POPULAR SCIENTIFIC ABSTRACT

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Neurorobotic Technology for Advanced Robot Motor Control

Legged robots have the potential to go anywhere that their biological counterparts can go and traverse terrain inaccessible by most wheeled robots. They can interact with harsh terrain with many obstacles or generic physical environments designed for legged movement. This is because legged robots are equipped with multiple legs that each has multiple degrees of freedom. While this redundancy creates high adaptability and robustness to failures, it also complicates the control design. There are, in general, three fundamental adaptation types to be considered when designing a controller for legged robots; frequency, phase, and amplitude adaptation. The hypothesis is that a biologically inspired movement controller for legged robots capable of all three types of adaptations will enable 1) savings in energy, 2) a general and understandable controller architecture, 3) adaptive movement, and 4) complex behaviors.

This thesis consists of five papers in which control mechanisms implementing the three fundamental types of adaptation are presented. Together, the mechanisms fill an important gap in the research field of legged robot control by being simple yet capable of generating complex behaviors. Moreover, the mechanisms are expandable, which makes it possible to extend them with new behaviors. This is especially useful in a fast-growing field like legged robot control, where new advances are introduced all the time.

The first four papers develop adaptive mechanisms for frequency and movement pattern adaptation. The adaptive frequency mechanism can adapt the movement frequency within seconds based on the robot body as well as external and internal perturbations. Doing so enables a robot to move energy-efficiently, prevent damage, and minimize tracking error. The adaptive movement pattern mechanism can facilitate both phase and amplitude adaptation. It can learn movement patterns within minutes based on the robot body, external perturbations, and the desired behavior. Furthermore, the mechanism is modular, meaning that it can be expanded with additional functionality based on the mission at hand. Being modular also allows for the removal of modules that relies on broken or faulty sensors. The final paper of the thesis is on the combination of the frequency and movement pattern adaptation mechanisms. Combining them is straightforward, as both mechanisms are using a biologically inspired oscillator as a core component. Results show that the mechanisms complement each other, and their combination can be seen as an essential step for further studies on adaptive legged robot control.