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SOME REMARKS ON MULTIOBJECTIVE OPTIMIZATION IN INDUSTRIAL APPLICATIONS

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ABSTRACT

The author has been collaborating with several industrial companies in Japan for a few decades. This paper points out several issues for industrial applications of multiobjective optimization along several examples through the authour's experience. Main issues in this paper are 1) how to treat a large number of objective functions, 2) how to treat black box objective functions, and 3) how to treat dynamic optimization with unknown dynamic models. Those are discussed along the erection management of cable stayed bridges, the reinforcement of cable-stayed bridges and the model predictive control for plant operation.

1. Erection Management of Cable Stayed Bridge

Cable-stayed bridges are gaining much popularity due to their beautiful shape. During and after construction, this kind of bridge needs to have the cable length adjusted in order to attain errors of cable tension and camber (the configuration of the girders of the bridge) within some allowable range [2]. To this end, the following criteria are considered: 1) residual error in each cable tension, 2) residual error in camber at each node, 3) amount of shim adjustment for each cable, 4) number of cables to be adjusted.

One of main features of this problems is a large number of objective functions. Since some large scale bridges have around 100 cables at each side, our problem easily have a few hundreds objective functions. In addition, the shim adjustment must usually be done during a relatively short period (say, 2:00 am to 8:00 am) with a stable temperature, because the cable length is greatly affected by change of temperature. Therefore, the decision of cable length adjustment must be made very quickly.

In this paper, we discuss how to deal such a large number of objective functions in a demanded time.

2. Application to Reinforcement of Cable-Stayed Bridges

After the big earthquake in Kobe in 1995, many in-service structures were required to improve their anti-seismic property by law regulation in Japan. However, it is very difficult for large and/or complicated bridges, such as suspension bridges, cable-stayed bridges, arch bridges and so on, to be reinforced because of impractical executing methods and complicated dynamic responses. Recently, many kinds of anti-seismic device have been developed. It is practical in the bridge to be installed a number of small devices taking into account of strength and/or space, and to obtain the most reasonable arrangement and capacity of the devices by using optimization technique. In this problem, the form of objective function is not given explicitly in terms of design variables, but the value of the function is obtained by seismic response analysis. Since this analysis needs much cost and long time, it is strongly desirable to make the number of analyses as few as possible. To this end, succesive approximate optimization (also, referred to as metamodeling) techniques can be applied [4]. In this approach, it is important to get a good approximation of functions with less sample points. We discuss several methods and comparison for this purpose.

3. Multi-objective Model Predictive Control

For dynamic optimization problems, the model predictive control has been developed along a similar idea to the above. In many plant operation, the dynamic behavior is complex and the system equation can not explicitly be given. Under this circumstance, we predict some of future state for a given control sequence.

For predicting the future state, we apply a support vector regression technique, namely $\mu - \nu -$SVR which was developed by the authors recently ([5]). $\mu - \nu -$SVR is a version for regression of $\mu - \nu -$SVM which was developed originally for pattern classification by reformulating the usual SVM (Support Vector Machine) on the basis of goal programming and multi-objective optimization. It has been observed that $\mu - \nu -$SVR provides less support vectors than other SVRs.

In plant operation, for example, objectives are the energy consumption, constraints of terminal state, the terminal time and so on. In order to get the final decision for this multi-objective problems, we apply the satisficing trade-off method ([1]) which is an aspiration level based method. The effectiveness of the proposed method will be shown through some numerical examples.

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