
Contents

Preface: Connected Innovation, the Heart of Industry X.0	xiii
Farouk YALAOUI, Nhan-Quy NGUYEN, Yassine OUAZENE, Maria ZEMZAMI and Leïla MERGHEM-BOULAHIA	
Part 1. Innovations in Production and Smart Supply Chain Management	1
Chapter 1. Supply Chain Views from an Industry 4.0 Perspective	3
Ghita BOUCHTAOUI, Lamia HAMMADI, Ridha DERROUCHE, Roberta COSTA-AFFONSO and Abdessamad EL BALLOUTI	
1.1. Introduction.	3
1.2. Smart supply chain	4
1.2.1. Definition	4
1.2.2. Characteristics of smart supply chain	5
1.3. The essential technologies for the development of the smart supply chain	6
1.3.1. Internet of Things.	6
1.3.2. Big Data	7
1.3.3. Blockchain.	8
1.4. Methodology	8
1.4.1. Systematic literature review.	9
1.5. Analysis and synthesis	10
1.5.1. Frequency analysis	10
1.5.2. Emerging technologies.	13
1.6. Discussion	14

1.7. Conclusion	15
1.8. References	15
Chapter 2. A Bibliometric Analysis of the Integration of Lean and Industry 4.0 in the Sustainable Supply Chain.	19
Assiya ZAHID, Lamia HAMMADI, Patrice LECLAIRE, Roberta COSTA-AFFONSO and Abdessamad EL BALLOUTI	
2.1. Introduction.	19
2.2. Theoretical background.	21
2.2.1. LM tools	21
2.2.2. I4.0 technologies	22
2.2.3. Linking LM, I4.0 and sustainability: sustainable Lean 4.0.	22
2.3. Research methodology	25
2.3.1. Search strategy	26
2.4. Results and discussion	27
2.4.1. Publication by year	27
2.4.2. Publication by country	27
2.4.3. Publication by source	28
2.4.4. Publication by authors	29
2.4.5. Keywords analysis	30
2.5. Conclusion	31
2.6. References	31
Chapter 3. Integrated Strategy for Condition-Based Maintenance, Production and Quality Control in Manufacturing Systems	35
Dorsaf DALDOUL and Nadia BAHRIA	
3.1. Introduction.	35
3.2. Literature review.	36
3.3. Integrated strategy, working hypotheses and notations	38
3.3.1. Integrated strategy	38
3.3.2. Assumptions.	41
3.3.3. Notations.	41
3.4. Mathematical model.	44
3.4.1. Average restoration cycle time	44
3.4.2. Probabilities of the three scenarios.	46
3.4.3. Average inventory cost	47
3.4.4. Average total maintenance costs	48
3.4.5. Average total cost of quality	49
3.4.6. Average total cost per time unit	49

3.5. Numerical example	50
3.6. Conclusion	50
3.7. References	51
Chapter 4. Optimizing Energy Efficiency in a Two-Level Supply Chain Model with Shortage Consideration	53
Hong-Nguyen NGUYEN, Matthieu GODICHAUD and Lionel AMODEO	
4.1. Introduction and literature review.	53
4.2. Problem description and mathematical modeling	56
4.3. Resolution.	58
4.4. Numerical analysis	61
4.5. Conclusion	63
4.6. References	63
Chapter 5. Advanced Planning and Scheduling in Off-Site Construction.	67
Amin CHAABANE, Nadia BAHRIA and Salim HEDFI	
5.1. Introduction.	67
5.2. Literature review.	68
5.3. Problem description	71
5.3.1. Simplified architecture.	71
5.3.2. Presentation of the basic element used in the architecture	72
5.3.3. Simplified architecture nomenclature	72
5.3.4. Description of transition matrix columns and lines	74
5.4. Mathematical model.	74
5.4.1. Sets	74
5.4.2. Parameters	75
5.4.3. Decision variables	75
5.4.4. Objective function	76
5.4.5. Model constraints.	76
5.5. Experimentations	78
5.5.1. Input data.	78
5.5.2. Results and interpretation	78
5.6. Conclusion	81
5.7. References	82

Part 2. Performance Evaluation and Optimization for Industry X.0	85
Chapter 6. Performance Evaluation of Networking Protocols for Industrial Internet of Things	87
Samira CHOUIKHI, Leïla MERGHEM-BOULAHIA, Moez ESSGHIR and Nur BINTI RAHMAT	
6.1. Introduction.	88
6.2. Quality of service and protocols for IIoT applications	90
6.2.1. IIoT applications' QoS requirements	90
6.2.2. An overview of some networking protocols	91
6.3. Experiments and performance evaluation	95
6.3.1. Experiment environment	95
6.3.2. Implementation scenarios	95
6.4. Conclusion	101
6.5. Acknowledgments	101
6.6. References	101
Chapter 7. Navigating Toward Enhanced Security and Resilience in 5G and 6G Network Architectures	103
Atiq AHMED, Ihsan ULLAH, Leïla MERGHEM-BOULAHIA, Dominique GAITI and Guy PUJOLLE	
7.1. Introduction.	103
7.2. Authentication and key agreement in NGN	105
7.2.1. Authentication mechanism	106
7.2.2. Key-agreement mechanism	109
7.2.3. Leveraging blockchain in NGN	109
7.3. Terminal equipment security in NGN	111
7.3.1. Capillary network of connectivity	112
7.3.2. Significance of terminal equipment security	113
7.4. Virtual environment security in NGN	114
7.5. Digital forensics operations in NGN	115
7.6. Conclusion	117
7.7. References	118

Chapter 8. New Technique for Selecting Key Metaheuristic Parameters: Case Study on the SAR Metaheuristic Algorithm	121
Hakima REDDAD, Maria ZEMZAMI, Nhan-Quy NGUYEN, Norelislam EL HAMI and Nabil HMINA	
8.1. Introduction.	121
8.2. Literature review and contribution	123
8.2.1. Common techniques used for fine-tuning algorithms.	123
8.2.2. State of the art of the search and rescue algorithm (SAR)	125
8.2.3. Key performance indicators.	126
8.3. Identifying SAR key parameters approach	127
8.3.1. Results and discussion	132
8.4. Conclusion and perspectives.	135
8.5. References	135
Chapter 9. Precedence-Based and Time-Indexed Formulations for the Flexible Job Shop Scheduling with Machine Availability Constraints	141
Tom PERROUX, Taha ARBAOUI and Leïla MERGHEM-BOULAHIA	
9.1. Introduction.	141
9.2. Problem definition.	143
9.3. Mathematical models	143
9.3.1. Precedence variable-based model (M1).	144
9.3.2. Time-indexed model (M2)	145
9.4. Computational results.	147
9.4.1. Instance generation	147
9.4.2. Results comparison.	148
9.5. Conclusion	150
9.6. References	151
Chapter 10. Multi-Criteria Approach Using Discrete Event Simulation to Balance Staff Workload and Reduce Patient Wait Time: An Emergency Department Case Study	153
Dorsaf DALDOUL	
10.1. Introduction	153
10.1.1. Mathematical modeling	154
10.1.2. Simulation approaches	154
10.1.3. Contributions.	156
10.2. Case study.	158
10.2.1. System description	158
10.2.2. Patient flow process.	158

10.3. Simulation approach	160
10.3.1. Data approximation	160
10.3.2. Discrete-event simulation model	161
10.4. Numerical results.	163
10.5. Conclusion	166
10.6. References.	166

Part 3. Sustainable and Efficient Solutions Design 169

Chapter 11. Automatic Weed Detection Using YOLOv5 Object Detector. 171

Mohammed HABIB, Salma SEKHRA,
Adil TANNOUCHE and Youssef OUNEJJAR

11.1. Introduction	171
11.2. Materials and methods	173
11.2.1. YOLOv5	173
11.2.2. Dataset acquisition	176
11.2.3. Software	178
11.3. Results and discussion.	179
11.3.1. Labels correlogram	179
11.3.2. The hyperparameters	180
11.3.3. YOLOv5 models training	181
11.3.4. YOLOv5 models evaluation.	181
11.3.5. Discussion	183
11.4. Conclusion and future work	185
11.5. References.	186

Chapter 12. Energy Management of Smart Buildings in the Era of Connected Innovation and Technology. 189

Lotfi DERRADJI, Chaima MAGRAOUI, Amel LIMAM,
Abdelouahab BOUTTOUT and Abdelatif MERABTINE

12.1. Introduction	189
12.2. Presentation of the case study	191
12.3. Materials and methods	192
12.3.1. Experimental study	193
12.3.2. Simulation	195
12.4. Results and discussion.	196
12.4.1. Experimental results	196
12.4.2. Simulation results	199

12.5. Conclusion	200
12.6. References.	202

Chapter 13. The Relevance of Frugal Innovation for Sustainability: The Case of Developing a Solution for Water Scarcity 205

Luis Miguel LÓPEZ SANTIAGO

13.1. Introduction	205
13.2. Prior research	206
13.2.1. Addressing water scarcity in BoP contexts	206
13.2.2. FI, core characteristics for BoP contexts	208
13.3. Research methodology	210
13.3.1. Research setting and case selection	210
13.3.2. Data collection and analysis	210
13.4. Findings	211
13.4.1. Description of the ceramic filter system.	211
13.4.2. The ceramic filter and the criteria of FI	212
13.5. Discussion and contributions.	214
13.5.1. Limitations	215
13.6. Conclusion and perspectives	216
13.7. Acknowledgments	216
13.8. References.	216

Chapter 14. Finite Element Analysis of the Tensile Stiffness of Additive Manufactured Triply Periodic Minimal Surface Lattices 221

Mohamed ABOUELMAJD, Issam EL KHADIRI, Ismail EZZARAA, Maria ZEMZAMI, Ismail ARROUB, Manuel LAGACHE, Ahmed BAHLAOUI, Nabil HMINA and Soufiane BELHOUIDEG

14.1. Introduction	221
14.2. Design and finite element modeling	224
14.2.1. Design of TPMS unit cell topologies	224
14.2.2. Finite element modeling of tensile loading regime	226
14.2.3. Validation of the FEA model	226
14.3. Results and discussion.	227
14.3.1. Elastic behavior of sheet TPMS unit cell topologies	227
14.3.2. Local stress distributions.	228
14.3.3. Prediction of elastic modulus using the Gibson–Ashby model	230
14.4. Conclusion and perspectives	231
14.5. References.	232

Chapter 15. Enhancing Heat Dissipation Using Optimized TPMS Designs in Additive Manufacturing	235
Issam EL KHADIRI, Mohamed ABOUELMAJD, Maria ZEMZAMI, Manuel LAGACHE, Nabil HMINA and Soufiane BELHOUIDEG	
15.1. Introduction	235
15.2. Methodology	237
15.2.1. Creation of TPMS lattice database	237
15.2.2. Topology optimization of multi-TPMS lattices	239
15.3. Results and discussion.	242
15.3.1. TPMS lattice cell database.	243
15.3.2. Thermal optimization.	244
15.3.3. Mapping of optimized topology	245
15.3.4. Efficiency and conductive behavior of optimized heat sinks	246
15.4. Conclusion	248
15.5. References.	249
 List of Authors	 253
 Index	 259