Morphological Computation – Connecting Brain, Body, and Environment

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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, artificial intelligence, and cognitive science.

Bio

Rolf Pfeifer received his master's degree in physics and mathematics and his Ph.D. in computer science from the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland. He spent three years as a post-doctoral fellow at Carnegie-Mellon University and at Yale University in the US. Since 1987 he has been a professor of computer science at the Department of Informatics, University of Zurich, and director of the Artificial Intelligence Laboratory. Having worked as a visiting professor and research fellow at the Free University of Brussels, the MIT Artificial Intelligence Laboratory, the Neurosciences Institute (NSI) in San Diego, and the Sony Computer Science Laboratory in Paris, he was elected "21st Century COE Professor,

Information Science and Technology" at the University of Tokyo for 2003/2004, from where he held the first global, fully interactive, videoconferencing-based lecture series "The AI Lectures from Tokyo" (including Tokyo, Beijing, Jeddah, Warsaw, Munich, and Zurich). His research interests are in the areas of embodiment, biorobotics, artificial evolution and morphogenesis, self-reconfiguration and self-repair, and educational technology. He is the author of the book "Understanding Intelligence", MIT Press, 1999 (with C. Scheier). His new popular science book entitled "How the body shapes the way we think: a new view of intelligence," MIT Press, 2006 (with Josh Bongard) is scheduled to appear this fall.