Controller Performance Monitoring and Ranking Algorithms

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Motivation

Control loop monitoring systems are widely used in process industries to effeciently operate the plants. Since the number of control loops in a plant is large, it is expected that the number of loops that need attention is equally large. It is economically infeasible and practically impossible to improve the performance of all control loops at the same time, creating a need for the development of a methodology for prioitization of control loops towards their optimization and maintenance. This is essential to ensure continuous and profitable operation of the plant.

In addition to this the pressing problem, identifying the cause of oscillating control loops needs to be addressed. These plant-wide disturbances are a common problem as process units are strongly linked with each other, with disturbances in one control loop propagating through the units of the plant causing upsets in many process variables. The causes for such oscillatory behavior of control loops include sticky valves and aggressively tuned controllers to name a few. These plant-wide oscillations have a negative impact on the product quality and running costs of the plant, cementing the need for identifying the cause of such oscillations at the earliest.

Problem

The challenge associated with the solutions to the problem of prioritization and root cause analyses of oscillatory behavior was primarily with the constraints placed on the available data.The techniques that were to be developed were to rely purely on the control loop's historical data without any information of the process knowledge. The only other piece of information that was provided was a notion of predefined criticality of the various control loops in the plant.

Solution

As a first step to the solution of identifying the root cause for oscillating control loops, spectral analyses of all available control loop data was done to group the control loops with similar oscillation periods. Each cluster of loops were then analysed separately to obtain its root cause control loop.

In order to isolate the source control loop which was causing plant-wide oscillations, causal relationship between all available control loop data was established. This was done through the use of two different approaches — Granger causality and cross-correlation functions, which were used as the underlying principle based on prior literature in this area.

The problem of prioritizing the control loops was addressed through performance analyses. The hypothesis here is that the performance of a control loop can be quantified through the variance observed in the control loop output i.e. if a control loop is said to be performing well and meeting the specified performance targets, it is also expected that the variability observed in its output would be within acceptable bounds. This idea was used to separate the control loops into those that were performing poorly and those that were not.

An algorithm was then designed to provide an importance score to each of the control loops which fell under the non-performing bin to prioritize them for optimization and maintenance. This ranking algorithm took into account the interactions and causal relationships between the process variables, the predefined notion of criticality and the potential economic benefits that could be realized by improving its performance.

All of these algorithms were validated on a set of simulation and industrial data sets and at the outset provided promising results. We are currently in the process of performing tests on more industrial data sets with the assistance of our client.