

ISEN 614 PROJECT

PHASE-1 ANALYSIS FOR MANUFACTURING PROCESS

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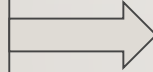
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PROCEDURE:

Analyzing the input Data

- Cleaning the input Data
- Estimating the distribution
- Identifying the method to use for PCA (Covariance matrix)



Dimension Reduction

- Using Scree plot, pareto chart identified the principal components.
- Performed simulation in R to plot individual x-bar, Hotelling Tsq, M-EWMA, M-CUSUM, combined T2 & MEWMA charts



In control parameters

- Performed several iterations, removed out of control data points, revised the control limits.

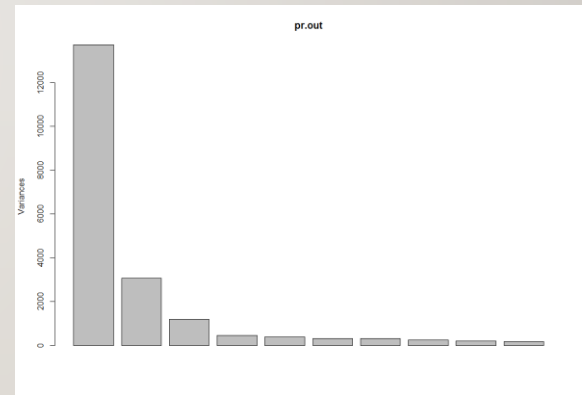
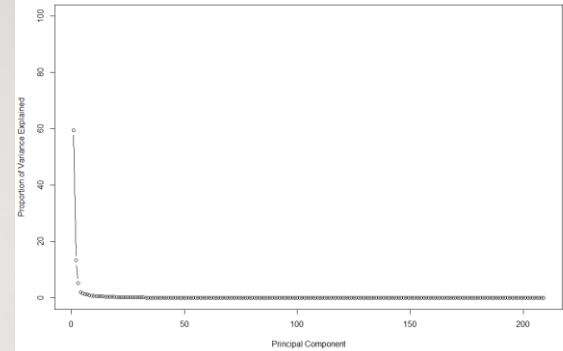
OUTLINE

- The given data set has sample size equal to 1, observations equal to 552 and 209 attributes.
- We carried out Principal Components Analysis to find the variables that explain the maximum variance.
- The data was centered and a covariance matrix of the principal components was computed.
- This was followed by applying individual \bar{x} -bar charts, T2 chart, MCUSUM, MEWMA and combined T2 and MEWMA charts to the given dataset to iteratively remove the out of control data points.
- The in control data points left at the end can be used to estimate the mean and covariance for Phase I analysis.



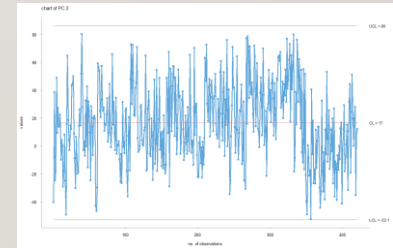
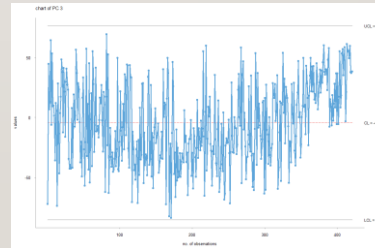
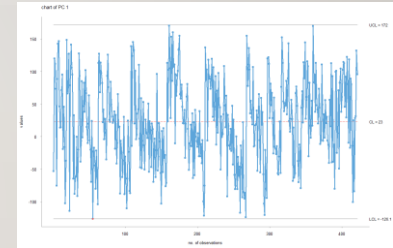
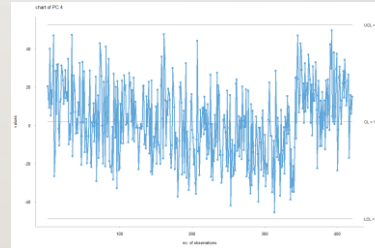
PRINCIPAL COMPONENT ANALYSIS

- No. of Principal components(PC) were decided from the scree plot and pareto chart.
- From the figure of scree plot we can see that the elbow bend takes place at 4 .
- Hence, first 4 PC explain the maximum amount of the total variation in the process.
- The first 4 PCs explain 80.1% of the total variation.



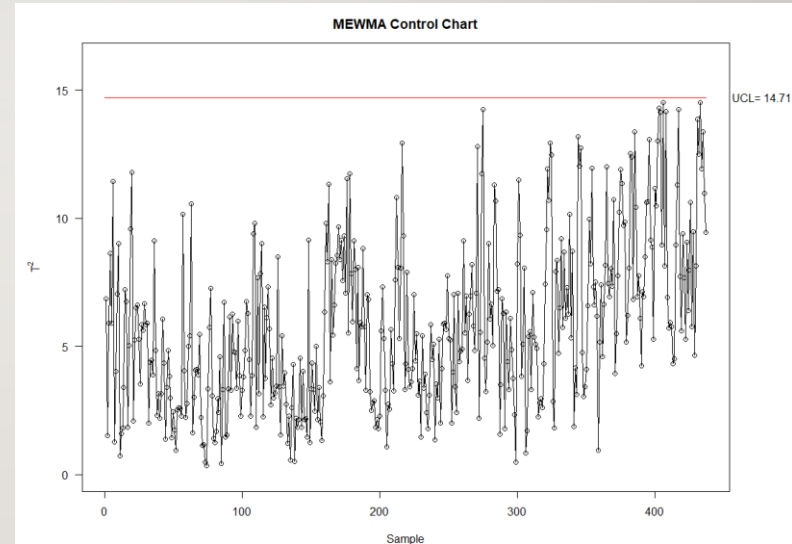
INDIVIDUAL X-BAR CHART

- Since the principal components as given by Principal Component Analysis are uncorrelated, individual x-bar charts can be applied.
- Four iterations were required to remove all the out-of-control data points. At the end of the procedure, we were left with 420 in-control data points which can be used for Phase I analysis.
- The control charts are shown:



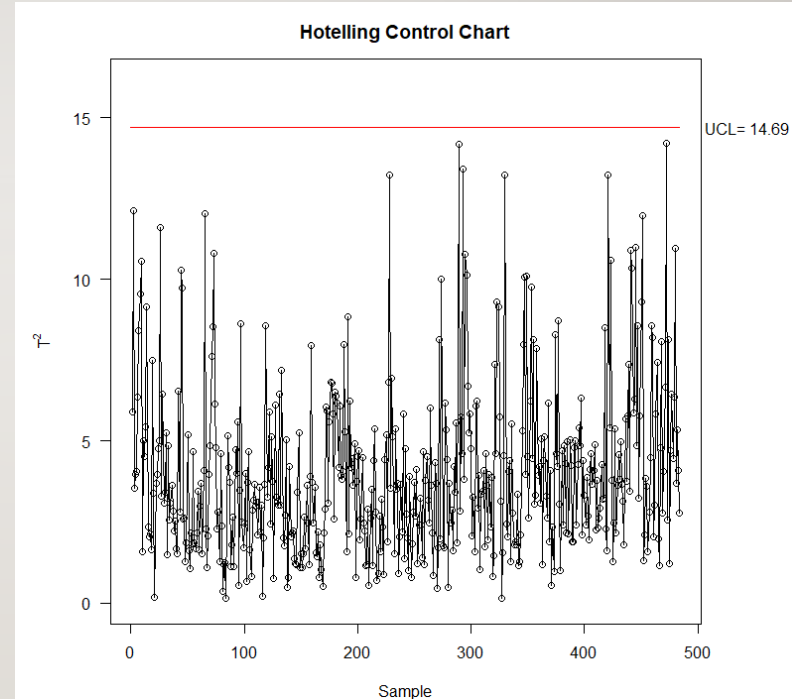
M-EWMA

- Initially, the given data set had 55 out of control data points, when M-EWMA chart was applied. The critical parameter values chosen were significance level = 0.005, $\lambda = 0.5$, $L_0 = 200$, $p = 4$ and smoothing parameter $I = 0.5$. After six iterations, 437 in control data points were left which are shown in the control chart:



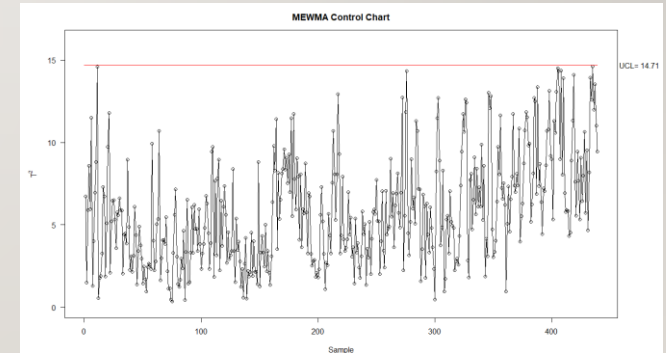
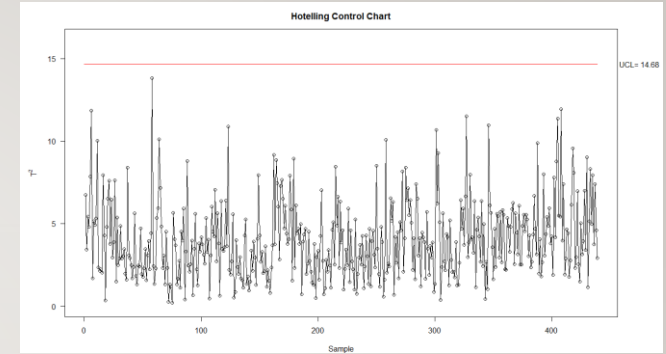
T2 CHART

- Initially, the data set had 15 out-of-control data points.
- After 13 iterations, 484 data were left.
- The final data control chart is shown:



COMBINED T2 AND M-EWMA CONTROL CHART

- While T2 chart is good at detecting large spikes and M-EWMA and M-CUSUM are good at detecting sustained mean shifts. To detect small consistent mean shifts and large spikes together in the given dataset, we used combined T2 and MEWMA charts.
- Six iterations were required to remove all out of control data points at the end of which 439 in control points were left which can be used for Phase I analysis.



JUSTIFICATIONS

- As the physical meaning of the data is absent, we used covariance matrix. Co-relation is used when the physical units of different attributes are different.
- As PCA produces variables that are not correlated, we used x-bar chart without worrying about the fact that they cannot detect change in correlation.
- T2 chart uses the covariance matrix and is good at detecting large spike type changes.
- MEWMA charts perform well for large and small sustained mean shifts.
- The combined T2 and MEWMA were used for detecting small sustained and large spike shifts.



CONCLUSION

- The table below compares different types of charts used in this project. T2 chart recommends the highest number of in-control data points while MCUSUM method recommend the lowest number of in-control points.
- If we want to select maximum number of in-control points out of the dataset and get an in-control sample without large spikes, we can select indexes of in-control points from T2 chart. If the objective is to detect small sustained mean shift M-EWMA chart should be used.
- To detect both large spikes and small mean shifts, we can go ahead with a combined analysis of T2 and M-EWMA to select in-control points.

Type of Charts	ARL0	No.of Iterations for In control data	UCL for last iteration	In control data Points
Individual X bar chart	370	4	52	420
T2 chart	200	13	14.69	484
MEWMA	200	6	14.71	437
MCUSUM	200	7	6	372
Combined T2 & MEWMA	200	6	14.68 & 14.71	439