

APC AND ARTIFICIAL INTELLIGENCE

How artificial intelligence can improve advanced process control.

INTRODUCTION

The development of manufacturing industries has seen a constant drive to improve operational efficiency.



Growing the business means outpacing your competitors to bring product to market quicker and cheaper. Central to driving those efficiency gains has been the development and adoption of new technology. However, having new technology doesn't mean that existing technology is superseded. Often the challenge we have is to work out how to use both new and existing technology in a way that we can get the best out of both.

A technology which has shown great benefit in manufacturing industries has been the application of algorithms which use data from the process to identify new improvement opportunities – a “data-driven” approach. A good example of a data-driven, real-time algorithm is Advanced Process Control (APC), built on multivariable, model-based predictive control (MVPC) techniques. While APC remains the dominant technique for optimising continuous processes, new technologies are emerging. New data-driven empirical methods, popularly described as Artificial Intelligence (AI) or Machine Learning (ML), expand the toolset we have. An open question though is how best to use these techniques. Do they replace APC? Do they assist APC? Do they solve a whole new class of problems? Let's look at some ways that AI/ML can be used in the process industries, and how that impacts the traditional APC space.

WHAT IS APC

Advanced Process Control (APC) is a real-time production optimization technology which has been proven to provide tangible benefits on manufacturing plants for over 30 years. Using multi-variable, model-based predictive control algorithms, it can simultaneously control and optimize complex processes in industry. By taking a closed-loop control approach to adjusting plant operation, it can increase throughput, maximise yield and reduce operating costs.

The multi-variable predictive control algorithm is one of the most practical examples of the use of empirical, data-driven analytic techniques to bring production benefits. It has particular strengths in being able to handle continuous processes, with highly interactive variables and a mix of dynamics. This accounts for many of the processes commonly encountered in industries such as refining, petrochemicals and minerals processing.

THE APPLICATION OF AI/ML

The benefits from AI/ML are not as straightforward as simply replacing what used to be done with APC with an AI/ML approach. A mix of technologies is needed to properly address the broad range of production optimization opportunities in industry. For linear, interactive problems, traditional APC can do a great job. It will identify and hold an optimum operating point consistently, the methodology is well established with low implementation risk, and the costs are generally low enough to generate a good return on investment. Choosing the simplest and most cost-effective solution to a problem makes good business sense.

Creating applications which utilise a traditional APC approach combined with AI/ML techniques allows us to broaden the type of problems APC can handle and improve the results from our APC application. One particular advantage which APC offers AI/ML is APC's well-established connectivity to field data, and the ability to download optimal setpoints while managing process dynamics. It also provides the real-time orchestration platform to execute AI/ML routines, feeding data to the model and taking results from it. In Honeywell Forge APC, this is achieved through embedded toolkits in the runtime environment, which can provide a range of supporting functions to the APC application. This includes the ability to run Python scripts as part of the APC application execution cycle. The strength of the AI/ML algorithm in this case is its ability to process data that APC cannot deal with directly, such as discrete data, or image data. In this hybrid approach, the AI/ML routine processes that non-analog data, and can provide guidance to the APC application, in terms of improved inferential measurements, dynamically modifying tuning or limits, or changing optimization strategies.

PRACTICAL EXAMPLES OF AI/ML WITH APC

The area where AI/ML techniques are finding most promise is in enabling and enhancing the capabilities of APC. AI/ML can help address some of the most common challenges with APC. Some of those opportunities are in the design and development phase, and some of those are in the online execution phase.

Here are three examples of using AI/ML to enhance APC benefits:

1. in the design phase to improve model identification from historical data
2. in the implementation phase, to identify models from operating data in real-time
3. in the online phase, to dynamically identify and manage changes in the process state (for example, due to a different feed or operating mode).

EXAMPLE 1

Improving model identification from historical data

Having an accurate process model is fundamental to achieving tight control. Better models mean better predictions, and better predictions mean better ability to control. Traditionally, developing and maintaining the APC models are one of the most time-consuming activities in an APC project. It requires time and effort over days or weeks to manually step-test the process, extract data, and conduct model identification.

New analytic techniques offer the opportunity to greatly improve this model development process. Firstly, we can try to get more information from our existing historical data, before we start active testing. Surely all those setpoint changes which the operator makes during normal operation is just “free” data? Traditionally this approach has proven problematic, because the historical data contains some useful, representative data, but also contains low quality data which is not representative of normal process behaviour. This can be due to upsets in the process, inaccurate process readings or simply long periods of data without any operator actions. Sifting through that data set manually to identify some “good” periods of operation will probably take longer than going ahead and doing some step testing on the process.

Honeywell has developed new capabilities in Honeywell Forge APC Engineering Studio to help with this process. The model identifier can select periods of high-quality data out of the historical data set, using similar rules to how a human might approach such a data mining task. Additionally, techniques like wavelet decomposition provide an accurate way to locate those useful operator set point changes. The model identification routine can then run using just this high-quality data and generate a reliable and representative process model.

EXAMPLE 2

Learning new models in real-time

An extension of model identification from historical data is to learn the model from operating data, in real-time. In this case, the APC application continues to perform its primary function of control and optimization of the process, but in the background, the application is also identifying new and potentially improved process models from the live operating data.

The tool which allows this real-time model identification is known as Honeywell Forge APC Online Modeller. There are several important functions that make up this learning process. Firstly, small perturbations in the setpoints are necessary to create some level of process response that the identifier can use. These small steps are implemented automatically by the modeller and do not require any manual actions by the user. The APC application remains in control of the process, and if any potential constraint violation is predicted, it will take normal action with manipulated variables to keep the process within constraints.



At a regular interval, the modelling algorithm will run, and identify new models from the real-time operating data. This algorithm, known as Global Multi-Stage (GMS), is fully capable of handling the closed-loop data collected in normal controller operation, including highly correlated data. The algorithm will present the identification results to the user, with detailed statistics indicating the confidence in the model results, and how the model response has been changing over time. Models which are considered to be accurate can then be downloaded to the running controller.

This ability to identify and refine the model in real-time offers great benefit to the user. Firstly, it opens new application implementation methodologies, allowing an initial model to be developed from historical data (a “seed” model), and then refined during the commissioning phase to come up with the final, high-quality model. This greatly reduces the time to get a new APC application installed and commissioned.

Secondly, once the controller is in service, it allows the user to quickly and easily update any suspect models. No manual actions are required to step test or model, with the Online Modeller simply presenting its results to the user on a regular basis. The user’s day-to-day controller maintenance activities are greatly streamlined, resulting in a more accurate process model, with less engineering effort required.

EXAMPLE 3

Use to identify change in process state

APC is effective when dealing with a process that displays consistent model responses. However, many things can cause a process to move away from its predicted process responses. A common example is a change in feed quality. Using a denser feed, a coarser feed, a feed with higher moisture content or a feed with a different composition may all require the operating point of the APC to be adjusted. In practice, this often requires the operator to recognise the change themselves, and manually change the limits on controlled or manipulated variables. With this guidance, the APC can return to optimising the process.

Analytics can help in this situation by identifying a change in feed type, and by selecting new limits to use for the APC application. In one specific example for a minerals processing operation, the application used a clusterization model to identify a change in feed quality. Input variables for the clusterization model include feed characteristics and operational conditions.

When a change in feed quality is detected, an optimization routine using a simulation of possible operating decisions identifies an optimum set of APC range and setpoints to maximise production. In this case, the clusterization models and optimization both run online, in real-time, and provide their recommendations to the operator as an open-loop advisory. The operator can then download these new operating conditions to the APC, which manages the dynamics of moving the process to its new operating point.

Using this approach, we can exploit the relative strengths of both AI/ML and APC. The AI/ML algorithms handle the detection of a change in feed type (a classification problem), and the selection of optimum limit sets (which has non-linear and discrete characteristics). The APC provides the framework to implement those objectives, ensuring the process is optimised within bounds. Experience on a SAG mill for copper processing has shown this combination can deliver a 3.5% increase in production and 0.9% improvement in recovery over APC alone.

SUMMARY

These examples show there are a broad range of techniques which can be used for production optimization. Likewise, there are a broad range of production challenges to be addressed in industry, each with their individual characteristics. There are no silver bullets but plenty of options for the skilled engineer to consider when choosing a production optimization approach.



The right choice will come through gaining a detailed understanding of the process, and then selecting a technique to apply. Both APC and AI/ML approaches can be complementary when correctly applied. Keep an open mind and know the technology, and the expected benefits for your next application will certainly be achieved.

This document is a non-binding, confidential document that contains valuable proprietary and confidential information of Honeywell and must not be disclosed to any third party without our written agreement. It does not create any binding obligations on us to develop or sell any product, service or offering. Content provided herein cannot be altered or modified and must remain in the format as originally presented by Honeywell. Any descriptions of future product direction, intended updates or new or improved features or functions are intended for informational purposes only and are not binding commitments on us and the sale, development, release or timing of any such products, updates, features or functions is at our sole discretion. All pictures shown in this document are for illustration purposes only; actual product may vary.

Honeywell® is a trademark of Honeywell International Inc. Other brand or product names are trademarks of their respective owners

Honeywell Connected Enterprise

715 Peachtree Street
Atlanta, GA 30308
1 (877) 841-2840
www.honeywell.com

APC and AI Whitepaper | 03/21
© 2021 Honeywell International Inc.

**THE
FUTURE
IS
WHAT
WE
MAKE IT**

Honeywell