Thinking Machines Inside Factories

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Concept

Chip manufacturing is an intricate process, and it is indispensable to systematically identify variation inducing sources. Substantial benefit is realized in identifying behavior of these sources in all combinations, meaning understanding the collective response of sources in various settings. Currently, these variation contributing elements are often looked at in a unitary fashion without studying the relationships they hold in a dynamic manufacturing scenario. Also, such an evaluation is performed in various degrees of automation in a shop floor, from manual to employing semi-automated methods. There are various reasons why many of these methods fail to fully understand the associations. The sheer number of these variables and to cognitively evaluate their interdependencies comes across as combinatorial explosion. Each source has a unique relationship with the other sources which when captured facilitates principal cause identification of every device failure in a factory. Applied E3® SPC Platform deeply studies such associations and believes in rapid communication of this information.

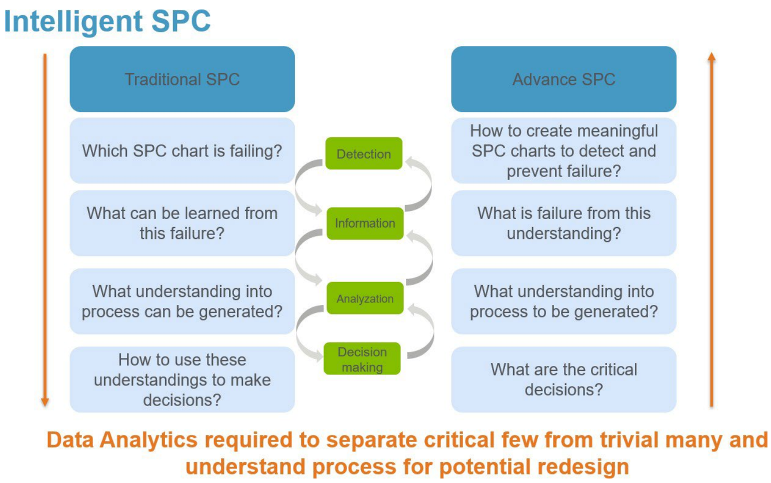

Figure 1. Smart or intelligent SPC is getting about beyond data to discover new insights

The purpose of SPC is to detect and prevent detrimental changes to a process as they occur rather than detecting them after the product has been produced. It is an essential to identify and implement SPC practices which understand all sources of variation. Conventionally, context is understood as any factor such as recipe, machine, raw material etc. which can influence a process line. Manufacturing sectors use manual immature strategies when analyzing such contexts which leads to ineffective SPC charts. These strategies do not enunciate the wide-ranging performance of each variable relationships. The chart constructed is a generic one and does not represent or explain when significant changes occur.

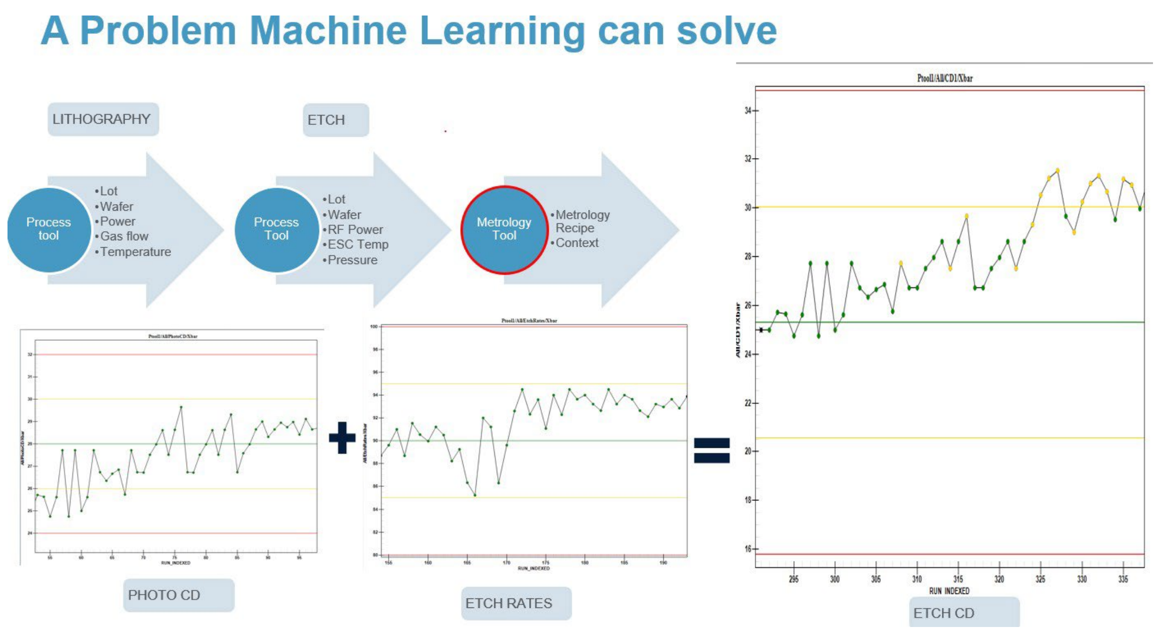

Figure 2. Outline's the confluence of 2 variables driving results outside of acceptable windows. Traditional SPC lack in the way it looks at the data, limits us to identify behaviors that can guide us to new understanding of the process.

Analysis of this type of data requires specific methods, referred to as frequent pattern mining. It is used to look for frequent patterns or associations from datasets and characterizes behaviors in following steps:

- Identify frequency of all variation inducing sources (SPC context)
- Compress data set to mine frequent itemset
- Derive association rules for these frequent itemset
- Apply a confidence statistic on variables association
- Augment results in real time to SPC data

Approach

Machine learning has traditionally been divided in unsupervised and supervised learning. Unsupervised learning is when users do not need to supervise the model. Instead, it allows the model to work on its own to discover patterns and information that were previously undetected.

- Pattern Recognition algorithm here is utilizing existing SPC information to derive new discoveries of process control. Context of SPC charts are the key ingredients that makes up the input parameters for frequent pattern algorithm. The algorithm is smart to only generate frequent itemset based a configurable count known as Support count. This support count warrants a certain frequency of context to classify as common itemset. This algorithm is a self-learning one as it constantly absorbs new context and derives matching pattern.

- The output of pattern mining is correlations among data by characterizing context based on frequencies. These frequent item correlations when evaluated over results recognize the influence of variables repeatedly. This influence can be caused by a single variable or a collective impact. It is not unusual that such techniques can discover correlations that humans are unable to perceive. This is an expert system that can chew data to find stronger as well as subtle patterns by fragmenting the paths of contexts.

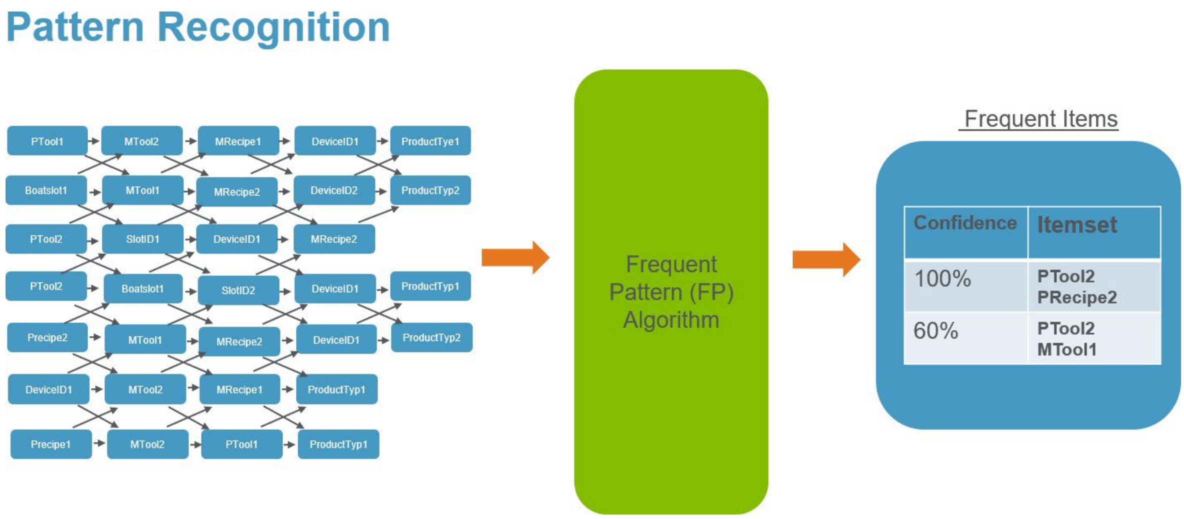

Figure 3. Pattern mining is a machine learning technique to find correlations among data by characterizing context based on frequencies.

Contextual pattern mining helps us with an unsupervised learning for categorizing and accurately grouping data regardless of human created categories. Pattern mining correlation results when transported to a factory dispatching system assists to select the optimum route a product can take ensuring quality and productivity. Golden behaviors exhibited by manufacturing artifacts can be used to find the best route to navigate material. Real time production modifications can be made to avoid or dedicate material for best results. The dynamics of a factory calls for a dynamic process control. When context behaviors from frequent pattern results are captured and consumed by an APC controller, the tuning model can be tweaked precisely to reach control targets for every context combination.

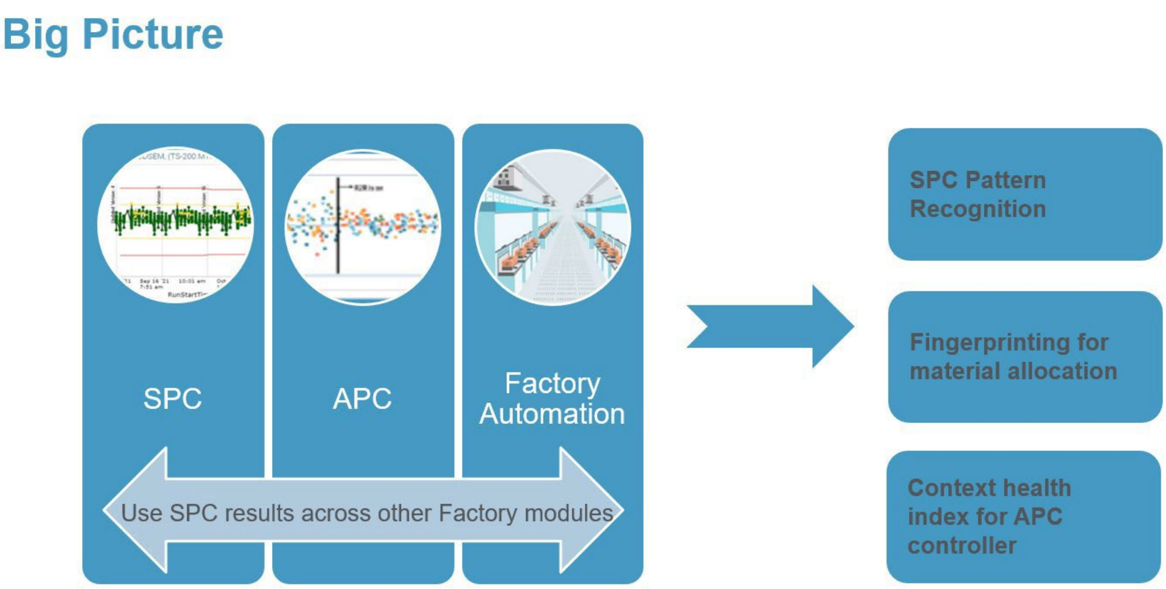

Figure 4. Outlines augmentation of machine learning algorithms to SPC application and its seamless integration to other factory modules.

Conclusion

Smart manufacturing is taking us to new levels of integration. It is opening opportunities for productivity and quality improvements for cost reduction. Industry is migrating towards integrated systems enabled by machine learning and hence, a close collaboration between these highly specialized technologies is needed for knowledge transfer.

The value of such data analytics tools to customer is:

- Detect signals rapidly by identifying changing behaviors which is key to reduce variation.
- Make-them-right-the-first time by recognizing the right variables and critical behaviors thereby minimizing noise and interruptions
- Empowers engineers with instant access to the best data and the ability to act on it immediately, resulting in faster time to resolution. Customers have seen 20% annualized reduction in variability with the help of such tools
- The newer insights in a factory used to streamline the production line to maximize efficiency. Pattern mining correlation results when transported to a factory dispatching system enhance tool matching and improve overall equipment availability.

Applied E3 SPC™ will empower end users to quickly learn the transient and true dynamics of what makes up a measurement. Such a technology also explicitly exposes the behavior of manufacturing tools and processes for customized, continuous, and automated adjustments. This improves the overall SPC practice by streamlining inspection process and make scientific data driven decisions. It will also help achieve high quality standards and efficiently push best in class material to its customer.

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