迭代学习神经网络控制在机器人示教学习中的应用[1]

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示教学习是机器人运动技能获取的一种高效手段。当采用摄像机作为示教轨迹记录部件时, 示教学习涉及如何通过反复尝试获得未知机器人-摄像机模型问题. 本文力图针对非线性系统重复作业中的可重复不确定性学习, 提出一个迭代学习神经网络控制方案，该控制器将保证系统最大跟踪误差维持在神经网络有效近似域内。为此本文提出了一个适合于重复作业应用的分布式神经网络结构。该神经网络由沿期望轨线分布的一系列局部神经网络构成，每一局部神经网络对对应期望轨迹点邻域进行近似并通过重复作业完成网络训练。由于所设计的局部神经网络相互独立，因此一个全程轨迹可以通过分段训练完成，由起始段到结束段，逐段实现期望轨迹的准确跟踪。该方法在具有未知机器人-摄像机模型的轨迹示教-模仿中得到验证，显示了它是一种高效的训练方法同时具有一致的误差限界能力。

关键词：迭代学习控制，神经网络控制，视觉伺服，模仿学习
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Iterative Learning Neural Network Control for Robot Learning by Demonstration

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Abstract

Programming by demonstration is an efficient way for transferring movement skill from a human teacher to a robot. Using a camera as a recorder of the demonstrated movement, a learning strategy is required to acquire knowledge about the nonlinearity and uncertainty of a robot-camera system through repetitive practice. The purpose of this paper is to design a neural network controller for vision-based movement imitation by repetitive tracking and to keep the maximum training deviation from a demonstrated trajectory in a permitted region. A distributed neural network structure along a demonstrated trajectory is proposed. The local networks for a segment

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of the trajectory are invariant or repetitive over repeated training and are independent to the other segments. As a result, a demonstrated trajectory can be decomposed into short segments and the training of the local neural networks can be done segment-wise progressively from the starting segment to the ending one. The accurate tracking of the whole demonstrated trajectory is thus accomplished in a step-by-step or segment-by-segment manner. It is used for trajectory imitation by demonstration with an unknown robot-camera model and shown effectiveness in ensuring uniformly bounded and efficiently training.
Keywords: iterative learning control; neural network control; visual servoing; imitation learning

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