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Morphological computation – connecting brain, body, and environment

ABSTRACT

Traditionally, in robotics, artificial intelligence, and neuroscience, there has been a focus on the study of the control or the neural system itself. Recently there has been an increasing interest into the notion of embodiment – and consequently intelligent agents as complex dynamical systems – in all disciplines dealing with intelligent behavior, including psychology, cognitive science and philosophy. In this talk, we explore the far-reaching and often surprising implications of this concept. While embodiment has often been used in its trivial meaning, i.e. „intelligence requires a body“, there are deeper and more important consequences, concerned with connecting brain, body, and environment, or more generally with the relation between physical and information (neural, control) processes. Often, morphology and materials can take over some of the functions normally attributed to control, a phenomenon called “morphological computation”. It can be shown that through the embodied interaction with the environment, in particular through sensory-motor coordination, information structure is induced in the sensory data, thus facilitating perception and learning. An attempt at quantifying the amount of structure thus generated will be introduced using measures from information theory. In this view, “information structure” and “dynamics” are complementary perspectives rather than mutually exclusive aspects of a dynamical system. A number of case studies are presented to illustrate the concepts introduced. Extensions of the notion of morphological computation to self-assembling, and self-reconfigurable systems (and other areas) will be briefly discussed. The talk will end with some speculations about potential lessons for robotics and intelligent and cognitive systems as outlined in the conclusions of the EU/ERCIM “Beyond-the-horizon” initiative.