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Lean Thoughts

CONTROL CHARTS

Almost every product, process, or service varies. The control chart is used to monitor natural process variation in an effort to expose times that the process has shifted such that non-natural variation is realized. Within the SPC domain, terms have been coined to define various types of variation. The natural variation in the process that cannot be avoided is commonly called common cause variation. It is assumed that such variation is not controllable. Alternatively, undesirable changes occur, causing a process to change in its natural behavior. The variation of the process may become excessively large in view of its common causes, or the central tendency of the data may shift in a positive or negative direction. Such unnatural variations in the data are known as special causes.

In view of these types of variation, it is desired to design SPC approaches such that the user maximizes opportunities for detecting special causes in the midst of the uncontrollable chance causes. In the application of SPC, samples or subgroups are collected and analyzed and are used for this judgment. The logical collection of the subgroups or samples such that opportunities for detecting special causes are maximized is commonly known as rational subgrouping. Most introductory texts in quality control have detailed discussion of this topic (i.e., Grant and Leavenworth 1980).

The tool that is used to monitor process variation over time is known as the control chart. Control charts originate from the work of Walter Shewhart (1927) and are often referred to as Shewhart control charts. Effectively, process observations based upon collected samples or subgroups, at fixed points in time, are plotted in accordance to time. As long as the current observation is within fixed intervals, called control limits, or no unnatural trends in the data are observed, it is concluded that the process is operating in the presence of common causes only. Such a process is declared to be operating in a state of statistical control. Alternatively, if the process yields observations that exceed the control limits, or unnatural variation exists, it is concluded that special causes exist in addition to the common causes. Commonly, this process state is known as being out of control.

As discussed, there exists a line defining the central tendency as well as the control limits. This process is obviously operating under the presence of both special causes and common causes and should be judged out of control. The basis of the centerline and the control limits are essentially the same for all charts with the exception of the type of data.

Data Patterns on Control Charts Control charts are powerful tools for monitoring the variation of a process. Furthermore, the non-natural trends on a control chart can provide significant diagnostic information regarding the cause of a process disturbance.

Where Lean Thoughts can become Reality

"Unless you try to do something beyond what you have already mastered, you will never grow."

Ronald. E. Osborn

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First, it is the assumption of most control chart applications that the process from which observations are collected is stable. That is, the statistical behavior of the process is time invariant in that the underlying distribution is fixed, yielding a fixed mean and variance. In some applications, process observations are collected such that multiple processes may feed the data-collection station. As a result, the observations may have a tendency to cluster around the control limits and be sparsely observed around the CL or the mean. This observation is commonly referred to as a mixture.

Secondly, processes may be overly sensitive to factors within the day; for example, temperature cycles. Such trends in the data are known as cycles and are not well suited for traditional applications of control charts, even though the cycling behavior is a natural part of the process variation. When faced with cycling or autocorrelation in the data, it is suggested the advanced techniques, such as the moving centerline exponentially weighted moving average chart, be considered, as presented in Montgomery and Mastrangelo (1991).

Third, a trend in the process is typically realized on the control chart as a generally increasing or decreasing trend in the data. Such trends in the data can be caused by process degradation, such as tool or machine wear. In some cases, such trends cannot be tolerated and can be adequately detected with standard control charts. In situations where such trends are a natural part of the process (i.e., tool wear), alternative approaches should be considered. The simplest approach is to fit a reasonable regression model to the process and monitor the process accordingly. Alternatively, Quesenberry (1988) develops an alternative SPC approach for a tool-wear process. If a shift has occurred in the central tendency of the process, the process data will cluster around the new mean. Such shifts are often caused by changes in raw materials or process settings. In most all cases, such process behavior is not desirable and can be detected quickly with traditional control charts.

In accordance with the AT&T handbook, a process is judged out of control or unstable if any one of the following rules apply:

Test 1: A single point falls outside of the control limits (beyond zone A).

Test 2: Two out of three successive points fall in zone A or beyond for a given side.

Test 3: Four out of five successive points fall in zone B or beyond for a given side.

Test 4: Eight successive points fall in zone C or beyond for a given side.

If these rules are consistently employed throughout a plant, type I errors should be adequately controlled while ensuring reasonable detection of undesirable process shifts. A type I error, in the context of control charts, is the event that the operator falsely concludes that the process is out of control.

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