

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

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Outline

1 Introduction

- 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



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Why do we look at challenges in Manufacturing?

- Important to check the sanity of the manufacturing.
- 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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Size

Eg: Fasteners, Sub-parts, etc.

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

Size

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

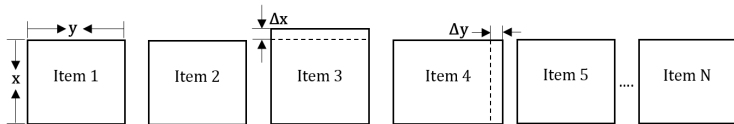


Figure: Production batch in which item no.3 & 4 are oversized by Δx & Δy units respectively.

Orientation

Eg: PCBs, Masks, Sub-parts etc.

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

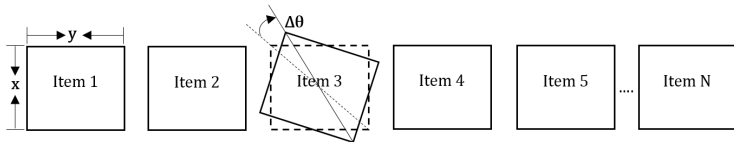


Figure: Anomaly in the production of item no. 3. The item has a defect in its orientation by an angle of $\Delta\theta^\circ$.

Tolerance

- Needed for better judgement of quality of product.
Eg: Allowance for Δx , Δy and $\Delta \theta$
- 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.



Time

Eg: Sorting in industries

- Very crucial when the throughput is of importance.
Eg: Japanese recycling industry. 2 tonne in 1 hr.!
- The decision making analytical methods must have low (or no) complexity.
- Linear models are preferable.



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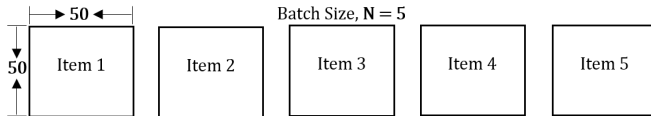
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Production Model

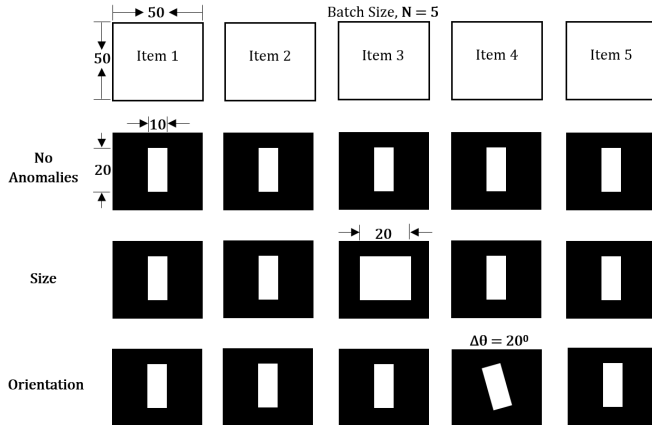
Assumptions

- 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 simulated with a series of binary images of size 50×50 pixels.



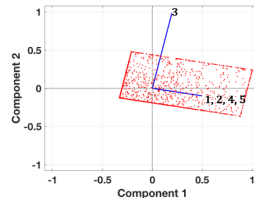
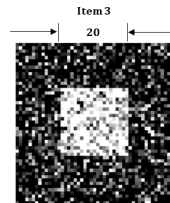
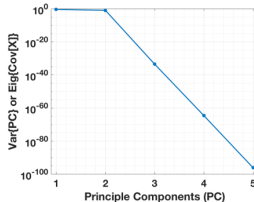
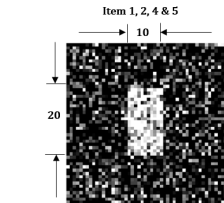
Production Model and Anomalies

Size and Orientation



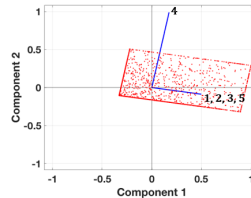
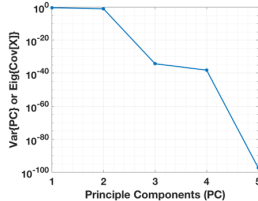
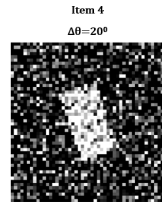
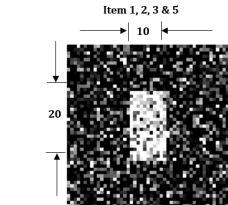
Anomaly due to change in Size

Batch Size $N = 5$, with Gaussian noise, $\mathcal{N}(\mu, \sigma^2) = \mathcal{N}(0, 0.25)$



Anomaly due to change in Orientation

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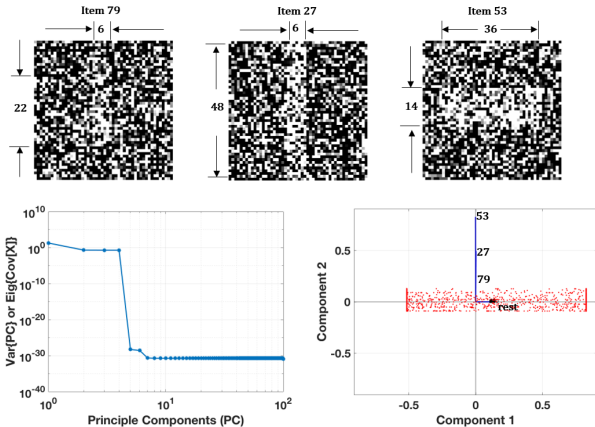


Robustness of PCA

- `nfaults=randi([1 5]); % Number of fault parts`
% -----Random Size of Parts-----
- `sz1 = randi([1 r/2], 1, nfaults); % Size rows`
- `sz2 = randi([1 c/2], 1, nfaults); % Size columns`
% -----Random Orientation-----
- `rt = randi([1 360], 1, nfaults); % Rotation angles`
% -----Random location of faults-----
- `Pos = randi([1 N], 1, nfaults); % Locations in stack`

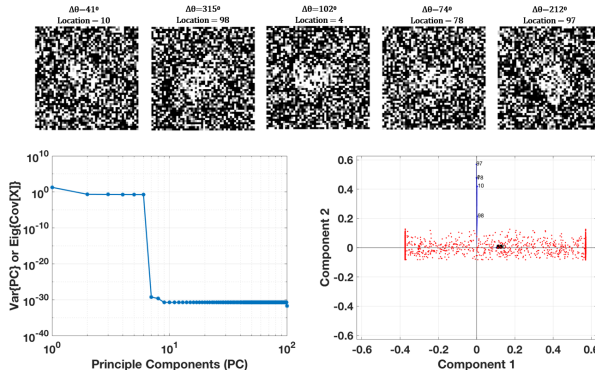
Robustness of PCA: Size

Batch Size $N = 100$, with Gaussian noise, $\mathcal{N}(\mu, \sigma^2) = \mathcal{N}(0, 2)$



Robustness of PCA: Orientation

Batch Size $N = 100$, with Gaussian noise, $\mathcal{N}(\mu, \sigma^2) = \mathcal{N}(0, 2)$



Summary

- The PCA method is robust in identifying abnormalities in the process.
- **Random** number of faulty images and their locations, $\Delta\theta$ and Sizes have been tested.
- PCA is a linear model. **Fast** decision maker.
- **Simpler, Cost effective** metrological method of fault detection in manufacturing and quality control.
- Outlook
 - The extent of abnormalities can be studied in depth in Endmember extraction methods such as Vertex Component Analysis (VCA) and random N-findr extraction.



Open Source Data I



GitHub: [vcangadi1](https://github.com/vcangadi1)

Matlab Codes, Documentation, L^AT_EX Slides and Data.

<https://github.com/vcangadi1/Presentations>

