# Handling Model Inadequacy in Iterative-Real-Time Optimization

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**Abstract:** Real-time optimization (RTO) comprises a family of optimization techniques that use rigorous nonlinear plant models and optimization methods to operate industrial processes at economically optimal operating conditions without compromising product quality and process constraints. The performance of the RTO depends highly on the accuracy of the model that is used. Thus, the available measurements are often used to adapt the parameters of the model (model adaptation). However, parameter adaptation provides good results only if the plant-model mismatch is parametric nature. The more recent modifier adaptation scheme iteratively adds bias and gradient correction terms to the model that is used for optimization. These affine corrections lead to the satisfaction of the first-order necessary conditions of optimality of the plant at convergence despite plant-model mismatch.

The traditional modifier adaptation does not guarantee to reach to the plant-optimum if the process model is not adequate. Model adequacy requires that the optimal plant operating conditions must satisfy the second-order necessary-condition of optimality (NCO) in addition to the first-order necessary conditions for the model based optimization problem. One option to overcome this issue is to use a convex approximation of the cost and constraint functions to guarantee model adequacy. However, this may reduce model accuracy and thereby also the rate of convergence to the plant optimum. Another approach is to combine the idea of modifier adaptation with local quadratic approximations similar to DFO techniques. This leads to the MAWQA (modifier adaptation with quadratic approximation) scheme. In this approach, model adequacy can be assured as well. However, the rate of the convergence depends on the collected data that is used to construct the quadratic approximations and is of course better when the model quality is high. Recently, an effective model adaptation (EMA) scheme was introduced to identify an adequate process model for the optimization. EMA uses transient measurements to determine the model parameters via least-squares fitting. The model however is only used in the optimization when the model with the updated parameter values is adequate such that the second-order NCO is satisfied upon convergence. EMA not only renders the first-principles model adequate but also increases the accuracy of the predictions. EMA can be combined with modifier-adaptation in order to meet the first-order necessary conditions of optimality in the presence of structural plant-model mismatch. We will compare the performance of each scheme by simulation studies of a fed-batch penicillin process.

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