Challenges in Manufacturing/Quality Control and Detection of Faults in Chain of Manufacturing by Multivariate Analysis.

(Principle Component Analysis)

Veerendra C Angadi

Department of Electronic and Electrical Engineering,
George Porter Building, Red Hill - Broad Lane,
University of Sheffield - S3 7HQ

September 19, 2017

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Outline

1. Why do we look at challenges of Manufacturing?
2. Challenges in Manufacturing and Quality Control
   - Size
   - Orientation
   - Tolerance
   - Time
3. Fault Detection using Multivariate Analysis
   - Production Model and Anomalies
   - Principle Component Analysis
   - Testing the robustness of the method

Outline

Introduction

Why do we look at challenges in Manufacturing?

- Important to check the sanity of the production.
- Is it producing what it is supposed to be producing?
- Are the analytics used in the decision making any sense?
  Eg: Confusion matrix.
- What are the cost associated w.r.t. metrology used?
  Eg: Time, Complexity and Design.

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Outline

Size

Eg: Fasteners, Sub-parts, etc.

- Items produced by one process must be of same/specified size.

Size

Eg: Fasteners, Sub-parts, etc.

- Items produced by one process must be of same/specified size.
- Whole point (!) of production (Custom or Mass).

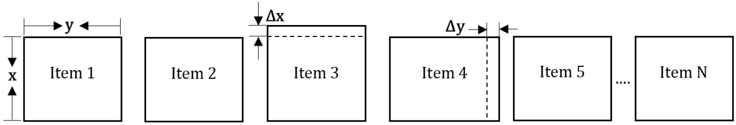

Figure: Production batch in which item no.3 & 4 are oversized by Δx & Δy units respectively.

Orientation

Eg: PCBs, Masks, Sub-parts etc.

- Similarly, items produced by single process must be of same/specific orientation.
- Or no anomaly in the expected orientation.

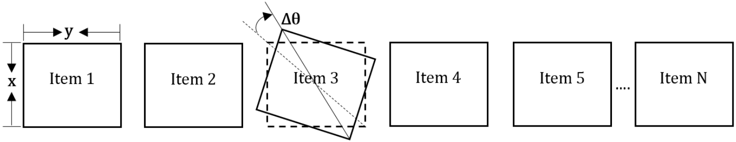

Figure: Anomaly in the production of item no. 3. The item is rotated by an angle of $\Delta\theta^\circ$.

Tolerance

- Needed for better judgement of quality of product.
- The errors occurred in measuring the parameters are due to actual physical error or analytical methods used or could be due to vibrations.
- It is important to know the source of error to precisely measure the parameters.

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Time

Eg: Sorting in industries

- Very crucial when the throughput is of importance.
- The decision making analytical methods must have low (or no) complexity.
- Linear models are preferable.

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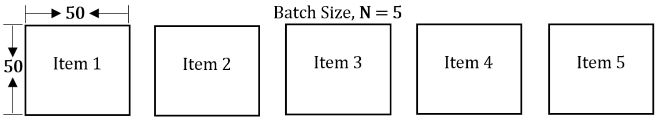
Production Model

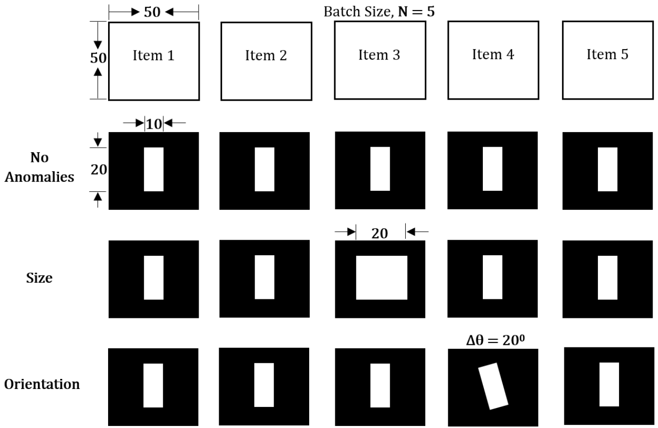
Assumptions

- Each product is scanned with a camera on top.
- The image is thresholded using standard methods.
  Eg: Otsu's global and Adaptive thresholds to mention a few.
- A batch size of N frames considered.
- Images are sumulated with a series of binary images of size 50×50 pixels.



Production Model and Anomalies

Size and Orientation



Results from $N = 5$

- results of $N = 5$ of both Size and Orientation.
- top left Variance of PC for Size
- top right biplot PC1 vs PC2 for Size
- bottom left Variance of PC for Orientation
- bottom right biplot PC1 vs PC2 for Orientation

Robustness of PCA

$N = 100$, Gaussian noise $\mu = 0$, $\sigma^2 = 2$

- 2×3 subplots
- Noisy binary image, Latent, biplot for Size
- Noise binary image, latent, biplot for orientation

Summary

- The random number of Image size, Batch size, Num of faulty images, $\Delta\theta$ and Sizes of items are tested with PCA methods.
- PCA is a linear model. Hence fast decision maker.
- Simpler, Cost effective metrological method of fault detection in manufacturing and quality control.

- Outlook
  - Something you haven't solved.
  - Something else you haven't solved.

For Further Reading I

A. Author.
Handbook of Everything.
Some Press, 1990.

S. Someone.
On this and that.
Journal of This and That, 2(1):50–100, 2000.