

CAN I TRUST THE ACCURACY OF STATISTICAL RESULTS FROM THE COMPUTER? HOW TO TEST THE ACCURACY OF SPC SOFTWARE

Marilyn K. Hart, College of Business, University of Wisconsin Oshkosh, 800 Algoma Blvd., Oshkosh, WI 54901, 920-424-7195, hart@uwosh.edu

ABSTRACT

The proliferation of statistical process control (SPC) software has made the decision to select accurate software more difficult. This paper presents two tests developed to test the accuracy of SPC software.

INTRODUCTION

Statistical analysis for research is almost completely dependent on computers. As we have backed away from programming the computer we have absolutely no idea as to whether the software is accurate. A recent article in the USA Today [4] pointed to the errors that have been found in scientific research due to the mistakes in software. For instance, it was found that Excel changed the names of genes into dates. It is particularly tempting to trust statistical output from computers if it comes from well-recognized software or if it is from an area in which the user is only slightly familiar. Having been asked by a number of organizations to evaluate well-known statistical process control (SPC) software packages, two tests have been developed by this author to screen the software packages and are discussed here.

TEST ONE FOR SCREENING SPC SOFTWARE

The control chart for individual values (called an I or X chart) is useful when individual readings are taken from discrete processes or from continuous processes when an occasional measurement is taken. Under some circumstances, observations may be taken only for a small number of consecutive pieces, followed by an interruption in either the manufacturing process (such as for short runs) or in the data acquisition process. A very short example is given at the bottom of Figure 1. “?” designates an interruption.

The control limits for the Individual chart are based upon the moving ranges of the data, where a moving range (MR) is defined as the absolute value of the difference between two consecutive observations that are not separated by either missing data or interruptions. The means of the X values and of the MR values are:

$\bar{X} = \frac{121}{10} = 12.1$ and $\overline{MR} = \frac{24}{6} = 4$. The control limits are calculated from these for the control chart (Figure 1). It is essential to note the discontinuous nature of the data by not using the moving range over the interruptions for the calculation of the control limits for either the Individual chart or the MR chart. Otherwise, if there were a large change over the interruption, a large \overline{MR} would occur resulting in wide control limits on both charts that would mask the change in the process [2]. Points are not connected over the interruptions.

If the interruptions were not considered in the calculation of the control limits, the resulting charts would be the ones shown in Figure 2. Note that the calculation of the MR value over the interruption caused the limits to be so wide that the analysis is no longer able to identify the points outside the correct control limits.

FIGURE 1. INTERRUPTED X AND MR CHART ON SHORT RUN DATA

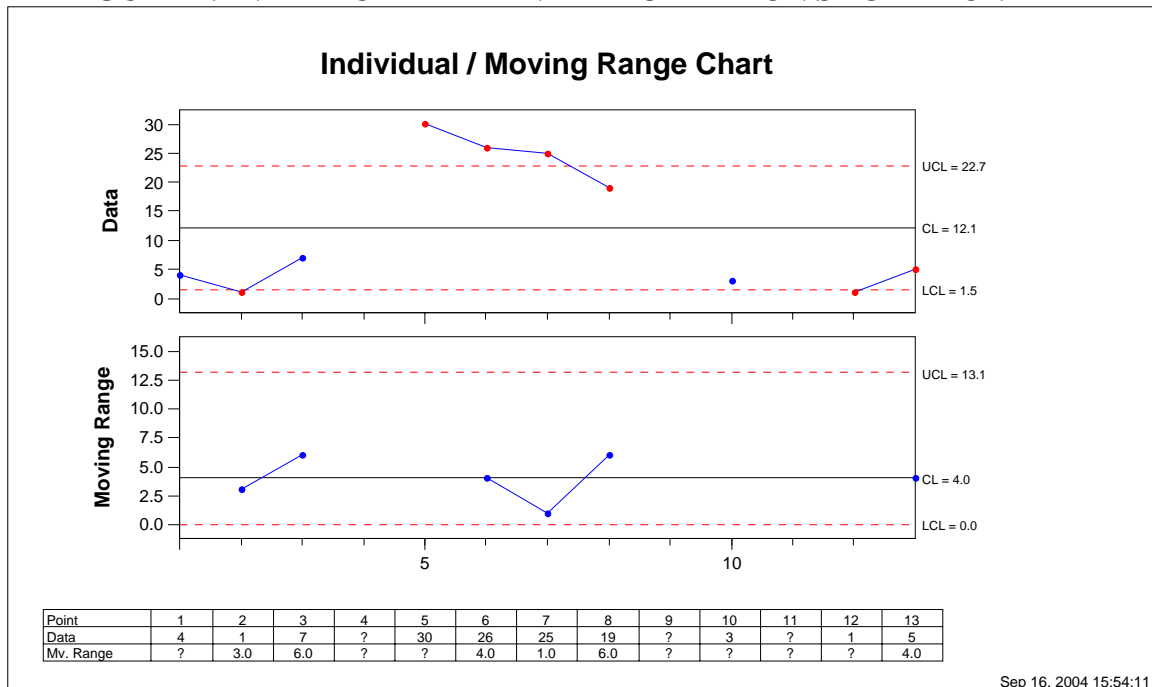
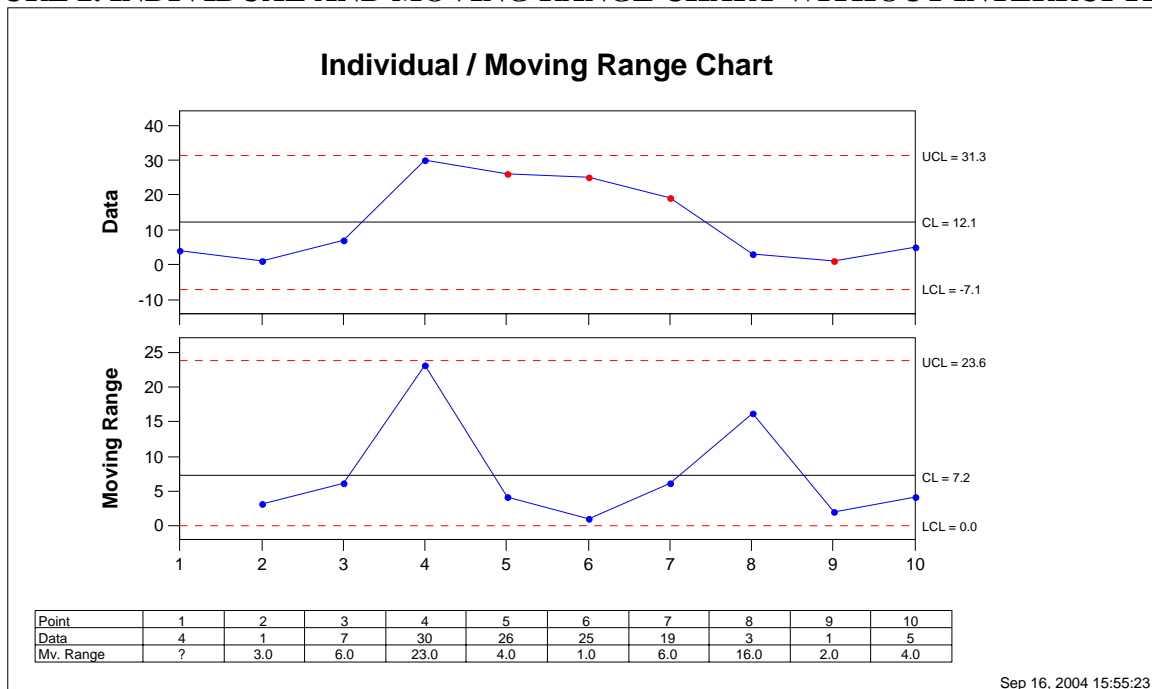


FIGURE 2. INDIVIDUAL AND MOVING RANGE CHART WITHOUT INTERRUPTIONS



TEST TWO FOR SCREENING SPC SOFTWARE

When making an \bar{X} and s chart with subgroups, if the population is normally distributed with constant subgroup size, the standard deviation of the population (σ) is estimated by

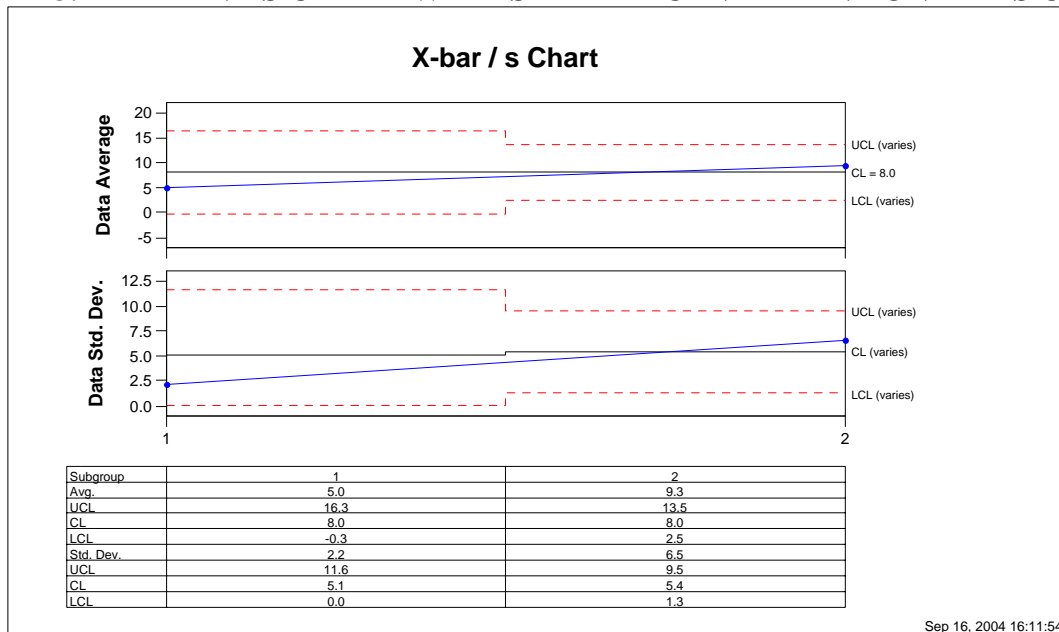
$$\hat{\sigma} = \frac{\bar{s}}{c_4} \quad (1)$$

where \bar{s} is the mean of the standard deviations of the subgroups and c_4 values are found in ASTM [1]. If subgroup sizes vary, there are different ways to estimate σ [3]. Whichever method is used, the control limits and the centerline for the s chart vary for different subgroup sizes because using (1)

$$\bar{s}_i = \hat{\sigma} c_4[n_i] \quad (2)$$

where $c_4[n_i]$ is the c_4 value for the i^{th} subgroup of size of n_i and \bar{s}_i will be the centerline value for the i^{th} subgroup. The stepped centerline may only be visually noticeable if the subgroup sizes are small. Consider two subgroups. One: 2, 5, 6, and 7. Two: 8, 4, 4, 5, 6, 15, 24, 8, and 10. Note the step in the centerline in the s chart (Figure 3). It will be noted that this author has found very few software packages that correctly pass these two tests.

FIGURE 3. XBAR AND S CHART WITH STEPPED CENTERLINE ON THE S CHART



SUMMARY

Two simple tests can be used to screen SPC software for accuracy. The first test is if it does not calculate the moving range over the interruption and does not connect the plotted values over the interruption. The second test is to check for steps in the centerline on an s chart with small but varying subgroup sizes.

REFERENCES

- [1] ASTM (American Society for Testing and Materials). *ASTM Manual on Presentation of Data and Control Chart Analysis*, MNL7, 6th ed. Philadelphia: ASTM, 1990.
- [2] Hart, Marilyn, and Robert Hart. *Statistical Process Control for Health Care*. Pacific Grove, California: Duxbury, 2002.
- [3] SAS Institute Inc. *SAS/QC Software: Usage and Reference*, version 6, ed. 1, vol. 2. Cary, NC: SAS Institute Inc., pp. 1214-1215, 1995.
- [4] Vergano, Dan. *USA Today*. "Computers: Scientific friend or foe?" August 31, 2004, p. 6D