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Design of Optimal STSMC Method Based on FPGA to Track the Trajectory of 2-DOF Robot Manipulator

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Abstract
This article emphasizes on a strategy to design a Super Twisting Sliding Mode Control (STSMC) method. The proposed controller depends on the device of Field Programmable Gate Array (FPGA) for controlling the trajectory of robot manipulator. The gains of the suggested controller are optimized using Chaotic Particle Swarm Optimization (PSO) in MATLAB toolbox software and Simulink environment. Since the control systems speed has an influence on their stability requirements and performance, (FPGA) device is taken in consideration. The proposed control method based on FPGA is implemented using Xilinx block sets in the Simulink. Integrated Software Environment (ISE 14.7) and System Generator are employed to create the file of Bitstream which can be downloaded in the device of FPGA. The results show that the designed controller based of on the FPGA by using System Generator is completely verified the effectiveness of controlling the path tracking of the manipulator and high speed. Simulation results explain that the percentage improvement in the Means Square Error (MSEs) of using the STSMC based FPGA and tuned via Chaotic PSO when compared with the same proposed controller tuned with classical PSO are 17.32 % and 13.98 % for two different cases of trajectories respectively.

Keywords
DOF Robot Manipulator, Lyapunov Theorem, FPGA, STSMC, Chaotic PSO.

I. Introduction

The robotics is a science which deals with many scopes such as the design, the controlling as well as modeling of robot. Nowadays the robots may be utilized everywhere in the daily life, where they can be used in different life jobs and industry. The utilization of robot is very wide, so, there are many different types of robots such as rectangular, revolute, spherical, horizontal jointed and cylindrical which used in manufacturing and industry. The robots may be used to supply the desired motion in the processes of manufacturing like drilling, painting, pick, cutting, milling and welding, etc. The configuration of two link robot manipulator with 2 Degrees of Freedom (2 - DoF) is generally well proper to insert and assemble the small parts such as electronic components. In spite of the major goal is to manufacture, design and control the real robotics, but it is important to perform the simulations to real robots. Simulations are characterized with they are less expensive, easier to setup, faster and more proper to use. The simulation of robots allows with better design by choosing the best and suitable values of parameters for the designed system.

The accumulate and multiply are the most operations which used in the control calculations. When any type of digital controller is dealing with such operations, so, the computational overhead will be reached to the maximum. The speed and the sampling rate will be limited by the system rate which performs such operations. The control system speed has influence on many matters like, its performance, robustness, stability, and the characteristics of disturbance rejection, so, the FPGAs represent the good choice.