BUDDHADEVA DAS
MPC BASED ON QP, REPORT 01

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OVERVIEW

1. QP vs SQP

QP was the quickest upgrade of LP. Just a quadratic term in the objective function makes an LP a QP.

SQP is a solution procedure for QP. Since the lowest strategy of QP uses LP, there exist a lot of inaccuracies, for which additional calls are made, thus the name ‘Successive’.

2. MPC based on QP

All MPCs available today are archaically based on QP. The objective function contains a symmetric matrix that acts as a weight multiplier to squared terms constituted of the difference of process output and its setpoint. Although QP can handle a full matrix, all QP MPCs used only the diagonal, for example move suppression of DMC. Off-diagonal elements of QP matrix was never explored, although it would have not added to computational load, they were just lots of unnecessary zero multiplications and additions.

3. Simulated MPC based on QP

This part of the project aims at recreating every component required by a QP based MPC.

Since in early days when computing power was limited, vendors had to choose which functionality to give and which not to give. The race was to execute something within a minute. Thus no vendor MPC is mathematically complete.

4. Squared vs non-Squared

‘Degree of freedom’ analysis is the quickest way to find out the behavior of an MPC. Weak/strong relationship analysis can be changed by tuning, but non-existent relationships do have a say.

For a system having a total relationship and the number of outputs are same as the number of inputs, a setpoint control can be configured. The calculated inputs are determined by control requirement calculated from the exact inverse of the system dynamics. No optimization is possible. This is a squared system. Subsequently, there exist a one-to-one relationship between the input and the outputs.

Optimality of a plant is always derived from the inputs, for example, the feed flows, product flows are inputs to MPC. But the optimizer does not want them to change from their optimal values. This leads to the conflict. The theoretical resolution of this conflict is to map the optimal inputs to their corresponding outputs and choose them as setpoints. This destroys the safety and operability concept of output setpoints. All optimizers are based on this, assuming that the plant is squared and non-optimal objectives can be superseded/replaced by optimal objectives. It also needs that the models used by optimizer must be same as the models used by controller, known as ‘model-model mismatch’. Resistance to adopt new ideas has developed these into myths and legends.

Real-life plants are seldom squared. But all current MPC vendors assume this and any work around to accommodate non-squared system has led to dysfunctional MPCs, thereby making implementation a voodoo magic.

QP, THE CORRECT WAY

1. Non-Squared MPC

Assume, no MPC is ever going to be squared. Also assume that the output setpoints are based on safety and operability. The of MPC design changes.