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Introduction to Control Charts

A control chart is a time-ordered plot of data used to study process behavior over time. Control charts are like run charts or line charts, but with extra information for understanding and characterizing variation.

In the introductory video, you learned some important terminology. A process that has only common cause variation, which is inherent to the process, is said to be stable or in control.

A process that has special cause variation, which is external to the process and is not inherent, is unstable, or out of control.

A process can also have systematic variation. For example there might be predictable seasonal changes in a process over time. Control charts enable you to visualize, understand, and quantify the variation in a process.

All control charts have four key components: a time axis to show the time ordering, a statistic that is plotted at regular time periods, a center line, representing the overall process average, and upper and lower control limits, representing the range of variation we can expect if the process is stable, or in control.

The plotted statistic can be individual measurements. Or the statistic can be computed from samples, like sample means or sample proportions.

Control limits are calculated using two numbers: an estimate of the mean, or the centering, of the process, and an estimate of the spread of the process based on only common cause variation.

As with many statistical methods, control charts are based largely on the knowledge of the normal distribution and the Central Limit Theorem, or the Rule of Averages.

We know that if data are normally distributed, then approximately 99.73% of the observations will fall within plus or minus 3 standard deviations of the mean. Only a small percentage of the time will observations fall outside this range by chance alone.

The Central Limit Theorem tells us that if we take samples of data from a process and compute averages of these samples, the sample averages will be approximately normally distributed.

It also tells us that the larger the sample size, the smaller the standard deviation of the sample averages.

The standard deviation of sample averages, or the standard error, gets smaller as the sample size, n, increases.

Because of our understanding of the Central Limit Theorem, we place control limits at approximately plus or minus 3 standard deviations of the plotted statistic. This assumes, of course, that the statistic is normally distributed.

For example, let's say that you are using a control chart to plot sample means over time. This chart is called an X-bar chart, where X-bar is the notation for sample means. From the Central Limit Theorem, we know that sample means are approximately normally distributed.

The control limits are placed at plus or minus 3 standard errors of the mean. If the process is in control, approximately 99.73% of the sample means will fall within the control limits.

If a point falls outside these limits, it is likely that this point is a special cause. Of course, there are other cues or signals that a special cause has occurred. You'll learn how to detect special causes in a future video.

There are different types of control charts for plotting different types of process measures.

The most commonly used control charts are for plotting continuous measures, like thickness, diameter, and width. These are referred to as variables control charts. Variables control charts are often referred to as Shewhart charts, after Walter Shewhart, who is credited with inventing control charts in the 1920s.

There are also control charts for plotting attribute data, like the number of defects or the proportion of defective units. These charts are aptly named attributes control charts.

There are also other special purpose charts, such as charts for studying rare events or for plotting multivariate data.

In this lesson, we focus on variables control charts.

Note that, historically, control charts were largely used for ongoing process control and monitoring.

They can also be used within a problem-solving framework. This is the focus of this course. Within this context, control charts can be used for different purposes throughout the life of a project: to determine whether a process is stable, to establish a baseline level of performance, to explore and analyze patterns of variation in a process, to identify potential problems within a process, to determine whether the process has improved, and to determine whether improvements are maintained, or sustained, over time.

In this lesson, you learn the basics of using control charts for problem solving. You learn about individual and moving range charts, for plotting individual values, common and special cause variation, and the effects of tampering, how to identify special causes, X-bar and R and S Charts, for plotting subgroup means, rational subgrouping, 3-way control charts, for plotting data with both within-group and between-group variation, and using control charts with phases.

In the interest of time, we omit the more theoretical and technical details, as well as the nuances of control charting and special purpose charts.

For additional information about the available types of control charts, and information about using control charts for process control and monitoring, see the Read About It for this module.

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