**Tell me about control charts (Chat GPT)**

Control charts are graphical tools used in statistical process control (SPC) to monitor and analyze processes over time. They are particularly useful in manufacturing and quality control settings where maintaining consistency and identifying anomalies are critical.

Key components of a control chart include:

1. **Central Line (CL)**: This represents the process mean or target value. It is typically calculated from historical data or established based on process specifications.

2. **Upper Control Limit (UCL) and Lower Control Limit (LCL)**: These lines are derived statistically from the process data and represent the boundaries within which the process is expected to operate under normal conditions. They are usually set at a certain number of standard deviations (often 3σ) from the mean.

3. **Data Points**: Each data point on the chart represents a sample or subgroup of measurements taken from the process at regular intervals (e.g., hourly, daily). These measurements could be dimensions, weights, counts, or other relevant metrics depending on the process.

The primary purpose of control charts is to distinguish between common cause variation (inherent variability of the process) and special cause variation (indicative of a specific issue or change in the process). Common causes are expected and inherent to the process, while special causes signal that something unusual has occurred that may require investigation and corrective action.

Types of control charts include:

- **Variable Control Charts**: Used when measurements can be taken on a continuous scale (e.g., weight, length). Examples include the X-bar and R chart (for sample means and ranges) and the X-bar and S chart (for sample standard deviations).

- **Attribute Control Charts**: Used when measurements result in discrete outcomes (e.g., pass/fail, yes/no). Examples include the p-chart (for proportions of non-conforming items in a sample) and the c-chart (for counts of non-conformities in a sample).

Benefits of using control charts include early detection of process shifts or trends, reduction of waste and defects, improved process understanding, and facilitation of data-driven decision-making.

In summary, control charts are a powerful tool in quality management and process improvement, providing a visual and statistical method to monitor process stability and identify opportunities for optimization and corrective action.

**Montgomery Textbook**

A quality characteristic that is measured on a numerical scal is called a variable. Examples include dimensions such as length or width, temperature, and volume. This chapter presents Shewhart control charts for these types of quality characteristics.

**Timmer Conference Paper**

The implementation of control charts is generally recognized to be done in two phases: Phase I is the retrospective phase and Phase II is the on-line monitoring phase. Montgomery [1] states that during a Phase I analysis a set of data is collected and analyzed (all at once), and trial control limits are calculated to determine if the process has been in a state of statistics control so that the trial control limits can be used in Phase II.

**Human, Chakraborti, and Smit Paper**

Control charts for variation play a key role in the overall statistical process control (SPC) regime. We study the popular Shewhart-type S^2, S and R control charts when the mean and the variance of a normally distributed process are both unknown and are estimated from m independent samples (subgroups) each of size n.

References

Borror, C.M., Champ, C.W.. (2001). Phase I control charts for independent Bernoulli data. *Quality and Reliability Engineering International*. 17, 391-396.

Montgomery, D. M.. (2005). Introduction to Statistical Quality control, 5th edition. John Wiley, New York, NY.