Chapter 49
Genetic Algorithms Quality Assessment Implementing Intuitionistic Fuzzy Logic

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ABSTRACT

Intuitionistic fuzzy logic has been implemented in this investigation aiming to derive intuitionistic fuzzy estimations of model parameters of yeast fed-batch cultivation. Considered here are standard simple and multi-population genetic algorithms as well as their modifications differ from each other in execution order of main genetic operators (selection, crossover, and mutation). All are applied for the purpose of parameter identification of S. cerevisiae fed-batch cultivation. Performances of the examined algorithms have been assessed before and after the application of a procedure for narrowing the range of model parameters variation. Behavior of standard simple genetic algorithm has been also examined for different values of proof as the most sensitive genetic algorithms parameter toward convergence time, namely, generation gap (GGAP). Results obtained after the intuitionistic fuzzy logic implementation for assessment of genetic algorithms performance have been compared. As a result, the most reliable algorithm/value of GGAP ensuring the fastest and the most valuable solution is distinguished.

INTRODUCTION

Fermentation Processes (FP) as representatives of biotechnological processes have enjoyed an enormous progress in recent years. Biotechnological processes, and in particular FP, differ from processes occur in the nonliving nature in many aspects. FP combine the dynamic of two fundamental components–biological and non-biological That is why their specific peculiarities are largely determined from characteristics of live microorganisms. Investigations of FP, because

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of its multidisciplinary essence, attract a great number of specialists such as microbiologists, biochemists, bioengineers, chemical engineers, food and pharmaceutical chemists. Due to the fact that FP are complex, dynamic systems with interdependent and time-varying process variables, their modeling, optimization and high quality control is a real challenge. An important step for adequate modeling of non-linear FP is the choice of a certain optimization procedure for model parameter identification. Failure of conventional optimization methods to lead to a satisfied solution provokes an idea some stochastic algorithms to be applied. As a quite promising stochastic global optimization method, genetic algorithms (GA), originally presented by Holland (Holland, 1975), are widely applied for solving a variety of complex problems (Goldberg, 1989; Cordon, 2001; Kuo, 2001; Carrillo-Ureta, 2001; Na, 2002; Jones, 2006; Vasant, 2009, 2013; Wang, 2009; Zhang, 2010; Chauhan, 2011; Milani, 2011). Among a number of searching tools, GA are one of the methods based on biological evolution and inspired by Darwin's theory of "survival of the fittest." GA are directed random search techniques, based on the mechanics of natural selection and genetics, and seek for the global optimal solution in complex multidimensional search space by simultaneously evaluating many points in the parameter space. GA require only information concerning the quality of the solution and do not require linearity in the parameters. Properties like hard problems solving, noise tolerance, easy to interface and hybridize make GA suitable and more workable for a parameter identification of fermentation models (Vassileva, 1999; Ranganath, 1999; Pencheva, 2006; Roeva, 2004, 2005, 2006, 2008, 2010, 2012, 2013; Roeva & Fidanova. 2013; Slavov, 2011; Adeyemo, 2011; Angelova, 2011, 2012a, 2012b, 2012c, 2012d).

The quality of performance of any algorithm could be assessed by some representative criteria such as value of objective function/model accuracy and algorithm convergence time. Due to the stochastic nature of GA obtained results might be quite diverse. That is why several runs have to be performed in order to achieve representative outcomes. The accumulation of data from different runs provoked the idea for purposeful genesis concerning model parameters intervals of variations. Such a procedure has been elaborated and firstly applied to Simple Genetic Algorithms (SGA) (Angelova, 2012d) and consequently successfully implemented also to Multi-population Genetic Algorithms (MpGA) (Angelova, 2012c), both for standard algorithms with a sequence selection, crossover and mutation and for many of developed modifications.

As an alternative for assessing the quality of different algorithms Intuitionistic Fuzzy Logic (IFL) is going to be applied for various purposes. In order to construct the degree of validity and non-validity it is required the algorithms to be performed in two different intervals of model parameters variation. One interval could be determined as so-called "broad" range known from the literature. The other one, called "narrow" range, is user-defined and might be obtained using different criteria (e.g. based on the minimum and maximum values, or on the average ones, or after the implementation of the procedure for purposeful model parameters genesis).

For the purpose of the algorithms quality assessment using intuitionistic fuzzy logic a procedure has been developed (Pencheva, 2012). Such a procedure might be implemented to assess model parameters of *S. cerevisiae* fed-batch cultivation when different kinds of SGA and MpGA are applied or different values of genetic algorithms parameters are examined. In this investigation developed procedure is going to be implemented in the following cases:

- To assess the performance of different modifications of SGA.
- To assess the performance of different modifications of MpGA.

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