OPTIMISATION AND OPERATIONS RESEARCH II: PROJECT HANDOUT 2, REVISION 1.0

1. Approximation

By now you should have translated your optimisation problem into mathematical form, however, you will have no doubt discovered that the problem is *non-linear*. In particular, if you have constructed the problem correctly you will have linear constraints, but a non-linear objective function.

There are several approaches one might take in this situation. If you knew more optimisation techniques, it might be possible to solve this directly using one of those techniques. However,

(1) You haven't been taught these techniques (and won't in this course). You must solve this project using techniques used in the course.
(2) Some optimisation problems in raw form are not possible to solve without some approximation, so this is a useful tool to know.
(3) Some optimisation problems in raw form are too computationally complex to solve in a reasonable amount of time.

Using approximation can be uncomfortable. It might seem "wrong". However, remember that the power-curves given to you as input are already approximations! Moreover, even when working with approximations we can often find very good, if not optimal solutions.

2. Approaches to approximation

There are many approaches to approximation. Start by considering an objective function (of the form given in the problem) of one variable, and:

(1) You could approximate the non-linear curve by the linear terms in a Taylor series approximation, that is, by taking a tangent to the curve at the origin. Or is there a better point to start the tangent curves?

(2) Using the previous approach, you might derive a better start point for your tangent line from the solution. You might repeat this procedure and see if you can get even more accurate answers. Does it converge?

(3) While input-output characteristic functions are often quadratic, many thermal power plants prefer to represent their generator cost functions as multiple-segment linear functions.

That is, approximate the quadratic $H_i(P_i)$ by a piece-wise linear function by dividing the *operating interval* $[P_{i,\min}, P_{i,\max}]$ into q sub-intervals (of equal length), and creating a linear approximation to H_i on each of these.

We can think of these sub-intervals as a series of buckets, with $P_i^{(j)}$ power coming from the jth. We organise these in order so that they are filled from the bottom: that is, when the jth is full, we start filling the $j + 1$th. So each bucket has a constraint on the power that can come from it, and a constraint relating to its neighbouring buckets. As a result, the approximate input-output functions $\widetilde{H}_i(P_i^{(1)}, P_i^{(2)}, \ldots, P_i^{(q)})$ are functions of q variables.

There are many other valid approximation approaches. It is up to you to determine which approximation is the best to use here. You may want to plot the power input-output characteristics, and your approximations to understand how useful a particular approximation is.

However, in your final report you must explain your choice of method and any parameters it uses, such as the number of iterations or the choice of q. You must (in your report) argue for your choice. Consider, for instance, trade-offs between accuracy and computational complexity.

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