Metamodel-based robust simulation-optimization assisted optimal design of multiloop integer and fractional-order PID controller

ABSTRACT

Classical proportional-integral-derivative (PID) tuning methods such as Ziegler-Nichols simply increase robustness against disturbances that may arise from the load. Thus, uncertainty in the load parameters has generally not been considered in previous methods, and tuning has been done only in fixed and under certain conditions. Moreover, when one or more load parameters are changed, the best previous results for the PID controller lose their validity and need to be adjusted according to the change in those load parameters. In such case, finding an optimal design for a PID controller might be too inefficient in terms of computational time and cost. This paper aims at proposing a new less time-consuming method for tuning of a multiloop PID controller for robustness when the output of the model is varying due to the changeability of load parameters in multiple subsystems as a source of variability. Kriging and radial basis function (RBF) metamodels as two common global approximation models together with the Latin hypercube sampling (LHS) method are used to fit input-output models with the least number of running computer experiments. Robust design terminology in the class of dual response is applied to design a multi-input multi-output (MIMO) mathematical programming model under disturbance factors. A MIMO numerical case in tuning a multiloop PID controller, proportional-integral (PI) controller, and fractional-order PID (FOPID) controller for speed control of a DC motor is provided as an example to show the flexibility and applicability of the proposed method.