

# Artificial Intelligence and Machine Learning Techniques in Engineering and Management

Komaragiri Srinivasa Raju · Dasika Nagesh Kumar

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# Foreword

The 2024 Nobel Prize in Physics was awarded to John J. Hopfield and Geoffrey Hinton *for foundational discoveries and inventions that enable machine learning with artificial neural networks*. Two of the three winners of the 2024 Nobel Prize in Chemistry, Demis Hassabis and John Jumper, both from Google Deepmind, were cited for developing an AI model to solve a 50-year-old problem: predicting complex structures of proteins. These coveted prizes to Artificial Intelligence (AI) researchers bear testimony to the sweeping influence of AI.

Driven by extraordinary strides made over the years, especially in the past decade, AI now has the potential to fundamentally transform human civilization. Its importance is now recognized by societies across the globe as a key technology with the ability to solve some of the most complex societal and engineering problems of our times such as universal access to healthcare and education, efficient transportation, increased efficiency in providing e-governance services to the public, etc. To harness the power of AI, large-scale national and international efforts are underway.

AI has now matured to a level where AI applications are beginning to impact our daily lives: generative AI tools like ChatGPT and Gemini are now extensively used by researchers, students, and even public. Among the myriad of disciplines impacted by AI, engineering and management disciplines occupy a prominent position. AI and data science are now providing a major tool box to solve a wide spectrum of problems in engineering and management.

There is a large corpus of textbooks and research monographs on the foundations, theory, and advances in artificial intelligence, machine learning (ML), and deep learning (DL). There is, however, an urgent need for a book that provides a convenient, friendly, and yet rigorous treatment of AI and ML techniques to researchers, professionals, and students engaged in core engineering disciplines and also core management topics. This gap is splendidly filled by authors Srinivasa Raju and Nagesh Kumar, by bringing out their fine and timely textbook *Artificial Intelligence and Machine Learning Techniques in Engineering and Management*.

This is a nice book accessible to anyone seeking to clearly understand and rigorously apply AI techniques to problems in engineering and management disciplines. In particular, it will be a precious resource to undergraduate, master's, and doctoral

students applying AI and data science to their projects and research problems. The coverage of topics in machine learning and deep learning models is gentle and thorough, focussing on the main principles. The illustrative numerical examples, completely worked out, elevate the utility and understandability of the contents. The final chapter is especially valuable, with more than 200 case studies reviewed; this will be a goldmine to look up detailed studies of real-world problems.

The authors must be congratulated for conceptualizing a much needed AIML companion to students and researchers and for presenting the content in a lucid manner. For engineering and management audience, this book is a lovely resource on a live and lively subject.

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# Preface

Artificial Intelligence (AI) is becoming familiar due to the minimum requirement of data, facilitating accurate predictions, and minimal necessity of understanding the physics behind input–output relationships. Its potential to tackle non-linear and complex problems with greater flexibility is an added advantage. Its applications in engineering, management, and allied fields are growing exponentially. Over time, numerous experts introduced books and developed blogs on the theme, which are primarily theoretical. However, the proposed book amalgamates relevant theory, numerical problems, case studies, and recent advances wherever possible. We believe that this new dimension will greatly benefit present-generation researchers and students.

The present book consists of seven chapters: (1) an introduction; (2) a description of performance indicators; (3) classical machine learning algorithms; (4) advanced machine learning algorithms; (5) fuzzy logic-based modelling algorithms; (6) emerging research areas, topics including, Blockchain, recent ML techniques, evolutionary algorithms, AI tools, the Internet of Things, big data, decision support systems, Taguchi design of experiments, data augmentation, and cross-validation; (7) representative case studies. The appendix covers representative AI tools, data sources related to AI, books, and journals on AI. The present book can support undergraduate, postgraduate, and Ph.D. students in AI, Data Mining, and Soft Computing in Engineering and Management and allied fields.

We are grateful to Prof. Yadati Narahari, Department of Computer Science and Automation, Indian Institute of Science, Bengaluru, who consented to write a Foreword for the book.

Special acknowledgments to Vogeti Rishith Kumar for posing thought-provoking, out-of-box questions, providing lots of input, and unstinting support wherever necessary. Heartfelt gratitude to Sistla Shashank, Prof. Alivelu Manga Parimi, Deepjyoti Deb, Dr. R. Madhuri, R. Bhavi Tej, Dr. Sriman Pankaj, Kathan Pranav Naik, Y. Sai Kiran, Pratyush Pandey, P. Sagar Subhash, Bhavesh Rahul Mishra, Harshal Nayan Rathi, Rahul Jauhari, Rishabh Daga, Ayushman Kar, Aakash Bansal, Kaustav Chatterji, and L. Ashoka Vardhan (who are presently or formerly associated with BITS) who contributed immensely for the book. Also, thanks to Prof. M. Janga Reddy (IIT Bombay), Prof. Shishir Gaur (IIT BHU), Prof. D. Graillot (EMSE France), Prof. D. V. Morankar (College of Military Engineering, Pune), and many others who supported us from time to time.

We referred to a number of research papers and many blog sites related to AI. Overall, they shaped the book in its present form. We acknowledge LINDO SYSTEMS INC. for providing access to the LINGO software trial version, Scopus for research data analysis, and Python for programming support.

We have incorporated a few portions from some of our published research papers, either utilizing CC BY 4.0 and CC BY-NC-ND 4.0 licenses under the open access category or taking permissions in case of non-open access category journals. All these research papers were referred at suitable places. We wholeheartedly express gratefulness to the publishers of these journals, IWA, Springer, ASCE and Wiley. We extend thanks to all the co-authors of the papers for their constant encouragement and support in realizing our plan to publish this book.

We made the best possible efforts to quote all the sources in the form of acknowledgements or references, but still, some would have been missed. We will incorporate them upon notice in the upcoming editions.

Professor Raju appreciates the institute leadership for providing the necessary ecosystem for writing this book. He acknowledges the help of his wife, Gayathri Devi; Daughter, Sai Swetha; and son, Sai Satvik; and Parents, Gopala Rao and Varalakshmi, for their unstinting support. He thanks Prof. A. Vasani, Subbulakshmi Vasani, Dr. K. Nagajyothi, and Mr. B. Surendra for their motivating support. Professor Nagesh acknowledges the support of his wife Padma, daughter Sruthi, son Saketh, and parents Subrahmanyam and Lakshmi.

We sincerely thank Sri D. V. Subrahmanyam for diligently checking the manuscript and proofs.

We wish to thank all our colleagues, friends, and students who encouraged us from time to time with pleasant inquiries and inputs, which undoubtedly accelerated the writing of the book.

Lastly, we are thankful to Swati Meherishi and her team at Springer for processing the book in a timely manner.

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# Contents

<b>1</b>	<b>Introduction</b>	1
1.1	Introduction	1
1.2	Representative Applications of AI	4
1.3	Scopus Analysis of AI	4
1.4	Organization	5
	References	7
<b>2</b>	<b>Description of Performance Indicators</b>	9
2.1	Introduction	9
2.2	Performance Indicators	9
2.3	Indicators in Binary Classification Problems	13
	References	21
<b>3</b>	<b>Classical Machine Learning Algorithms</b>	23
3.1	Introduction	23
3.2	Activation Function	23
3.3	Artificial Neural Networks	23
3.4	Wavelet Neural Networks	31
3.5	Support Vector Regression	37
3.6	Extreme Learning Machine	48
3.7	Logistic Regression	54
3.8	K-Nearest Neighbours	63
	References	69
<b>4</b>	<b>Advanced Machine Learning Algorithms</b>	71
4.1	Introduction	71
4.2	Convolutional Neural Networks	71
4.3	Recurrent Neural Networks	79
4.4	Long Short-Term Memory	80
4.5	Bi-Directional-LSTM	93
4.6	Gated Recurrent Unit	94
4.7	Hybridization of CNN, LSTM, RNN, and GRU Algorithms	94

4.8	Boosting Algorithms	96
4.8.1	Adaptive Boosting	96
4.8.2	eXtreme Gradient Boosting	105
4.8.3	Categorical Boosting	116
	References	120
<b>5</b>	<b>Fuzzy-Based Modelling Algorithms</b>	<b>123</b>
5.1	Introduction	123
5.2	Fuzzification and Defuzzification	123
5.3	Adaptive Neuro-Fuzzy Inference System	130
5.4	Fuzzy Cognitive Mapping	138
5.5	Fuzzy Logic-Based Optimization	146
5.6	Fuzzy CNN, Fuzzy LSTM, and Fuzzy CNN-LSTM	151
	References	156
<b>6</b>	<b>Emerging Research Areas</b>	<b>159</b>
6.1	Introduction	159
6.2	Blockchain	159
6.2.1	Architecture of Blockchain	159
6.2.2	Water Management Ecosystem	163
6.3	Recent ML Techniques	169
6.3.1	Federated Learning	169
6.3.2	Neural Architecture Search	170
6.3.3	Miscellaneous Techniques	171
6.4	Evolutionary Algorithms	172
6.5	Large Language Model (LLM)-Based Generative AI	173
6.6	IoT, Big Data, and DSS	176
6.7	Taguchi Design of Experiments	178
6.8	Data Augmentation	180
6.9	Cross-Validation	181
	References	183
<b>7</b>	<b>Case Studies</b>	<b>199</b>
7.1	Introduction	199
7.2	Further Research Work	236
	References	237
	<b>Appendix A Representative AI Tools and Data Sources Related to AI</b>	<b>245</b>
	<b>Appendix B Representative Books and Journals on AI</b>	<b>253</b>
	<b>Index</b>	<b>261</b>

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# Acronyms

AARLF	Average Absolute Relative Loss Function
ACO	Ant Colony Optimization
AdaBoost	Adaptive Boosting
AI	Artificial Intelligence
ALO	Ant Lion Optimizer
ANFIS	Adaptive Neuro-Fuzzy Inference System
ANN	Artificial Neural Networks
ANOVA	Analysis of Variance
AUC-ROC	Area Under the Curve-Receiver Operating Characteristic
Bi-LSTM	Bi-directional Long Short-Term Memory
BP	Back-Propagation
BRT	Boosted Regression Tree
CART	Classification And Regression Tree
CatBoost	Categorical Boosting
ChatGPT	Chat Generative Pre-trained Transformer
CNN	Convolutional Neural Networks
CNN-LSTM	Convolutional Neural Networks-Long Short-Term Memory
CS	Constraint Space
CSA	Cuckoo Search Algorithm
DE	Differential Evolution
DHL	Differential Hebbian Learning
DL	Deep Learning
DNN	Deep Neural Networks
DSS	Decision Support Systems
DT	Decision Tree
DV	Decision Variables
EA	Evolutionary Algorithms
ELM	Extreme Learning Machine
FCM	Fuzzy Cognitive Mapping
FCMe (or FCA)	Fuzzy Cluster Means (or Fuzzy Cluster Analysis)
FFBP	Feed-Forward with Back-Propagation

FIS	Fuzzy Inference Systems
FL	Federated Learning
FN	False Negative
FNR	False Negative Rate
FP	False Positive
FPR	False Positive Rate
FSS	Fractional Skill Score
GA	Genetic Algorithm
GB	Gradient Boosting
GBDT	Gradient Boosting Decision Tree
GRNN	General Regression Neural Network
GRU	Gated Recurrent Unit
GWO	Grey Wolf Optimizer
HC	Hierarchical Clustering
HGSO	Henry Gas Solubility Optimization
HL	Hebbian Learning
ICA	Imperialist Competitive Algorithm
IoT	Internet of Things
KGE	Kling Gupta Efficiency
KMe	K-Means clustering
KNN	K-Nearest Neighbour
LFM	LSTM-RF Framework with Multitasking
LFS	LSTM-RF Framework with Single tasking
LGBBoost	Light Gradient Boosting
LiR	Linear Regression
LP	Linear Programming
LR	Logistic Regression
LSTM	Long Short-Term Memory
MARS	Multivariate Adaptive Regression Spline
ML	Machine Learning
MLiR	Multiple Linear Regression
MLP	Multilayer Perceptron
MSLF	Mean Square Loss Function
NAS	Neural Architecture Search
NB	Naïve Bayes
NGBoost	Natural Gradient Boosting
NHL	Non-linear Hebbian Learning
NLP	Natural Language Processing
Non-LP	Non-linear Programming
NRMSLF	Normalized Root Mean Square Loss Function
NSE	Nash–Sutcliffe Efficiency
NSGA-II	Non-dominated Sorting Genetic Algorithm-II
NSLF	Normalized Standard Loss Function
OF	Objective Function
PCA	Principal Component Analysis

PoET	Proof of Elapsed Time
PoS	Proof of Stake
PoW	Proof of Work
PSO	Particle Swarm Optimization
QP	Quadratic Programming
$R_0$	The highest possible R based on the perception of the user
R (or CC)	Correlation Coefficient
RBF	Radial Basis Function
ReLU	Rectified Linear Unit
RF	Random Forest
RMSLF	Root Mean Square Loss Function
RNN	Recurrent Neural Networks
RSA	Reptile Search Algorithm
RSM	Response Surface Methodology
SA	Simulated Annealing
SC	Subtractive Clustering
SHAP	SHapley Additive exPlanations
SI	Swarm Intelligence
SS	Search (Decision) Space
SSLF	Sum of Square Loss Function
SVM	Support Vector Machine
SVR	Support Vector Regression
TEE	Trusted Execution Environment
TLBO	Teaching Learning-Based Optimization
TN	True Negative
TNR	True Negative Rate
TP	True Positive
TPR	True Positive Rate
TSS	Taylor Skill Score
WGAN	Wasserstein Generative Adversarial Networks
WI	Willmott Index
WNN	Wavelet Neural Networks
XGBoost	EXtreme Gradient Boosting

# List of Figures

Fig. 1.1	Classification of AI into ML and DL	2
Fig. 1.2	The flow of the topics in the chapters	6
Fig. 2.1	Selected indicators and their values	15
Fig. 2.2	Confusion matrix	15
Fig. 2.3	Representative AUC-ROC training curves for different algorithms (Modified and adapted from Madhuri et al., (2021) under CC BY-NC-ND 4.0 license)	16
Fig. 2.4	Confusion matrix for the given numerical problem	17
Fig. 2.5	Confusion matrix for the given numerical problem	18
Fig. 2.6	AUC-ROC curve	20
Fig. 3.1	Weighted sum input to the neuron (or node), activation function, and the resulting output	24
Fig. 3.2	Activation functions <b>a</b> Sigmoid <b>b</b> Rectified Linear Unit (ReLU) <b>c</b> Binary step function <b>d</b> and Hyperbolic Tangent and their mathematical philosophy	25
Fig. 3.3	The representative architecture of ANN	26
Fig. 3.4	The architecture of ANN for the given numerical problem	27
Fig. 3.5	The architecture of ANN for the given problem	29
Fig. 3.6	Architecture of WNN	31
Fig. 3.7	Hyperplane of SVR	37
Fig. 3.8	The architecture of basic ELM	49
Fig. 3.9	Dataset representation for the problem (Red: Non-flooded; Blue: Flooded)	57
Fig. 3.10	Status of flood nodes at epoch 2915 (Red: Non-flooded; Blue: Flooded)	59
Fig. 3.11	KNN-three nearest neighbours (Red: Non-flooded; Blue: Flooded)	64
Fig. 4.1	Architecture of CNN	72
Fig. 4.2	Workflow of CNN	74
Fig. 4.3	Architecture of RNN	80



Fig. 4.4     Architecture of LSTM (modified and adapted from Vogeti et al., 2024 under CC BY-NC-ND 4.0 License) ..... 81

Fig. 4.5     Workflow of LSTM ..... 83

Fig. 4.6     Architecture of Bi-LSTM (adapted from Deb et al., 2024 under CC BY 4.0 License) ..... 93

Fig. 4.7     Architecture of GRU ..... 95

Fig. 4.8     Tree constructed using DNS at a value of 5.2 ..... 98

Fig. 4.9     Tree constructed using midpoint DNS at a value of 4.7 ..... 100

Fig. 4.10    Tree constructed using DNS at ET of 8.15 ..... 101

Fig. 4.11    The first tree constructed using DNS at DNS = 4.7 ..... 102

Fig. 4.12    Classification by AdaBoost after 50 trees were constructed (Red: Non-flooded; Blue: Flooded) ..... 106

Fig. 4.13    Architecture of XGBoost (adapted from Deb et al., 2024 under CC BY 4.0 License) ..... 107

Fig. 4.14    First branching of the tree (0.5 and -0.5 are the residuals; brackets denote the dataset number) ..... 111

Fig. 4.15    Second branching of the tree ..... 112

Fig. 4.16    Complete branching of the tree ..... 113

Fig. 4.17    XGBoost—results after construction of 100 trees (Red: Non-flooded; Blue: Flooded) ..... 115

Fig. 4.18    Tree formation in CatBoost (adapted from Mishra et al., 2024 under CC BY-NC-ND 4.0 License) ..... 117

Fig. 5.1     Sources of uncertainty and their impact on output ..... 124

Fig. 5.2     **a, b.** Non-linear MF (Modified and adapted from Vasani et al., (2022) under CC BY-NC-ND 4.0 License) ..... 124

Fig. 5.3     **a and b.** Hyperbolic MF (Modified and adapted from Vasani et al., (2022) under CC BY-NC-ND 4.0 License) ..... 125

Fig. 5.4     **a, b** Exponential MF (Modified and adapted from Vasani et al., (2022) under CC BY-NC-ND 4.0 License) ..... 125

Fig. 5.5     MF and corresponding equation for **a** triangular and **b** trapezoidal ..... 126

Fig. 5.6     Triangular MF for the rainfall ..... 127

Fig. 5.7     Stepped MF for the rating score of students ..... 128

Fig. 5.8     Non-linear MF for the working hours of the machine ..... 129

Fig. 5.9     Non-linear MF for the AQI ..... 129

Fig. 5.10    ANFIS architecture for two features, *x* and *y* [1, 2, 3, 4, 5 are layers denoting MF, Multiplication, Normalization, Rule Functions, Summation] ..... 131

Fig. 5.11    Pictorial representation of fuzzy cognitive maps ..... 140

Fig. 5.12    Training process of FCM ..... 141

Fig. 5.13    Input data for FCM ..... 142

Fig. 5.14    The architecture of fuzzy CNN ..... 152

Fig. 5.15    The architecture of fuzzy LSTM (Modified and adapted from Vogeti et al., 2024 under CC BY-NC-ND 4.0 License) .... 153

Fig. 6.1    Typical components of Blockchain ..... 160

Fig. 6.2	Water management ecosystem . . . . .	164
Fig. 6.3	Comparison of water usage in centralized and decentralized distribution systems . . . . .	168
Fig. 6.4	Comparison of water bills in centralized and decentralized distribution systems . . . . .	169
Fig. 6.5	The basic structure of an EA (Adapted from Reddy & Kumar, 2020 under CC BY- 4.0 License) . . . . .	173
Fig. 7.1	Organization of the chapter . . . . .	200

# List of Tables

Table 2.1	Observed and simulated values and related calculations	12
Table 2.2	Indicators and corresponding values	13
Table 2.3	Observed and simulated values and related calculations	14
Table 2.4	Indicators and corresponding values	15
Table 2.5	Data of FPR and TPR for various thresholds	19
Table 2.6	Data of FPR and TPR for various thresholds	21
Table 3.1	Updated weights connecting nodes in layers 1 and 2	28
Table 3.2	Updated weights connecting nodes in layers 2 and 3	28
Table 3.3	Updated weights connecting nodes in layers 1 and 2	30
Table 3.4	Updated weights connecting nodes in layers 2 and 3	30
Table 3.5	Information about datasets	33
Table 3.6	Computation of simulated strains ( $y$ ) and anomalies	34
Table 3.7	Information about datasets	35
Table 3.8	Computation of simulated flood damage ( $y$ ) and error	36
Table 3.9	Information about input and output	38
Table 3.10	Kernel matrix $K =$	40
Table 3.11	Observed, simulated, and loss function values	42
Table 3.12	Information about input and output	43
Table 3.13	Kernel matrix $K =$	44
Table 3.14	Observed, simulated, and loss function values	47
Table 3.15	Information about input and output	50
Table 3.16	Random weight matrix	50
Table 3.17	MSLF computation	52
Table 3.18	Information about input and output	52
Table 3.19	Random weight matrix	53
Table 3.20	MSLF computation	54
Table 3.21	Datasets considered for the problem	56
Table 3.22	Results at epoch 1	58
Table 3.23	The average loss in each epoch	59
Table 3.24	Observed and predicted flood occurrences at epoch 2915	60
Table 3.25	Dataset for the problem	61

Table 3.26	Results at epoch 1	62
Table 3.27	Datasets related to flood occurrence	64
Table 3.28	Distance of test dataset from each training dataset	65
Table 3.29	Dataset related to Solar power plants	65
Table 3.30	Distance of test dataset from each training dataset	66
Table 3.31	Information about datasets	67
Table 3.32	Information about datasets	68
Table 3.33	Information about datasets	68
Table 3.34	Information about features and flooding status	69
Table 4.1	Loss function	87
Table 4.2	Loss function	92
Table 4.3	Dataset for the numerical problem	97
Table 4.4	Initial sample weights and classes of the entire dataset	99
Table 4.5	DNS in ascending order	99
Table 4.6	DNS in ascending order—Gini impurity	101
Table 4.7	ET in ascending order—Gini impurity	102
Table 4.8	Datasets for the numerical problem	108
Table 4.9	Residual probabilities and middle points of ET	109
Table 4.10	Gain values of the first branch for ET	110
Table 4.11	Gain values of first branch for DNS	110
Table 4.12	Points belonging to the left leaf of the first branch	111
Table 4.13	Gain values of the second branch (ET)	111
Table 4.14	Gain values of the second branch (DNS)	111
Table 4.15	Gain values of the third branch (ET)	112
Table 4.16	Gain values of the third branch (DNS)	112
Table 4.17	Updated probabilities	115
Table 4.18	Conceptual differences in boosting algorithms (adapted from Mishra et al., 2024 under CC BY-NC-ND 4.0 License)	117
Table 4.19	Information about features and foundation status	119
Table 5.1	Dataset used for ANFIS analysis	133
Table 5.2	Membership values for <i>IQ</i> and <i>LD</i> for each dataset	134
Table 5.3	Firing strengths of each rule for each dataset	134
Table 5.4	Normalized firing strength of each rule for each dataset	135
Table 5.5	Predicted outputs for each rule and each dataset	136
Table 5.6	Dataset with two inputs and one output	136
Table 5.7	Membership values for <i>EP</i> and <i>MPG</i> for each dataset	137
Table 5.8	Firing strengths of each rule for each dataset	138
Table 5.9	Normalized firing strength of each rule for each dataset	138
Table 5.10	Predicted outputs for each rule for each dataset	139
Table 5.11	Characteristics of concepts and weights	140
Table 5.12	Random weight matrix	143
Table 5.13	Weight matrix after iteration 1	144
Table 5.14	Weight matrix after iteration 2	145
Table 5.15	Weight matrix after iteration 1	146

Table 5.16	Example for demonstrating chosen optimization techniques .....	147
Table 5.17	Results of fuzzy optimization .....	150
Table 5.18	Random weight matrix .....	155
Table 6.1	Information about various stakeholders' access to different modules .....	161
Table 6.2	Details of household numbers, water consumed per month, and water bill .....	167
Table 6.3	Details of cost and lower and upper bounds of water usage ...	167
Table 6.4	Details of house numbers and water usage per month .....	168
Table 6.5	Additional techniques falling under advanced aspects of ML techniques .....	171
Table 6.6	Representative reference(s) where the EAs were discussed ...	174
Table 6.7	Full factorial design .....	179
Table 7.1	Case studies related to Civil Engineering .....	201
Table 7.2	Case studies related to Chemical Engineering .....	217
Table 7.3	Case studies related to Mechanical Engineering .....	224
Table 7.4	Case studies related to Electronics and Computer Science Engineering .....	227
Table 7.5	Case studies related to management and allied fields .....	231
Table A.1	Insight of representative AI tools .....	246
Table A.2	Representative data sources .....	250