Cooperative enhanced scatter search with opposition-based learning schemes for parameter estimation in high dimensional kinetic models of biological systems

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A B S T R A C T

Industrial bioprocesses development nowadays is concerned with producing chemicals using yeast, bac- teria and therapeutic proteins in mammalian cells. This involves the utilization of microorganism cells as factories and re-engineering them in silico. The tools that could facilitate this process are known as the ki- netic models. Kinetic models of cellular metabolism are important in assisting researchers to understand the rational design of biological systems, predicting metabolites production, and improving bio-products development. However, the most challenging task in model development is parameter estimation, which is the process of identifying an unknown value of model parameters which provides the best fit between the model output and a set of experimental data. Due to the increased complexity and high dimension- ality of the models, which are extremely nonlinear and contain large numbers of kinetic parameters, parameter estimation is known to be difficult and time-consuming. This study proposes a cooperative enhanced scatter search with opposition-based learning schemes (CeSSOL) for parameter estimation in large-scale biology models. The method was executed in parallel with the proposed cooperative mecha- nism in order to exchange information (kinetic parameters) between individual threads. Each thread con- sists of different parameters settings that enhance the systemic properties in obtaining the global min- imum. The performance of the proposed method was assessed against two large-scale microorganisms models using mammalian and bacteria cells. The results revealed that the proposed method recorded faster computation time compared to other methods. The study has also demonstrated that the proposed method can be used to provide more accurate and faster estimation of kinetic models, indicating the potential benefits of utilizing this method for expert systems of industrial biotechnology.

Keywords:
Parameter estimation Metabolic engineering Kinetic model Opposition-based learning Global optimization Cooperative metaheuristic