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Recent trends in robot learning and evolution for swarm robotics

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Swarm robotics is a promising approach to control large groups of robots. However, designing the individual behavior of the robots so that a desired collective behavior emerges is still a major challenge. In recent years, many advances in the automatic design of control software for robot swarms have been made, thus making automatic design a promising tool to address this challenge. In this article, I highlight and discuss recent advances and trends in offline robot evolution, embodied evolution, and offline robot learning for swarm robotics. For each approach, I describe recent design methods of interest, and commonly encountered challenges. In addition to the review, I provide a perspective on recent trends and discuss how they might influence future research to help address the remaining challenges of designing robot swarms.

KEYWORDS

swarm robotics, robot evolution, robot learning, automatic design, neuro-evolution, automatic modular design, embodied evolution, imitation learning

1 Introduction

Robot swarms are decentralized systems of relatively simple robots that only rely on local information to operate (Breni, 2005; Sahin, 2005; Brambilla et al., 2013; Dorigo et al., 2014; Haddad, 2018). Like animal swarms in nature, a robot swarm is a group of robots that are efficient at performing tasks due to their cooperation. Robot swarms are multi-robot systems that exhibit some particular characteristics. They are decentralized and highly redundant. The high redundancy requires that there is no role in the swarm that can only be executed by a single robot¹. Furthermore, in a robot swarm, there exists no single central point of control (neither internal nor external to the swarm), as a centralized point of control would be a single point of failure. Therefore, complex collective behaviors, such as task allocation, cannot be planned and orchestrated by an operator. Instead, the swarm is required to be self-organizing: the collective behavior of the swarm must emerge from the interactions between the individual robots. Additionally, the robots in the swarm are relatively simple (both in terms of hardware and software) with respect to the task they perform and have only local sensing and communication capabilities.

¹ Classically, a robot swarm is a homogeneous system—i.e., all robots have the same capabilities and execute the same software. There have been examples of heterogeneous robot swarms (Dorigo et al., 2015), in which parts of the swarm are specialized in such a way that their role cannot be performed by some of the other robots in the swarm. Yet, in these examples, heterogeneous swarms are also redundant to some degree, as each role has at least several robots being able to perform it.

Recent Advances In Robot Learning

**Judy A. Franklin, Tom M.
Mitchell, Sebastian Thrun**



Recent Advances In Robot Learning:

Recent Advances in Robot Learning Judy A. Franklin, Tom M. Mitchell, Sebastian Thrun, 2012-12-06 Recent Advances in Robot Learning contains seven papers on robot learning written by leading researchers in the field As the selection of papers illustrates the field of robot learning is both active and diverse A variety of machine learning methods ranging from inductive logic programming to reinforcement learning is being applied to many subproblems in robot perception and control often with objectives as diverse as parameter calibration and concept formulation While no unified robot learning framework has yet emerged to cover the variety of problems and approaches described in these papers and other publications a clear set of shared issues underlies many robot learning problems Machine learning when applied to robotics is situated it is embedded into a real world system that tightly integrates perception decision making and execution Since robot learning involves decision making there is an inherent active learning issue Robotic domains are usually complex yet the expense of using actual robotic hardware often prohibits the collection of large amounts of training data Most robotic systems are real time systems Decisions must be made within critical or practical time constraints These characteristics present challenges and constraints to the learning system Since these characteristics are shared by other important real world application domains robotics is a highly attractive area for research on machine learning On the other hand machine learning is also highly attractive to robotics There is a great variety of open problems in robotics that defy a static hand coded solution *Recent Advances in Robot Learning* is an edited volume of peer reviewed original research comprising seven invited contributions by leading researchers This research work has also been published as a special issue of Machine Learning Volume 23 Numbers 2 and 3

Recent Advances in Robot Learning from Demonstration Harish Ravichandar, 2020 In the context of robotics and automation learning from demonstration LfD is the paradigm in which robots acquire new skills by learning to imitate an expert The choice of LfD over other robot learning methods is compelling when ideal behavior can be neither easily scripted as is done in traditional robot programming nor easily defined as an optimization problem but can be demonstrated While there have been multiple surveys of this field in the past there is a need for a new one given the considerable growth in the number of publications in recent years This review aims to provide an overview of the collection of machine learning methods used to enable a robot to learn from and imitate a teacher We focus on recent advancements in the field and present an updated taxonomy and characterization of existing methods We also discuss mature and emerging application areas for LfD and highlight the significant challenges that remain to be overcome both in theory and in practice

Recent Advances in Robotic Systems Guanghui Wang, 2016-09-28 This book brings together some recent advances and development in robotics In 12 chapters written by experts and researchers in respective fields the book presents some up to date research ideas and findings in a wide range of robotics including the design modeling control learning interaction and navigation of robots From an application perspective the book covers UAVs USVs mobile robots humanoid robots graspers and underwater robots The

unique text offers practical guidance to graduate students and researchers in research and applications in the field of robotics *Recent Advances in Robotics and Automation* Gourab Sen Gupta,Donald Bailey,Serge Demidenko,Dale Carnegie,2013-05-23 There isn't a facet of human life that has not been touched and influenced by robots and automation What makes robots and machines versatile is their computational intelligence While modern intelligent sensors and powerful hardware capabilities have given a huge fillip to the growth of intelligent machines the progress in the development of algorithms for smart interaction collaboration and pro activeness will result in the next quantum jump This book deals with the recent advancements in design methodologies algorithms and implementation techniques to incorporate intelligence in robots and automation systems Several articles deal with navigation localization and mapping of mobile robots a problem that engineers and researchers are grappling with all the time Fuzzy logic neural networks and neuro fuzzy based techniques for real world applications have been detailed in a few articles This edited volume is targeted to present the latest state of the art computational intelligence techniques in Robotics and Automation It is a compilation of the extended versions of the very best papers selected from the many that were presented at the 5th International Conference on Automation Robotics and Applications ICARA 2011 which was held in Wellington New Zealand from 6-8 December 2011 Scientists and engineers who work with robots and automation systems will find this book very useful and stimulating **Recent Advances in Neuromorphic Computing** ,2025-07-02 Artificial Intelligence AI is a transformative technology that reshapes our daily lives Machine Learning ML the engine of such a revolution empowers computers to learn from data driving innovation in areas such as medicine robotics and smart cities through edge applications These applications bring AI processing closer to the data source enabling real time insights and decisions This evolution is fueled by advancements in hardware and architecture 1 neuromorphic computing promises unparalleled efficiency 2 in memory computing eliminates data access bottlenecks while emerging memory materials offer denser faster and more energy efficient storage Looking ahead AI promises even more profound changes For instance explainable AI will make decision making more transparent and truly autonomous systems will adapt to unforeseen circumstances Last but not least the convergence of AI with quantum computing could unlock entirely new possibilities This journey showcases a deep understanding of both the theoretical foundations and practical applications of AI It also demands careful consideration of ethical implications and a commitment to responsible development ensuring that AI benefits all of humanity *Recent Advances in Material, Manufacturing, and Machine Learning* Bjorn Schuller,Rajeev Gupta,Rakesh Mote,Abhishek Sharma,J.P. Giri,R.B. Chadge,2024-06-17 The main aim of the 2nd international conference on recent advances in materials manufacturing and machine learning processes 2023 RAMMML 23 is to bring together all interested academic researchers scientists engineers and technocrats and provide a platform for continuous improvement of manufacturing machine learning design and materials engineering research RAMMML 2023 received an overwhelming response with more than 530 full paper submissions After due and careful scrutiny about 120 of them have

been selected for presentation The papers submitted have been reviewed by experts from renowned institutions and subsequently the authors have revised the papers duly incorporating the suggestions of the reviewers This has led to significant improvement in the quality of the contributions Taylor Francis publications CRC Press have agreed to publish the selected proceedings of the conference in their book series of Advances in Mechanical Engineering and Interdisciplinary Sciences This enables fast dissemination of the papers worldwide and increases the scope of visibility for the research contributions of the authors

Recent Advances in Artificial Intelligence Research and Development

Jordi Vitrià, Petia Radeva, Isabel Aguiló, 2004 Artificial Intelligence AI is a scientific field of longstanding tradition with origins in the early years of computer science Today AI has reached a level of maturity that allows us to build highly sophisticated systems which perform very different tasks Nevertheless its evolution has opened up a number of new problems ranging from specific algorithms to system integration which remain elusive and assure a long life for this research field Research progress in this area is today an international challenge that must be supported by world class meetings and organizations but in spite of this fact there is also an objective need for meetings and organizations that support and disseminate research at other levels This book focuses on new and original research on Artificial Intelligence

Recent Advances in the Treatment of Colorectal Cancer Hideyuki Ishida, Keiji Koda, 2018-12-31 This book examines the latest indications and techniques for various endoscopic and surgical colorectal cancer treatments discussing not only on the standard lymph node dissection technique but also on laparoscopic and robotic surgery It particularly focuses on the treatment of rectal cancer with chapters on radiation therapy and sphincter preservation which is analyzed from Asian perspectives that differ from those of Western treatment Further it presents the results of combining chemotherapy and oral drugs as well as the treatment of hereditary cancer using next generation sequencing for genetic diagnosis Edited by surgeons who have pioneered the research and treatment of colorectal cancer Recent Advances in the Treatment of Colorectal Cancer presents extensive information for clinicians such as endoscopic surgeons colorectal surgeons as well as oncologists and researchers specializing in this field Providing a foundation for new ideas it enables advanced surgeons to further develop their skills and offers thought provoking instructive and informative reading for residents students and medical staff

Recent Advances in Mechanism Design for Robotics Shaoping Bai, Marco Ceccarelli, 2015-05-05 This volume contains the Proceedings of the 3rd IFToMM Symposium on Mechanism Design for Robotics held in Aalborg Denmark 2 4 June 2015 The book contains papers on recent advances in the design of mechanisms and their robotic applications It treats the following topics mechanism design mechanics of robots parallel manipulators actuators and their control linkage and industrial manipulators innovative mechanisms robots and their applications among others The book can be used by researchers and engineers in the relevant areas of mechanisms machines and robotics

Recent Advances in Soft Computing and Cybernetics

Radek Matoušek, Jakub Kůdela, 2021-02-05 This monograph is intended for researchers and professionals in the fields of computer

science and cybernetics Nowadays the areas of computer science and cybernetics mainly its artificial intelligence branches are subject to an immense degree of study and are applied in a wide range of technical and industrial projects The individual chapters of this monograph were developed from a series of invited lectures at the Brno University of Technology in the years 2018 and 2019 The main aim of these lectures was to create an opportunity for students academics and professionals to exchange ideas novel research methods and new industrial applications in the fields related to soft computing and cybernetics The authors of these chapters come from around the world and their works cover both new theoretical and application oriented results from areas such as automation control robotics optimization statistics reinforcement learning image processing and evolutionary algorithms

This book delves into Recent Advances In Robot Learning. Recent Advances In Robot Learning is an essential topic that needs to be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Recent Advances In Robot Learning, encompassing both the fundamentals and more intricate discussions.

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