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How Morphology Affects Learning of a Controller for Movement

Nathan Labhart, Shuhei Miyashita
Artificial Intelligence Laboratory, Department of Informatics
University of Zurich, Switzerland
[labhart | miya]@ifi.unizh.ch

According to the “Principle of Ecological Balance” [1], the control mechanism (neural substrate) of an agent has to match its morphological complexity, and vice versa. Inspired by the centipede, where locomotion is achieved by controlling a number of two-legged body segments, we investigate in this research how the morphology affects the learning of a neural controller for similarly segmented artificial agents.

Like building blocks, simple two-wheeled modules are combined in order to form various morphologies, where the wheels are restricted in movement from to to simulate leg movement and exploit ground friction. A three-layered neural network is employed for learning a control mechanism for each wheel (or pair of wheels) such that the distance traveled within a certain time is maximised (Fig. 1).

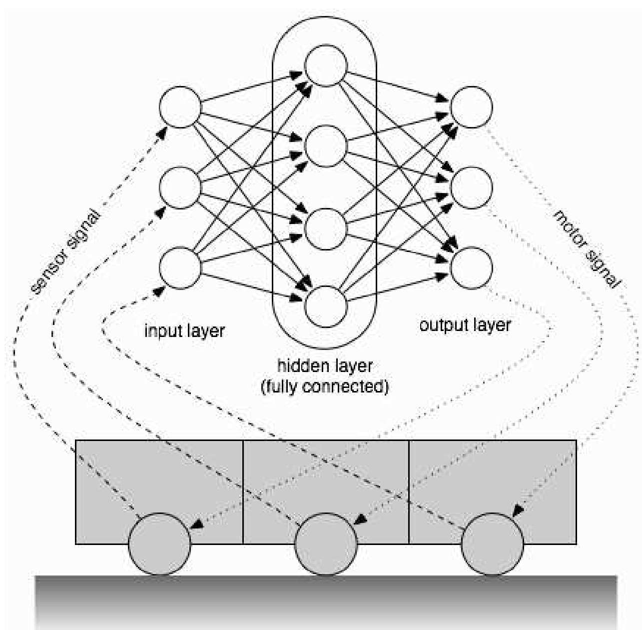

Figure 1: 2-dimensional example configuration with controller

In this project, the agents are modeled using a physics simulator. A learning algorithm is implemented in order to train the network for a specific morphology; for example, the two configurations depicted in Figs. 2 and 3 both consist of the same number of modules, but the position of their center of mass is different (in the “hat”-shaped configuration, it is in the middle of its length, whereas in the “baseball cap” configuration it is closer to one end). This asymmetry leads to different friction on the ground, which is reflected in a different neural controller.

By systematically exploring various configurations, the influence of embodiment on performance (i.e. movement) is examined. The findings contribute to a better understanding of the relationship between morphology and control and give insights on how a control mechanism is learned depending on a specific morphology.

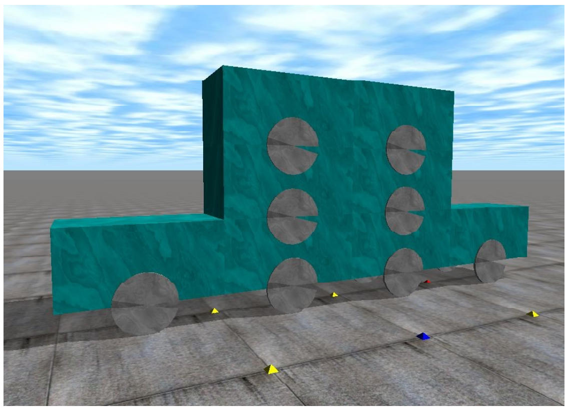

Figure 2: Hat-shaped configuration

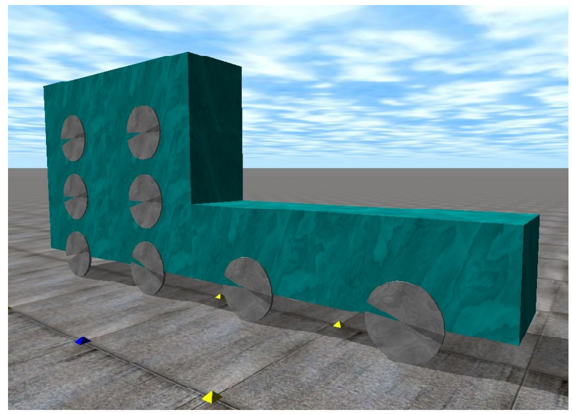

Figure 3: Cap-shaped configuration

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