Field: *Mathematics/Applied Mathematics/Computer Science*

Introductory Speakers:

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Session Topic:

Frontiers in Robotics

Title : Models of the Environment for Control

One of the strongest driving forces in robotics research is an insatiable desire to understand the outstanding art of animals and humans composed of a body, sensors, motors, and nervous systems, and others are to provide useful tools such as medical robots and rescue robots, and to create super-human robots. As represented by HRP2, ASIMO and AIBO, the rapid development of computers and mechatronic devices has produced animal-like robots and humanoid robots, some of which are already commercially available. Nevertheless, robotics has been challenged by high-dimensional, non-linear, and non-stationary working environments including the robot's body itself.

As it is generally infeasible to model whole possible environments in advance (model-based approach), due to bounded computational resource as well as non-stationary environments, robots should learn the environments on the fly. With the help of improved computer power, machine learning research provides several theoretically-sound learning algorithms, some of which are suited for real-time computation, e.g., support vector machines, particle filters, and reinforcement learning methods. Even though these devices are available, it is still a very hard question that what are embedded in robots innately and what are to be developed through interactions with environments. In addition to the model-based approach, model-free approaches have also been studied. Typical examples are nonparametric mapping from states to actions and nonlinear oscillators. The former approach uses supervised learning and reinforcement learning. The latter utilizes non-linear dynamical systems such as c!
oupled neural oscillators and van der Pol oscillator in order to efficiently reduce the dimensions of models.

The model-based and model-free approaches may seem competitive, but they can be collaborative. Recent computational/robotics studies have shown that a simple strategy, switching/mixing of a few functionally-contrasted modules based on on-line learning, enables to deal with unknown environments. Example contrasts are simple and complex. This approach would be one promising way for intelligent robotics because (1) it is intuitive and thus preparing such contrasted modules is relatively easy, and (2) explicit modeling of the environment is not necessary, and it may be considered that the model is embedded in the dynamic module-selection process.