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Knowledge, Skill, and Behavior Transfer in Autonomous Robots

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Abstract: The AAAI Fall Symposium on Knowledge, Skill, and Behavior Transfer in Autonomous Robots took place in Arlington, Virginia on November 13 – 15, 2014. The aim of the symposium was to investigate methods for obtaining more general, versatile and capable robots through knowledge transfer in a broad sense, such as between similar problems, similar robots, or humans and robots.

Autonomous robots have achieved high levels of performance and reliability at specific tasks. However, for them to be practical and effective at everyday tasks in our homes and offices, they must be able to learn to perform different tasks over time, demonstrating versatility. Learning each task in isolation is an expensive process, requiring large amounts of both time and data. In robotics, this expensive learning process also has secondary costs, such as energy usage and joint fatigue. Recent developments in transfer and multi-task learning provides a potential solution to this problem, enabling robots to minimize the time and cost of learning new tasks by building upon knowledge learned from other tasks. This ability is essential to enable the development of versatile autonomous robots that are expected to perform a wide variety of tasks and rapidly learn new abilities.

Various aspects of this problem have been addressed by research across several different communities, including machine learning, knowledge representation, optimal control, and robotics. This symposium brought together researchers from these different communities toward the goal of enabling autonomous robots to support a wide variety of tasks, rapidly and robustly learn new abilities, adapt quickly to changing contexts, and collaborate effectively with other robots and humans to achieve a common goal.

One of the main themes of the symposium was human-robot interaction, that is how knowledge can be effectively transferred from humans to robots or vice-versa. This was related to both single skill transfer, for instance teaching a robot how to clean the table, and to more general interaction through which robots can affect humans' behaviors, such as in healthier life choices. Three invited speakers have explored various aspects of human-robot interaction: Yiannis Demiris (Imperial College London), Andrea Thomaz (Georgia Institute of Technology) and Maja Mataric (University of Southern California).

Another major theme was skill abstraction in a reinforcement learning setting. Understanding the similarities between different problems, and exploiting such similarities in order to generalize and transfer behaviors is an area increasingly active in reinforcement learning, although the applications to robotics are still limited. Two invited speakers discussed different methods for hierarchical learning and control: Peter Stone (University of Texas at Austin), and Nathan Ratliff (Max Planck Institute for Intelligent Systems). Manuela Veloso (Carnegie Mellon University), furthermore, gave an invited talk on an historical perspective of transfer learning, from when similarities across tasks where studied in symbolic reasoning under different names, to more recent results in the reinforcement learning setting.

The symposium participants discussed with interest the diversity of the methods in this emerging area, and the difficulties that still arise in their application to physical robots. The challenge of knowledge transfer can take different shapes in the different fields related to artificial intelligence and robotics. Participants agreed that future symposia on this topic will help identify connections across such fields, in order to overcome the difficult problem of overly specialized robots, unable to generalized to similar

contexts and exhibit versatile behaviors.

Matteo Leonetti served as chair of the symposium, with the collaboration of Eric Eaton and Pooyan Fazli as co-chairs. The papers of the symposium were published as AAAI Press Technical Report FS-13-01.

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