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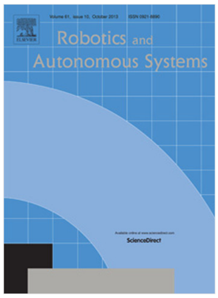

Predicting the internal model of a robotic system from its morphology

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Predicting the internal model of a robotic system from its morphology

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Abstract

The estimation of the internal model of a robotic system results from the interaction of its morphology, sensors and actuators, with a particular environment. Model learning techniques, based on supervised machine learning, are widespread for determining the internal model. An important limitation of such approaches is that once a model has been learnt, it does not behave properly when the robot morphology is changed. From this it follows that there must exist a relationship between them. We propose a model for this correlation between the morphology and the internal model parameters, so that a new internal model can be predicted when the morphological parameters are modified. Different neural network architectures are proposed to address this high dimensional regression problem. A case study is analyzed in detail to illustrate and evaluate the performance of the approach, namely, a pan-tilt robot head executing saccadic movements. The best results are obtained for an architecture with parallel neural networks. Our results can be instrumental in state-of-the-art trends such as self-reconfigurable robots, reproducible research, cyber-physical robotic systems or cloud robotics, in which internal models would available as shared knowledge, so that robots with different morphologies can readily exhibit a particular behavior in a given environment.

Keywords: model learning, internal model, morphology, neural networks, visual learning

1. Introduction

A robot system interacting with a particular environment is characterized by its morphology and internal model. The morphology could be considered as a representation of the physical properties of the robotic system. Most of these properties can be measured. In turn, the internal model represents the interaction between the robot system and the environment. Different research areas within Robotics have been established that differ in the way in which the relations among these three elements are handled. Thus, in some cases, the morphology of a robot is determined by its interaction with the environment [1], whereas in other cases, the simulation of the environment and incomplete self-knowledge models the robot behavior [2]. A third perspective estimates the internal model from the interaction of a particular kind of robot with the environment. These model learning approaches typically consider exclusively the relationships between states and actions, and the information about the states and actions of the past, present and even the expected future is needed to model the robot behavior. The process of learning is a regression problem where the training samples are obtained from the state and controls of the plant along time [3]. Internal-model-based control theory is well established, but internal models are typically expressed as mathematical models of the plant, normally by means of a set of differential equations [4].

While classical robotics relies on those manually generated models, an autonomous cognitive robot needs to automatically generate internal models based on information extracted from data streams accessible to the robot from the environment [5]. From an operational point of view, there are two approaches to deal with the adaptation of the robot internal model: adaptive control and model learning. Whereas the former uses on-line parameter identification [6], the latter uses supervised learning. In our research, we adopt the model learning approach because it makes no assumption about the structure of the model and includes all phenomena in a general function built out of experimental data.

A relationship always exists between the internal model and the morphology, and they are inseparable from each other because both affect how information is processed in the robotic system [7]. The first aim

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