

الجمهورية الشعبية الديمقراطية الجزائرية
République Algérienne Démocratique et Populaire
وزارة التعليم العالي و البحث العلمي
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
المدرسة العليا للإعلام الآلي . 08 ماي 5491 . بسيدي بلعباس
École Supérieure en Informatique
-08 Mai 1945- Sidi Bel Abbès



Mémoire de fin d'études

Pour l'obtention du diplôme d'ingénieur d'État
Filière : Informatique
Spécialité: Systèmes d'Information et Web (SIW)

Thème

Reconfigurable Manufacturing Systems: A Comprehensive Review and A Deep Reinforcement Learning Framework

Présenté par: Abdelfatah KERMAI

Date de soumission: **26/09/2023**

Devant le jury composé de:

Présidente	Mme. ^r	Dif Nassima	Dr.	ESI-SBA, Algérie.
Encadreur	M.	Soleyman Chaib	Dr.	ESI-SBA, Algérie.
Co-Encadreur	M.	BEZOUJ Madani	E.C.	CESI, France.
Co-Encadreur	M.	OUCHANI Samir	E.C.	CESI, France.
Examinatrice	Mme. ^r	Taouli Amina	Dr.	ESI-SBA, Algérie.

Année académique : 2022/2023

LIST OF ACRONYMS

- ABILS** Archive-Based Iterated Local Search heuristic.
- ACO** Ant Colony Optimisation.
- AHP** Analytic Hierarchy Process.
- AI** Artificial Intelligence.
- ALC** Average Linkage Clustering.
- AMOS** Archived Multi-Objective Simulated Annealing.
- ANP** Analytical Network Process.
- ASRP** Assembly System Reconfiguration Planning.
- AUGECON** Augmented $\epsilon - Constraint$.
- BS** Boundry Search.
- CNC** Computer Numerical Control Machine.
- DCMS** Dynamic Cellular Manufacturing System.
- DM** Dedicated machine.
- DML** Dedicated manufacturing line.
- DP** Dynamic Programming.
- DRL** Deep Reinforcement Learning.
- FLCS** Flow Line Configuration Selection problem.
- FLP** Facility Layout Problem.

FMS Flexible manufacturing system.

GA Genetic Algorithms.

GAMS GAMS software.

ICA Imperialist Competitive Algorithm.

IM Integer/Mixed Integer programming.

JIT Just In Time.

JS Job Shop.

LP Linear programming.

LSSUPP iterated Local Search on Single-Unit Process Plans heuristic.

MC Machine level objective: Cost.

MO Machine level objective: Others.

MOPSO Multiple-Objective Particle Swarm Optimization.

MR Machine level objective: Reconfigurability.

MT Machine level objective: Time.

NLP Non-linear programming.

NSGA-II Non Sorting Genetic Algorithms II.

PPS Process Planning and Scheduling problem.

PVNS Parallel Variable Neighborhood Search.

RCMS Reconfigurable Cellular Manufacturing System.

RL Reinforcement Learning.

RMS Reconfigurable Manufacturing System.

RMT Reconfigurable Machine Tool.

RSUPP Repetitive Single-Unit Process Plan heuristic.

SC System level objective: Cost.

SE System level objective: Energy consumption.

SO System level objective: Others.

SP System level objective: Performance.

SPEA-II Strength Pareto Evolutionary Algorithm II.

SPP Shortest Path Problems.

ST System level objective: Time.

STO Stochastic model.

TOPSIS Technique for Order Preference by Similarity to Ideal Solution.

TS Tabu Search.

VNS Variable Neighborhood Search.

Dedication

I would like to begin by expressing my deepest gratitude to ALLAH, the Most Merciful and Compassionate, for giving me the strength, wisdom and resilience to embark on this academic journey. I dedicate this thesis to my beloved mother, CHAKER Farida, and my father, KERMAI Bachir, for their unwavering love and endless support. To my dear sister Sarah and brothers Mohammed, Abdelhakim and Houcine, your belief in my abilities has been a constant source of motivation. To my esteemed supervisors, CHAIB Souleyman, BEZOUI Madani and OUCHANI Samir, your guidance has been invaluable. To my teachers and directors at ESI-SBA School, thank you for your commitment to providing me with knowledge. To all those who shared their expertise, time and knowledge, I extend my heartfelt gratitude. Finally, to my friends who have shared this journey with me, your friendship has added to the joy and companionship. This thesis is dedicated to all of you for being the pillars of strength and wisdom in this remarkable journey. Thank you for making this chapter of my life so special.

by KERMAI Abdelfatah

Abstract

The evolving paradigm of [Reconfigurable Manufacturing System \(RMS\)](#) stands as a promising response to the rapidly changing requirements of both the market and the manufacturing systems. Characterised by its inherent flexibility, scalability and adaptability, RMS has received considerable attention in recent years. This thesis provides a comprehensive review of RMS, including a thorough exploration of their theoretical foundations, practical implementations, and emerging optimisation methods. Furthermore, this thesis presents a novel [Deep Reinforcement Learning \(DRL\)](#) solution for scheduling, reconfiguration, and balancing RMS problems. It highlights its potential to improve system performance and adaptability. Ultimately, this work aims to stimulate further research and development in this field and to serve as a valuable resource for researchers and practitioners seeking to harness the transformative power of RMS in modern manufacturing.

Keywords— Reconfigurable Manufacturing System, Comprehensive Review, RMS Analysis, Deep Reinforcement Learning , Hierarchical Systems, Multi-Agent Systems

المخلص

يمثل النموذج المتطور لنظام التصنيع القابل لإعادة التشكيل (RMS) بمثابة استجابة واعدة للمتطلبات المتغيرة بسرعة لكل من السوق وأنظمة التصنيع. وقد حظي نظام RMS، الذي يتميز بالمرونة المتأصلة وقابلية التوسع والقدرة على التكيف، باهتمام كبير في السنوات الأخيرة. تقدم هذه الأطروحة مراجعة شاملة لـ RMS، بما في ذلك استكشاف شامل لأسسها النظرية والتطبيقات العملية وطرق التحسين الناشئة. علاوة على ذلك، تقدم هذه الأطروحة حلاً جديداً للتعلم المعزز لمشاكل الجدولة وإعادة التكوين والموازنة. وهو يسلط الضوء على قدرته على تحسين أداء النظام والقدرة على التكيف. وفي النهاية، يهدف هذا العمل إلى تحفيز المزيد من البحث والتطوير في مجال RMS ويكون بمثابة مورد قيم للباحثين والممارسين الذين يسعون إلى تسخير القوة التحويلية لـ RMS في التصنيع الحديث.

الكلمات الدالة:

نظام التصنيع القابل لإعادة التشكيل، دراسة متعمقة، تحليل RMS، التدريب على التعزيز العميق، الأنظمة الهرمية، الأنظمة متعددة العملاء

Résumé

Le modèle évolutif des systèmes de fabrication reconfigurables (RMS) constitue une réponse prometteuse à l'évolution rapide des exigences du marché et des systèmes de fabrication. Cette thèse fournit un examen complet des RMS, y compris une exploration approfondie de leurs fondements théoriques, de leurs implémentations pratiques et des méthodes d'optimisation émergentes. En fin de compte, ce travail vise à stimuler la recherche et le développement dans le domaine des RMS et à servir de ressource précieuse pour les chercheurs et les praticiens qui cherchent à exploiter le pouvoir de transformation des RMS dans la fabrication moderne.

Mots Clés— Système de fabrication reconfigurable, étude approfondie, analyse RMS, apprentissage par renforcement profond, systèmes hiérarchiques, systèmes multi-agents