frontiers | Frontiers in Robotics and AI

TYPE: Review
PUBLISHED: 24 April 2023
DOI: 10.3389/frobt.2023.1134841

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Robot Learning and Evolution, a section of the journal Frontiers in Robotics and AI

RECEIVED 30 December 2022
ACCEPTED 21 March 2023
PUBLISHED 24 April 2023

CITATION
Kuckling J (2023), Recent trends in robot learning and evolution for swarm robotics.
Front. Robot. AI 10:1134841.
doi: 10.3389/frobt.2023.1134841

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 (Beni, 2005; Şahin, 2005; Brambilla et al., 2013; Dorigo et al., 2014; Hamann, 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 robot[1]. 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., 2013), 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

Bjorn Schuller,Rajeev Gupta,Rakesh Mote,Abhishek Sharma,J.P. Giri,R.B. Chadge

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 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 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 manufactur ing machine learning design and materials engineering research RAMMML 2023 received an overwhelm ing 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 dissemina tion of the papers worldwide and increases the scope of visibility for the research contributions of the authors **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 **IAGES Recent Advances in Minimal Access Surgery - 3** Subhash Khanna,2023-01-16 **Recent Advances in Mobile Robotics** Andon Topalov,2011-12-14 Mobile robots are the focus of a great deal of current research in robotics Mobile robotics is a young multidisciplinary field involving knowledge from many areas including electrical electronic and mechanical engineering computer cognitive and social sciences Being engaged in the design of automated systems it lies at the intersection of artificial intelligence computational vision and robotics Thanks to the numerous researchers sharing their goals visions and results within the community mobile robotics is becoming a very rich and stimulating area The book Recent Advances in Mobile Robotics addresses the topic by integrating contributions from many researchers around the globe It emphasizes the computational methods of programming mobile robots rather than the methods of constructing the hardware Its content reflects different complementary aspects of theory and practice which have recently taken place We believe that it will serve as a valuable handbook to those who work in research and development of mobile robots **Modelling Human Motion** Nicoletta Noceti,Alessandra Sciutti,Francesco Rea,2020-07-09 The new frontiers of robotics research foresee future scenarios where artificial agents will leave the laboratory to progressively take part in the activities of our daily life This will require robots to have very sophisticated perceptual and action skills in many intelligence demanding applications with particular reference to the ability to seamlessly interact with humans It will be crucial for the next generation of robots to understand their human partners and at the same time to be intuitively understood by them In this context a deep understanding of human motion is essential for robotics applications where the ability to detect represent and recognize human dynamics and the capability for generating appropriate movements in response sets the scene for higher level tasks This book provides a comprehensive overview of this challenging research field closing the loop between perception and action and between human studies and robotics The book is organized in three main parts The first part focuses on human motion perception with contributions analyzing the neural substrates of human action understanding how perception is influenced by motor control and how it develops over time and is exploited in social contexts The second part considers motion perception from the computational perspective providing perspectives on cutting edge solutions available from the Computer Vision and Machine Learning research fields addressing higher level

perceptual tasks Finally the third part takes into account the implications for robotics with chapters on how motor control is achieved in the latest generation of artificial agents and how such technologies have been exploited to favor human robot interaction This book considers the complete human robot cycle from an examination of how humans perceive motion and act in the world to models for motion perception and control in artificial agents In this respect the book will provide insights into the perception and action loop in humans and machines joining together aspects that are often addressed in independent investigations As a consequence this book positions itself in a field at the intersection of such different disciplines as Robotics Neuroscience Cognitive Science Psychology Computer Vision and Machine Learning By bridging these different research domains the book offers a common reference point for researchers interested in human motion for different applications and from different standpoints spanning Neuroscience Human Motor Control Robotics Human Robot Interaction Computer Vision and Machine Learning Chapter The Importance of the Affective Component of Movement in Action Understanding of this book is available open access under a CC BY 4 0 license at link springer com **From batch-size 1 to serial production: Adaptive robots for scalable and flexible production systems** Mohamad Bdiwi,Arvid Hellmich,Steffen Ihlenfeldt,Andreas Mueller,2023-05-24 **AETA 2019 - Recent Advances in Electrical Engineering and Related Sciences: Theory and Application** Dario Fernando Cortes Tobar,Vo Hoang Duy,Tran Trong Dao,2020-08-10 This proceedings book features selected papers on 12 themes including telecommunication power systems digital signal processing robotics control systems renewable energy power electronics soft computing and more Covering topics such as optoelectronic oscillator at S band and C band for 5G telecommunications neural networks identification of eleven types of faults in high voltage transmission lines cyber attack mitigation on smart low voltage distribution grids optimum load of a piezoelectric based energy harvester the papers present interesting ideas and state of the art overviews *Recent Advances in Applications of Computational and Fuzzy Mathematics* Snehashish Chakraverty,Sanjeewa Perera,2018-07-17 This book addresses the basics of interval fuzzy set theory artificial neural networks ANN and computational methods It presents step by step modeling for application problems along with simulation and numerical solutions In general every science and engineering problem is inherently biased by uncertainty and there is often a need to model solve and interpret problems in the world of uncertainty At the same time exact information about models and parameters of practical applications is usually not known and precise values do not exist This book discusses uncertainty in both data and models It consists of seven chapters covering various aspects of fuzzy uncertainty in application problems such as shallow water wave equations static structural problems robotics radon diffusion in soil risk of invasive alien species and air quality quantification These problems are handled by means of advanced computational and fuzzy theory along with machine intelligence when the uncertainties involved are fuzzy The proposed computational methods offer new fuzzy computing methods that help other areas of knowledge construction where inexact information is present Scientific Methods in Mobile Robotics Ulrich Nehmzow,2006-04-10 Aims at a theoretical

understanding of the operation of autonomous mobile robots This book presents the research on the application of chaos theory parametric and non parametric statistics and dynamical systems theory in this field Practical examples and case studies show how robot behaviour can be logged analysed interpreted and modelled Smart, Sustainable Manufacturing in an Ever-Changing World Konrad von Leipzig,Natasha Sacks,Michelle Mc Clelland,2023-03-03 This book presents recent developments research results and industrial experience to increase the knowledge base of academics and industry In a small world where trade is the new global driving force conquering countries and continents alike international competitiveness is becoming the ultimate challenge It requires high quality products manufactured with state of the art technologies at low cost under the assumption of highly efficient operations management as well as clear corporate goals and strategy This in turn is based on improved engineering training and education relevant applied research and an active interaction between academia and industry **Recent Advances in Electrical Engineering, Electronics and Energy** Miguel Botto Tobar,Henry Cruz,Angela Díaz Cadena,2021-03-24 This book constitutes the proceedings of the XV Multidisciplinary International Congress on Science and Technology CIT 2020 held in Quito Ecuador on 26 30 October 2020 proudly organized by Universidad de las Fuerzas Armadas ESPE in collaboration with GDEON CIT is an international event with a multidisciplinary approach that promotes the dissemination of advances in Science and Technology research through the presentation of keynote conferences In CIT theoretical technical or application works that are research products are presented to discuss and debate ideas experiences and challenges Presenting high quality peer reviewed papers the book discusses the following topics Electrical and Electronic Energy and Mechanics **Neural Information Processing** Biao Luo,Long Cheng,Zheng-Guang Wu,Hongyi Li,Chaojie Li,2023-11-14 The six volume set LNCS 14447 until 14452 constitutes the refereed proceedings of the 30th International Conference on Neural Information Processing ICONIP 2023 held in Changsha China in November 2023 The 652 papers presented in the proceedings set were carefully reviewed and selected from 1274 submissions They focus on theory and algorithms cognitive neurosciences human centred computing applications in neuroscience neural networks deep learning and related fields

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