delivered findings for the therapy of Parkinson's disease [12]. This disease causes disorders in the human brain, giving symptoms like stiffness, vibration, and difficulty in performing easy actions like being steady, walking, or making coordinated movements. The ailments of Parkinson's disease gradually worsen as time passes by. BERG makes use of AI to establish the linkage between a human's body chemicals that were earlier unknown. As a result, the usage of AI is proving to be tremendously helpful in the medical industry and will continue to be so in the coming period.

1.4.5 Automation of Repetitive Jobs

An important role of AI is to automate the performance of repetitive and time-consuming functions in medical and affiliated work. As a result, medical professionals and other workers can utilize the time saved to carry out emergency tasks. An example of this is "Olive". This is a platform based on AI. It mechanizes the process of checking whether judicially unsettled medical claims are eligible; it also conveys the medical data to the respective professionals, etc. Olive can easily incorporate the tools and other necessary software existing in the hospital. Thus, it eliminates the downtime required for integrating a new AI tool.

1.4.6 Handling and Supervision of Medical Records

As the first step in healthcare is to manage, analyze, and compile large amounts of data, such as medical records, data management is the most widely used application of AI and digital automation. Important and costly data may not be visible in a heap of data, but rather be like needles in a haystack. This could lead to huge losses, in billions of dollars, within a year for an industry [12]. Also, if significant data analysis is not done then this can result in the decline of growth in finding new medications and drugs.

Thus, medical firms turn to AI to resist the loss of significant information. AI increases the pace of connecting significant data and extracting useful knowledge which traditionally took many years.

1.4.7 Development of New Medicines

As the healthcare industry advances with technology, the development of new medicines is not far away. Seeking cures and finding drugs are time-consuming and exhaust monitory assets, as trials go on for long periods. The distinct advantage of AI technology is that it helps medical experts to scan previous drugs and utilize them to design a remedy which will be effective against a specific illness. This is how drugs are developed at cheaper cost.

1.4.8 Robot-assisted Surgery

The automation world has been growing rapidly, as has robot-assisted surgery which is gaining admiration nowadays. Various hospitals use robotics which help them and aid them to accomplish tasks which are precision oriented and need monitoring as well as having quick adaptability [13]. This is linked with minimally infectious surgical procedures performed through tiny slits. It is utilized to accomplish medical support like open-heart surgery and tasks that humans cannot accomplish with precision. Mechanical arms, surgical equipment, high-definition video and image capturing cameras, and so on, when integrated into a robot, make it possible to precisely diagnose and cure, resulting in enhanced and efficient surgery.

Operations which are carried out in an environment where AI robots are helping break down complexity and enable tasks to be performed smoothly and increase the recovery rate.

1.4.9 Automation of Medical Image Diagnoses

Applications based on AI make it easy to decode pictures resulting in enhanced analysis. Deep Learning technologies and functionalities are used by AI. This can enhance the speed and accuracy of scanning images obtained from sources like CT scans as well as MRIs. Automated diagnostics of images results in the enhanced accomplishment of tasks by doctors which in turn improves disease recognition in a patient. This tool has proven to be essential to carry on the work of radiologists and similar critical medical task requirements. AI growth in recent years in the field of image processing has been elevated (Table 1.1).

TABLE 1.1
Comparative Study of AI Applications in Healthcare Along with the Technology Used

Healthcare Applications	Technology
Obesity management	NLP, chatbot, SVMs, neuro-fuzzy model, artificial neural network (ANN)
Cardiac arrhythmia	Supervised ML, convolutional neural network (CNN), ANN
Renal disease	CNN, ANN, Random Forest (RF), multivariate logistic regression
Diabetes	Hierarchical recurrent neural network (HRNN), ANN, SVM, evolutionary algorithms
Chemotherapy	Reinforcement learning, supervised ML
Thyroid diseases	SVM, CNN, Koios DS
General surgery	ML, robotics
Prediction of ovarian cancer	Neural networks, supervised ML, Deep Convolutional Neural Network (DCNNs)
In vitro fertilization (IVF)	Multilayer perceptron (MLP), CNN, SVM, Bayesian networks (BNS)
Prediction of male infertility	AutoML Vision, SVM, MLP
Retinopathy	RetmarkerDR, IDx-DR, Eye Nuk
Alzheimer diagnosis	RestNet18, CapsNets, deep neural networks (DNNs)
Identification of genetic patterns and disorders	DeepVariant, domain adaptive neural networks (DANNs), SpliceAI
Mental health	NLP, DL, supervised ML
Drug discovery and design	Machine learning

1.5 CHALLENGES AND SOLUTIONS

Despite the extensive research and progress, the implementation of AI to solve real world problems is often difficult. It often poses ethical issues that need to be addressed [14]. Though these challenges should not be considered as a reason to totally discard AI technologies [15]. Rather, there is a need to understand the risks and challenges involved in the incorporation of AI in healthcare and to try to bridge the gap existing there (Figure 1.2).

1.5.1 AI Bias

AI algorithms require a large amount of data during training. This data basically determines how the model will perform on unseen data. Hence, the data provided should be representative of the target population and should not be biased in that they must represent all classes equally, which for example has been demonstrated in an algorithm for auditory tests for neurological diseases by Winterlight Labs, a Canadian Company [27]. This registered the way a person spoke and analyzed the data to determine the early stage of Alzheimer's disease. The majority of the data collected

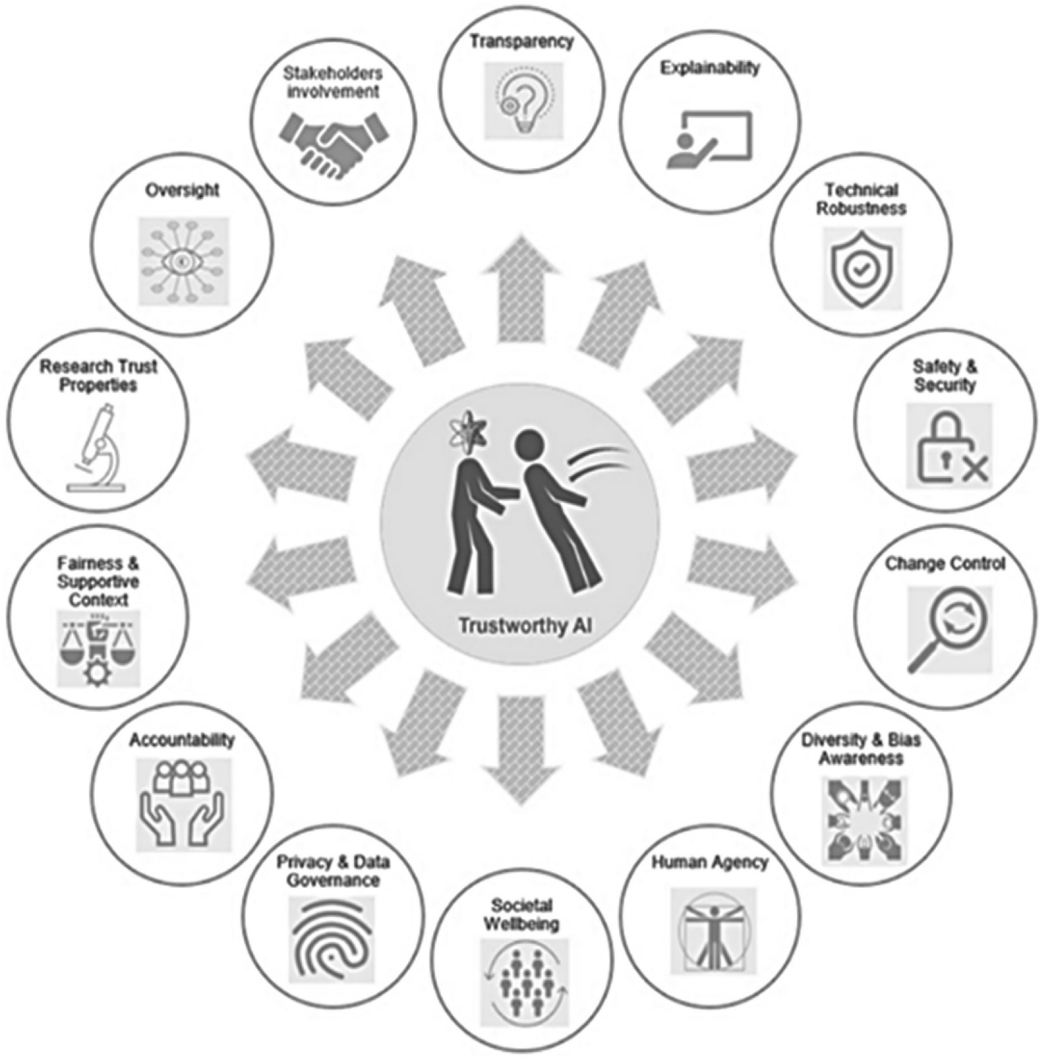

FIGURE 1.2 Different challenges currently faced by AI.

corresponded to native English speakers. The accuracy obtained was greater than 90%; however, the test produced inaccurate results for non-native English. The pauses and mispronunciations were identified as symptoms of the disease. Although the notion of bias is complex, humans too have prejudiced thinking. This necessitates the design of ethical AI systems that help to identify human biases and lead to outcomes that are fair and free from any kind of discrimination.

Some ways in which it is possible to reduce AI bias are:

1. Narrowing the problem definition: This can reduce the number of labels required in the dataset since information that is too general would make it difficult to develop a clear framework for examining the research problem.
2. Improve diversity: This is necessary to ensure that the data represents the maximal diversity of the population in order to include any minority groups that might be left out due to social discrimination such as poor access to healthcare facilities.
3. Understand the end users: This is necessary in order to acknowledge the fact that people come from different backgrounds and hence have different experiences. It is important to anticipate how different people would interact with the technology.

1.5.2 Personal Security

Data concerning the health of a patient is sensitive information since it is linked with the physical and mental well-being of the patient and his or her personal autonomy. Unauthorized disclosure or misuse of healthcare data could lead to a breach of the fundamental rights of patients and psychologically or physically harm them. Since AI models require a huge amount of data for their training there is a possibility that such data collected from patients could be used without their consent. Examples depicting present concerns about privacy breaches include the recent case of Cambridge Analytica, a British consulting firm that used personal data which was collected by Facebook for political advertising, and the case of the Royal Free London NHS Foundation trust that shared the private data of its patients for the development of a medical application without obtaining the patients' consent explicitly [16]. Hence, it is an ethical necessity to respect the confidentiality of patients and ensure that consent is obtained from them before any health interventions as well as before accessing, sharing, or using their private data.

Some ways in which it is possible to ensure security are:

1. Establishing business agreements: Under the Health Insurance Portability and Accountability Act, 1996, organizations called "covered entities" are required to protect patients' health data. Hence, health organizations should establish business agreements with AI vendors that ensure the protection and security of data.
2. Protection of data resources: The servers and computers that store and retrieve patient health data for research purposes must be secure and data should solely remain within the concerned organization's jurisdiction.
3. Data anonymization: Data should be shared with researchers and developers only after they have been properly de-identified. The entities using the data must be bound under ethical laws to prevent attempts at re-identification or reselling.

1.5.3 Transparency

AI is a relatively new term, and a lot of people are still skeptical about its applicability and incorporation in real world scenarios [17]. In healthcare as well, though the performance of AI in the investigation of therapeutic cloning and medical danger estimation has been extremely

promising, it is hard to expound the model since the software may learn and evolve over time, quickly repealing algorithmic explanations. This increases problems in the medical world, where clarity and the capability to describe scientific verdicts are very important. Lack of transparency can reduce the credibility of AI models in healthcare. In some cases, AI vendors include clauses in the contract which solely hold the clinical professional responsible in the case of any errors. The burden of lack of knowledge in detecting problems is entirely placed on clinicians, patients, or other consumers, making the former liable and consumers and patients vulnerable. It is very crucial for medical professionals to understand the system before using it since they will be held liable if they ignore any system warnings or alerts. Patients should also be involved in the process so as to allow them to make decisions related to their health themselves without duress or any kind of undue pressure.

Transparency in AI can be ensured through:

1. Using XAI: XAI frameworks are tools that try to explain AI. The concept here is to combine simpler and more sophisticated models. The main emphasis of XAI techniques in healthcare and the medical sector is the functional understanding of the model as opposed to algorithmic understanding that is not so complex [18]. Though XAI frameworks tend to be simple, they are not very accurate. Hence, it is necessary to maintain a balance between explainability and sophistication.
2. Involving clinicians in the process: AI algorithms tend to perform well on certain data but perform poorly on some other. If clinicians are educated about concepts like AI bias, they might be able to identify and provide suitable patient data on which the AI algorithms can be implemented.
3. Divulgence and consent: To be able to accept new technology, people must trust the technology, and in order to build trust, transparency has to be ensured. This means that entities who are impacted by the AI system are aware and have provided consent to be a part of an automated system.

1.5.4 Data Formats

Formats in AI application development are mainly image data formats and image annotation formats. The Digital Imaging and Communication in Medicine (DICOM) format is used by most Picture Archiving and Communication Systems (PACS) to store medical images, which can be converted into other formats like PNG or a TIFF, by groups who collect such images. During such conversion, important DICOM metadata are erased [19]. Image annotation storage is not in a single file format. Current commercial imaging systems that obtain image annotations face a major limitation of reuse for AI development as they do not store annotations in the required format [20].

To solve the problem of data formats the DICOM standards can be adopted.

To save regions of interest in an image, there exists an important image annotation format: DICOM segmentation map format [21]. This is a part of the DICOM standard. Image labels, i.e. radiologic findings or diagnoses, and Annotation and Image Markup (AIM) were developed and incorporated recently into the DICOM-SR standard [20]. DICOM can be used to store data from various medical imaging systems including those from CT scans, MRI or ultrasound (Figure 1.3). This was developed for nongraphic annotations. This standard has been supported by a few AI product vendors and PACS. The adoption of these standards for image annotation data storage will enable sharing, such as multicenter sharing, aggregating, and repurposing, for the study of quantitative imaging biomarkers [19].

DICOM Web Viewer (DWV) is a browser-based DICOM image viewer written in JavaScript and HTML [2].

FIGURE 1.3 DICOM web view of Patella (knee cap).

1.5.5 Societal Acceptance/Human Factors

Generally, many patients show acceptance towards incorporation of new technology and are willing to give it a try. People are open to AI-based diagnosis, but when it differs from that of the doctor, patients tend to start doubting AI technology. Apart from this, medical workers in less developed areas are concerned about whether AI technology will replace them and make them unemployed in the future. Although AI may aid cost saving and reduce the stress that is built into clinics, it may also lead to unemployment by rendering certain jobs redundant and automating them. To date, there are many people who fear that AI in the healthcare sector might lead to unemployment because it has been proved that in certain scenarios it gave better results as compared to humans. This makes more sense when it comes to those healthcare professionals who invested time and money in pursuing a medical education, thereby introducing egalitarian challenges. AI promises to improve several facets of healthcare and medicine but it is still vital to consider the social ramifications of integrating this technology (Figure 1.4 and Table 1.2).

It is understandable that people fear that the development of AI in the healthcare sector might lead to unemployment. But to solve or treat this fear we should keep the following things in mind:

1. If the number of jobs in one sector is decreasing, then at the same time the needs of people are increasing in another sector. To create AI models, we require more and more intelligent brains, i.e., we need people who have knowledge of medicine or technology or both.
2. We need to understand that enhancing the accessibility of data and using them to understand patterns can assist healthcare professionals in taking the right steps towards preventing illnesses at an early stage. Also, real-time data which are characterized by their high velocity can prove to be of great value for informing diagnoses.

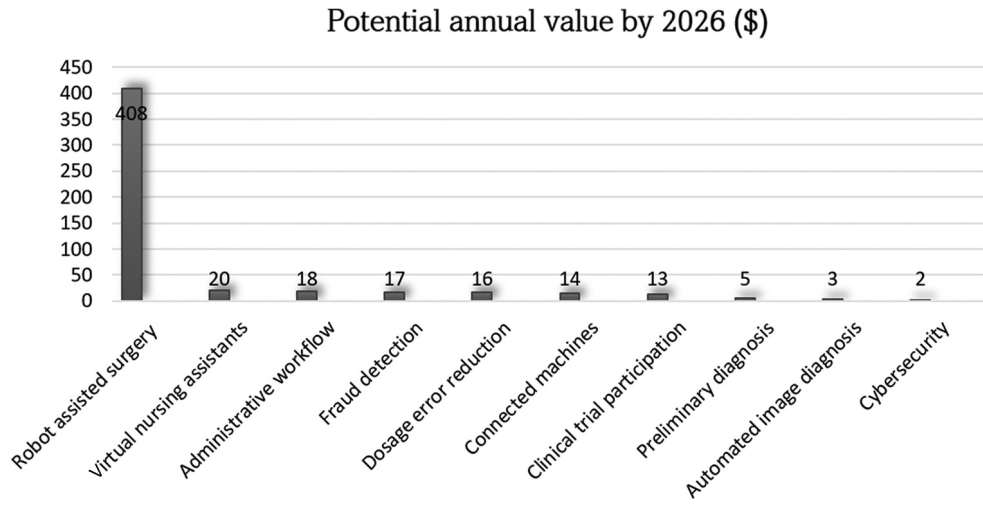

FIGURE 1.4 AI applications that could change healthcare [22].

TABLE 1.2
AI Applications and Its Key Drivers [22]

Application	Key Drivers in Adoption
Robot-assisted surgery	Technological advances in robotic solutions for more types of surgery
Virtual nursing assistants	Increasing pressure caused by medical labor shortages
Administrative workflow	Easier integration with existing technology infrastructure
Fraud detection	Need to address increasingly complex service and payment fraud attempts
Dosage error reduction	Prevalence of medical errors, which leads to tangible penalties
Connected machines	Proliferation of connected machines/devices
Clinical trial participation	Patent cliff; plethora of data; outcomes-driven approach
Preliminary diagnosis	Interoperability/data architecture to enhance accuracy
Automated-image diagnosis	Storage capacity; greater trust in AI technology
Cybersecurity	Increase in breaches; pressure to protect health data

3. Most importantly, we need to remember that AI is just a product developed by humans. It still requires human assistance and surveillance, it may neglect or fail to perceive social factors, it might experience gaps in population information, and it is very susceptible to cyberattacks, owing to the advancement of technology and the rise in instances of extremely proficient and calculated cyberattacks.

From this section we can conclude that, despite the challenges and limitations AI faces, both it and humans are equally important for the development of the healthcare sector in the coming years.

1.6 CONCLUSION AND FUTURE SCOPE

We believe that AI has a paramount role to play in the advancement of healthcare in the future. For example, machine learning, a subset of AI, is the prime mover behind the roll out of precision medicine, which is widely believed to be an indispensable element of the healthcare domain [24, 26]. Although initial efforts at providing diagnosis, disease detection, and treatment guidance are exigent, we expect that AI will eventually master that domain as well. Owing to the rapid advances

in AI for medical imaging analysis, there is a possibility that most radiology and pathology images will be examined at some point in the future by a machine. Speech and text recognition are already working for tasks like patient communication and capture of clinical notes, and their usage will escalate gradually [20].

AI plays a crucial role in the domain of biomedicine, not only because of its nonstop advancement, but also due to the connatural multifaceted nature of biomedical glitches and the aptness of AI to resolve such issues. AI has been chasing an extensive series of healthcare requests. In particular, it has been used in signal processing, image processing, and for estimations of variations in functions such as urinary bladder control, epileptic seizures, and stroke predictions. The development of biomedicine involves the innovations emerging from AI. This combination of supply and demand and its relation to development will permit the two fields to be enhanced meaningfully in the foreseeable future, which will eventually ameliorate the life of individuals in society.

The use of AI is associated with a number of moral and social issues pertaining to the lack of transparency and trustworthiness among the general population. Many of these issues are related to those raised by the use of data and healthcare technologies more broadly. A key challenge for the future governance of AI technologies will be ensuring that it is developed and used in a way that is clear and suited to the public interest, whilst driving innovation in the sector.

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