

Review

# Reinforcement Learning-Based Intelligent Control Strategies for Optimal Power Management in Advanced Power Distribution Systems: A Survey

Mudhafar Al-Saadi <sup>\*</sup>, Maher Al-Greer  and Michael Short 

School of Computing, Engineering, and Digital Technologies, Teesside University, Middlesbrough TS1 3BX, UK  
<sup>\*</sup> Correspondence: m.al-saadi@tees.ac.uk

**Abstract:** Intelligent energy management in renewable-based power distribution applications, such as microgrids, smart grids, smart buildings, and EV systems, is becoming increasingly important in the context of the transition toward the decentralization, digitalization, and decarbonization of energy networks. Arguably, many challenges can be overcome, and benefits leveraged, in this transition by the adoption of intelligent autonomous computer-based decision-making through the introduction of smart technologies, specifically artificial intelligence. Unlike other numerical or soft computing optimization methods, the control based on artificial intelligence allows the decentralized power units to collaborate in making the best decision of fulfilling the administrator's needs, rather than only a primitive decentralization based only on the division of tasks. Amongst the smart approaches, reinforcement learning stands as the most relevant and successful, particularly in power distribution management applications. The reason is it does not need an accurate model for attaining an optimized solution regarding the interaction with the environment. Accordingly, there is an ongoing need to accomplish a clear, up-to-date, vision of the development level, especially with the lack of recent comprehensive detailed reviews of this vitally important research field. Therefore, this paper fulfills the need and presents a comprehensive review of the state-of-the-art successful and distinguished intelligent control strategies-based RL in optimizing the management of power flow and distribution. Wherein extensive importance is given to the classification of the literature on emerging strategies, the proposals based on RL multiagent, and the multiagent primary secondary control of managing power flow in micro and smart grids, particularly the energy storage. As a result, 126 of the most relevant, recent, and non-incremental have been reviewed and put into relevant categories. Furthermore, salient features have been identified of the major positive and negative, of each selection.

**Keywords:** microgrid; smart grid; multiagent; artificial intelligence; decentralization; autonomy; renewable energy



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## 1. Introduction

The control of renewable energy in modern power distribution applications, such as microgrids, smart grids, smart buildings, and electric vehicles (EVs) applications, is experiencing a large, fundamental transition due to several technological advances and environmental considerations. For instance, the world is gearing toward the enhancement of the introduction of renewable energy and transportation based on either EVs or alternative fuels, due to their economic, technical, and environmental advantages [1]. However, the current global electricity and alternative fuel generation is still a mixed fuel, with the supremacy of fossil fuel remaining in many regions of the world. In fact, both trends are fundamentally related since the use of renewable energy in charging EVs or generating alternative fuels such as hydrogen would significantly reduce greenhouse gas emissions [2]. Optimal power distribution control is the most prominent challenge in enhancing the penetration and sustainability of renewable energy and reducing the use of fossil fuels, due

# Power Of Reinforcement

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*The Power of Reinforcement* Stephen Ray Flora, 2004-01-16 Makes the controversial argument that reinforcement is a real and valuable force in human behavior      **The Power of Positive Reinforcement** Judith E. Favell, 1977      *The Power of Positive Reinforcement* Fred Luthans, Mark J. Martinko, 1978-07-01      **Fire Officer** International Association of Fire Chiefs, National Fire Protection Association, 2010 The National Fire Protection Association NFPA And The International Association of Fire Chiefs IAFC are pleased to bring you the Second Edition of Fire Officer Principles and Practice a modern integrated teaching and learning system For The Fire Officer I and II levels Fire officers need to know how to make the transition from fire fighter to leader Fire Officer Principles and Practice Second Edition is designed to help fire fighters make a smooth transition to fire officer Covering the entire scope of NFPA 1021 Standard for Fire Officer Professional Qualifications 2009 Edition Fire Officer combines current content with dynamic features and interactive technology to better support instructors and help prepare future fire officers for any situation that may arise Safety is Principle the Second Edition features a laser like focus on fire fighter safety Reducing fire fighter injuries and deaths requires the dedicated efforts of every fire fighter fire officer fire department And The entire fire community working together it is with this goal in mind that we have integrated the 16 Firefighter Life Safety Initiatives developed by the National Fallen Firefighters Foundation into the text Likewise In each of the chapters actual National Fire Fighter Near Miss Reporting System cases are discussed to drive home safety And The lessons learned from those incidents Some of the guiding principles added To The new edition include Description of the Everybody Goes Home And The National Fire Fighter Near Miss Reporting System including over a dozen company officer near miss examples throughout the text Description of the IAFC IAFF Firefighter Safety and Deployment Study The latest fire fighter death and injury issues as reported by the NFPA National Fallen Firefighters Foundation IAFC and IAFF including results of a thirty year retrospective study Changes in fire ground accountability and rapid intervention practices Results of National Institute of Standards and Technology research on wind driven fires thermal imaging cameras and fire dynamics as related to fire fighter survival The latest developments in crew resource management The Second Edition also reflects the latest developments in Building a personal development plan through education training self development and experience including a description of the Fire and Emergency Services Higher Education FESHE program The impact of blogs video sharing and social networks How to budget for a grant Changes in the National Response Framework and National Incident Management System Additional items related to fire fighter safety and health are included Click here to view a sample chapter from Fire Officer Principles and Practice Second Edition

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Tennessee Valley Authority. Engineering and Construction Divisions, 1957

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**Constitutionalism** Charles M. Fombad, 2016-03-03 The new series Stellenbosch Handbooks in African Constitutional Law will engage with contemporary issues of constitutionalism in Africa filling a notable gap in African comparative constitutional law Separation of Powers in African Constitutionalism is the first in the series examining one of the critical measures introduced by African constitutional designers in their attempts to entrench an ethos of constitutionalism on the continent Taking a critical look at the different ways in which attempts have been made to separate the different branches of government the Handbook examines the impact this is having on transparent and accountable governance Beginning with an overview of constitutionalism in Africa and the different influences on modern African constitutional developments it looks at the relationship between the legislature and the executive as well as the relationship between the judiciary and the political branches Despite differences in approaches between the different constitutional cultures that have influenced developments in Africa there remain common problems One of these problems is the constant friction in the relationship between the three branches and the resurgent threats of authoritarianism which clearly suggest that there remain serious problems in both constitutional design and implementation The book also studies the increasing role being played by independent constitutional institutions and how they complement the checks and balances associated with the traditional three branches of government

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#### **Standard Rules for the Construction of**

**Steam Boilers and Other Pressure Vessels and for Their Care in Service** American Society of Mechanical Engineering, 1928

*Barge Canal Bulletin* New York (State). State Engineer and Surveyor, 1914

#### **Public Information**

**Management and E-Government: Policy and Issues** Brown, Mary Maureen, Garson, G. David, 2013-02-28 Recently the public sector has given an increasing amount of national and international attention to electronic government systems Therefore it is inevitable that the theoretical implications and intersections between information technology and governmental matters are more widely discussed Public Information Management and E Government Policy and Issues offers a fresh comprehensive dialogue on issues that occur between the public management and information technology domains With its focus on political issues and their effects on the larger public sector this book is valuable for administrators

researchers students and educators who wish to gain foundational and theoretical knowledge on e government policies

**Energy Management System for Dispatchable Renewable Power Generation** Amer Al-Hinai, Hassan Haes Alhelou, 2022-11-30 Enhancing the integration of renewable power generation from wind and solar into the traditional power network requires the mitigation of the vulnerabilities affecting the grid as a result of the intermittent nature of these resources Variability and ramp events in power output are the key challenges to the system operators due to their impact on system balancing reserves management scheduling and commitment of generation units This book presents development of energy management system for renewable power generation EMSRPG tool that aims to achieve power dispatching strategies based on forecasting renewable energy resources outputs to guarantee optimal dispatch of hybrid wind solar photovoltaic power systems HWSPPS The key selling points of the book include the following Renewable energy management in modern and future smart power systems Energy management systems Modeling and simulations using a real time digital simulator RTDS High penetration level of renewable energy sources Case studies based on Oman s power systems and other power grids This book discusses the challenges of integrating renewable resources including low inertia systems hosting capacity limitations of existing power systems and weak grids It further examines the detailed topologies operation principles recent developments in control techniques and stability of power systems with a large scale of renewables Finally it presents case studies of recent projects from around the world where dispatchable power plant techniques are used to enhance power system operation

**American Highway Engineers' Handbook** Arthur Horace Blanchard, 1919

**Fire Officer** Michael J. Ward, IAFC, 2013-12-06 Your Complete Fire Officer I and Fire Fighter II Training Solution The National Fire Protection Association NFPA and the International Association of Fire Chiefs IAFC are pleased to bring you the Third Edition of Fire Officer Principles and Practice the next step in the evolution of Fire Officer I and II training Covering the entire spectrum of the 2014 Edition of NFPA 1021 Standard for Fire Officer Professional Qualifications the Third Edition includes the following updates Separation of Fire Officer I and II Level content throughout the textbook and student instructor and technology resources The latest developments in social media and media relations NIST research on fire dynamics fire fighter safety and health issues and fireground accountability and rapid intervention practices A reorganization of chapters to improve course delivery including a new chapter on Rules of Engagement New end of chapter tools including Fire Captain Fire Officer II activities and comprehensive case studies that progress within each chapter throughout the textbook All new Voices of Experience essays and Near Miss Reports Addresses the course objectives for FESHE s Principles of Fire and Emergency Service Administration model curriculum Build the next generation of great fire service leaders with the Third Edition of Fire Officer Principles and Practice

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powers were either pre occupied with their domestic problems or deferred to the United States As a consequence on the eve of 11 September 2001 the United Nations Security Council remained an older outmoded power configuration incapable of responding efficiently to the with novel challenges besetting it Its relevance has been further questioned by the unilateral occupation of Iraq by the United States

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**Military Thought**, 1998

**CHINA IN INDIAN OCEAN REGION** Dr. Sidda Goud, Manisha Mookherjee, 2015-02-28 This edited book is the outcome of the International Conference on China in Indian Ocean Region held on 13th 14th November 2014 organized by UGC Centre for Indian Ocean Studies Osmania University Hyderabad Indian Ocean third largest ocean in the world surpasses the Atlantic and Pacific Oceans as the world s largest and most strategically significant trade corridor Indian Ocean Region IOR which is surrounded by Africa Asia and Australia serves as a maritime highway linking trans continental human and economic relationships Being the world s most populated region one third of the world s bulk cargo and around two thirds of world s oil ship tankers pass through it China s interest in the Indian Ocean Region IOR can be traced back to the early 1960s Ever since Beijing has been increasingly deepening its presence in the IOR for a variety of reasons oil trade security etc over 30 per cent of China s seaborne trade worth about US 300 billion transits across IOR Sharing a quarter of the world s population China faces ever increasing demand for energy China has little choice but to look beyond its borders for its energy needs About 77 per cent of its oil imports are sourced from West Asia and Africa and these are transported through the Indian Ocean Thus China s dependence on the Indian Ocean continues to grow for energy imports from the Gulf to import resources from Africa and trade with Europe With China steadily spreading its footprints in the Indian Ocean Region with increasing military presence and with the rapidly growing Navy being equipped with warships destroyers and nuclear submarines this book analyses in depth growing Chinese influence in Indian Ocean Region IOR Geopolitical interests of China Security and Economic implication for India This volume will be of considerable interest to the students and scholars of international relations in the contemporary situation

**Soft Computing: Theories and Applications** Tarun K. Sharma, Chang Wook Ahn, Om Prakash Verma, Bijaya Ketan Panigrahi, 2021-06-26 This book focuses on soft computing and how it can be applied to solve real world problems arising in various domains ranging from medicine and healthcare to supply chain management image processing and cryptanalysis It gathers high quality papers

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