Genetic fuzzy decoupling of nonlinear multiple-input multiple-output processes

Sarah Nikbakhsh

John Hedengren

Abstract

There are varying degrees of interaction between inputs and outputs of a multiple-input multiple-output (MIMO) system. In the other words, an input may affect several outputs, and an output may be affected by several inputs. One method to control multivariate systems is to properly pair manipulated and controlled variables and decouple the loops into multiple non-interacting single-input single-output (SISO) systems. Loop interactions can destabilize a control system, and tuning controllers in an interacting MIMO system can be difficult. Therefore, decoupling is one of the important issues in control theory that has been studied in linear and nonlinear system domains. Conventional decoupler design is based on an exact model of the multivariate process. As a less exact model of the process is available, the performance of conventional decoupling approaches degrades. The contribution of this work is to seek one approach that does not require a precise process model. The approach taken is to perform fuzzy decoupling based on a linguistic model of the process. Fuzzy decoupling adopts a series of fuzzy if-then rules instead of a crisp mathematical model of the process. Hence, a set of decoupling rules leads to omit interconnections in a MIMO system. The design of a fuzzy system involves tuning the membership function parameters, fuzzy if-then rules, input scaling factors and output gains. To tackle this problem, either the experts' knowledge or some learning and optimization algorithm is applied. Because these optimization problems are often a large scale mixed-integer problem, evolutionary computations such as genetic algorithms are effective solution methods. The purpose of this work is to design and implement a genetic fuzzy decoupling framework for nonlinear MIMO systems with unknown mathematical models. The genetic algorithm (GA) has been utilized to determine optimal fuzzy rules, output gains and control parameters. The performance of the structure has been assessed for a MIMO nonlinear system via its implementation on chemical benchmark process. The results show the appropriate performance of the genetic fuzzy decoupling method despite the independence from the exact nonlinear model of processes.