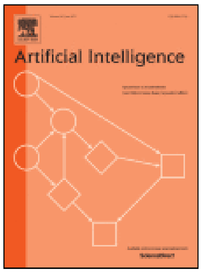
Search all fields | Author name | --This Journal/Book-- | Volume | Issue | Page | Advanced search



Artificial Intelligence

Supports Open Access | About this Journal | Submit your Article

This journal has an Open Archive.

- Get new article feed
- Get new Open Access article feed
- Subscribe to new volume alerts
- Add to Favorites

Visit IJCAI

< Previous vol/iss | Next vol/iss >

Artificial Intelligence
Volume 247, Pages 1-440 (June 2017)
Special Issue on AI and Robotics
Edited by Kanna Rajan and Alessandro Saffiotti

Articles **1 - 20**

Purchase | Export | All access types

Editorial Board

Page IFC
PDF (45 K)

Towards a science of integrated AI and Robotics

Pages 1-9
Kanna Rajan, Alessandro Saffiotti
Close abstract | Purchase PDF - $35.95

Abstract

Citing articles (0)

The early promise of the impact of machine intelligence did not involve the partitioning of the nascent field of Artificial Intelligence. The founders of AI envisioned the notion of embedded intelligence as being conjoined between perception, reasoning and actuation. Yet over the years the fields of AI and Robotics drifted apart. Practitioners of AI focused on problems and algorithms abstracted from the real world. Roboticists, generally with a background in mechanical and electrical engineering, concentrated on sensori-motor functions. That divergence is slowly being bridged with the maturity of both fields and with the growing interest in autonomous systems. This special issue brings together the state of the art and practice of the emergent field of integrated AI and Robotics, and highlights the key areas along which this current evolution of machine intelligence is heading.

Deliberation for autonomous robots: A survey Review Article

Pages 10-44
Félix Ingrand, Malik Ghallab
Close abstract | Purchase PDF - $35.95

Abstract

Citing articles (2)

Autonomous robots facing a diversity of open environments and performing a variety of tasks and interactions need explicit deliberation in order to fulfill their missions. Deliberation is meant to endow a robotic system with extended, more adaptable and robust functionalities, as well as reduce its deployment cost.

The ambition of this survey is to present a global overview of deliberation functions in robotics and to discuss the state of the art in this area. The following five deliberation functions are identified and analyzed: planning, acting, monitoring, observing, and learning. The paper introduces a global perspective on these deliberation functions and discusses their main characteristics, design choices and constraints. The reviewed contributions are discussed with respect to this perspective. The survey focuses as much as possible on papers with a clear robotics content and with a concern on integrating several deliberation functions.

Volumes 181 - 190 (2012)
Volumes 171 - 180 (2007 - 2012)
Volumes 161 - 170 (2005 - 2006)
Volumes 151 - 160 (2003 - 2004)
Volumes 141 - 150 (2002 - 2003)
Volumes 131 - 140 (2001 - 2002)
Volumes 121 - 130 (2000 - 2001)
Volumes 111 - 120 (1999 - 2000)
Volumes 101 - 110 (1998 - 1999)
Volumes 91 - 100 (1997 - 1998)
Volumes 81 - 90 (1996 - 1997)
Volumes 71 - 80 (1994 - 1996)
Volumes 61 - 70 (1993 - 1994)
Volumes 51 - 60 (1991 - 1993)
Volumes 41 - 50 (1989 - 1991)
Volumes 31 - 40 (1987 - 1989)
Volumes 21 - 30 (1983 - 1986)
Volumes 11 - 20 (1978 - 1983)
Volumes 1 - 10 (1970 - 1978)

Artificial cognition for social human–robot interaction: An implementation Original Research Article

Open Access

Pages 45-69

Séverin Lemaignan, Mathieu Warnier, E. Akin Sisbot, Aurélie Clodic, Rachid Alami

Close abstract | PDF (2316 K)

Abstract

Citing articles (1)

Human–Robot Interaction challenges Artificial Intelligence in many regards: dynamic, partially unknown environments that were not originally designed for robots; a broad variety of situations with rich semantics to understand and interpret; physical interactions with humans that requires fine, low-latency yet socially acceptable control strategies; natural and multi-modal communication which mandates common-sense knowledge and the representation of possibly divergent mental models. This article is an attempt to characterise these challenges and to exhibit a set of key decisional issues that need to be addressed for a cognitive robot to successfully share space and tasks with a human.

We identify first the needed individual and collaborative cognitive skills: geometric reasoning and situation assessment based on perspective-taking and affordance analysis; acquisition and representation of knowledge models for multiple agents (humans and robots, with their specificities); situated, natural and multi-modal dialogue; human-aware task planning; human–robot joint task achievement. The article discusses each of these abilities, presents working implementations, and shows how they combine in a coherent and original deliberative architecture for human–robot interaction. Supported by experimental results, we eventually show how explicit knowledge management, both symbolic and geometric, proves to be instrumental to richer and more natural human–robot interactions by pushing for pervasive, human-level semantics within the robot's deliberative system.

Scalable transfer learning in heterogeneous, dynamic environments Original Research Article

Pages 70-94

Trung Thanh Nguyen, Tomi Silander, Zhuoru Li, Tze-Yun Leong

Close abstract | Purchase PDF - $35.95

Abstract

Citing articles (1)

Reinforcement learning is a plausible theoretical basis for developing self-learning, autonomous agents or robots that can effectively represent the world dynamics and efficiently learn the problem features to perform different tasks in different environments. The computational costs and complexities involved, however, are often prohibitive for real-world applications. This study introduces a scalable methodology to learn and transfer knowledge of the transition (and reward) models for model-based reinforcement learning in a complex world. We propose a variant formulation of Markov decision processes that supports efficient online-learning of the relevant problem features to approximate the world dynamics. We apply the new feature selection and dynamics approximation techniques in heterogeneous transfer learning, where the agent automatically maintains and adapts multiple representations of the world to cope with the different environments it encounters during its lifetime. We prove regret bounds for our approach, and empirically demonstrate its capability to quickly converge to a near optimal policy in both real and simulated environments.

Transferring skills to humanoid robots by extracting semantic representations from observations of human activities Original Research Article

Pages 95-118

Karinne Ramirez-Amaro, Michael Beetz, Gordon Cheng

Close abstract | Purchase PDF - $35.95 | Supplementary content

Abstract

Citing articles (1)

In this study, we present a framework that infers human activities from observations using semantic representations. The proposed framework can be utilized to address the difficult and challenging problem of transferring tasks and skills to humanoid robots. We propose a method that allows robots to obtain and determine a *higher-level* understanding of a demonstrator's behavior via semantic representations. This abstraction from observations captures the "essence" of the activity, thereby indicating which aspect of the demonstrator's actions should be executed in order to accomplish the required activity. Thus, a *meaningful semantic* description is obtained in terms of human motions and object properties. In addition, we validated the semantic rules obtained in different conditions, i.e., three different and complex kitchen activities: 1) making a pancake; 2) making a sandwich; and 3) setting the table. We present quantitative and qualitative results, which demonstrate that without any further training, our system can deal with time restrictions, different execution styles of the same task by several participants, and different labeling strategies. This means, the rules obtained from one scenario are still valid even for new situations, which demonstrates that the inferred representations do not depend on the task performed. The results show that our system correctly recognized human behaviors in *real-time* in around 87.44% of cases, which was even better than a random participant recognizing the behaviors of another human (about 76.68%). In particular, the semantic rules acquired can be used to effectively improve the dynamic growth of the ontology-based knowledge representation.

Robot task planning and explanation in open and uncertain worlds Original Research Article
Pages 119-150
Marc Hanheide, Moritz Göbelbecker, Graham S. Horn, Andrzej Pronobis, Kristoffer Sjöö, Alper Aydemir, Patric Jensfelt, Charles Gretton, Richard Dearden, Miroslav Janicek, Hendrik Zender, Geert-Jan Kruijff, Nick Hawes, Jeremy L. Wyatt
Close abstract | Purchase PDF - $35.95 | Supplementary content

Abstract Citing articles (10)

A long-standing goal of AI is to enable robots to plan in the face of uncertain and incomplete information, and to handle task failure intelligently. This paper shows how to achieve this. There are two central ideas. The first idea is to organize the robot's knowledge into three layers: instance knowledge at the bottom, commonsense knowledge above that, and diagnostic knowledge on top. Knowledge in a layer above can be used to modify knowledge in the layer(s) below. The second idea is that the robot should represent not just how its actions change the world, but also what it knows or believes. There are two types of knowledge effects the robot's actions can have: epistemic effects (I believe X because I saw it) and assumptions (I'll assume X to be true). By combining the knowledge layers with the models of knowledge effects, we can simultaneously solve several problems in robotics: (i) task planning and execution under uncertainty; (ii) task planning and execution in open worlds; (iii) explaining task failure; (iv) verifying those explanations. The paper describes how the ideas are implemented in a three-layer architecture on a mobile robot platform. The robot implementation was evaluated in five different experiments on object search, mapping, and room categorization.

Representations for robot knowledge in the KnowRob framework Original Research Article
Pages 151-169
Moritz Tenorth, Michael Beetz
Close abstract | Purchase PDF - $35.95

Abstract Citing articles (2)

In order to robustly perform tasks based on abstract instructions, robots need sophisticated knowledge processing methods. These methods have to supply the difference between the (often shallow and symbolic) information in the instructions and the (detailed, grounded and often real-valued) information needed for execution. For filling these information gaps, a robot first has to identify them in the instructions, reason about suitable information sources, and combine pieces of information from different sources and of different structure into a coherent knowledge base. To this end we propose the KnowRob knowledge processing system for robots. In this article, we discuss why the requirements of a robot knowledge processing system differ from what is commonly investigated in AI research, and propose to re-consider a KR system as a semantically annotated view on information and algorithms that are often already available as part of the robot's control system. We then introduce representational structures and a common vocabulary for representing knowledge about robot actions, events, objects, environments, and the robot's hardware as well as inference procedures that operate on this common representation. The KnowRob system has been released as open-source software and is being used on several robots performing complex object manipulation tasks. We evaluate it through prototypical queries that demonstrate the expressive power and its impact on the robot's performance.

Intrinsically motivated model learning for developing curious robots Original Research Article
Pages 170-186
Todd Hester, Peter Stone
Close abstract | Purchase PDF - $35.95

Abstract Citing articles (1)

Reinforcement Learning (RL) agents are typically deployed to learn a specific, concrete task based on a pre-defined reward function. However, in some cases an agent may be able to gain experience in the domain prior to being given a task. In such cases, intrinsic motivation can be used to enable the agent to learn a useful model of the environment that is likely to help it learn its eventual tasks more efficiently. This paradigm fits robots particularly well, as they need to learn about their own dynamics and affordances which can be applied to many different tasks. This article presents the TEXPLORE with Variance-And-Novelty-Intrinsic-Rewards algorithm (TEXPLORE-VANIR), an intrinsically motivated model-based RL algorithm. The algorithm learns models of the transition dynamics of a domain using random forests. It calculates two different intrinsic motivations from this model: one to explore where the model is uncertain, and one to acquire novel experiences that the model has not yet been trained on. This article presents experiments demonstrating that the combination of these two intrinsic rewards enables the algorithm to learn an accurate model of a domain with no external rewards and that the learned model can be used afterward to perform tasks in the domain. While learning the model, the agent explores the domain in a developing and curious way, progressively learning more complex skills. In addition, the experiments show that combining the agent's intrinsic rewards with external task rewards enables the agent to learn faster than using external rewards alone. We also present results demonstrating the applicability of this approach to learning on robots.

Efficient interactive decision-making framework for robotic applications Original Research Article

Pages 187-212

Alejandro Agostini, Carme Torras, Florentin Wörgötter

Close abstract | Purchase PDF - $35.95

Abstract

Citing articles (1)

The inclusion of robots in our society is imminent, such as service robots. Robots are now capable of reliably manipulating objects in our daily lives but only when combined with artificial intelligence (AI) techniques for planning and decision-making, which allow a machine to determine how a task can be completed successfully. To perform decision making, AI planning methods use a set of planning operators to code the state changes in the environment produced by a robotic action. Given a specific goal, the planner then searches for the best sequence of planning operators, i.e., the best plan that leads through the state space to satisfy the goal. In principle, planning operators can be hand-coded, but this is impractical for applications that involve many possible state transitions. An alternative is to learn them automatically from experience, which is most efficient when there is a human teacher. In this study, we propose a simple and efficient decision-making framework for this purpose. The robot executes its plan in a step-wise manner and any planning impasse produced by missing operators is resolved online by asking a human teacher for the next action to execute. Based on the observed state transitions, this approach rapidly generates the missing operators by evaluating the relevance of several cause–effect alternatives in parallel using a probability estimate, which compensates for the high uncertainty that is inherent when learning from a small number of samples. We evaluated the validity of our approach in simulated and real environments, where it was benchmarked against previous methods. Humans learn in the same incremental manner, so we consider that our approach may be a better alternative to existing learning paradigms, which require offline learning, a significant amount of

Robotic manipulation of multiple objects as a POMDP Original Research Article

Open Access

Pages 213-228

Joni Pajarinen, Ville Kyrki

Close abstract | PDF (2080 K)

Abstract

Citing articles (1)

This paper investigates manipulation of multiple unknown objects in a crowded environment. Because of incomplete knowledge due to unknown objects and occlusions in visual observations, object observations are imperfect and action success is uncertain, making planning challenging. We model the problem as a partially observable Markov decision process (POMDP), which allows a general reward based optimization objective and takes uncertainty in temporal evolution and partial observations into account. In addition to occlusion dependent observation and action success probabilities, our POMDP model also automatically adapts object specific action success probabilities. To cope with the changing system dynamics and performance constraints, we present a new online POMDP method based on particle filtering that produces compact policies. The approach is validated both in simulation and in physical experiments in a scenario of moving dirty dishes into a dishwasher. The results indicate that: 1) a greedy heuristic manipulation approach is not sufficient, multi-object manipulation requires multi-step POMDP planning, and 2) on-line planning is beneficial since it allows the adaptation of the system dynamics model based on actual experience.

Geometric backtracking for combined task and motion planning in robotic systems Original Research Article

Pages 229-265

Julien Bidot, Lars Karlsson, Fabien Lagriffoul, Alessandro Saffiotti

Close abstract | Purchase PDF - $35.95

Citing articles (1)

Abstract

Planners for real robotic systems should not only reason about abstract actions, but also about aspects related to physical execution such as kinematics and geometry. We present an approach to hybrid task and motion planning, in which state-based forward-chaining task planning is tightly coupled with motion planning and other forms of geometric reasoning. Our approach is centered around the problem of *geometric backtracking* that arises in hybrid task and motion planning: in order to satisfy the geometric preconditions of the current action, a planner may need to reconsider geometric choices, such as grasps and poses, that were made for previous actions. Geometric backtracking is a necessary condition for completeness, but it may lead to a dramatic computational explosion due to the large size of the space of geometric states. We explore two avenues to deal with this issue: the use of heuristics based on different geometric conditions to guide the search, and the use of geometric constraints to prune the search space. We empirically evaluate these different approaches, and demonstrate that they improve the performance of hybrid task and motion planning. We demonstrate our hybrid planning approach in two domains: a real, humanoid robotic platform, the DLR Justin robot, performing object manipulation tasks; and a simulated autonomous forklift operating in a warehouse.

Temporally and spatially flexible plan execution for dynamic hybrid systems Original Research Article

Pages 266-294

Andreas G. Hofmann, Brian C. Williams

Close abstract | Purchase PDF - $35.95

Citing articles (1)

Abstract

Planners developed in the Artificial Intelligence community assume that tasks in the task plans they generate will be executed predictably and reliably. This assumption provides a useful abstraction in that it lets the task planners focus on what tasks should be done, while lower-level motion planners and controllers take care of the details of how the task should be performed. While this assumption is useful in many domains, it becomes problematic when controlling physically embedded systems, where there are often delays, disturbances, and failures. The task plans do not provide enough information about allowed flexibility in task duration and hybrid state evolution. Such flexibility could be useful when deciding how to react to disturbances. An important domain where this gap has caused problems is robotics, particularly, the operation of robots in unstructured, uncertain environments. Due to the complexity of this domain, the demands of tasks to be performed, and the actuation limits of robots, knowledge about permitted flexibility in execution of a task is crucial. We address this gap through two key innovations. First, we specify a *Qualitative State Plan* (QSP), which supports representation of spatial and temporal flexibility with respect to tasks. Second, we extend compilation approaches developed for temporally flexible execution of discrete activity plans to work with hybrid discrete/continuous systems using a recently developed Linear Quadratic Regulator synthesis algorithm, which performs a state reachability analysis to prune infeasible trajectories, and which determines optimal control policies for feasible state regions. The resulting *Model-based Executive* is able to take advantage of spatial and temporal flexibility in a QSP to improve handling of disturbances. Note that in

Relational reinforcement learning with guided demonstrations Original Research Article

Pages 295-312

David Martínez, Guillem Alenyà, Carme Torras

Close abstract | Purchase PDF - $35.95

Citing articles (1)

Abstract

Model-based reinforcement learning is a powerful paradigm for learning tasks in robotics. However, in-depth exploration is usually required and the actions have to be known in advance. Thus, we propose a novel algorithm that integrates the option of requesting teacher demonstrations to learn new domains with fewer action executions and no previous knowledge. Demonstrations allow new actions to be learned and they greatly reduce the amount of exploration required, but they are only requested when they are expected to yield a significant improvement because the teacher's time is considered to be more valuable than the robot's time. Moreover, selecting the appropriate action to demonstrate is not an easy task, and thus some guidance is provided to the teacher. The rule-based model is analyzed to determine the parts of the state that may be incomplete, and to provide the teacher with a set of possible problems for which a demonstration is needed. Rule analysis is also used to find better alternative models and to complete subgoals before requesting help, thereby minimizing the number of requested demonstrations. These improvements were demonstrated in a set of experiments, which included domains from the international planning competition and a robotic task. Adding teacher demonstrations and rule analysis reduced the amount of exploration required by up to 60% in some domains, and improved the success ratio by 35% in other domains.

Continual curiosity-driven skill acquisition from high-dimensional video inputs for humanoid robots Original Research Article

Pages 313-335

Varun Raj Kompella, Marijn Stollenga, Matthew Luciw, Juergen Schmidhuber

Abstract

In the absence of external guidance, how can a robot learn to map the many raw pixels of high-dimensional visual inputs to useful action sequences? We propose here Continual Curiosity driven Skill Acquisition (CCSA). CCSA makes robots intrinsically motivated to acquire, store and reuse skills. Previous curiosity-based agents acquired skills by associating intrinsic rewards with world model improvements, and used reinforcement learning to learn how to get these intrinsic rewards. CCSA also does this, but unlike previous implementations, the world model is a set of compact low-dimensional representations of the streams of high-dimensional visual information, which are learned through incremental slow feature analysis. These representations augment the robot's state space with new information about the environment. We show how this information can have a higher-level (compared to pixels) and useful interpretation, for example, if the robot has grasped a cup in its field of view or not. After learning a representation, large intrinsic rewards are given to the robot for performing actions that greatly change the feature output, which has the tendency otherwise to change slowly in time. We show empirically what these actions are (e.g., grasping the cup) and how they can be useful as skills. An acquired skill includes both the learned actions and the learned slow feature representation. Skills are stored and reused to generate new observations, enabling continual acquisition of complex skills. We present results of experiments with an iCub humanoid robot that uses CCSA to incrementally acquire skills to topple, grasp and pick-place a cup, driven by its intrinsic motivation from raw pixel vision.

Model-based furniture recognition for building semantic object maps Original Research Article

Pages 336-351

Martin Günther, Thomas Wiemann, Sven Albrecht, Joachim Hertzberg

Abstract

This paper presents an approach to creating a semantic map of an indoor environment incrementally and in closed loop, based on a series of 3D point clouds captured by a mobile robot using an RGB-D camera. Based on a semantic model about furniture objects (represented in an OWL-DL ontology with rules attached), we generate hypotheses for locations and 6DoF poses of object instances and verify them by matching a geometric model of the object (given as a CAD model) into the point cloud. The result, in addition to the registered point cloud, is a consistent mesh representation of the environment, further enriched by object models corresponding to the detected pieces of furniture. We demonstrate the robustness of our approach against occlusion and aperture limitations of the RGB-D frames, and against differences between the CAD models and the real objects. We evaluate the complete system on two challenging datasets featuring partial visibility and totaling over 800 frames. The results show complementary strengths and weaknesses of processing each frame directly vs. processing the fully registered scene, which accord with intuitive expectations.

Envisioning the qualitative effects of robot manipulation actions using simulation-based projections Original Research Article

Pages 352-380

Lars Kunze, Michael Beetz

Abstract

Autonomous robots that are to perform complex everyday tasks such as making pancakes have to understand how the effects of an action depend on the way the action is executed. Within Artificial Intelligence, classical planning reasons about whether actions are executable, but makes the assumption that the actions will succeed (with some probability). In this work, we have designed, implemented, and analyzed a framework that allows us to *envision* the physical effects of robot manipulation actions. We consider *envisioning* to be a qualitative reasoning method that reasons about actions and their effects based on simulation-based projections. Thereby it allows a robot to infer *what could happen* when it performs a task in a certain way. This is achieved by translating a qualitative physics problem into a parameterized simulation problem; performing a detailed physics-based simulation of a robot plan; logging the state evolution into appropriate data structures; and then translating these sub-symbolic data structures into interval-based first-order symbolic, qualitative representations, called timelines. The result of the envisioning

is a set of detailed narratives represented by timelines which are then used to infer answers to qualitative reasoning problems. By envisioning the outcome of actions before committing to them, a robot is able to reason about physical phenomena and can therefore prevent itself from ending up in unwanted situations. Using this approach, robots can perform manipulation tasks more efficiently, robustly, and flexibly, and they can even successfully accomplish previously unknown variations of tasks.

Automated aerial suspended cargo delivery through reinforcement learning Original Research Article

Pages 381-398

Aleksandra Faust, Ivana Palunko, Patricio Cruz, Rafael Fierro, Lydia Tapia

Close abstract | Purchase PDF - $35.95 | Supplementary content

Abstract

Citing articles (1)

Cargo-bearing unmanned aerial vehicles (UAVs) have tremendous potential to assist humans by delivering food, medicine, and other supplies. For time-critical cargo delivery tasks, UAVs need to be able to quickly navigate their environments and deliver suspended payloads with bounded load displacement. As a constraint balancing task for joint UAV-suspended load system dynamics, this task poses a challenge. This article presents a reinforcement learning approach for aerial cargo delivery tasks in environments with static obstacles. We first learn a minimal residual oscillations task policy in obstacle-free environments using a specifically designed feature vector for value function approximation that allows generalization beyond the training domain. The method works in continuous state and discrete action spaces. Since planning for aerial cargo requires very large action space (over 10^6 actions) that is impractical for learning, we define formal conditions for a class of robotics problems where learning can occur in a simplified problem space and successfully transfer to a broader problem space. Exploiting these guarantees and relying on the discrete action space, we learn the swing-free policy in a subspace several orders of magnitude smaller, and later develop a method for swing-free trajectory planning along a path. As an extension to tasks in environments with static obstacles where the load displacement needs to be bounded throughout the trajectory, sampling-based motion planning generates collision-free paths. Next, a reinforcement learning agent transforms these paths into trajectories that maintain the bound on the load displacement while following the collision-free path in a timely manner.

Anticipatory action selection for human–robot table tennis Original Research Article

Pages 399-414

Zhikun Wang, Abdeslam Boularias, Katharina Mülling, Bernhard Schölkopf, Jan Peters

Close abstract | Purchase PDF - $35.95

Abstract

Citing articles (1)

Anticipation can enhance the capability of a robot in its interaction with humans, where the robot predicts the humans' intention for selecting its own action. We present a novel framework of anticipatory action selection for human–robot interaction, which is capable to handle nonlinear and stochastic human behaviors such as table tennis strokes and allows the robot to choose the optimal action based on prediction of the human partner's intention with uncertainty. The presented framework is generic and can be used in many human–robot interaction scenarios, for example, in navigation and human–robot co-manipulation. In this article, we conduct a case study on human–robot table tennis. Due to the limited amount of time for executing hitting movements, a robot usually needs to initiate its hitting movement before the opponent hits the ball, which requires the robot to be anticipatory based on visual observation of the opponent's movement. Previous work on Intention-Driven Dynamics Models (IDDM) allowed the robot to predict the intended target of the opponent. In this article, we address the problem of action selection and optimal timing for initiating a chosen action by formulating the anticipatory action selection as a Partially Observable Markov Decision Process (POMDP), where the transition and observation are modeled by the IDDM framework. We present two approaches to anticipatory action selection based on the POMDP formulation, i.e., a model-free policy learning method based on Least-Squares Policy Iteration (LSPI) that employs the IDDM for belief updates, and a model-based Monte-Carlo Planning (MCP) method, which benefits from the transition and observation model by the IDDM.

Model-based contextual policy search for data-efficient generalization of robot skills Original Research Article

Pages 415-439

Andras Kupcsik, Marc Peter Deisenroth, Jan Peters, Ai Poh Loh, Prahlad Vadakkepat, Gerhard Neumann

Close abstract | Purchase PDF - $35.95

Abstract

Citing articles (1)

In robotics, lower-level controllers are typically used to make the robot solve a specific task in a fixed context. For example, the lower-level controller can encode a hitting movement while the context defines the target coordinates to hit. However, in many learning problems the context may change between task executions. To adapt the policy to a new context, we utilize a hierarchical approach by learning an upper-level policy that generalizes the lower-level controllers to new contexts. A common approach to learn such upper-level policies is to use policy search. However, the majority of current contextual policy search approaches are model-free and require a high number of interactions with the robot and its environment. Model-based approaches are known to significantly reduce the amount of robot experiments, however, current model-based techniques cannot be applied straightforwardly to the problem of learning contextual upper-level policies. They rely on specific parametrizations of the policy and the reward function, which are often unrealistic in the contextual policy search formulation. In this paper, we propose a novel model-based contextual policy search algorithm that is able to generalize lower-level controllers, and is data-efficient. Our approach is based on learned probabilistic forward models and information theoretic policy search. Unlike current algorithms, our method does not require any assumption on the parametrization of the policy or the reward function. We show on complex simulated robotic tasks and in a real robot experiment that the proposed learning framework speeds up the learning process by up to two orders of magnitude in comparison to existing methods, while learning high quality policies.