Unravelling events and alarms with data analytics tools

ABB’s new comprehensive, experience-tailored data analysis and diagnostic tools provide process industries with transparent ways to identify, compare and handle disturbances, alarm floods and time series data. Deployed onsite or in the cloud, this remarkable new system helps engineers make better decisions.

Nowadays, process automation systems continuously produce immense quantities of data. Considering an upstream oil and gas system for instance: ABB service engineers receive around 1.5 GB of compressed data monthly with more than 3900 tags and 250,000 alarms and events. For industrial use, this flood of information must be available and its veracity incontrovertible.

DiAs combines modern data analytics approaches with the rich experience of ABB’s service engineers for a comprehensive analytical process solution.

Data analytics is the ultimate key to unlocking the wealth of information generated so that desirable and undesirable process states can be discerned, recommendations for improvements can be issued and operators can follow through with necessary actions. Nevertheless, the process of unearthing truly useful information from raw data requires deep domain knowledge, and the process is highly tedious.

Because safety, efficiency and profitability go hand in hand, ABB developed a new analytics solution for today’s process industry automation needs: Data Analytics Tools for Industrial Automation (DiAs). Created in 2017 to boost analysis and diagnostic capabilities, DiAs combines modern data analytics approaches with the rich experience of ABB’s service engineers to deliver customers a comprehensive yet experience-tailored analytical process solution. Customers obtain a holistic view of historical data, complete with interactive plots that allow engineers to zero in on important details and perform intelligent and efficient data analysis. In this way, context and insight into processes are won. The result is better decision-making and a safer and more profitable operation.

Alarm and event explorer
Alarms indicate disturbances in process plants. Once triggered, alarms can spread rapidly and
these alarm floods can overload operators who might not be able to handle these events safely. Such alarm floods in the chemical sector cause most industrial incidents investigated by the US Chemical Safety Board [1]. Not only is the safe operation of a plant imperative for the human workforce, costs associated with these events can impair profitability.

For this reason, ABB explored ways to improve the data analysis process in an offshore gas and oil separation plant [2]. These plants are designed to separate crude oil, gas, and condensates at a location near the well before these materials are exported. ABB was entrusted with the operational data of a plant to evaluate the DIAS system; this data was recorded over a period of 382 days.

ABB’s system allows service engineers to find and investigate a suspicious event. AE Explorer rearranges the view to inspect the event rapidly and easily.

Relying on their experience, ABB service engineers began by investigating process alarms and trip events. The DIAS Alarm and Event Data Explorer (AE Explorer) was shown to help the engineers to quickly identify interesting events. The results can be presented in comprehensive, yet human-readable views. By diving into details, dragging, and many other actions, engineers can easily explore the data to gain clarity about the event or situation in question.

If service engineers find a suspicious event occurrence, they can click on this event occurrence and activate the “investigate” function. AE Explorer will then rearrange the view to allow the operators to inspect the event of interest rapidly and easily. And, based on the sorting result, a clear picture of the causal chain of events is presented to the user [4]. Thus, DIAS allows engineers to be more responsive to their day-to-day situations, eg, disturbances.

Abnormal situation analysis
The use of distributed control systems and the interconnectivity of process plants has meant that alarm flooding is a real challenge for the alarm management of modern process plants [2]. The ability to quickly and accurately diagnose recurrent alarm floods can add substantial value to the operation of a plant. Therefore, DIAS offers an innovative machine learning-based tool to cluster and classify problematic alarm floods; thereby selectively identifying the recurrent alarm floods among the vast quantity of operational data.

ABB rigorously tested this useful function on an offshore gas-oil separation plant [2]. In this case DIAS identified 1,473 unique alarm tags. Given an alarm flood threshold of eight alarms per 10 minutes, DIAS identified 926 alarm floods and grouped them, automatically, into five classes based on their similarity. In one abnormal situation, DIAS grouped 16 alarm floods into the same class. DIAS also accurately identified the location of the abnormal situation, ie, Produced Water Reinjection (PWRI) system →5.

Alarm flood sequences, in this aforementioned class, start with a low-flow alarm in the pump P11 (A FICA 130 L, the outlet flow) and are, shortly thereafter, followed by a low-flow alarm in pump P21 (A FICA 116 L, the outlet flow), this leads to trips of both pumps. The level of the degassing drum increases quickly until high-level alarms for the water level (C LIC 128A H) and the oil level (C LT 118 H) are successively triggered.

Because it is crucial for humans to understand and interpret the results of machine learning algorithms, DIAS adds invaluable capabilities: it provides engineers with transparency and allows them to improve the clustering results based on their process knowledge. This is accomplished with an intuitive Graphical User Interface (GUI). For instance, two of the 16 alarm floods that have been grouped together by the algorithm are presented within the same vertical box →6a. Consequently, engineers can inspect and validate the resultant classes by applying specific comparison tools or the AE Explorer.

To further support service engineers determine the all-important root causes of similar alarm floods, AE Explorer can tag similar alarm floods with vector rulers, and then AE Explorer can search for events that occurred frequently, shortly before and, or, after these tagged alarm floods →6b.

DiAS offers an innovative machine learning-based tool to cluster and classify problematic alarm floods.

This new approach of alarm co-activation was shown to be appropriate for the analysis of ongoing sequences and was superior to the established sequence alignment approach for the analysis of abnormal episodes in this oil and gas separation plant [2,3].

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DIAS can redirect them to the transient view, where they can compare and analyze the time series data recorded shortly before and after the selected event →7a.

The transient recorder viewer allows service engineers to gain deep insights into the history of an event. For instance, they can identify a sensor failure by comparing the difference between current values measured for motor input and motor output →7b.

DIAS provides heat map views that highlight important features in time series data. In addition to providing an overview of specific interesting situations across signals, DIAS provides heat map views that highlight important features in time series data, e.g., a heat map that shows abrupt changes in signals →8a. Each observed heat map episode represents the abrupt change level of a signal at a specific moment. The darker the color, the greater is the change level. When engineers click on one episode, they are redirected to a high-resolution trend viewer for more detailed inspections. Another helpful tool is the DIAS high density trend viewer, which can provide engineers with an overview of the queried time series data →8b. To help engineers understand time variation

The higher the frequency of an event, the greater is the possibility that this event has a cause common to that of the tagged alarm floods →6c. This ability to classify events and root out alarm flood causes contributes to safety, productivity and hence profitability.

Exploring time series data
The minerals and cement industries rely on gearless mill drives to function free from impediments. To improve the analytics capability of these systems, ABB service engineers analyze operational data generated from these drives, but are particularly focused on time series signal values produced shortly before and after an event. To do this, they can initially use AE Explorer to identify the event of interest. Subsequently

DIAS provides heat map views that highlight important features in time series data.
Due to the wide diversity of alarm management systems used currently by process industries, there are various popular alarm and event data storage paradigms. To shift the complexity of data connection away from the service engineer’s work, DIAS offers configurable data connections. Additionally, different data connections can be switched seamlessly via the user interface, such as ABB Real Time Database (RTDB) file system, Microsoft SQL Server, Oracle database and Elastic search. Regardless of which data storage paradigm is connected, the service engineer can search for interesting alarms and events with a universal query interface. Such queries embed a wealth of process knowledge. To share that knowledge and save query efforts, DIAS stores query templates and makes them accessible to different users. Thus, a comprehensive user-friendly and flexible system is available to serve customers.

DIAS evolution and future applications

Setting on decades of experience providing exemplary service to process industries, ABB’s service engineers have accumulated deep domain knowledge about operational data and developed best practices for ways to analyze data. DIAS has been iteratively developed with expert input from engineers to support their daily work in the best possible way. For ABB, this means providing the most reliable analysis results possible. Utilizing state-of-the-art technologies, DIAS has been developed as a web application. Each DIAS tool is modularized and can be deployed either on-site or in the cloud.

Currently, ABB service engineers from various business units use DIAS to address real-world customer cases. In addition to upstream oil and gas plants, and industries that rely on gearless mill drives, power generation plants have employed DIAS successfully. In the future, ABB will release individual tools within ABB products such as: ABB Ability™ Manufacturing Operations Management and ABB Ability™ Performance Optimization for Control Loops to enable better control and insight.