

# TRACKING CONTROL OF ROBOT MANIPULATORS USING SECOND ORDER NEURO SLIDING MODE

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**Abstract**— Few works on neural networks-based robot controllers address the issue of how many units of neurons, hidden layers and inputs are necessary to approximate any functions up to a bounded approximation error. Thus, most proposals are conservative in a sense that they depend on high dimensional hidden layer to guarantee a given bounded tracking error, at a computationally expensive cost, besides that an independent input is required to stabilize the system.

In this paper, a low dimensional neural network with online adaptation of the weights is proposed with an stabilizer input which depends on the same variable that tunes the neural network. The size of the neural network is defined by degree of freedom of the robot, without hidden layer. The neuro-control strategy is driven by a second order sliding surface which produce a chattering-free control output to guarantee tracking error convergence. To speed the response up even more, a time base generator shapes a feedback gain to induce finite time convergence of tracking errors for any initial condition. Experimental results validate our proposed neuro-control scheme.

**Keywords**— Robot control, Neural networks, Second order sliding mode, Chattering-free, Neuro-sliding controller.

## I. INTRODUCTION

In robotics, one of main objectives is to design simple controllers to compensate nonlinear couplings, parameters variation and disturbances to execute complex tasks with greater precision in tracking regime.

Although previously in 1980 the computed torque controller was presented;<sup>1</sup> it was not until 1986 when Slotine and Li (1987) showed that a particular structure of manipulator dynamics exist to develop a simple

controller avoiding measurements or estimates of the manipulator joint accelerations. Through this adaptive control scheme it is possible to compensate parameter variations to guarantee local stability of the system as well as asymptotic convergence of the tracking errors without any knowledge of the parameters, though the exact regressor is a requirement. Based on this result, many schemes in adaptive control has been developed and applied to a wide class of systems. Although the adaptive control represents a problem solution of parameter variation in the robots, the principal drawback is that it is a model-based controller, therefore the computation effort increases proportionally to degree of freedom of the robot or when the robotic system is more complex, *e.g.* in cooperative robots or mechanical hands.

At the same time, in the 80's the simple PD controller was presented, where it can compensate nonlinearity and uncertainties of robot dynamics (Arimoto, 1996). In addition it is recognized that one of the generic characteristic of robot dynamics is its open loop passivity property from torque input to velocity output as a way to exploit the robot system's physical structure and design energetically stable controllers. In this case, for stability purposes, a storage energy function arises which gives rise to stable behavior, then the challenge is to produce passivity in closed-loop via a given error velocity as its output.

In another way, as a result of the work done by many researchers started by McCulloch and Pitts, the neural networks attracted attention as networks ability to mimic basic patterns of the human brain, such as its ability to learn and respond in consequence, as if it were employed the learning capability to produce a control action.

In terms of control design, the main interest in neural networks is their capability to approximate a large class of continuous nonlinear maps from the collective action of autonomous processing units interconnected in simple ways, as well as inherent parallel and highly redundant processing architecture, that makes it possible to develop parallel adaptation update laws and reduce latency. These neural network

<sup>1</sup>The exact knowledge of the parameters of robot and a great computational power is required and it can not compensate parameter variations.