

Preface

Traditional mathematical model-based control has a history of over hundred years. The term traditional or conventional control is used to refer to theories and methods that were developed in the past decades to control dynamical systems, the behaviour of which is primarily described by differential and difference equations.

In fact, it is well known that there are control problems that cannot be adequately formulated and studied in the form of differential or difference equation mathematical framework. To address these problems in a systematic way led researchers to develop a number of methods that are collectively known as intelligent control methodologies.

In this context, the term intelligent control has come to mean some form of control using fuzzy logic and/or neural network methodologies. However, intelligent control does not restrict itself only to those methodologies. Research into intelligent control incorporates and integrates different techniques and concepts from different disciplines including control theory, computer science, fuzzy logic, neural networks and genetic algorithms. Considerable research is currently being devoted to intelligent control techniques for systems that are ill-defined, poorly understood or highly nonlinear such as flexible-link robot arm. However, application of intelligent control to flexible-link robot arm is not widespread.

Modelling and control of flexible robot arm for both space and industrial applications is a research area that has recently aroused considerable interest. For robots to meet the demands of industry, lightweight arms are needed so that they move faster without requiring high-powered bulky actuators. As manipulator arms are made lighter, their deformation under stress increases. Conventional control methods of flexible manipulators require fast and accurate models for dynamic performance. The demand for such an accurate mathematical model for the system under a variety of different operating conditions complicates the design of control systems. A non-conventional control strategy is sought without requiring expensive computing machinery.

The aim of this research monograph is to develop intelligent control schemes. Application of those control techniques was verified on a flexible robotic arm. To allow this, first, investigations into modelling and simulation of flexible arm are carried out. A simulation environment characterizing the dynamic behaviour of an arm is initially developed for test and verification of controller designs. Second,

investigations into different types of fuzzy controller such as PD-, PI- and PID-type controllers and their performances are carried out. Third, a rule reduction scheme for a fuzzy PID-type controller is developed by implementing a switching PD-PI-type controller where a PD-type controller is executed first to attain fast rise time and smaller overshoot and then switched to a PI-type controller to gain the advantage of minimized steady-state error.

To optimise and tune the membership functions of the fuzzy controller, evolutionary algorithms and neural learning systems are applied. Efforts are made in developing systems that are capable of learning in a real-time manner by utilizing intelligent methodologies such as fuzzy logic, neural networks, genetic algorithms and a combination of those paradigms. The flexible robot arm is utilized in this work as a practical level test and verification platform for controller design.

Intelligent Control

A Hybrid Approach Based on Fuzzy Logic, Neural
Networks and Genetic Algorithms

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2014, XVII, 282 p. 158 illus., 55 illus. in color.,

Hardcover

ISBN: 978-3-319-02134-8