Interpreting Control Charts

Processes, whether manufacturing or service in nature, are variable. You won't always get the same result each time. The reason for this is that there are sources of variation in all processes.

There are two major sources of variation. One is common cause variation, which is the inherent variation in the process due to the way it was designed and is managed. It can be reduced only by *fundamentally* changing the process. This is usually management's responsibility. There will always be common cause variation present in a process. The second type of variation is special cause variation, which is caused by things that don't normally happen in the process. People closest to the process have the responsibility for finding and removing (if possible) special causes of variation. A process is in statistical control if only common cause variation is present. How do we know if only common cause variation is present or if there are also special causes of variation present? The only way to determine this is through the use of a control chart.

A control chart represents a picture of a process over time. To effectively use control charts, one must be able to interpret the picture. What is this control chart telling me about my process? Is this picture telling me that everything is all right and I can relax? Is this picture telling me that something is wrong and I should get up and find out what has happened? This module presents various methods of interpreting a control chart.

Purpose

The purpose of this module is to introduce the general model used for control charts, how control charts relate to a process, how to recognize a process in statistical control and the various tests for out of control situations. These out of control tests include points beyond the limits, the zones tests, tests for stratification and mixtures, and the rule of seven tests.

The Model for Control Charts

The control chart is a powerful tool for monitoring variation in a process. The chart allows you to determine when variation is simply due to random (common cause) variation or when the variation is due to special causes.

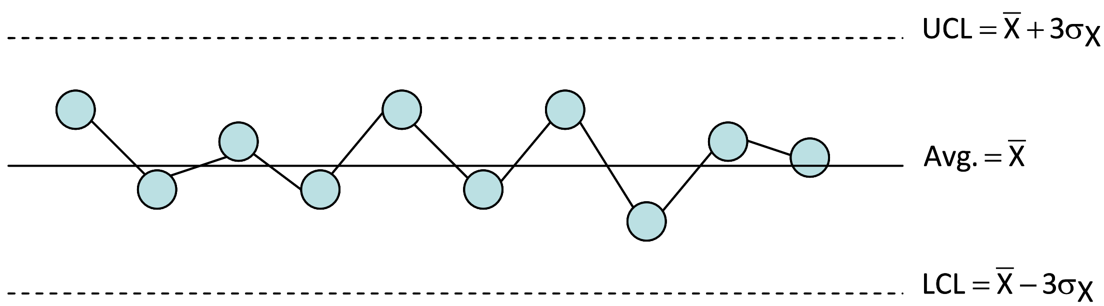
How does a control chart tell if only common cause variation is present? This is determined by the data itself. Using the data, we compute a range of values we would expect if only common cause variation is present. The largest number we would expect is called the upper control limit. The smallest number we would expect is called the lower control limit. In general, if all the results fall between the smallest and the largest number and there is no evidence of nonrandom patterns, the process is in statistical control, i.e., only common cause variation is present.

However, to determine if the process is in control, you must be able to interpret the control chart. We always say communication is important – vital to the success of any organization or relationship. The control chart is the way the process communicates with you. If you know how to interpret the control chart, the process will tell if you everything is operating as designed (only common cause present) or if there is a problem that needs to be addressed (special causes present).

Time is critical in finding the reasons for special causes of variation. The faster you can detect an out of control situation, the more likely it is you will find the cause. This is why putting control charts in the hands of those closest to the process is a powerful way of controlling a process. If the process goes out of control, the person keeping the chart can immediately begin to look for the special cause of variation.

You will often hear that control charts are based on a ± 3 sigma model, i.e., the control limits are based on ± 3 standard deviations. This is true, but the key point to remember is that the control limits are based on ± 3 standard deviations of what is being plotted. The basic layout for a control chart is shown in Figure 1.

Figure 1: Control Chart



Data (the X values) are plotted over time in a control chart. The average is calculated ($\overline{X}$) and then plotted. This average is sometimes called the centerline of the control chart. The control limits are then calculated and plotted. The upper control limit (UCL) is the average plus three standard deviations (σ_X) of the data (the X values). The lower control limit (LCL) is the average minus three standard deviations of the data. A standard deviation is a measure of how much variation there is in the process.

The key thing to remember is that σ_X is the standard deviation of ***what is being plotted.*** For example, wit the $\overline{X}$ control chart, you are plotting subgroup averages ($\overline{X}$). The ± 3 standard deviation limits are based on the standard deviation of those subgroup averages, not the individual values. In addition, the standard deviation is not calculated directly from the range, but is estimated from a range chart. And not all control limits are based on the normal distribution. For example, the c control chart is based on the Poisson distribution. Those limits are then based on the standard deviation of the Poisson distribution.

Why the three sigma limits? When a process goes out of control, the person closest to the process should look for the reasons for the special cause of variation. This takes time and represents a cost to the organization. In fact, the out of control situation could be a cost itself to the organization. The 3 sigma limits are used because they represent a balance between the costs of looking for special causes when they are not present and the costs of not hunting them when they are present.

This can intuitively been seen in the following exact mathematical example. Suppose X is normally distributed (bell-shaped histogram) with an average of $\overline{X}$ and a standard deviation of σ. Since we know the average, the standard deviation and the fact that the data is normally distributed, we can draw the curve shown in Figure 2.

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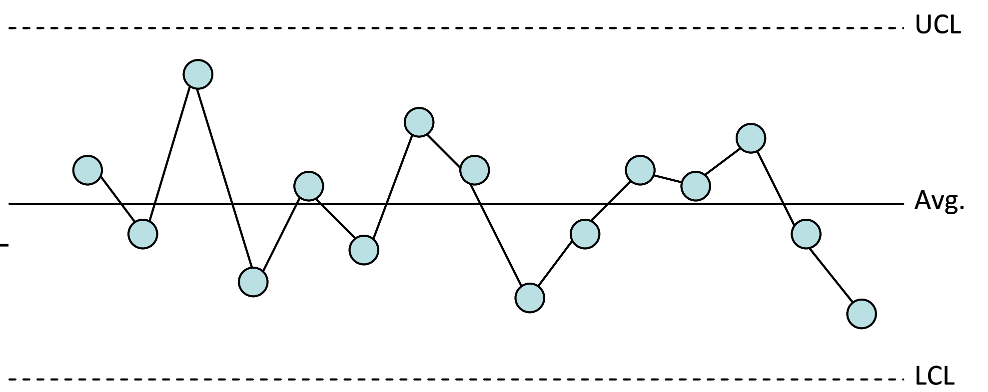
You should not tamper with the process.

-Dr. W. Edwards Deming



Processes and Variation

- Always have variation
- Two types
  - Common
  - Special
- Control Charts
  - Picture of process over time
- Interpretation
  - Key to effectively using control charts

Common

&

Special

Causes