Abstract

This paper focuses on the use of an EXEC driven text editing language such as INTERACT or WYLBUR to generate SAS programs.

This technique has been used to "write" SAS programs to provide a Statistical Quality Control System for the Quality Engineering Department at Syntex Laboratories. The system has been in use for two years to provide reports, plots, and statistical analyses of pharmaceutical data and has given us the ability to periodically review our products and check for trends in the data.

The system is called the Quality Engineering Report and Plot Generator and was designed to allow personnel with no programming experience the ability to use SAS to generate summaries, plots, and reports using data from our Quality Assurance database.

Although this EXEC has been written using the INTERACT language the basic approach will be useful to any EXEC driven text editing language such as ORVILLE or WYLBUR. While TSO clists or SAS/AF would provide a more interactive environment, the INTERACT batch approach is more cost effective and still maintains an interactive feel to the user.

The EXEC language provides a front end to the SAS system so that users may request a variety of analyses without having to write programs. The following are some of the capabilities provided:

Control Charts
Regression Plots
Sample Size Analysis

Range Charts
Trend Testing
Summary Statistics

The system consists of a single EXEC program that uses 20 external SAS skeletons. The user chooses the program of interest and the EXEC places the appropriate skeleton in its working file. As the user responds to prompts from the EXEC the responses are used to edit the skeleton to create the working SAS program. This finished program is then saved in a temporary file and submitted for execution.

Due to the large size of the system (the EXEC itself is over 2600 lines long) it is not possible to fully demonstrate its use in the space available to this paper. Instead an example of a control chart program written by a sample EXEC will be used to demonstrate the technique.

The Control Chart

Background - The use of control charts to monitor processes dates back before 1940. They are generally called Shewhart Control Charts after W.A. Shewhart (a statistician who developed methods to improve process control using basic statistical techniques and a colleague of W.E. Deming; one of the well known names in statistical quality control).

The basic purpose of a control chart is to study a process for potential improvements the capability of a process. As put by Grant and Leavenworth in their book "Statistical Quality Control":

"Measured quality of manufactured product is always subject to a certain amount of variation as a result of chance. Some stable system of chance causes is inherent in any particular scheme of production and inspection. Variation within this stable pattern is inevitable. The reasons for variation outside this stable pattern may be discovered and corrected."

Generally control charts are used in a dynamic manner. For example, a process is manufacturing some widget that should have a weight of 100.0 ± 5 grams. Every fifteen minutes 7 widgets are taken from the production line and weighed individually. The mean and standard deviation of each group of 7 is calculated and the means are plotted on a graph as shown in Figure 1.
After several points have been measured, a grand mean and standard deviation are calculated. Using a subgroup size table, the appropriate Shewhart factors are obtained for a subgroup size of 7 and upper and lower control limits can be established. These limits are statistically derived from the means and S.D.s of the individual observations and represent the process capability. In addition the overall mean is plotted. In Figure 1, it appears that the process is running above target. It's averaging 100.8 gram widgets and the widgets are generally between 97 and 104 grams. Up to point 10; all widgets were within the control limits. Notice that the process could be in control with unacceptable overall variation; that is all points are within the control limits but the "stable system of chance causes" has made the control limits too wide to be acceptable.

In our example, the limits are within the upper and lower tolerance levels (these define an acceptable product) so the control limits are reasonable.

At point 11 the subgroup mean falls outside the control limits. This point is outside of the "stable system" and there may be some assignable cause for the deviation. Although this could happen randomly, the probability of this happening by random chance is quite small. If the process is out of control, the widget maker should be stopped; the process investigated and corrective action taken. Even before a point is out of control, trends such as S or more consecutive points on one side of the mean can signal a change in the process and suggest corrective action. Generally 20-25 subgroups are needed to establish meaningful control limits.

Program Description

The program creates both an SD chart and an Xbar chart from an external data set containing the average of each subgroup at each time point; the standard deviation at the time point; and a variable N1 to order the points. N1 may be any information to order the points in time. For example, for data taken at regular 15 minute intervals, it would be sufficient to use a sequential numbering of the data. Table 1 shows a sample file used for the example.

<table>
<thead>
<tr>
<th>N1</th>
<th>Average</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99.2</td>
<td>2.1</td>
</tr>
<tr>
<td>2</td>
<td>101.3</td>
<td>1.8</td>
</tr>
<tr>
<td>3</td>
<td>102.1</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>97.8</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td>98.2</td>
<td>2.1</td>
</tr>
<tr>
<td>6</td>
<td>105.4</td>
<td>2.4</td>
</tr>
<tr>
<td>7</td>
<td>101.8</td>
<td>1.9</td>
</tr>
<tr>
<td>8</td>
<td>99.4</td>
<td>1.8</td>
</tr>
<tr>
<td>9</td>
<td>102.5</td>
<td>1.7</td>
</tr>
<tr>
<td>10</td>
<td>101.5</td>
<td>4.3</td>
</tr>
<tr>
<td>11</td>
<td>105.1</td>
<td>2.1</td>
</tr>
<tr>
<td>12</td>
<td>102.7</td>
<td>2.3</td>
</tr>
<tr>
<td>13</td>
<td>98.2</td>
<td>2.4</td>
</tr>
<tr>
<td>14</td>
<td>99.4</td>
<td>2.1</td>
</tr>
<tr>
<td>15</td>
<td>101.7</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Table 1

Table 2 shows a portion of the external file called factors used to read in the Shewhart factors. This table shows SD and Xbar charts factors for subgroups up to 15. This is the file FACTORS used by the program.

<table>
<thead>
<tr>
<th>SUBGROUP SIZE</th>
<th>A1</th>
<th>B3</th>
<th>B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.76</td>
<td>0</td>
<td>3.27</td>
</tr>
<tr>
<td>3</td>
<td>2.39</td>
<td>0</td>
<td>2.57</td>
</tr>
<tr>
<td>4</td>
<td>1.88</td>
<td>0</td>
<td>2.37</td>
</tr>
<tr>
<td>5</td>
<td>1.60</td>
<td>0</td>
<td>2.09</td>
</tr>
<tr>
<td>6</td>
<td>1.41</td>
<td>0.03</td>
<td>1.97</td>
</tr>
<tr>
<td>7</td>
<td>1.28</td>
<td>0.12</td>
<td>1.88</td>
</tr>
<tr>
<td>8</td>
<td>1.17</td>
<td>0.19</td>
<td>1.81</td>
</tr>
<tr>
<td>9</td>
<td>1.09</td>
<td>0.24</td>
<td>1.76</td>
</tr>
<tr>
<td>10</td>
<td>1.03</td>
<td>0.28</td>
<td>1.72</td>
</tr>
<tr>
<td>11</td>
<td>0.97</td>
<td>0.32</td>
<td>1.68</td>
</tr>
<tr>
<td>12</td>
<td>0.93</td>
<td>0.35</td>
<td>1.65</td>
</tr>
<tr>
<td>13</td>
<td>0.88</td>
<td>0.38</td>
<td>1.65</td>
</tr>
<tr>
<td>14</td>
<td>0.85</td>
<td>0.41</td>
<td>1.59</td>
</tr>
<tr>
<td>15</td>
<td>0.82</td>
<td>0.45</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Table 2

An example of the SAS® skeleton program is shown in Listing 1. Variable information that will be changed by the EXEC program is preceded by an @ sign enclosed by parenthesis. A description of these fields is as follows:

1) @DSN - Choose the data set of interest.
2) @TITLE1 - Title for the graph, product name.
3) @ID - Any identifying information to help identify the output.
4) @XX - Title for the X Axis.
5) @YXSD + @YXXBAR - Title for the Y Axis for the SD + XBAR plot.
6) @NS - The number of tests averaged for each observation.
7) @LPL1 + @UPL1 are the upper and lower plot limits for the SD chart. @Step 1 is the Step Size.
8) @LPL2 + @UPL2 are the upper and lower plot limits for the X chart. @Step 2 is the Step Size.
9) @REF1 is used for the upper reference lines on the SD chart.
10) @REF2 + @REF5 are used for any desired reference lines on the X chart.

Reference lines may be omitted if desired.

This example reads the data from an external file; however, a cards statement could be used to read the data inline. Footnotes are automatically placed on each chart; showing the lower confidence level, mean and upper confidence level. An external file called FOOT is used to store the footnote for the graph.

The EXEC program is shown in Listing 2 and an example of a dialogue between the system and a user is shown in Example 1. The output of the Xbar chart is shown in Figure 2. An S.D. chart is also created by the program.
1. // JOB (L3228,L3228,000010),'R 18 PI-250'
2. // EXEC SAS
3. //INPUT DO disp=old,dsn=men,l3228,chp,.dsn
4. ///IN2 DO disp=sh,dsn=men,l3228,chp,.FACTORS
5. //FOOT DO DISP=(NEM,PASS),UNIT=SYSDA,SPACE=(TRK,1)
6. //FOOT2 DO DISP=(NEM,PASS),UNIT=SYSDA,SPACE=(TRK,1)
7. //SYSIN DD *
8. 9. OPTIONS devadon=(,...) device=ibms267f gdest=j9j;
10. OPTIONS vsize=8;
11. 12. $PROC CARD TMS;
13. $TITLE _J=R._I1=1 JOB RUN &SYSDATE &SYSTIME;
14. $END;
15. 16. DATA TABLE; /*READ IN SHEWHART FACTORS*/
17. INFILE IH2;
18. INPUT NI AVG SO; /*READ IN DATA FOR CHART*/
19. 20. DATA STUFF; KEEP NI AVG SO; /*READ IN DATA FOR CHART*/
21. INFILE INPUT;
22. INPUT NI AVG SO;
23. 24. LABEL NI="BOX SD=RXSD AVG = @MOBAR";
25. PROC SORT;
26. BY NI;
27. 28. PROC MEANS;
29. VAR SO;
30. OUTPUT OUT=STATS MEAN=MSD STD=RXSD RANGE=RSD n=MSD;
31. 32. PROC MEANS DATA=WORK.STUFF;
33. VAR AVG;
34. OUTPUT OUT=STAT2 MEAN=GM STD=RXGSD RANGE=RANG n=GMG;
35. 36. DATA FACTS; NS=5;
37. SET STATS; SET TABLE POINT = NS; SET STAT2;
38. OUTPUT;
39. 40. DATA STAT1; SET FACTS; /*CALCULATE CONTROL LIMITS*/
41. LCL=3*MSD; UCL=4*MSD;
42. LCL2=GM-1*MSD; UCL2=GM+1*MSD;
43. 44. DATA _NULL_; SET STAT1;
45. FILE FOOT NOPRINT;
46. PUT '"FOOTNOTE1 _J=R _H=1 LCL=1 MEAN=' GM 'UCL=1 UCL2=' UCL2 ';
47. FILE FOOT2 NOPRINT;
48. PUT '"FOOTNOTE2 _J=R _L=1 LCL2 MEAN=' GM 'UCL2=1 UCL2 ';
49. 
50. PROC PRINT;
51. 52. DATA COMBINED;
53. SET STUFF;
54. IF _N_+1 THEN SET STAT1;
55. 56. PROC PRINT;VAR NI AVG SO;
57. 58. PROC SGPLOT; /*PLOT SD CONTROL CHART*/
59. PLOT SD * N1 MSD * N1 UCL * N1 LCL * N1
60. /VAXIS = @UPU TO @UPU BY @STEP1 VREF1=REF1 LVREF=25
61. OVERLAY;
62. TITLE F=TRIPLEX H=2 @TITLE1;
63. TITLE2 F=TRIPLEX H=2 S.B. CONTROL CHART;
64. TITLE3 J=R H=1 @ID;
65. $TMS;
66. FOOTNOTE1;
67. $INCLUDE FOOT1;
68. SYMBOL1 C=BLACK L=1 V=SQUARE I=JOIN;
69. SYMBOL2 C=RED L=0 V=NONE I=JOIN;
70. SYMBOL3 C=BLUE L=2 V=NONE I=JOIN;
71. SYMBOL4 C=BLUE L=2 V=NONE I=JOIN;
72. 
73. PROC SGPLOT; /*PLOT XBAR CONTROL CHART*/
74. PLOT AVG * N1 GM * N1 UCL2 * N1 LCL2 * N1
75. /VAXIS = @UPU TO @UPU BY @STEP2 VREF2=REF2 LVREF2=25
76. OVERLAY;
77. TITLE F=TRIPLEX H=2 @TITLE1;
78. TITLE2 F=TRIPLEX H=2 XBAR CONTROL CHART;
79. TITLE3 J=R H=1 @ID;
80. $TMS;
81. FOOTNOTE1;
82. $INCLUDE FOOT2;
83. SYMBOL1 C=BLACK L=1 V=SQUARE I=JOIN;
84. SYMBOL2 C=RED L=0 V=NONE I=JOIN;
85. SYMBOL3 C=BLUE L=2 V=NONE I=JOIN;
86. SYMBOL4 C=BLUE L=2 V=NONE I=JOIN;
87. */
88. */

LISTING 1

SAS skeleton - @ Variables will be Replaced by the EXEC Program.
LISTING 2

EXEC Program to Request Control Charts

715
GOOD MORNING CHIP, WELCOME TO...
THE CONTROL CHART PLOTTING PROGRAM
VERSION 1.12 ASSEMBLED DEC 6, 1985
TODAY'S DATE IS 01/20/86
THE TIME IS 09:54:09

This program will generate a control chart. You will need to know the data set name, the subgroup size, the upper and lower plot limits, and the value to be used for reference lines such as NDA limits or internal specs.

Press enter to continue control chart section.

Enter the data set name of the data for the control chart
Data Set Name = Weights.

Enter a title for the plots
Title = Control Chart Example

Enter an ID to identify the plot
ID Quality Assurance Engineering

Enter a title for the X axis
X Axis Timepoint

Enter a title for the Y axis of the SD chart
Y Axis Process S.D.

Enter a title for Y axis of the XBAR chart X axis Process Average

EXAMPLE 1

Example of Dialogue to Request Control Charts

CONTROL CHART EXAMPLE
XBAR CONTROL CHART

How many tests per observation
Subgroup Size =

Enter the upper and lower limits for the SD plot
Enter upper plot limit: 7
Enter lower plot limit: 9

Enter Step Size: 1

Enter an upper reference line for the SD chart
Enter upper plot limit: 120
Enter lower plot limit: 90

Enter Step Size: 5

Enter upper and lower reference lines for the XBAR chart
Enter Upper XBAR Chart: 105
Enter Lower XBAR Chart: 95

CONTROILST replaced on INTERS

Do you want this program run now or
Do you want to edit CONTROILST or relum the program.

Run now Y/N Y

FIGURE 2
Xbar Chart Output
The use of an EXEC prompted dialogue to "write" SAS programs has been quite useful to the Quality Engineering Department of Syntex Labs. This technique has allowed us to provide a Statistical Quality Control System tailored to our Quality Assurance Database and capable of providing statistical analyses, plots, and reports to personnel with no programming experience.

The system has provided a uniform method of performing the basic plotting and statistical manipulation needed prior to product capability analyses, and has simplified the administration of product reviews and retrospective validation of process capability. This has been primarily due to the ease of training personnel in the use of the system. Several other departments have been trained and use the system regularly.

Some examples of the types of plots created by the system are shown in Figures 3 and 4 below.

This paper has described the basic technique used in creating this system. Questions regarding this paper or the system should be addressed to the author.

References


2. Grant & Leavenworth, "Statistical Quality Control" Appendix 3, Table D.

Note

SAS and SAS/Graph are registered trademarks of SAS Institute, Inc., Cary, North Carolina, USA.

SAS/AF is a trademark of SAS Institute, Inc.

Authors Address

Chris Potter
Syntex Labs
3401 Hillview Avenue, Pl-230
Palo Alto, California 94304