Motor primitives for human-centered robotics: applications in state filtering, impedance control, and adaptive control

Renaud Ronsse (Centre for Research in Mechatronics, UCL)

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The concept of motor primitives emerged from biology (animal and human studies), as an account for explaining the planning and control of complex and coordinated movements. It postulates that complex movements are generated by the appropriate coordination of a limited set of "simple" movements, called the primitives. By distributing the computational processes through a multi-layered architecture (grossly speaking, the low-level layer would contain the pre-coded primitives, and the higher levels would activate them through a limited number of open parameters), it offers a lot of advantages to the nervous systems in terms of modularity, adaptivity, learning, computational distribution, etc... For these reasons, the concept progressively percolated within the robotics community for projects involving the execution of human- and animal-like movements. A classical way of implementing motor primitives in robotics is through dynamical systems. It offers complementary advantages, like to possibility to code a desired pattern with a dynamical attractor with customized stability properties.

In this talk, I will introduce the relevance of primitive-based controllers for a field lying at the intersection between biology and robotics, namely human-centered robotics in general, and rehabilitation robotics in particular. I will focus on (quasi-)rhythmic tasks, targeting applications in walking assistance. As such, the fundamental primitives introduced in this talk will be adaptive oscillators.

I will cover recent research illustrating the relevance of using adaptive oscillators in the design of novel rehabilitation robotics designs: (i) state filtering and model-based assistance; (ii) model-free impedance control; (iii) active prosthesis; and (iv) adaptive control of a bipedal walker.