

HEALTHCARE INDUSTRY

Edited By

Abhishek Kumar, T. Ananth Kumar, Prasenjit Das, Chetan Sharma, and Ashutosh Kumar, Dubey



WILEY

# Explainable Artificial Intelligence in the Healthcare Industry

#### **Scrivener Publishing**

100 Cummings Center, Suite 541J Beverly, MA 01915-6106

Publishers at Scrivener
Martin Scrivener (martin@scrivenerpublishing.com)
Phillip Carmical (pcarmical@scrivenerpublishing.com)

# Explainable Artificial Intelligence in the Healthcare Industry

Edited by

Abhishek Kumar T. Ananth Kumar Prasenjit Das Chetan Sharma

and

**Ashutosh Kumar Dubey** 





This edition first published 2025 by John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA and Scrivener Publishing LLC, 100 Cummings Center, Suite 541J, Beverly, MA 01915, USA © 2025 Scrivener Publishing LLC

For more information about Scrivener publications please visit www.scrivenerpublishing.com.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, except as permitted by law. Advice on how to obtain permission to reuse material from this title is available at http://www.wiley.com/go/permissions.

#### Wiley Global Headquarters

111 River Street, Hoboken, NJ 07030, USA

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

#### Limit of Liability/Disclaimer of Warranty

While the publisher and authors have used their best efforts in preparing this work, they make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives, written sales materials, or promotional statements for this work. The fact that an organization, website, or product is referred to in this work as a citation and/or potential source of further information does not mean that the publisher and authors endorse the information or services the organization, website, or product may provide or recommendations it may make. This work is sold with the understanding that the publisher is not engaged in rendering professional services. The advice and strategies contained herein may not be suitable for your situation. You should consult with a specialist where appropriate. Neither the publisher nor authors shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages. Further, readers should be aware that websites listed in this work may have changed or disappeared between when this work was written and when it is read.

#### Library of Congress Cataloging-in-Publication Data

ISBN 9781394249268

Front cover images supplied by Adobe Firefly Cover design by Russell Richardson

Set in size of 11pt and Minion Pro by Manila Typesetting Company, Makati, Philippines

Printed in the USA

10 9 8 7 6 5 4 3 2 1

# **Contents**

Pr	eface	: x	xix
1	A R	eview on Explainable Artificial Intelligence for Healthcare	1
	Rak	hi Chauhan	
	1.1	Introduction	2
	1.2	Literature Review	3
	1.3	Reason for Using XAI	7
		1.3.1 Applications of XAI Algorithms in Different Scenarios	8
		1.3.2 Discussion on Different Aspects of XAI	8
	1.4	Challenges and Future Prospects	10
	1.5	Conclusion	11
		References	12
2	Exp	lainable Artificial Intelligence (XAI) in Healthcare:	
	_	tering Transparency, Accountability, and Responsible	
		Deployment	17
	Ash	a S. Manek, Shruti Vashist, Geeta Tripathi	
	and	Savita Sindhu	
	2.1	Introduction	18
	2.2	Roles of XAI	20
	2.3	Why XAI	22
	2.4	XAI in Different Sectors	23
	2.5	XAI in Healthcare	26
	2.6	Challenges of XAI Adoption	28
	2.7	Models Used in XAI Adoption	30
	2.8	Conclusion	32
	2.9	Future of XAI in Healthcare	33
		References	34

### vi Contents

3			ng the Diagnostic Path: Unveiling Explainability	
			Imaging	39
			ım S., Anwar Basha H., Thanuja K.,	
	Shaf	,	nu M., Maithili K. and AnilKumar Ambore	
	3.1		luction	40
	3.2	The N	eed for Explainability in Medical Imaging AI	42
			d Works	43
	3.4		nable AI Techniques for Medical Imaging	44
			Saliency Maps	44
			Attention Mechanisms	46
			Decision Trees	46
		3.4.4	Gradient-Weighted Class Activation Mapping	
			(Grad-CAM)	47
		3.4.5	LIME (Local Interpretable Model—Agnostic	
			Explanations)	47
			Integrated Gradients	48
		3.4.7	SHAP (SHapley Additive exPlanations)	48
		3.4.8	Layer-Wise Relevance Propagation (LRP)	48
			SmoothGrad	49
			Occlusion Sensitivity	49
		3.4.11	Feature Visualization	50
			Attention Condensation	51
		3.4.13	Counterfactual Explanations	51
	3.5	Real-V	Norld Applications and Case Studies	51
	3.6	Deep :	Learning Approaches for Pneumonia Identification	
			est X-Ray Images: Methods and Methodology	53
			Dataset Collection and Preprocessing	53
			Deep Learning Model Selection	53
			VGG16	53
			Inception V3	54
			ResNet 50V2	55
			Training and Evaluation	55
	3.8		mance Evaluation	58
	3.9	Comp	arative Analysis	59
		3.9.1	Implications for Regulatory Compliance, Patient	
			Safety, and Ethics	60
			Regulatory Compliance	60
			Patient Safety	60
	3.10	Ethica	l Considerations	61

			CONTE	ENTS	VII
	3.11	Advar	ncing Clinical Workflows with Explainable AI		61
		Concl			62
		Refere	ences		63
4	Haal	lattaale	th A.L. Huyyailing Danganalinad Haalth as no Insight		
4			thAI: Unveiling Personalized Healthcare Insight Source Fine-Tuned LLM	8	67
		•	and Lakshmi Sangeetha		07
		-	duction		68
	4.1		HealsHealthAI Objective		68
	12		w Analysis		68
	7.2		Literature Review		68
			Additional Review		69
	43	Motiv			70
	1.5		Motto		70
	4 4		odology		70
	1.1		Data Collection and Processing		70
			Storage		70
			User Interaction		71
			Model Creation and Loading		71
	4.5		LLMs, FAISS, and Langchain are Utilized		
			alsHealthAI		71
		4.5.1	Personalized Insights		71
			Langchain in HealsHealthAI		71
	4.6		el Overview and Working		72
		4.6.1	Overall Flowchart		72
		4.6.2	Showcases of HealsHealthAI's Functionality		73
	4.7	Comr	nunity Contribution		73
		4.7.1	The Call for Contributions		73
	4.8	Exper	rimental Findings		74
			Quantitative Performance Metrics		74
		4.8.2	Results		75
			Scalability and Resource Usage		75
	4.9		enges and Future Paths		76
			Known Issues		76
			Deployment Without Internet Connectivity		76
	4.10	Concl			76
		Refere	ences		76

5	Introduction to Explainable AI in EEG Signal Processing:							
	A Re	eview	79					
	Para	ng Puranik and Rahul Pethe						
	5.1	Introduction	80					
	5.2	Solution Approaches	82					
		5.2.1 Survey of Machine Learning for EEG Signal Processing	82					
		5.2.2 DL Procedures for EEG Signal Processing	85					
		5.2.2.1 Neural Network for EEG	87					
		5.2.3 Feature Extraction and Pre-Processing for EE	87					
	5.3	Classification Models for EEG Signals	87					
	5.4	Results and Discussions	93					
	5.5	Future Scope and Issues	95					
	5.6	Proposed Methodology	96					
	5.7	Conclusions	98					
		References	99					
6	Tran	sparency in Disease Diagnosis: Leveraging Interpretable						
		hine Learning in Healthcare	105					
	Inam Ul Haq, Adil Husain Rather, Syed Zoofa Rufai,							
	Ahmad Shah, Sheetal and Akib Mohi Ud Din Khanday							
	6.1	Introduction	106					
	6.2	Introduction to the Overarching Theme of Transparency						
		and Accountability in AI-Driven Healthcare Solutions	108					
	6.3	The Significance of Model Interpretability in Clinical						
		Decision Making and Patient Management Within the						
		Context of Disease Diagnosis	110					
	6.4	Importance of Model Interpretability	112					
	6.5	Examination of How Interpretable ML Models Facilitate						
		Clearer Understanding and Interpretation of Diagnostic						
		Decisions	113					
	6.6	Importance of Transparency in Ensuring Accountability						
		and Fostering Acceptance of AI Technologies Among						
		Healthcare Professionals and Patients	115					
	6.7	Techniques for Interpretable Machine Learning	116					
	6.8	Explanation of How Each Technique Contributes						
		to Enhancing Diagnostic Accuracy While Providing						
		Transparent Decision Rationale	118					
	6.9	Comparative Analysis of Different Interpretable ML						
		Approaches in Terms of Their Applicability and Effectiveness						
		in Disease Diagnosis	119					
	6.10	Case Studies and Applications	121					

	6.11	Examin	nation of How Interpretable ML has been Utilized	
			rove Disease Diagnosis, Treatment Planning,	
		-	tient Outcomes	124
	6.12	Analys	is of the Benefits and Challenges Associated with	
			nenting Interpretable ML in Clinical Practice	
		Throug	gh Case Examples and Empirical Evidence	125
	6.13	Conclu	ision	126
		Referen	nces	127
7	Tran	sparen	cy in Text: Unraveling Explainability in Healthcare	
	Natu	ıral Lan	nguage Processing	131
	Mad	han Ve	eramani, Karthick P., S. Venkateswaran,	
	Srim		Shaik Thasleem Bhanu and V. Seedha Devi	
	7.1	Introdu		132
	7.2		ch Objectives	134
			The Promise of NLP in Healthcare	135
			Challenges in NLP Models in Healthcare	135
			The Importance of Transparency and Explainability	136
	7.3		nt Research Landscape	136
	7.4		d Works	137
			ure Survey	139
	7.6		ble of Explainability in Healthcare NLP	141
			Defining Explainability in Healthcare NLP	141
			Limitations of Traditional Black-Box NLP Models	141
			Benefits of Transparent and Interpretable NLP Models	142
	7.7		cing Clinical Documentation with Interpretable NLP	143
			Methodology	145
			System Development	146
			Integration of Explainable AI Techniques 7.7.3.1 Steps	<ul><li>147</li><li>148</li></ul>
	7.8		ure Survey: Integrating Explainable AI Techniques	140
	7.0		atural Language Processing for Healthcare	149
	7.9		nentation Process	151
		Results		153
			nges and Future Directions	154
			Directions	154
			Considerations and Regulatory Implications	155
		Conclu	·	155
		Referen	nces	156

8			_	plainable AI in Healthcare: Enhancing	
		•	ncy and T		161
				Chaithanya Kumar Viralam Ramamurthy,	
	Sara			varan and Shermin Shamsudheen	
	8.1	Intro		Explainable AI in Healthcare	162
		8.1.1		lution of AI in Healthcare	162
		8.1.2		ed for Explainable AI	162
	8.2	Explo	ring Expl	lainability Techniques	163
		8.2.1	Machin	e Learning Explainability Methods	164
		8.2.2	Explain	ability in Deep Learning	164
		8.2.3	Explain	able Natural Language Processing (NLP)	165
	8.3	Real-	World Ap	plications and Case Studies	166
		8.3.1	Enhanc	ing Clinician Comprehension	166
		8.3.2	Facilitat	ing Regulatory Compliance	167
		8.3.3	Fosterin	g Patient Trust	168
		8.3.4	Patient-	Centric Applications of Explainable AI	168
			8.3.4.1	Shared Decision Making	168
			8.3.4.2	Personalized Care Planning	169
			8.3.4.3	Empowering Patient Advocacy	169
	8.4	Challe	enges and	l Ethical Considerations	169
		8.4.1	Ethical 1	Implications of Explainable AI	170
			8.4.1.1	Discussion of Ethical Principles	170
			8.4.1.2	Fairness	170
			8.4.1.3	Accountability	170
				Patient Privacy	170
		8.4.2		ng Transparency with Privacy	170
			8.4.2.1	Pseudonymization and Data Anonymization	171
			8.4.2.2	Granular Access Controls	171
			8.4.2.3	Consent and Opt-Out Mechanisms	171
		8.4.3		ciplinary Collaboration and User-Centered	
			Design	•	171
			8.4.3.1	Importance of Collaboration	171
			8.4.3.2	Ethical Review Boards	171
			8.4.3.3	Ethics-Driven Design	172
		8.4.4		entered Design Principles	172
				Human-Centered AI Interfaces	172
				Incorporating User Feedback	172
			8.4.4.3		172
		8.4.5			173

		8.4.6	Performance Assessments	173
		8.4.7	Feedback Loops	174
	8.5	Addr	essing Ethical Concerns and Algorithmic Biases	175
		8.5.1	Ethical Decision-Support Tools: A Framework	
			for Ethical Deliberation	175
			8.5.1.1 Ethical Principles and Considerations	175
			8.5.1.2 Patient Preferences and Values	176
			8.5.1.3 Ethical Dilemma Analysis	176
			8.5.1.4 Real-Time Guidance and Feedback	177
	8.6		re Directions and Considerations	177
		8.6.1	Summary of Key Points	178
		8.6.2	1	178
		8.6.3	Benefits of Transparency, Accountability, and	
			Patient Trust	178
		8.6.4	Future Directions in Explainable AI Research	178
		8.6.5	1 / 1	179
		8.6.6	0 1 7	179
		8.6.7	Ethical Considerations and Regulatory Compliance	179
	8.7		mmendations for Policymakers, Researchers,	
			Healthcare Practitioners	179
	8.8		lusion	180
		Refer	ences	180
9	Inte	rpreta	ble Machine Learning Techniques	185
	V. K	avitha	, K. Suresh, G. Priyadharshini,	
	Sha	ik Rasl	heeda Begum and R. Vidhya	
	9.1	Intro	duction	186
		9.1.1	Definition of Interpretable Machine Learning	186
		9.1.2	Importance of Interpretability in Machine Learning	
			Models	186
		9.1.3	Real-World Applications and Implications	187
	9.2	Impo	rtance of Interpretability	188
		9.2.1	Significance in Various Domains	189
		9.2.2	7 1	189
		9.2.3	Legal, Ethical, and Regulatory Considerations	190
	9.3		niques for Interpretable Machine Learning	190
			Intrinsic Methods	191
			Post-Hoc Methods	191
		9.3.3	Hybrid Approaches	191
			9.3.3.1 Intrinsic Methods	191

#### xii Contents

		9.3.3.2	<i>Post-Hoc</i> Methods	192		
		9.3.3.3	Hybrid Approaches	192		
9.4	Intrin	sic Metho	ods	193		
	9.4.1	Decision	n Trees	193		
		9.4.1.1	How do Decision Trees Work?	193		
		9.4.1.2	Examples of Decision Tree Applications	193		
	9.4.2	Linear N	Models	194		
		9.4.2.1	When and How to Use Linear Models			
			for Interpretability	194		
		9.4.2.2	Trade-Offs Between Interpretability			
			and Model Performance	194		
9.5		Hoc Meth		195		
	9.5.1		ive Examples	195		
	9.5.2	Partial I	Dependence Plots	195		
		9.5.2.1	Construction and Interpretation	195		
		9.5.2.2	Case Studies Demonstrating the Utility			
			of Partial Dependence Plots	196		
9.6	Hybrid Approaches 19					
	9.6.1	Local In	terpretable Model-Agnostic Explanations			
		(LIME)		196		
			Conceptual Overview	196		
	9.6.2	Implem	entation Details	197		
	9.6.3		l Examples	197		
	9.6.4		SHapley Additive exPlanations)	197		
		9.6.4.1	How SHAP Values are Computed	197		
			Use Cases and Benefits	198		
9.7	Evaluating Interpretability 19					
	9.7.1		for Evaluating Interpretability	198		
	9.7.2		rison of Different Techniques	199		
	9.7.3		rations for Choosing the Appropriate Method	200		
9.8	Case		nterpretable Machine Learning in Healthcare	200		
	9.8.1	Predicti	ng Patient Readmission Risk	200		
		9.8.1.1	Challenges and Lessons Learned	201		
	9.8.2		lized Treatment Recommendations	201		
		9.8.2.1	Overview	201		
			Challenges and Lessons Learned	201		
	9.8.3	•	etection of Disease Progression	202		
		9.8.3.1	Overview of Early Disease Progression	202		
		9.8.3.2	Challenges and Lessons Learned	202		
9.9	Risk S	Stratificat	ion for Preventive Care	202		

			Con	ITENTS	xiii
	Ç	9.9.1 O	verview of Preventive Care		202
	(	9.9.2 Cl	hallenges and Impact		203
		Conclusi	-		203
		Referenc			204
10	Inter	pretable	Machine Learning Techniques in AI		209
	Shave	z, Poorn	ima, Kanu Goyal, Shweta Sharma		
	and F	Parul Sha	ırma		
	10.1	Introdu	ction		210
	10.2	History			211
	10.3	Making	ML Interpretable		212
		10.3.1	Benefits and Challenges to Interpretability		212
		10.3.2	Challenges with Interpretable ML, Including	ıg	213
		10.3.3	Limitations of Machine Learning		213
	10.4	Machin	e Learning Models		214
		10.4.1	Local Method Explanation		214
		10.4.2	Global Method Explanation		215
	10.5	Technic	ues of Interpretable Machine Learning		215
	10.6	Model o	of Intrinsic Interpretable		217
		10.6.1	Globally Interpretable Model		217
		10.6.2	Adding Interpretability Constraints		217
		10.6.3	Interpretable Model Extraction		218
		10.6.4	Locally Interpretable Model		218
	10.7	Post-Ho	c Global Explanation		219
		10.7.1	Traditional ML Explanation		219
		10.7.2	Model Agnostic Explanation		220
		10.7.3	Model-Specific Explanation		220
	10.8	DNN R	epresentation Explanation		221
		10.8.1	Explanation of CNN Representation		222
		10.8.2	Explanation of RNN Representation		223
	10.9	Post-Ho	c Local Explanation		224
		10.9.1	Model-Agnostic Explanation		224
		10.9.2	Explanation Based on Local Approximation	18	224
		10.9.3	Perturbation-Based Explanation		225
		10.9.4	Model-Specific Explanation		226
	10.10	Backpro	ppagation		226
	10.11	Mask Po	erturbation		226
		10.11.1	Investigation of Deep Representations		227
	10.12	Conclus	sion		227
		Referen	CAC		228

11	-			Learning Techniques in Medical ata Analytics and Machine Learning	233
	•			ntha D. and Lakshmi S.	233
	11.1	Introdu		mma D. ana Laksimii G.	234
	11.1	11.1.1		ation of Interpretable Methods	236
		11.1.2		Diagnosis Using Interpretable Machine	250
		11.1.2	Learning		239
		11.1.3	_	nterpretable Machine Learning	239
		11.1.5	11.1.3.1	Importance of Interpretability	237
			11.1.5.1	in Healthcare Models	240
			11.1.3.2	Challenges in Achieving Interpretability	
			11.1.3.2		241
			11.1.3.4	Human–AI Collaboration	242
	11.2	Materia	als and Me		243
	11.2	11.2.1			243
		11.2.2		Learning Algorithms	244
		11.2.2	11.2.2.1		244
			11.2.2.2	11	244
			11.2.2.3		244
			11.2.2.4		244
			11.2.2.5		245
		11.2.3		Prediction Process	246
		111210	11.2.3.1		246
			11.2.3.2	Training and Testing	246
			11.2.3.3	Implementation of the Classification	_ 10
			11121010	Model	247
	11.3	Experin	nental Res	sult and Discussion	249
		11.3.1		ince Metrics	249
			11.3.1.1		249
				Confusion Matrix	249
			11.3.1.3		250
				Precision	250
			11.3.1.5	Recall	250
		11.3.2	Results as	nd Discussion	250
	11.4	Conclu	sion		252
		Referen	ices		252
12	Interi	oretable	AI: Shedo	ling Light on Medical Image Analysis	
	_			ng Techniques	257
	_			and Prithiviraj Rajalingam	
	12.1	Introdu		, , ,	258

	12.1.1	Interpretability in AI for Healthcare	258			
	12.1.2	Scope of the Chapter	258			
12.2	Medica	al Image Analysis: A Critical Application				
	of Mac	hine Learning	259			
	12.2.1	Significance of Medical Image Analysis	259			
	12.2.2	Challenges and Complexities in Medical Image				
		Data	259			
	12.2.3	Role of Machine Learning in Automating				
		Image Analysis	259			
12.3	Interpretable AI Techniques					
	12.3.1	Historical Roots of Deep Learning	260			
	12.3.2	Google Net: A Game-Changer	260			
	12.3.3	CNN Architecture	260			
	12.3.4	Types of Learning	260			
		12.3.4.1 Learning Problems	261			
		12.3.4.2 Hybrid Learning Problems	262			
		12.3.4.3 Statistical Inference	263			
		12.3.4.4 Learning Techniques	264			
12.4	0 1 0 1					
	Open-S	Source Frameworks	265			
	12.4.1	Tensor Flow	265			
	12.4.2	Caffe	265			
		Caffe 2	266			
	12.4.4	ONNX (Open Neural Network Exchange)				
	12.4.5	Keras	266			
	12.4.6		266			
	12.4.7	Other Deep Learning Tools and Libraries	266			
	12.4.8		267			
12.5	The Machine Learning Landscape in Medical Image					
	Analys	is	267			
	12.5.1	Deep Learning Networks: Tailored Architectures				
		and Objectives	267			
	12.5.2	Image Registration: Aligning Medical Images				
		for Enhanced Analysis	268			
		12.5.2.1 Objective and Techniques	268			
		12.5.2.2 Clinical Applications and Perspectives	269			
		12.5.2.3 Tools and Toolkits	269			
	12.5.3	Object Localization in Medical Image Analysis	269			
		12.5.3.1 Objective and Techniques	269			
		12.5.3.2 Challenges in Localization	270			
		12.5.3.3 Novel Strategies	271			

		12.5.4	Classifica	tion and Detection in Medical Image	
			Analysis	_	271
			12.5.4.1	Exam Classification	271
			12.5.4.2	Object Classification	271
			12.5.4.3	Classification Algorithms	272
			12.5.4.4	Algorithm Types Related	
				to Classification	272
			12.5.4.5	Important Phrases Used in Classification	ı
				Algorithms	272
			12.5.4.6	Application in Disease Diagnosis	273
			12.5.4.7	Transfer Learning for Disease	
				Identification	273
			12.5.4.8	Hierarchical Medical Image	
				Classification	273
		12.5.5	Object D	etection in Medical Image Analysis	274
		12.5.6	Segmenta		274
			12.5.6.1	Substructure/Organ Segmentation	274
			12.5.6.2	Lesion Segmentation	274
			12.5.6.3	Role of Medical Image Segmentation	274
		12.5.7	-	f AI and Machine Learning	275
	12.6		-	plications: Interpretable AI's Role	
				are—Diagnosis, Treatment, and Analysis	275
		12.6.1		iagnosis: Unveiling Clarity	275
		12.6.2		zed Treatment Planning: Excellence	
			in Every		275
		12.6.3		cs Analysis: Expanding on It	275
		12.6.4		n of Algorithm Performance	276
	12.7		~	ep Learning for Medical Imaging	277
		12.7.1		ed Data and Lack of Confidence Interval	277
		12.7.2		Availability of Annotated Data	277
		12.7.3		n to End-to-End Learning	277
		12.7.4		mentation Techniques	278
		12.7.5	-	ability and "Black-Box" Models	278
		12.7.6		-Intensive Training	278
		Referer	ices		278
13	Explo	ring the	Role of E	xplainable AI in Women's Health:	
	Chall	enges aı	nd Solutio	ns	283
	Inam	Ul Haq	and Akib	Mohi Ud Din Khanday	
	13.1	Introdu	iction		283

	13.2	The Importance of Addressing Women's Health Concerns Beyond Major Diseases	288
	13.3	The Role of Explainable AI (XAI) in Providing Precise Medicine Solutions Tailored to Women's Specific Health	200
		Needs	289
	13.4	Challenges in the Application of Explainable AI	
		in Women's Health	290
	13.5	Women's Health Concerns	292
	13.6	The Promise of Machine Learning (ML) and Explainable	
		AI (XAI) Technologies in Women's Health	296
	13.7	Potential Applications of Machine Learning (ML) and	
		Explainable AI (XAI) Technologies in Women's Health	297
	13.8	Case Studies and Examples of Successful Implementations	299
	13.9	Specific XAI Techniques and Methodologies	299
	13.10	Conclusion	302
		References	303
14	Expla	inable AI in Healthcare: Introduction	307
	_	ideep Kaur and Sonali Goyal	
	14.1	Introduction to AI and Explainable AI	308
	14.2	Introduction to Explainable AI in Healthcare	314
	14.3	Applications of Explainable AI in Healthcare	317
	14.4	Implementing Explainable AI in Healthcare: Practical	
		Considerations	319
	14.5	Future Directions and Emerging Trends	319
		Conclusion	320
	14.7	Future Work	320
		References	321
15	Ethica	al Implications of Emotion Recognition Technology	
		ental Healthcare: Navigating Privacy, Bias,	
	and T	herapeutic Boundaries	325
	R. Ra	vi, V. Jeya Ramya, B. Prameela Rani, Srikanth Nalluri	
		1. Jenath	
	15.1	Introduction	326
	15.2	Background	327
		15.2.1 Objectives	328
		Related Works	329
	15.4	4	330
		15.4.1 Capabilities and Applications of ERT	331
		15.4.2 Ethical Considerations in ERT	331

#### xviii Contents

		15.4.3	Clinical Applications and Efficacy of ERT	331
		15.4.4	Challenges and Limitations of ERT	332
		15.4.5	•	332
	15.5	Method	lology	332
		15.5.1	Search Strategy for Literature Review	332
		15.5.2	<u> </u>	333
		15.5.3	Data Extraction Process	334
			Analysis of Literature	334
			Validation and Peer Review	335
			Ethical Considerations	335
	15.6	Researc	ch Process: Emotion Recognition Technology (ERT)	
		in Ment	tal Healthcare	337
		15.6.1	Defining the Research Scope and Objectives	337
		15.6.2	Literature Review Protocol Development	337
			Search Strategy Formulation	337
			Literature Search and Screening	338
		15.6.5	Selection of Studies	338
			Data Extraction	338
			Thematic Analysis	338
			Synthesis and Interpretation	338
			Validation and Peer Review	339
			Ethical Considerations	339
	15.7		ch Validation and Methodology Confirmation	339
			Research Methodology	339
			Research Execution	339
		15.7.3	Validation Process	340
	15.8	Results		340
			Privacy Concerns	341
		15.8.2	Algorithmic Biases	341
		15.8.3	Accuracy and Validation	341
			Directions	343
	15.10	Conclu		345
		Referen	ices	346
16	Bridg	ing the	Gap: Clinical Adoption and User Perspectives	
			e AI in Healthcare	349
		-	l Ahamed and J. Jabez	
	16.1	Introdu	To the second se	350
	16.2	Backgro		352
	16.3	_	ch Objectives and Hypotheses	352
	10.5	16.3.1	Research Objectives	353
		10.0.1		000

				CONTENTS	XIX
	16.3.2	Hypothese	oc.		353
16.4		• -			354
		ire Survey			355
10.5	16.5.1	•	Foundations of XAI		355
	16.5.2		Clinical Decision Making		356
	16.5.3	1	ectives and Acceptance		356
	16.5.4	1	and Considerations		356
	16.5.5		d Implementations and Case	Studies	356
	16.5.6		linary Perspectives		357
16.6	Propos	ed Methodo			357
	16.6.1				357
	16.6.2	•	ection Methods		358
	16.6.3	Sampling S	Strategy		358
	16.6.4		e.		358
	16.6.5	Ethical Co	nsiderations		358
16.7	Project	Managemen	nt		359
	16.7.1	Surveys			359
	16.7.2	Interviews			360
	16.7.3	Observation	onal Studies		360
	16.7.4	Document	Analysis		361
	16.7.5	Focus Gro	ups (if Applicable)		361
	16.7.6	Data Analy	ysis Plan		362
16.8	Quanti	tative Data 1	Analysis		362
	16.8.1	Descriptive			363
	16.8.2	Inferential	Statistics		363
	16.8.3	U	•		363
	16.8.4	•	ve Integration		363
	16.8.5		e Data Analysis		363
			Data Coding		363
			Theme Development		364
			Interpretation and Conflation	1	364
16.9	U	tion of Find	Č		364
	16.9.1	•	: Implementation and Impac	it .	
		-	able AI (XAI) in Radiology		364
	16.9.2	•	rch Questions to be Addresse		
			e Study May Include the Follo	owing	365
	16.9.3	Literature	•	_	366
			Technical Foundations of XA	.1	
			in Radiology		366
			Clinical Applications and Imp	pact	
		(	of XAI in Radiology		366

			16.9.3.3	User Perspectives and Acceptance	
				of XAI in Radiology	366
			16.9.3.4	Implementation Challenges and	
				Considerations	367
			16.9.3.5	Regulatory and Ethical Implications	
				of XAI in Radiology	367
			16.9.3.6	Real-World Implementations and Case	
				Studies	367
			16.9.3.7	Interdisciplinary Perspectives on XAI	265
	16 10	<b>M</b> . (1 )	1.1	in Radiology	367
	16.10	Method		CD 1. C'4	368
				of Research Sites	368
	16 11		Data Col	lection Instruments	368
	10.11	Results	VATAJ.		369 369
				ption and Awareness	
			-	n Diagnostic Accuracy and Efficiency	369
				spectives and Experiences	369 370
			-	ntation Challenges and Considerations	370
	16 12	Conclus		endations for Future Implementation	370
	10.12	Referen			370 371
		Referen	ices		3/1
17				d Technologies in the Healthcare Sector:	
				nges, and Its Impact—Review	375
	- 0	•		Kirubadurai	
		Introdu			376
				y, Methodology, and Analysis	377
		Method			382
	17.4	Analysi			383
	17.5			imitations	387
		Conclus			389
		Referen	ces		389
18	A Co	mplete F	Road Map	for Interpretable Machine Learning	
				Various Real-Time Applications	393
		_	_	llingam, J. Venkata Subramanian,	
				nar and S. Padmini	
	18.1	Introdu	ction		394
	18.2	Feature	Importan	ice	399
	18.3	Rule-Ba	ased Mode	els	401
	18.4	Model 7	Transpare	ncy	403

			Contents	xxi
	18.5	Visual	Explanation	405
	18.6		retable Deep Learning	408
	18.7		ting Interpretability	410
	18.8		t of the Current Study	412
	18.9	Conclu	·	414
		Referen		415
19	Futur	re Resea	rch Directions: Explainable Artificial Intelligence	
	in He	althcar	e Industry	423
	Sham	ineesh S	harma, Neha Kumra, Meghna Luthra,	
	Vikas	<i>Verma</i>	and Komal Sharma	
	19.1	Introdu	action	424
	19.2		ound and Literature Review	426
	19.3	Explair	nable Artificial Intelligence Techniques in Healthcare	429
		19.3.1	Local Interpretable Model-Agnostic Explanations	431
			SHAP (SHapley Additive exPlanations)	432
			Rule-Based XAI Techniques	432
	19.4		ations of XAI in Healthcare	433
	19.5		dology and Result Analysis	434
			Dataset Information	434
			Research Methodology	435
			Result Analysis	436
	19.6	Future	Directions	440
		19.6.1	11 1 1	
			Models	440
		19.6.2	Research Area II    Dynamic and Adaptive	
			Explanations	441
		19.6.3	Research Area III    Integration With Electronic	
		10 ( )	Health Records (EHRs)	441
		19.6.4	II III	442
	10.7	19.6.5	Research Area V: Explainable Genomic Medicine	442
	19.7	Conclu		443
		Referei	nces	444
20	Real-	World A	Applications of Explainable AI in Healthcare	451
	Urvi,		harma, Kanu Goyal and Shweta Sharma	
	20.1	Introdu		452
		20.1.1	Explainable Artificial Intelligence: Concepts	
			and Techniques	453

#### xxii Contents

		20.1.2	Overview of Popular Explainable Artificial					
			Intelligence Techniques	455				
	20.2	Real-W	Vorld Applications of Explainable Artificial					
		Intellig	ence in Healthcare	457				
		20.2.1	Diagnostic Imaging	457				
		20.2.2	Clinical Decision Support Systems (CDSS)	458				
		20.2.3	0 1	459				
			Personalized Medicine	460				
		20.2.5	Patient Outcome Prediction	460				
	20.3		nges and Ethical Considerations for Explainable					
		Artifici	al Intelligence Usage in Healthcare	461				
	20.4	Future	*	462				
	20.5	Conclu		463				
		Referen	nces	463				
21	Expla	inable A	AI in Medical Imaging, Personalized Medicine,					
	•		uction: A New Era in Healthcare	467				
	Koma	ıl, Gane	sh K. Sethi, Shamneesh Sharma					
	and Rajender Kumar							
		Introdu		468				
	21.2	Explair	nable AI Techniques	470				
			nges in Healthcare AI	474				
			exity of Machine Learning Models	476				
	21.5	Explair	nable AI Techniques	477				
	21.6	Benefit	s of XAI in Healthcare	479				
	21.7	Improv	ved Trust and Adoption by Healthcare Professionals	481				
	21.8	Case St	tudies of Explainable Artificial Intelligence	483				
	21.9	Challer	nges and Limitations	486				
	21.10	Future	Directions	487				
	21.11	Conclu	sion	488				
		Referen	nces	489				
22	Unde	rstandiı	ng Explainability in Medical Imaging	493				
			S. H., R. Tamizh Kuzhali, Akshaya V.,					
		,	bha T. S., Immanuvel Arokia James K.					
		3. Srima	•					
	22.1	Introdu		494				
		22.1.1	Definition of Explainability in Medical Imaging	494				
		22.1.2	Importance of Explainability in Healthcare	494				
		22.1.3	Overview of the Chapter Structure	496				

22.2	The Ro	e of Medical l	maging in Healthcare	497
	22.2.1	Brief History	and Evolution of Medical Imaging	
		Technologies	3	497
	22.2.2	Current Sign	ificance of Medical Imaging	
		in Healthcare	e	499
22.3	Explair	ability Challe	nges in Medical Imaging	500
	22.3.1	Complexity	of Medical Imaging Data	
		and Techniqu	ues	500
	22.3.2	Black-Box N	ature of Deep Learning Models	501
	22.3.3	Ethical and F	Regulatory Considerations	
		in Medical A	I	503
22.4	Techni	lues for Expla	inability in Medical Imaging	504
	22.4.1	Feature Impo	ortance Methods	504
	22.4.2	, -	os and Gradient-Based Methods	504
	22.4.3	_	stic Techniques	505
	22.4.4	Rule-Based S		506
			se Study 1: Melanoma Classification	
			th SHAP	506
			inical Implications	507
			inical Implications	508
22.5		etability vs. Ex		508
	22.5.1	-	of Providing Understandable	
		Explanations		509
	22.5.2		and Limitations of Explainability	
		in Medical Ir		510
	22.5.3		of Explainable AI in Medical Imaging	510
			hancing Trust and Transparency	510
			cilitating Collaboration Between AI	
		•	stems and Healthcare Professionals	510
	22.5.4		and Challenges of Explainable AI	
		in Medical Ir		511
			ade-Offs Between Explainability	
			d Performance	511
			terpreting Complex Models	511
			eneralization and Robustness	511
22.6	_	•	e and Standards	512
	22.6.1		rameworks in AI Healthcare	512
	22.6.2		ion Efforts in AI Healthcare	513
	22.6.3		nd Future Directions	513
	22.6.4	Future Direc	tions	514

Contents xxiii

#### xxiv Contents

	22.7	Case St	tudies and	Applications of Explainable AI	
		in Med	lical Imagir	ng	515
		22.7.1	Success St	tories and Lessons Learned	516
		Conclu	ısion		517
		Referei	nces		517
23	Expla	ainabilit	y and Regi	ılatory Compliance in Healthcare:	
				hical XAI Implementation	521
	Uma	Mahesu	vari Kalia I	Moorthy,	
	Astho	ampatti .	Marimuthi	u Jayapalan Muthukumaran,	
	Vijay	alakshn	ıi Kaliyape	rumal, Shobana Jayakumar	
	and I	Kalpana	Ayanellore	e Vijayaraghavan	
	23.1	Introdu	uction		522
	23.2	Explair	nability Tec	hniques and Methodologies	527
		23.2.1	Real-Wor	ld Examples of Explainable AI	
			in Health	care	529
	23.3			cape in Healthcare	531
		23.3.1		re Regulations and Policies Related	
				blementation	533
		23.3.2		acy and Patient Confidentiality	
			Consider		535
		23.3.3		Ethical Challenges in Deploying AI	
			in Health		537
			23.3.3.1	Privacy and Security	537
			23.3.3.2	Informed Consent	537
			23.3.3.3	Bias and Fairness	538
			23.3.3.4	Transparency and Explainability	538
			23.3.3.5	Liability and Accountability	538
			23.3.3.6	Clinical Validation and Regulation	538
			23.3.3.7	Human Oversight and Autonomy	539
			23.3.3.8	Consent for Research and Innovation	539
	22.4	п.	23.3.3.9	Equity and Access	539
	23.4			ory Compliance	540
	23.5	_		ply with Healthcare Regulations	T 40
	22.6		andards	lia similia a ma Callah a mati a mina Da malata ma	540
	23.6			lisciplinary Collaboration in Regulatory	T 42
	23.7	Compl		ol Concerns and Mitigating Piece	542
	43.7	in AI N		ll Concerns and Mitigating Bias	543
	23.8			arency in Healthcare AI	545 546
	40.0	11 USL A	114 11411500		240

		23.8.1 Building Trust with Patients an	d Healthcare	
		Professionals Through Explain	able AI	547
		23.8.2 The Impact of Transparency or	n AI Adoption	
		and User Acceptance	_	547
		23.8.3 Human-AI Interaction and the	e Role	
		of Explanations in Decision Ma	aking	548
		23.8.4 AI Projects in Healthcare That	Lacked	
		Transparency or Compliance		548
		23.8.5 Ethical Considerations in Expl	ainable	
		AI Implementation		550
		23.8.6 Ethical Principles for Explainab	le AI in Healthcare	551
		23.8.7 Ensuring Patient Safety and We	ell-Being Through	
		Explainable AI		553
		23.8.8 Ethical Challenges in Balancing	g Privacy,	
		Transparency, and Utility in He	ealthcare AI	555
	23.9	Future Trends and Recommendations		557
		References		558
24	Envis	sioning Explainable AI: Significance, R	eal-Time	
		ications, and Challenges in Healthcare		563
		ian Chakrapani, Mohamed Iqubal Safa,		
		nya Gangadhara Moorthy, Meenakshi K		
		George Parimala		
	24.1	Introduction		564
	24.2	Definition and Significance of XAI		565
	24.3	•		565
	24.4	2	3	574
	24.5	Applications of XAI in Healthcare Indu		576
		24.5.1 Application in Medical Diagno	•	578
	24.6	Applications of XAI in Finance		579
	24.7	Applications of XAI in Judiciary		582
	24.8	Applications in the Judiciary		583
	24.9	Challenges and Limitations of XAI		585
		Limitations of XAI		585
	24 11			=0.
	24.11	Future Directions in XAI		586
	24.11	Future Directions in XAI Conclusion		588

## xxvi Contents

25	_	htened XAI: Illuminating Ethics and Equitable	
	-	inability	593
		ılatha P., Manikandan J., B. Balaji and V. Sujitha	
	25.1	Introduction	594
		25.1.1 Definition of XAI	596
		Ethical Considerations of AI in Healthcare	598
	25.3	The Need for Ethical Guidelines in AI in Healthcare	
		Development	599
	25.4	Risks Associated with Opaque and Black-Box AI	
		in Healthcare Models	601
	25.5	Transparency and Interpretability in XAI	602
		25.5.1 Importance of Transparency in Decision-Making	
		Algorithms	602
		25.5.2 Interpretable Models vs. Complex Models	602
		25.5.3 Techniques for Achieving Interpretability in AI	603
	25.6	Fairness in AI	604
		25.6.1 Understanding Algorithmic Bias	604
		Consequences of Biased AI Decision Making	604
		Real-World Examples of AI Fairness Issues	606
	25.9	1	608
		The Tradeoff Between Fairness and Interpretability	609
		Evaluating Fairness in Explainable AI Models	610
	25.12	Guidelines and Frameworks for Ethical XAI	611
		25.12.1 Existing Principles and Guidelines for Responsible	
		XAI Development	611
		25.12.2 Regulatory Considerations and Legal Frameworks	611
		25.12.3 Industry Initiatives Promoting Ethical XAI	612
	25.13	The Future of Ethical XAI	612
	25.14	Conclusion	614
		References	614
26	Enha	ncing Trust and Collaboration Using Explainability	
		tural Language Processing for AI-Driven Healthcare	619
		ndian, K. Pradeep Mohankumar, S. Padmini,	
		maran and K. Sreekumar	
	26.1	Introduction	620
	•	26.1.1 Background of NLP in Healthcare	621
	26.2	Importance of Explainability in NLP	622
	26.3	Challenges of Black-Box NLP Models in Healthcare	625
	26.4	Opacity of NLP Models	627
	26.5	Addressing the Incompatibility of NLP Models	629

26.6	Implications of Lack of Explainability in Medical	
	Decision Making	629
26.7	Necessity for Explainable AI in Healthcare	631
26.8	Building Trust and Confidence in NLP Predictions	632
26.9	Validation and Accountability in Medical Applications	633
26.10	Techniques for Achieving Explainability in NLP	634
	26.10.1 Rule-Based Explanations	635
	26.10.2 Visualizations	636
	26.10.3 Grad-CAM (Gradient-weighted Class Activation	
	Mapping)	637
	26.10.4 Textual Explanation Generation	638
26.11	Advantages of Explainability for Healthcare Professionals	640
	26.11.1 Empowering Healthcare Practitioners	
	With AI Insights	640
	26.11.2 Enhancing Collaboration between AI and	
	Medical Experts	643
26.12	Future Directions and Challenges	645
26.13	Challenges Associated With Explainable AI for Healthcare	645
	Conclusion	646
	References	647
About th	ne Editors	651
Index		653