Abstract

Most of the industrial machine tools have a nonlinear behaviour. Robots are an important component in the nonlinear mechanical machines, and play a key role in industrial revolution. Controlling an industrial machine has a pivotal role in reaching a fast, accurate, and reliable output from the machine. Nonlinear behaviour is one of the main obstacles for controlling the machine. Recently, researchers have shown an increased interest in control theories, which guarantee high performance for those machines output. Robotics control engineering has been an object of research since 1950s. Many of control techniques have been used in controlling robots. The experimental data are rather controversial, and there is no general agreement about a certain controller. Previous studies on robot control techniques have not dealt with an individual technique that described as the most powerful one. Every control technique introduced for robots has advantages and shortages in its behaviour.

This thesis will examine the way in finding a systematic procedure to come out with a controller that guarantees the stability and high performance in the presence of uncertain nonlinear behaviour. Robots provided the most used nonlinear industrial machine. A direct drive 2-DOF arm robot has been selected as a nonlinear mechanical system. The proposed controllers have the characteristics of linearity and homogeneity in its design compared to the nonlinear controllers, therefore a very promising output will be shown relative to the previous techniques. High accuracy trajectory tracking control is a very challenging topic in direct drive robot control. This is due to the nonlinearities and input couplings present in the dynamics of robotic arms. Gain-scheduling control with multi-loop PID technique will be introduced on the 2-DOF robotic arm.

The controller in this study is given by a feedback structure, where the controller has information about the system and use this information to effect the system. Linear parameter varying based Gain-scheduling is introduced. A nonlinear dynamic model of the robot is obtained. A method of linearization is used for obtaining a linearized model for every operating point selected along the trajectory. A different approach of merging between linearized models is introduced. A comparison between the output behaviour of the nonlinear model and the linearized model with

the developed technique has been carried out. Then, the designed controller has been applied to the nonlinear plant using the same merging technique approach. The results are compared at different trajectory inputs to guarantee the robustness and performance of the controller.

Gain-scheduling control technique is the first proposed controller that is applied to control robot joints motion. The first linear technique procedures are linearizing nonlinear differential equation around certain operating points, merging between the developed linearized models, and design a linear controller for every model individually. The output results by the controller are shown a stable motion for the robot joints and accurate tracking for the desired trajectory input.

Simplified Universal Intelligent-PID is the second linear proposed controller that is applied to control the robot motion. The technique is depending on self-tuning for the PID gains neglecting the changes in the system parameters, a simple design procedure for the controller is introduced. The results are shown with a stable motion for the robot joints and improve in transient response values than previous controllers. A robust performance is shown dealing with robot inertia and mechanical coupling.

The two proposed linear controllers are introduced in controlling 2-robotic arm, which is nonlinear system in its dynamic behavoir. Linear controllers are simple in design and implement for any nonlinear system with robust and stable performance.