Individuals and Moving Range Charts

Data Science for Quality Management:
Xbar and R / Xbar and S charts /
X and MR charts

with **Wendy Martin**

Learning objective:

Use the X and MR chart to monitor different aspects of variation

Example: Treating Averages as Individuals

- Assume you have a process that is “machine” dominant – the largest source of variation is found spindle-to-spindle

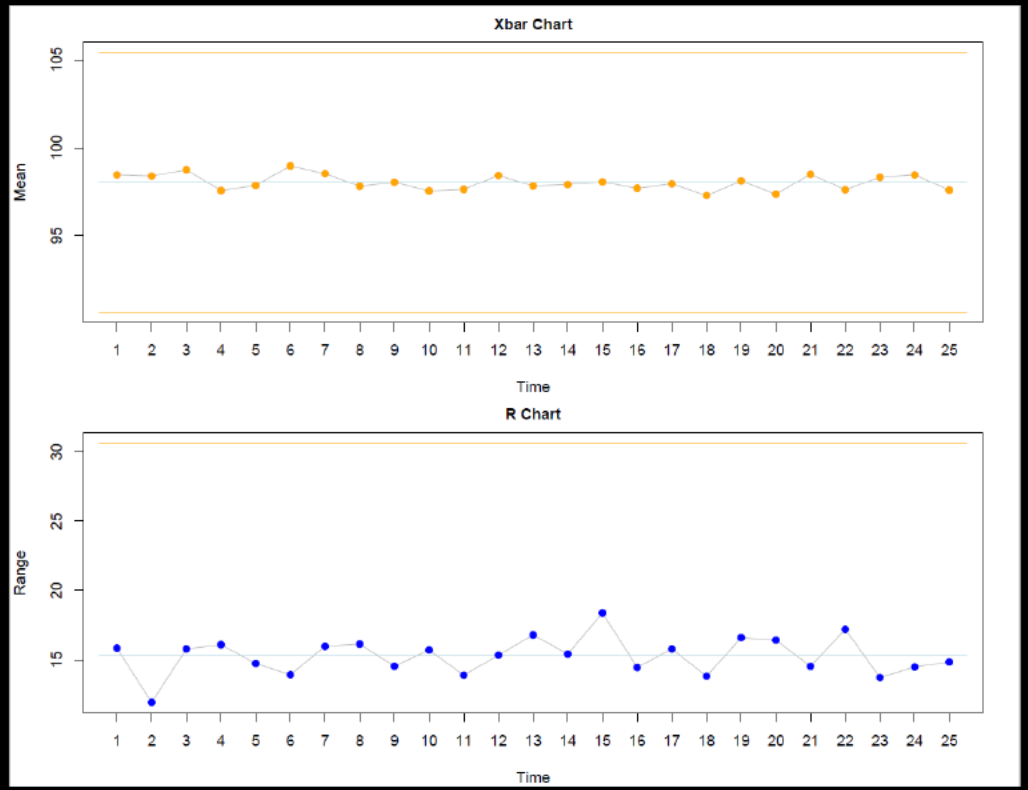
- You have six spindles that all produce product during a run

Example: Treating Averages as Individuals

- In addition, you would like to monitor “within run” process variation so samples are taken from each spindle

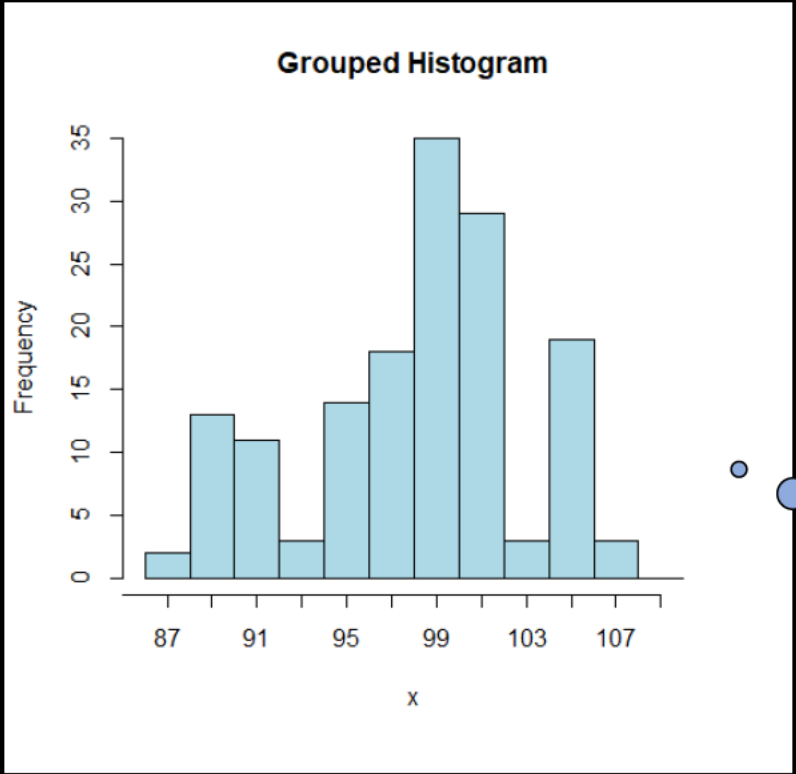
- The process is to be monitored with an X-Bar and R chart

Multiple Setup $\bar{X}$ and R



Why are the data points so close to the centerline?

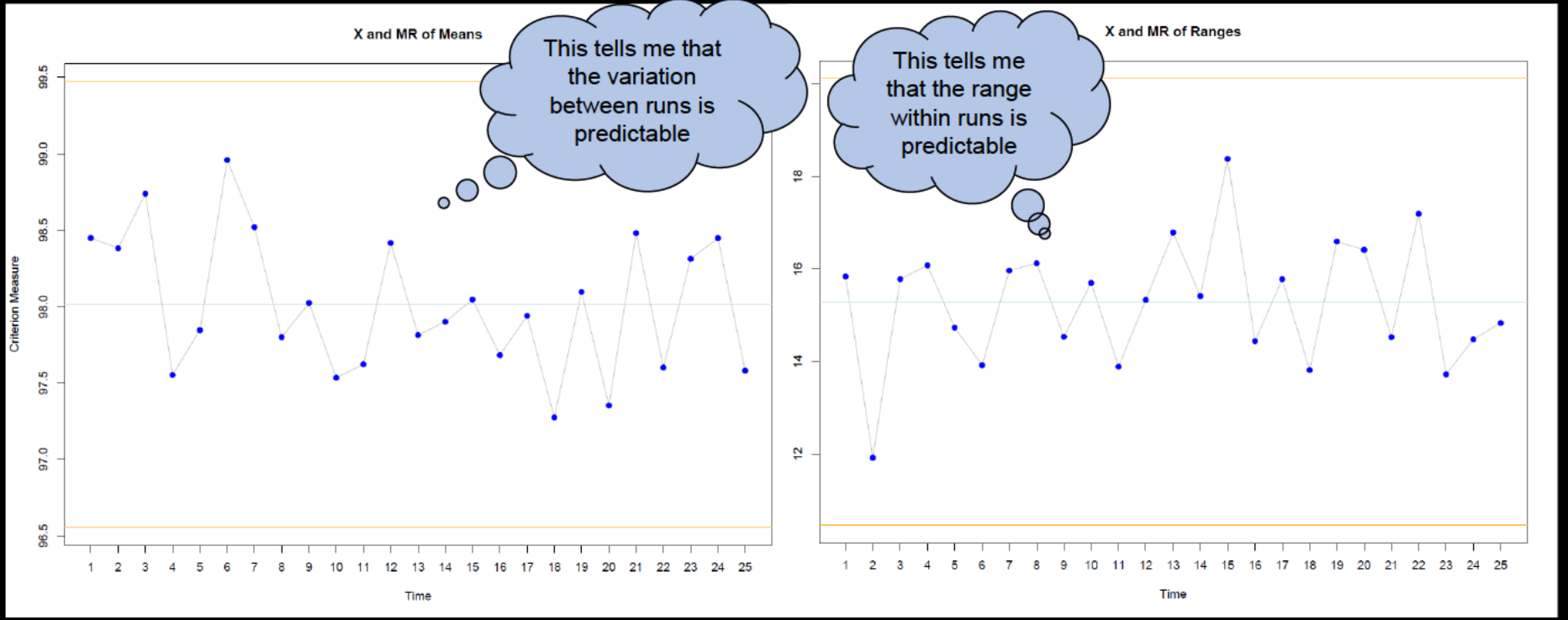
Multiple Setup Histogram

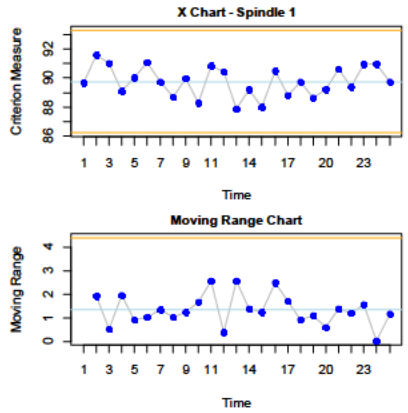


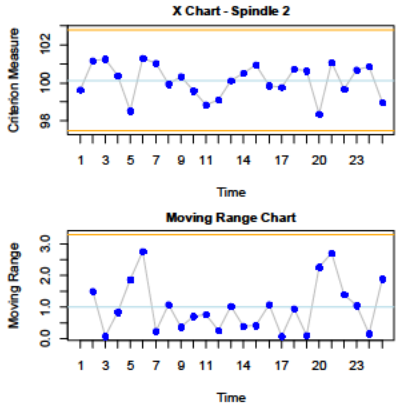

```
nqtr(summary.continuous(xbar.r.column$measure), 5)
n                150
mean             98.01483
var              23.86374
g3.skewness      -0.35412
g3test.p         0.07409
g4.kurtosis      -0.60761
g4test.p         0.03928
```

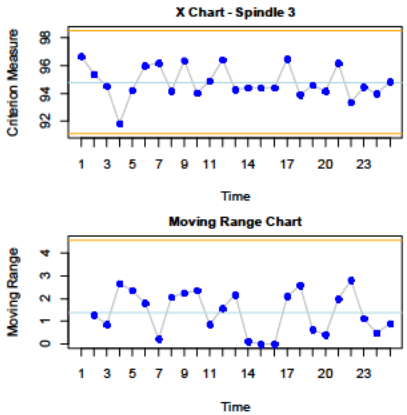
The individuals are not distributed normally. Could I have a non-normal distribution?

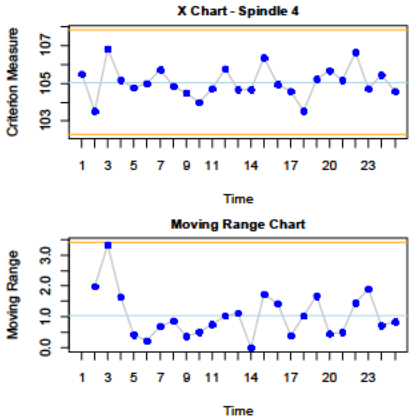
Moving Range of Means used for Control Limits of Means and Ranges

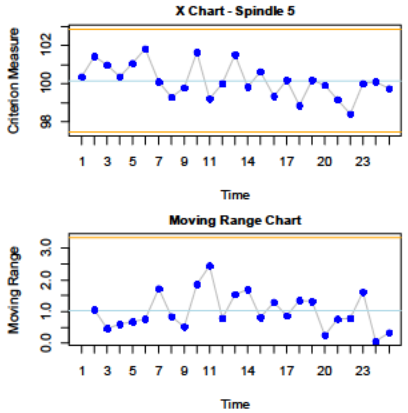


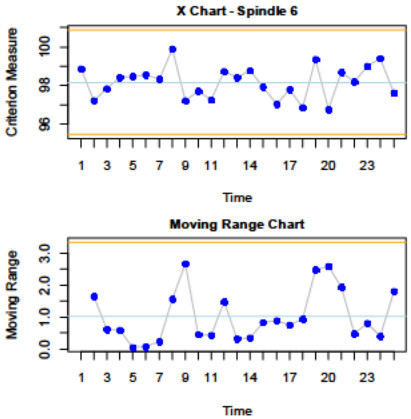

X Chart - Spindle 1
Criterion Measure
86 88 90 92
1 3 5 7 9 11 14 17 20 23
Time
Moving Range Chart
Moving Range
0 1 2 3 4
1 3 5 7 9 11 14 17 20 23
Time


X Chart - Spindle 2
Criterion Measure
98 100 102
1 3 5 7 9 11 14 17 20 23
Time
Moving Range Chart
Moving Range
0.0 1.0 2.0 3.0
1 3 5 7 9 11 14 17 20 23
Time


X Chart - Spindle 3
Criterion Measure
92 94 96 98
1 3 5 7 9 11 14 17 20 23
Time
Moving Range Chart
Moving Range
0 1 2 3 4
1 3 5 7 9 11 14 17 20 23
Time


X Chart - Spindle 4
Criterion Measure
103 105 107
1 3 5 7 9 11 14 17 20 23
Time
Moving Range Chart
Moving Range
0.0 1.0 2.0 3.0
1 3 5 7 9 11 14 17 20 23
Time


X Chart - Spindle 5
Criterion Measure
98 100 102
1 3 5 7 9 11 14 17 20 23
Time
Moving Range Chart
Moving Range
0.0 1.0 2.0 3.0
1 3 5 7 9 11 14 17 20 23
Time


X Chart - Spindle 6
Criterion Measure
96 98 100
1 3 5 7 9 11 14 17 20 23
Time
Moving Range Chart
Moving Range
0.0 1.0 2.0 3.0
1 3 5 7 9 11 14 17 20 23
Time

More Than One Chart Needed

- The X-bar plotted on an X chart would be used to monitor overall run-to-run variation

- The Range as individuals chart would be used to monitor within run variation

More Than One Chart Needed

- Individuals charts on each spindle monitor the within-spindle variation across runs
- The Moving Range of the X-bars could be used to monitor sudden run-to-run changes

Averages as Individuals Notes

- Each run is to the same target, but for some reason the spindles within each run are to a different target – they are a different process
- Therefore, the within-run output variation is larger than the between-run average variation

Averages as Individuals Notes

- In this case, you can use a random effects ANOVA, but you will see atypically low F-ratios.

- This procedure is available in R.

Sources

The material used in the PowerPoint presentations associated with this course was drawn from a number of sources. Specifically, much of the content included was adopted or adapted from the following previously-published material:

- Luftig, J. An Introduction to Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1982
- Luftig, J. Advanced Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1984.
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- Littlejohn, R., Ouellette, S., & Petrovich, M. Black Belt Business Improvement Specialist Training, Luftig & Warren International, 2000
- Ouellette, S. Six Sigma Champion Training, ROI Alliance, LLC & Luftig & Warren, International, Southfield, MI 2005