Postdoctoral position:
Learning-based motivation dynamics for high performance multi-robot systems

Contact:

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Multi-robot systems are systems where robots interact among themselves to act cooperatively. They can efficiently carry out complex tasks in a variety of areas such as manufacturing, health, and intelligent transportation systems, to name a few [2, 4]. Therefore, fundamental research on the design and control of multi-robot systems constitutes a major challenge for the upcoming years, which requires strong collaborations between researchers from robotics, control theory, machine learning, and computer science.

The main approach has been to incorporate tools from single-robot control to the multi-robot set up according to the properties of the robots in hand. These properties can be described for example in terms of the robot dynamics and its actuation capabilities, as well as its communication and sensing limitations [8, 1]. The control design considers these properties while aiming at providing stabilization and tracking guarantees for the multi-robot system [6]. However, many applications involve more complex tasks that may not be cast as a classic control objective, but rather involve a higher level of specification definition and planning. A current trend is to employ tools from computer science such as Signal Temporal Logic [7] (i.e., a type of formal verification language) to specify more general task specifications that induce a sequence of control actions rather than a stand-alone traditional control objective. In this context, standard tools from motion planning [5] and symbolic control [11] can be used. However, such approaches are generally based on state-space discretization which is inevitably incomplete since it is inherently rigid and depends on the models of both, the agent and its environment. Moreover, these approaches are generally suffering from scalability issues and would fail to deal with large-scale multi-robot systems. The very recent concept of *motivation dynamics* [10] may solve these difficulties in an orthgonal way. It is a continuous dynamical system that reactively composes low-level control vector fields using valuation functions designed based on value-sensitive decision-making models (e.g., [9]). Due to the continuous internal representation of the selection process, the motivation dynamics can be considered as a useful alternative to the existing hybrid framework, especially in situations where the control operates at a low level close to the physical hardware.

This project aims to develop a new paradigm that enhances the high performance of the future generation of multi-robot systems. A novel theoretical and algorithmic framework that synthesizes high-level decision-making models with low-level motion control will be built based on cutting-edge techniques such as motivation dynamics and Signal Temporal Logic. Moreover, since it is challenging to design the parameters of the motivation dynamics, especially for complex tasks in dynamic environments, in this project, we aim at using learning-based approaches to learn these parameters [3], while providing formal proofs such that the learned parameters will make it possible to ensure the satisfaction of the required specification.

Duration: 1-year postdoc at L2S

Qualifications:
Required:
- PhD degree in Control theory, Robotics or related fields
- Experience of publishing high quality research papers
- Speaking and writing English at the scientific and professional level
- Good communication skills and ability to cooperate

Desired but not mandatory:
- Experience in multi-agent control systems
- Experience in robotic systems

Deadline for applications: June 1st, 2022

References

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[9] Darren Pais, Patrick M Hogan, Thomas Schlegel, Nigel R Franks, Naomi E Leonard, and James AR Marshall. A mechanism for value-sensitive decision-making. *PloS one*, 8(9):e73216, 2013.

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