
Contents

Preface	xv
Abhishek KUMAR, Priya BATTA, S. RAVI and R. MOHAN	
Introduction	xvii
Abhishek KUMAR, Priya BATTA, S. RAVI and R. MOHAN	
Part 1. Embedded Graph Intelligence and IoT Analytics	1
Chapter 1. Topology-Aware Spectral Graph Learning for Unsupervised IoT Device Clustering and Anomaly Detection.	3
M. SHANMUGHAM, A. KAMESWARAN, M. PRAKASH, K. SIVAPRAKASH, C. NANDAGOPAL and M. ANITHA	
1.1. Introduction	4
1.2. Related work	4
1.3. Methodology	6
1.3.1. Spectral graph convolutional network.	6
1.3.2. Clustering module	7
1.3.3. Openbox versus blackbox recent research	7
1.4. Results	8
1.5. Conclusion	11
1.6. References	12
Chapter 2. Graph Intelligence–Driven Deep Reinforcement Learning Framework for Adaptive Control and Predictive Maintenance of Coupled-Inductor DC–DC Converters in Hybrid Electric Vehicles	15
Elankurisil S.A. and N. Dhivya DEVI	
2.1. Introduction	16
2.1.1. Background	16

2.1.2. Objectives	17
2.1.3. Scope.	17
2.2. Literature review.	18
2.3. Methodology	19
2.3.1. System development framework.	19
2.3.2. Deep reinforcement learning framework	20
2.3.3. Load forecasting and predictive analytics.	20
2.3.4. Multi-modal health monitoring system	22
2.3.5. Experimental validation protocol	23
2.3.6. Performance evaluation metrics	23
2.4. Results	23
2.4.1. Experimental performance analysis	23
2.4.2. Efficiency and power conversion performance.	24
2.4.3. Dynamic response and control performance	26
2.4.4. Thermal management and component protection	26
2.4.5. Predictive maintenance and health monitoring performance	28
2.4.6. System integration and real-time performance	28
2.5. Conclusion	28
2.6. References	29
Chapter 3. Apache Kafka Streams and Time-Series ARIMA Modeling for IoT-Enabled SME Supply Chain Visibility	31
Manam Vamsi KRISHNA, Bobbiti Jyothika REDDY, Bandaru RUCHITHA, Adla JAHNAVI, B. PAVITHRA and A. CHATHURYA	
3.1. Introduction	31
3.1.1. Background	32
3.1.2. Objective.	32
3.1.3. Scope.	33
3.2. Literature review.	33
3.3. Methodology	35
3.3.1. Data acquisition and ingestion	35
3.3.2. Feature engineering and real-time processing	37
3.3.3. Modeling, assessment and implementation.	38
3.4. Results	39
3.5. Conclusion	42
3.6. References	42
Chapter 4. Ensemble XGBoost and LSTM-Based Predictive Analytics for Real-Time Industry 4.0 Decision Support Systems	45
Narendhar MULUGU, Fariha NAAZ, Chakilela SRIVIDHYA, B. ANJALI, Aduri SMILEY and Bommadeni Sanjana SRI	
4.1. Introduction	45

4.1.1. Background	46
4.1.2. Objective.	46
4.1.3. Methodology	47
4.2. Literature review.	47
4.3. Methodology	49
4.3.1. Data preprocessing, synchronization and acquisition	50
4.3.2. Model architecture, training and ensemble fusion	51
4.3.3. Explainability, real-time implementation and monitoring.	51
4.4. Results	53
4.5. Conclusion	57
4.6. References	58
Chapter 5. Isolation Forests with Local Outlier Factor and Mahalanobis Distance for Real-Time Fraud Detection	61
Lahari MEKALA, Kammalapally VARSHA, Kapuganti NIHARIKA, Karne NAMITHA, Kuchur AKSHARA and Mothewar SRIJA	
5.1. Introduction	62
5.2. Literature review.	63
5.3. Technology and methodology/detection framework	64
5.3.1. Problem formulation fraud detection	64
5.3.2. Isolation Forest algorithm	65
5.3.3. Algorithm approximating the local outlier factor, based on the set of data being studied	66
5.3.4. Mahalanobis distance.	67
5.3.5. Ensemble integration and score combination.	68
5.4. Findings and performance report.	69
5.4.1. The dataset characteristics and experimental setting.	69
5.4.2. Fraud-type detection and algorithm specialization.	71
5.4.3. Real-time performance and computational efficiency	74
5.5. Conclusion	75
5.6. References	75
Part 2. Embedded AI Optimization and Learning Architectures	77
Chapter 6. Optimized Variational Autoencoder–Reinforcement Learning Architectures for Autonomous IoT Resource Allocation and Load Balancing	79
Iyappan MURUGESAN, S. PRAKASH, Maheswaran THANGASAMY, Kokilavani THANGARAJ, R. MUTHUKUMAR and Brindha G.	
6.1. Introduction	80
6.2. Related work	81

6.3. Methodology	83
6.3.1. Problem formulation and system model	83
6.3.2. Deep Q-network in latent space	83
6.3.3. Decentralized deployment architecture	84
6.3.4. DRL agent configuration	85
6.3.5. Evaluation framework and metrics	86
6.4. Results	86
6.4.1. Resource allocation efficiency	86
6.4.2. Energy consumption and latency analysis	88
6.4.3. Load balancing and convergence characteristics	89
6.4.4. Device category performance	90
6.5. Discussion	91
6.6. Conclusion	92
6.7. References	93

Chapter 7. Proximal Gradient Methods and Federated Learning: Distributed Optimization for Edge Computing Environments

Ch. Sandeep REDDY, Mallaiahgari KAMALINI, K. MOUNIKA,
Lingam KAVYANJALI, M. DIVYA and Gundeboina SUSHMITHA

7.1. Introduction	96
7.2. Literature review	96
7.3. Methodology	98
7.3.1. Question: is the most significant and challenging aspect of this project determining the scope and purpose of the proposed research?	98
7.3.2. Adaptive proximal federated algorithm	99
7.3.3. Occasional reduction of communication variance and efficiency	100
7.3.4. Implementation architecture	101
7.4. Results	103
7.4.1. The primary issue of convergence performance and accuracy as one of the main points	103
7.4.2. Communication efficiency analysis	105
7.4.3. Heterogeneity robustness and device performance	107
7.5. Discussion	108
7.5.1. Theoretical underpinnings and 12-point analysis	108
7.5.2. Deployment prudentials	109
7.5.3. Limitations and future directions	110
7.6. Conclusion	110
7.7. References	111

Chapter 8. Convex Relaxation with ADMM and Second-Order Cone Programming for Renewable Energy Microgrids	113
D. Vemana CHARY, Bodi TEJASWINI, Dharavath SNEHA, Donda AKSHITHA, E. VYSHNAVI and D. SANJANA	
8.1. Introduction	114
8.2. Literature review.	114
8.3. Problem formulation and methodology	116
8.3.1. The microgrids model	116
8.3.2. Convex relaxation methodology.	117
8.3.3. ADMM-based distributed optimization.	118
8.3. Implementation and computational framework	120
8.4. Results and performance review	120
8.4.1. Computational process on standard testing systems	120
8.4.2. Solution quality and optimality assessment.	121
8.4.3. Competitive analysis with other approaches	122
8.4.4. Scalability and real-time performance	123
8.5. Discussion	124
8.6. Conclusion	124
8.7. References	125
Chapter 9. Deep Q-Networks with Prioritized Experience Replay for Autonomous Vehicle Decision-Making	127
L. Srinivasa REDDY, Neha KASANAGOTTU, Maloth Sai VAISHNAVI, Mosali ASHRITHA, Kuntala SREEJA and K. TEJASWI	
9.1. Introduction	128
9.2. Related work	128
9.3. Methodology	130
9.3.1. Deep Q-network architecture	130
9.3.2. Prioritized experience replay mechanism.	131
9.3.3. Simulation environment and scenario design.	132
9.3.4. Training process and evaluations measures.	132
9.4. Results	133
9.5. Conclusion	138
9.6. References	138
Chapter 10. Cold Start Optimization Techniques for Function-as-a-Service Using Lambda@Edge and Container Reuse	141
S. SPANDANA, Singirikonda SAMHITHA, Suguru SIREESHA, Ramanolla ASHWITHA, Talasila HARSHITHA and Vaddadhi THANUSHA	
10.1. Introduction	142
10.2. Related work	143

10.3. Methodology	144
10.3.1. Experimental framework and infrastructure configuration.	144
10.3.2. Implementation strategy for cold-start optimization	144
10.3.3. Container reuse strategy development	145
10.3.4. Measurement and data collection protocol	145
10.4. Results.	147
10.4.1. Cold start latency reduction analysis.	147
10.4.2. Container reuse and warm start performance analysis	150
10.4.3. Lambda@Edge performance and geographic distribution analysis	153
10.5. Conclusion	154
10.6. References	155
Part 3. Embedded Security, DevOps and Cyber-Physical Systems	157
Chapter 11. Adversarial Deep Neural Networks for Intrusion Prevention in Heterogeneous IoT Ecosystems: A Robustness Analysis	159
Jaikumar R., Ravikumar S., K. TAMILSELVI, Iyappan MURUGESAN, B. SUGANTHI and Brindha G.	
11.1. Introduction	159
11.2. Related work	160
11.3. Methodology	162
11.3.1. System architecture	162
11.3.2. Constraint-aware adversarial training	163
11.3.3. Training procedure	163
11.3.4. Dataset and evaluation metrics	164
11.4. Results.	164
11.4.1. Overall performance.	164
11.4.2. Adversarial robustness analysis	166
11.4.3. Device-specific performance	167
11.5. Discussion.	168
11.6. Conclusion	169
11.7. References	170
Chapter 12. Adaptive Threat-Aware Clustering for Enhanced Security in IoT-Enabled Smart Cities: A Machine Learning Enhanced Approach	171
C. NANDINI and Priyadarsini K.	
12.1. Introduction	171
12.2. Related work	173
12.3. System model and threat analysis.	175

12.3.1. Network model	175
12.3.2. Enhanced threat model	175
12.4. ATAC algorithm design	176
12.4.1. Architecture overview.	176
12.4.2. Ensemble threat detection framework	176
12.4.3. Dynamic trust threshold mechanism.	177
12.4.4. Security-aware CH selection	178
12.4.5. Proactive cluster reconfiguration.	178
12.5. Performance evaluation	179
12.5.1. Simulation setup and baseline comparison	179
12.5.2. Results and analysis	180
12.6. Discussion.	183
12.7. Conclusion	184
12.8. References	185
Chapter 13. Graph Intelligence-Enabled Multi-Layered Framework for Revolutionizing Industrial Cyber-Physical System Security	187
K. SELVI and Golda DILIP	
13.1. Introduction.	188
13.2. Related work	188
13.3. Methodology	190
13.3.1. DRNN-based threat detection	191
13.3.2. GWO-optimized ECC.	192
13.3.3. Blockchain integration	192
13.3.4. Framework integration	193
13.4. Results.	193
13.4.1. DRNN performance	193
13.4.2. GWO-ECC optimization	194
13.4.3. Blockchain efficiency	195
13.4.4. Integrated framework	196
13.5. Discussion.	197
13.6. Conclusion	198
13.7. References	199
Chapter 14. Intelligent DevOps Monitoring and Automated Incident Response using Anomaly Detection and Self-Healing Pipelines	201
Amrutha Varshini MANNAVA, Kakumanu Venkata Sai Keerthi PRIYANKA, Vegesna Kumar Durga Abhirama RAJU, Penumala LAVENIA and B. Prameela RANI	
14.1. Introduction.	202
14.1.1. Problem statement.	202

14.1.2. Motivation	203
14.2. Literature review	203
14.3. Methodology	205
14.3.1. Data collection layer	205
14.3.2. Monitoring and visualization layer.	206
14.3.3. Anomaly detection engine	206
14.3.4. Incident classification module	206
14.3.5. Feedback and continuous learning	207
14.4. Results.	207
14.4.1. Mean time to recovery	207
14.4.2. Service uptime and reliability	208
14.4.3. Operational efficiency and human effort reduction.	209
14.4.4. Discussion of results	209
14.5. Conclusion	210
14.6. References	211
 Chapter 15. Multi-Cloud Load Balancing with Application Performance Monitoring (APM) and Chaos Engineering Practices	 213
Kammara Venkatarangaiah ACHARI, Oruganti NIKHILA, Nangunoori SRIJA, Nimmanagoti SARASWATHI, Mekala KAVYA and Sunkari MAMATHA	
15.1. Introduction.	214
15.2. Literature review	214
15.3. Methodology	216
15.3.1. Intelligent load-balancing implementation	217
15.3.2. APM integration.	218
15.3.3. Experimentation framework: chaos engineering experimentation framework.	218
15.4. Results and performance analysis.	220
15.4.1. Multi-cloud load-balancing performance	220
15.4.2. APM insight and performance abnormal detection.	221
15.4.3. Findings on chaos engineering and resilience corroboration	223
15.5. Conclusion	225
15.6. References	226

Part 4. Embedded Communication, Edge and Cloud Integration. 229

Chapter 16. MQTT Protocol Stack Optimization with Edge–Fog–Cloud Hierarchical Architecture and CoAP Lightweight Alternatives for Graph-Based IoT Network Communication 231

Vijayalakshmi CHINTAMANENI, Bathini VIGNANI, Gande SANNIHITHA,
A. HAARIKA, B. HARSHITHA and G. PRIYANKA

16.1. Introduction	232
16.2. Literature review	233
16.3. Methodology	234
16.3.1. There is a hierarchical IoT deployment architecture	234
16.3.2. Implementation of MQTT protocol stack optimization	235
16.3.3. CoAP alternative evaluation of ultra-constrained devices	236
16.3.4. Broker architecture ranking construction	236
16.3.5. Framework of measurement and performance evaluation	238
16.4. Results and performance analysis.	238
16.4.1. Hierarchical architecture latency impact	238
16.4.2. Protocol stack optimization and device resource efficiency	240
16.4.3. CoAP alternative protocol performance and applicability	242
16.5. Conclusion	245
16.6. References	246

Chapter 17. 5G Edge Computing with MEC and RAN Slicing for Ultra-Low Latency IoT Applications 249

B. Vijaya DURGA, Sarampelly ANANYA, Thadisetty VAISHNAVI,
V. Chandra KEERTHI, Vuppu SHRIYA and Mamidi GAYATHRI

17.1. Introduction	250
17.2. Literature review	251
17.3. Methodology	252
17.3.1. 5G MEC infrastructure and IoT deployment set-up	252
17.3.2. MEC deployment and resource management	253
17.3.3. RAN slicing setup and traffic isolation	253
17.3.4. Performance evaluation and measurement framework	255
17.4. Results and performance analysis.	255
17.4.1. MEC impact on latency reduction	255
17.4.2. RAN slicing effectiveness and traffic isolation	258
17.4.3. Computational offloading impact on cloud load reduction	260
17.5. Conclusion	262
17.6. References	263

Chapter 18. IoT-Based ESG Metrics Integration with Edge Computing and Cloud Orchestration: A Sustainable Digital Infrastructure Approach	265
Narendhar MULUGU, Aramati Poojani REDDY, Adepu NEHA, Dodda MEGHANA, Bazar PRIYANSHU and Bommena Sri KEERTHANA	
18.1. Introduction	265
18.1.1. Background	266
18.1.2. Objective	266
18.1.3. Scope	267
18.2. Literature review	267
18.3. Methodology	269
18.3.1. Experimental design, metrics and datasets	269
18.3.2. Implementation, coordination patterns.	270
18.3.3. Observability, evaluation and validation	272
18.4. Results.	273
18.5. Conclusion	277
18.6. References	277
List of Authors	279
Index.	289