ISIR/LIP6 Robotics–Computer science workshop

November 12, 2013,
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9h40	F. Kordon	Self-Reconfigurable Modular Robots and their Symbolic Configuration Space
10h10	S. Ivaldi	Object learning through active exploration: MACSI experiments
10h40	*PAUSE*	
11h10	P. Bidaud	Predictive control and HPC implementation
11h40	P. Perny	Approximation of Lorenz-Optimal Solutions in Multiobjective Markov Decision Processes
12h10	M. Ziane	A Top-Down Approach to Managing Variability in Robotics Algorithms
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14h00	J. Malenfant	Autonomic Computing and Control Architectures of Robots,which convergence?
14h30	C. Chaudet	Mobile Robot Networks for Hostile Environments
15h00	J.-B. Mouret	Resilient robotics
15h30	*PAUSE*	
16h00	S. Russell	Discrete and continuous planning: Some ideas on their combination
16h30	L. Denoyer	Sequential Model for Budgeted Classification
17h00	S. Doncieux	Acquisition of Grounded Knowledge for a Robot

2 Abstracts

Self-Reconfigurable Modular Robots and their Symbolic Configuration Space *F. Kordon*

Modular and self-reconfigurable robots are a powerful way to design versatile systems that can adapt themselves to different physical environment conditions. Self-reconfiguration is not an easy task since there are numerous possibilities of module organization. Moreover, some module organizations are equivalent one to another.

In this work, we apply symbolic representation techniques from model check- ing to provide an optimized representation of all configurations for a modular robot. The proposed approach captures symmetries of the system and avoids storing all the equivalences generated by permuting modules, for a given configuration. From this representation, we can generate a compact symbolic configuration space and use it to efficiently compute the moves required for self-reconfiguration (i.e. going from one configuration to another). A prototype implementation is used to provide some benchmarks showing promising results.

Object learning through active exploration: MACSI experiments *S. Ivaldi*

During the talk I will present the developmental approach of the MACSI project to address the problem of active object learning by a humanoid robot. We proposed a cognitive architecture where the visual representation of the objects is built incrementally through active exploration. I will present the design guidelines of the architecture, its main functionalities, and outline the learning process of the robot by showing how it learns to recognize objects in a human-robot interaction scenario inspired by social parenting. The robot actively explores the objects through manipulation, driven by a combination of social guidance and intrinsic motivation. Besides the robotics and engineering achievements, our experiments replicate some observations about the coupling of vision and manipulation in infants, particularly on how the focus on the most informative objects. I will briefly discuss the benefits and limitations of our approach, and provide some perspectives on how it can be used for symbol grounding.

Predictive control with HPC implementation *P. Bidaud*

Approximation of Lorenz-Optimal Solutions in Multiobjective Markov Decision Processes *P. Perny*

This presentation is devoted to fair optimization in Multiobjective Markov Decision Processes (MOMDPs). A MOMDP is an extension of the MDP model for planning under uncertainty while trying to optimize several reward functions simultaneously. This applies to multiagent problems when rewards define individual utility functions, or in multicriteria problems when rewards refer to different features or objectives. In this setting, we study the approximation of the set of Lorenz-non-dominated tradeoff s. Lorenz dominance is a refinement of Pareto dominance that was introduced in Social Choice theory for the measurement of inequalities. After recalling a general method for the approximation of Pareto-optimal tradeoffs with performance guarantee, we introduce two methods to approximate the set of Lorenz-non-dominated solutions in infinite-horizon discounted MOMDPs. The proposed methods provide a representative approximation of the set of Lorenz-optimal solutions, with performance guarantee, while remaining polynomially bounded in size. Some numerical tests are given for illustration.

Resilient robotics *J.-B. Mouret*

Damage recovery is critical for autonomous robots that need to operate for a long time without assistance. Most current methods are complex and costly because they require anticipating potential damage in order to have a contingency plan ready. As an alternative, we introduce the T-resilience algorithm, a new algorithm that allows robots to quickly and autonomously discover compensatory behavior in unanticipated situations. This algorithm equips the robot with a self-model and discovers new behavior by learning to avoid those that perform differently in the self-model and in reality. Our algorithm thus does not identify the damaged parts but it implicitly searches for efficient behavior that does not use them. We evaluate the T-resilience algorithm on a hexapod robot that needs to adapt to leg removal, broken legs and motor failures; we compare it to stochastic local search, policy gradient and the self-modeling algorithm proposed by Bongard et al. The behavior of the robot is assessed on-board thanks to an RGB-D sensor and a SLAM algorithm. Using only 25 tests on the robot and an overall running time of 20 min, T-resilience consistently leads to substantially better results than the other approaches.

A Top-Down Approach to Managing Variability in Robotics Algorithms *M. Ziane*

One of the defining features of the field of robotics is its breadth and heterogeneity. Unfortunately, despite the availability of several robotics middleware services, robotics software still fails to smoothly handle at least two kinds of variability: algorithmic variability and lower-level variability. The consequence is that implementations of algorithms are hard to understand and impacted by changes to lower-level details such as the choice or configuration of sensors or actuators. Moreover, when several algorithms or algorithmic variants are available it is difficult to compare and combine them. In order to alleviate these problems we propose a top-down approach to express and implement robotics algorithms and families of algorithms so that they are both less dependent on lower-level details and easier to understand and combine. This approach goes top-down from the algorithms and shields them from lower-level details by introducing very high level abstractions atop the intermediate abstractions of robotics middleware. This approach is illustrated on 7 variants of the Bug family which were implemented using both laser and infrared sensors.

Autonomic Computing and Control Architectures of Robots,which convergence? *J. Malenfant*

Autonomic computing aims at automating the self-management andthe self-adaptation of software systems through the use ofautonomic managers implementing a feedback control overthem, their properties and their execution context. Autonomicmanagers of a distributed application therefore makes up anactual distributed real-time control architecture for whichinspirations from control architectures of robots can providevery useful insights. On the other hand, the need for meta-controland dynamic adaptations in control architectures of robots canbenefit from an autonomic computing approach. Thispossiblecross-fertilisation leads naturally to a convergence betweenboth areas, and speaks in favor of making the two coming together.

Mobile Robot Networks for Hostile Environments *C. Chaudet*

In this talk, I will introduce our on-going works on robots networks mobility from a distributed algorithmic perspective. The aim of this work is to let a group of robots move together to realize an objective (reaching a destination (flocking), scattering across an area) without explicit communication. The algorithms we propose avoid relying on the existence of a single leader that would drive the group movement and are hence tolerant to faults.

Discrete and continuous planning: Some ideas on their combination *S. Russel*

Sequential Model for Budgeted Classification *L. Denoyer*

With the emergence of Big Data, the conventional methods of learning are no longer appropriate, first because they have not been developed to take into account application constraints (time, memory usage, ...) and second because they are mainly focused on the treatment of simple data while Web data often have a complex topology. The talk will describe how these two aspects can be handled by using sequential learning models (based on reinforcement learning techniques) for the problem of automatic classification and I will present different applications of these methods to real-world problems. The presentation will also introduce the problem of learning with a budget that is at the root of the OnBul Project (SMART LABEX).

Acquiring grounded knowledge for a robot *S. Doncieux*

To interact with complex objects, a robot needs specific motor and perceptual skills. What objects are important to interact with? What to do with them? In this work, a bottom-up approach is proposed to address these challenges. Before identifying relevant objects or motor skills, the robot should first exhibit it, resulting in a chicken and egg problem. Rather than relying on demonstrations, a method based on stochastic optimization is considered. Once interesting behaviors have been generated, an analysis of learning traces aims at extracting relevant features with regard to robot's task. The relevance of extracted knowledge is then validated using transfer learning: a new and related task is considered, and a learning experiment is performed. The relevance of extracted knowledge is validated if learning is more efficient on the new task when exploiting it with regards to a learning experiment not using it. Preliminary results are presented on a ball collecting task.