Multivariate Process Control with Applications of Projection to Latent Structures

by

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Agenda

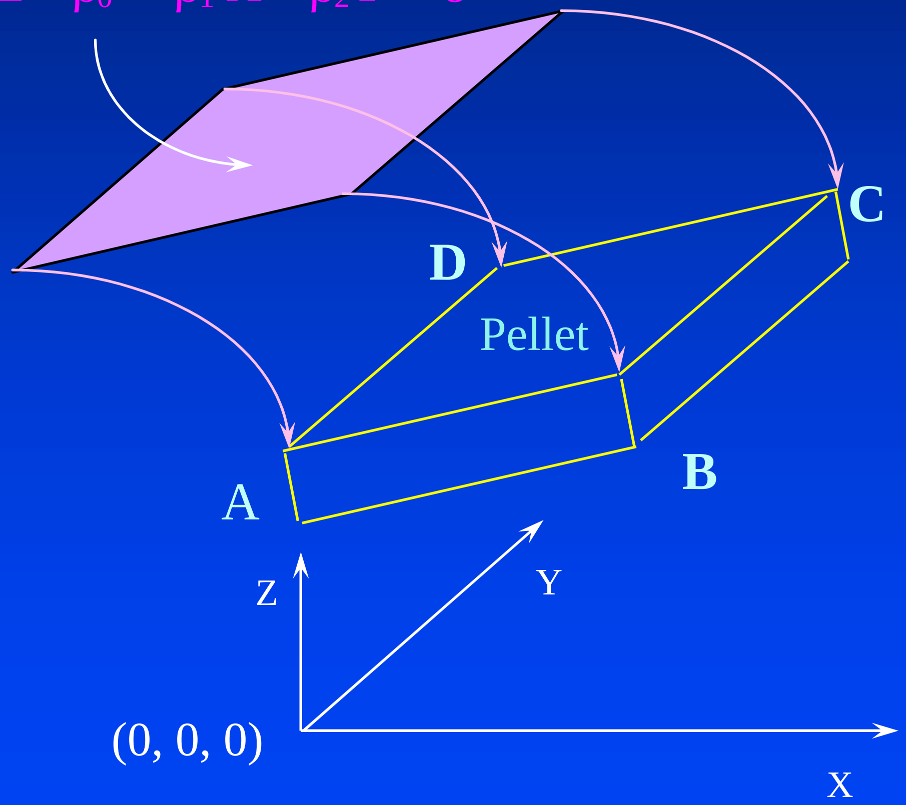
- Bivariate Control Chart for Pellet Tilt
- Multivariate Control Using PLS/PCA
- Questions

Pellet Tilt Control

- Why Control Pellet Tilt?
  - Pellet tilt creates difficulty in wire bond pattern recognition systems.
  - Wedge bonding (for thick aluminum wire on power devices) needs a flat pellet surface to avoid damage or scratches due to contact of the bond wedge.

Fitting a Plane to the Corner Heights

$$Z = \beta_0 + \beta_1 X + \beta_2 Y + \varepsilon$$



$$\hat{\beta}_0 = Z_A$$

$$\hat{\beta}_1 = \frac{Z_B - Z_A}{\text{length}(\overline{AB})}$$

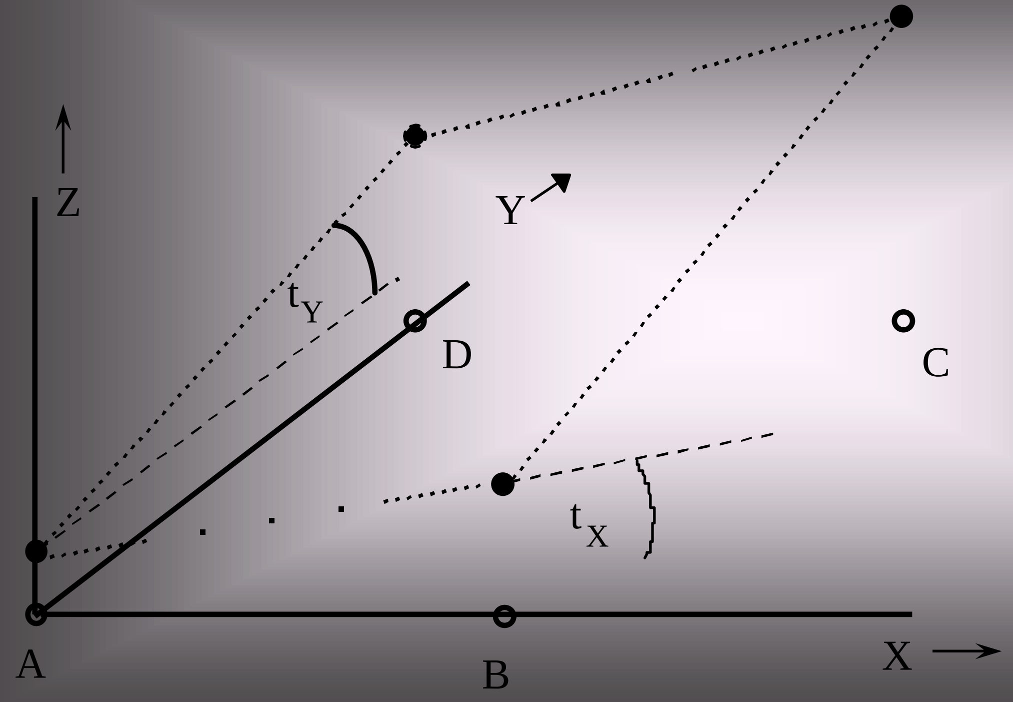
$$\hat{\beta}_2 = \frac{Z_D - Z_A}{\text{length}(\overline{AD})}$$

$$\hat{\beta}_0 = \overline{Z} + \frac{Z_A - Z_C}{2}$$

$$\hat{\beta}_1 = \frac{Z_B - Z_A + Z_C - Z_D}{2 \times \text{length}(\overline{AB})}$$

$$\hat{\beta}_2 = \frac{Z_C - Z_B + Z_D - Z_A}{2 \times \text{length}(\overline{AD})}$$

Calculating the Tilt Angles

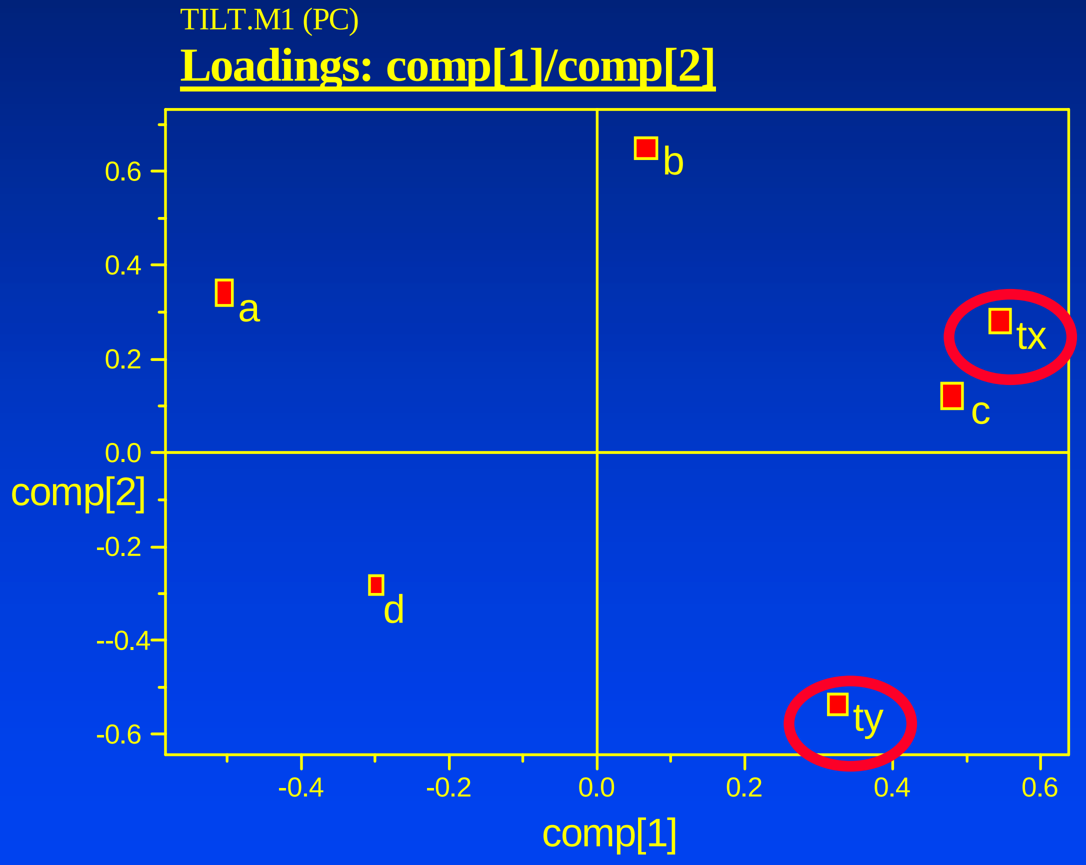


$$t_X = \tan^{-1}(\hat{\beta}_1)$$

$$t_Y = \tan^{-1}(\hat{\beta}_2)$$

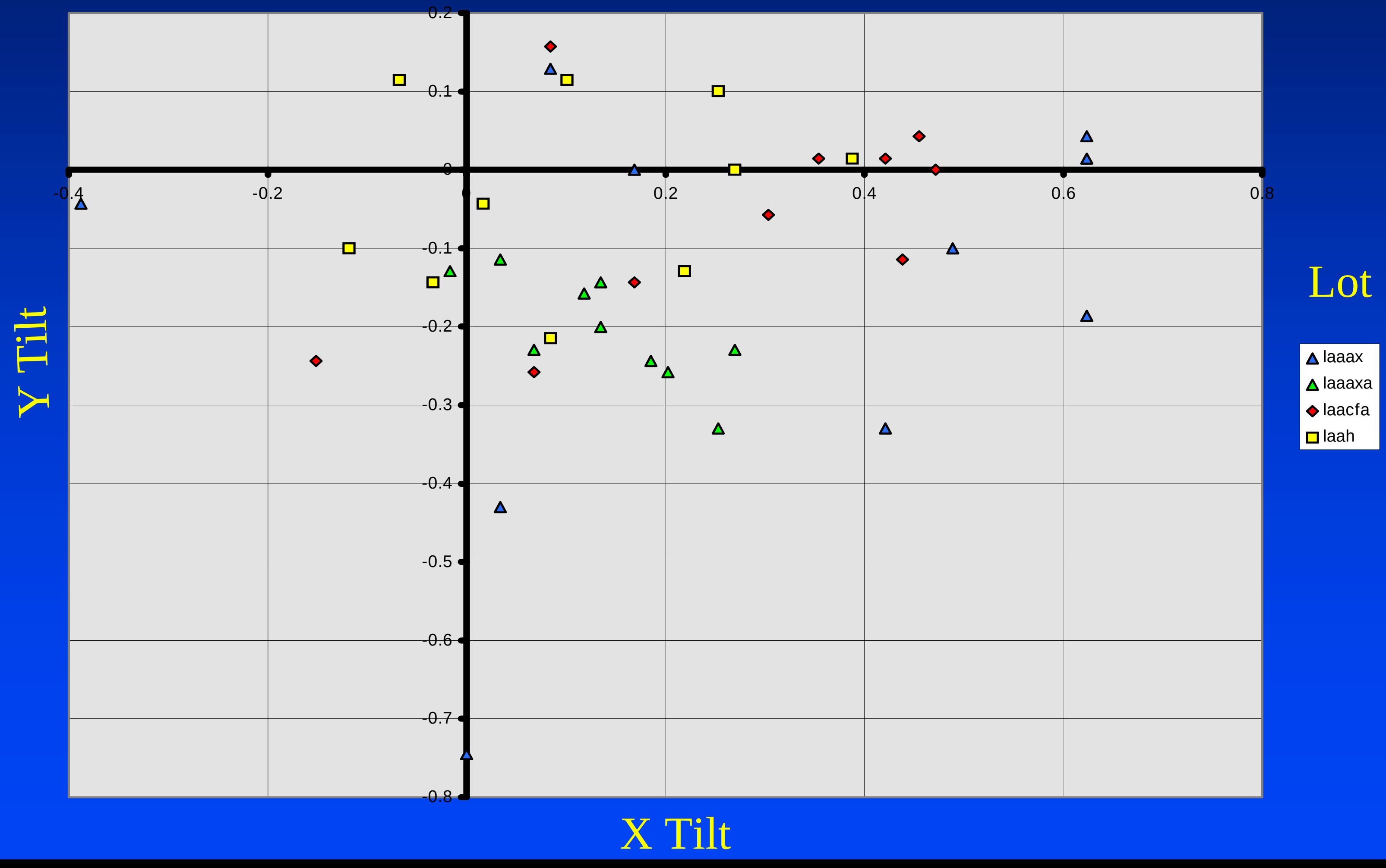
PCA Analysis of Tilt Angles

0.



The tilt angles account for about 82% of the total variation in corner heights.

Scatterplot of X and Y Tilt Angles



Calculation of Bivariate Control Limits

$$\left(\frac{t_X - \bar{t}_X}{s_X}\right)^2 - 2\rho\left(\frac{t_X - \bar{t}_X}{s_X}\right)\left(\frac{t_Y - \bar{t}_Y}{s_Y}\right) + \left(\frac{t_Y - \bar{t}_Y}{s_Y}\right)^2 = -2\left(1-\rho^2\right)\ln\left(1-\gamma\right)$$

ρ = correlation coefficient between t_X and t_Y

γ = probability content of the bivariate control ellipse

$1-\gamma$ = false alarm rate

Bivariate Control Limits for Pellet Tilt