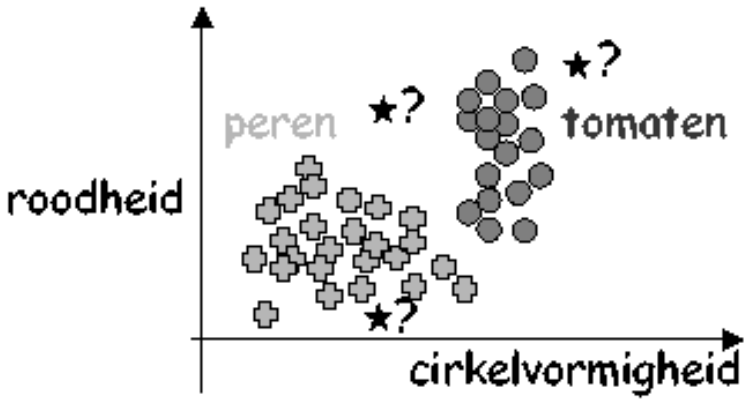
Reduksi Dimensi Image dengan Principal Components Analysis (PCA)

Sumber:

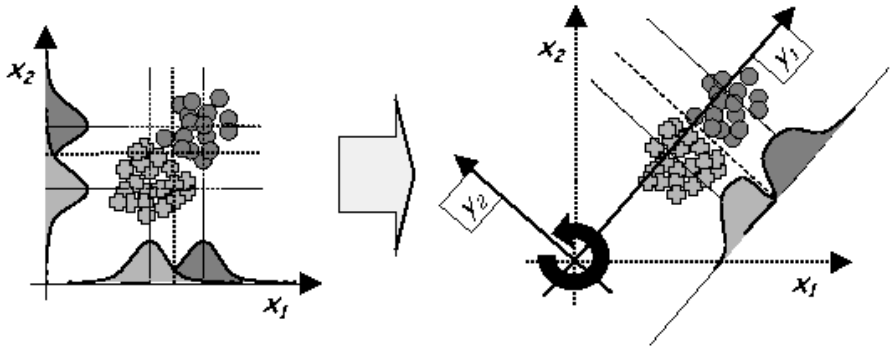
-**Trucco & Verri** chap. 10

-Standford Vision & Modeling

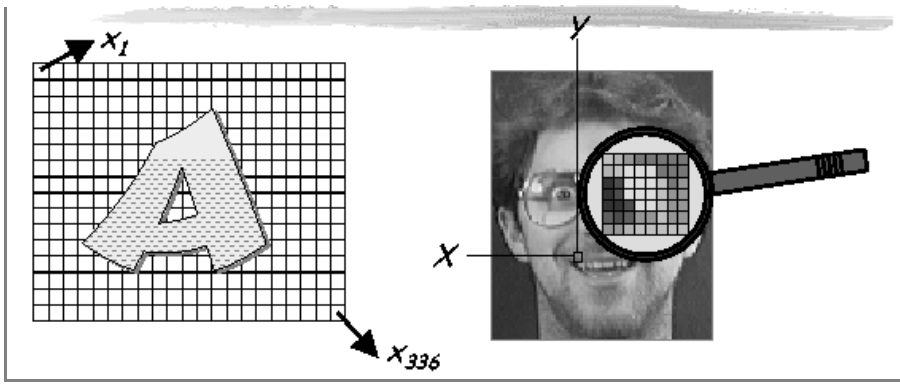
Contoh: problem Pattern Recognition



Rotate coordinate system:



Problem Dimensi tinggi ??



PCA (Principal Component Analysis)

- Untuk reduksi dimensi data (Dimensional Reduction) !!!
- Ekstraksi struktur data dari dataset high dimenson.
- Mencari basis signal berdasarkan data statistik objek.

PCA

- Let x_i = data lives in M-dimensional space
- x_i is a column vector
- Let N = number of data
- Matrix A = [x_1 x_2 x_3 . . . x_N]

PCA algorithms

- Correlation matrix
- Singular value decomposition

PCA

PCA: Correlation matrix

- Assume zero-mean data
- $C = AA^T$
- Solve $Cv = \lambda v$ or find eigenvectors and eigenvalues of matrix C

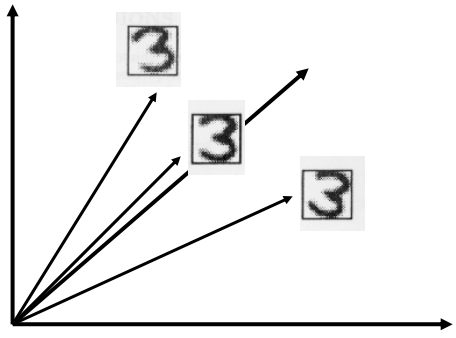
Demo dengan Matlab:

- Mencari basis signal citra wajah.
- Image recognition, face recognition.

PCA

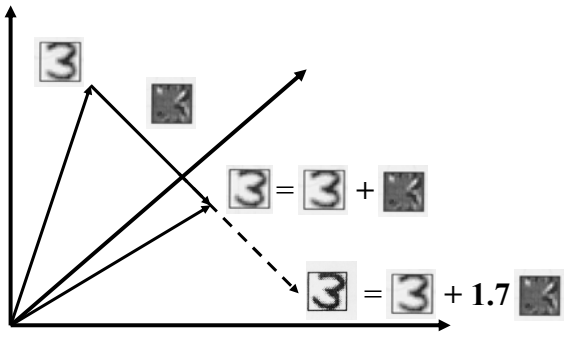
- Project data into new space
  - $\omega_i = v_i \cdot x$
- Assume data is zero-mean
- Data $x_i = \omega_1 v_1 + \omega_2 v_2 + \ldots + \omega_M v_M$

Reduksi dimensi linear:

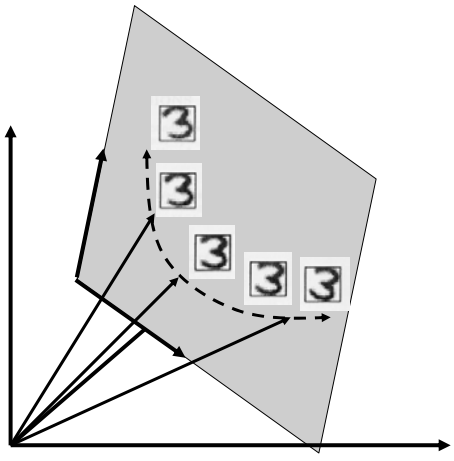


High-dimensional
Input Space

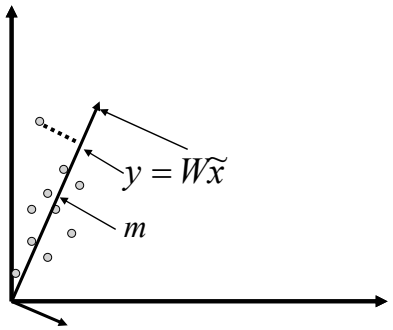
Linear Subspace:



Linear Subspace:



Principal Components Analysis:



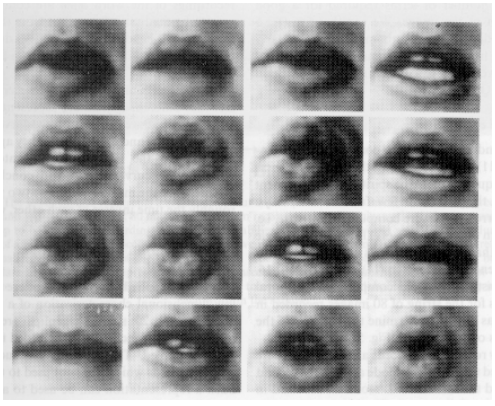
$$s_T^2 = \sum_{n=1}^{N} (y[n] - m)^2$$

$$S_T = \sum_{n=1}^{N} (\tilde{x} - \mu)(\tilde{x} - \mu)^T$$

$$s_T^2 = W S_T W^T$$

Contoh:

Data:



Kirby, Weisser, Dangelmayer 1993

Contoh:

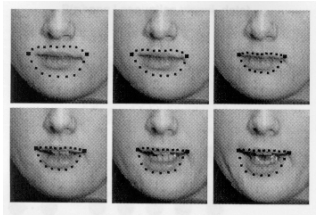
Data:

PCA

New Basis Vectors

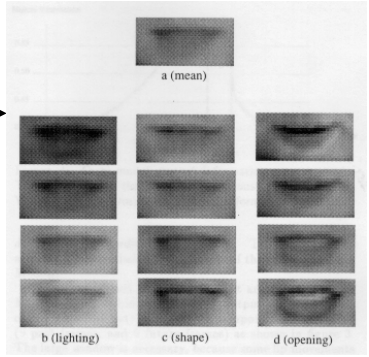
Contoh:

Data:



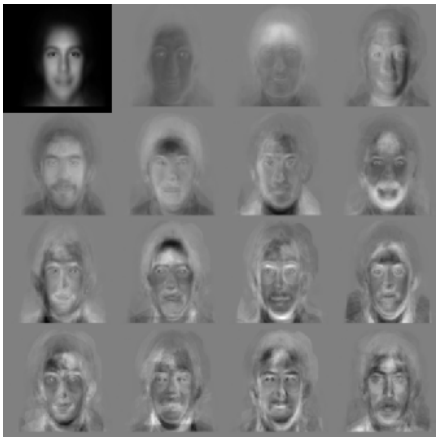
PCA

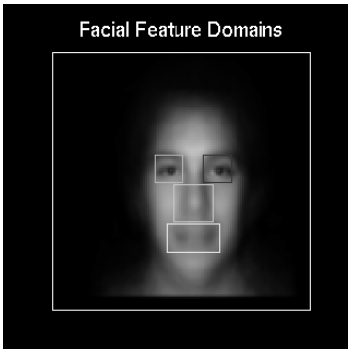
EigenLips



Contoh:

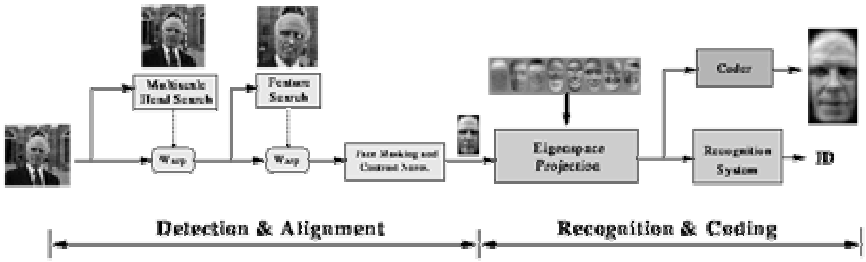
Face Recognition dengan Eigenfaces (Turk+Pentland,):



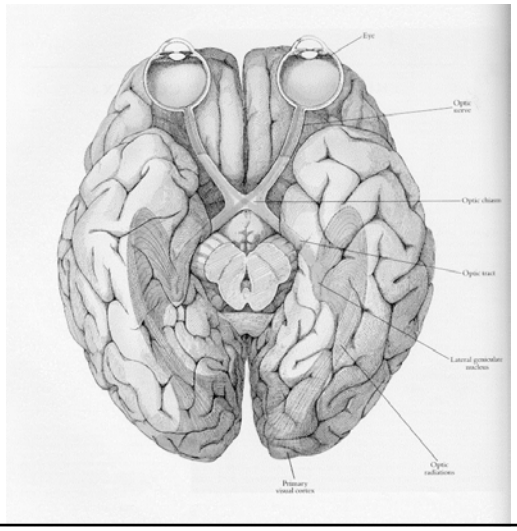


Contoh:

Face Recognition System (Moghaddam+Pentland):

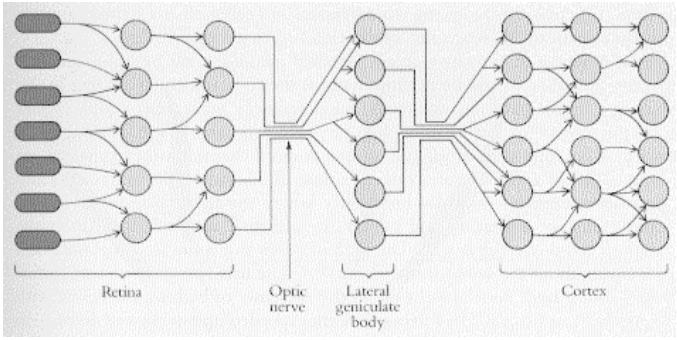


Contoh: Visual Cortex



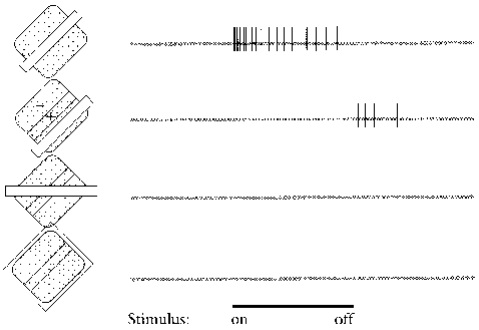
Hubel

Contoh: Visual Cortex



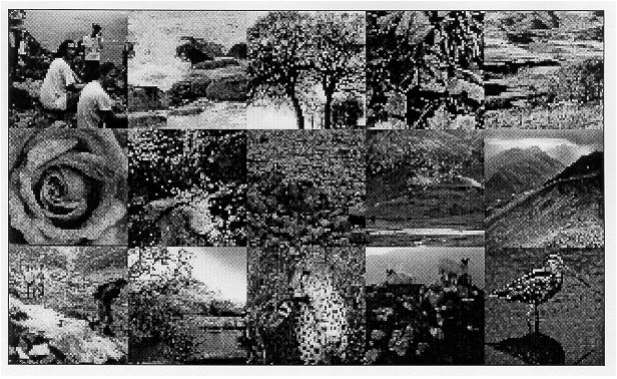
Hubel

Contoh: Receptive Fields



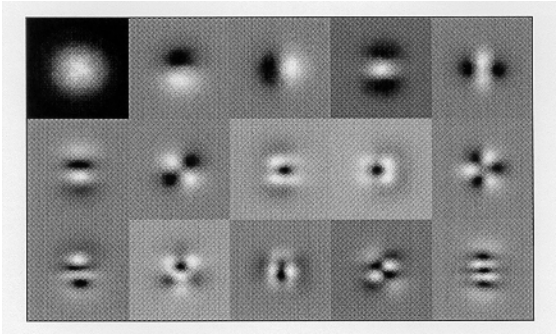
Hubel

Contoh: Receptive Fields



Hancock et al: The principal components of natural images

Contoh: Receptive Fields



Hancock et al: The principal components of natural images

Contoh:

Active Appearance Models (AAM): (Cootes et al)

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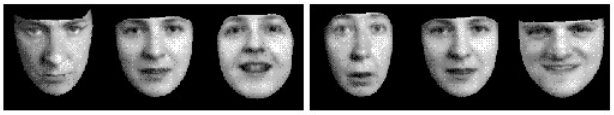
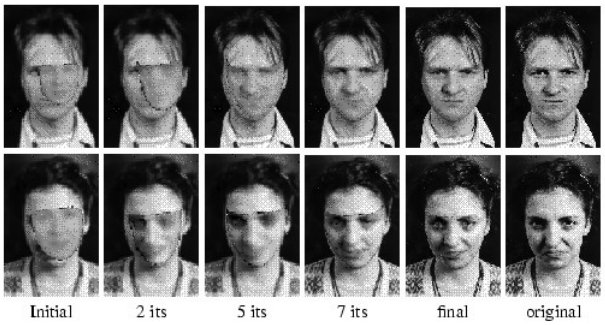


c_1 varies by ± 2 s.d.s c_2 varies by ± 2 s.d.s

Figure 2: First two modes of appearance model of a face

Contoh:

Active Appearance Models (AAM): (Cootes et al)

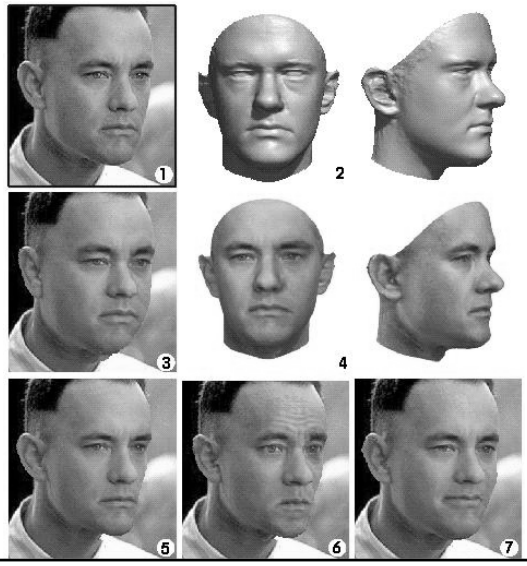


Initial 2 its 5 its 7 its final original

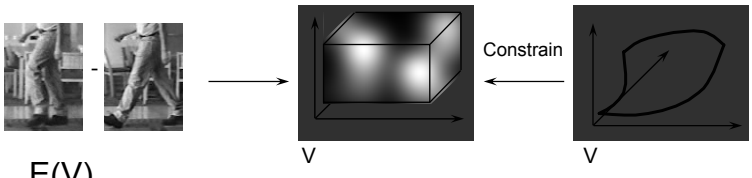
Figure 3: Multi-resolution AAM search from a displaced position

Contoh:

3D Morphable Models
(Blanz+Vetter)



Ulasan

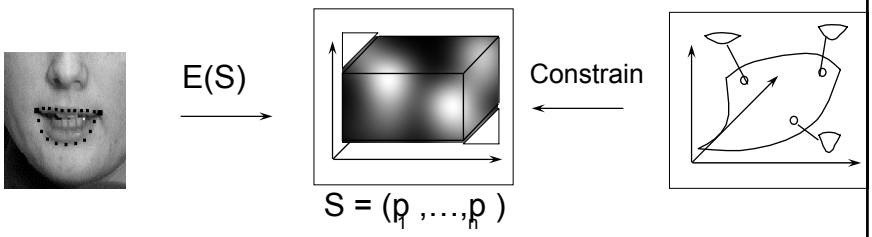


E(V)

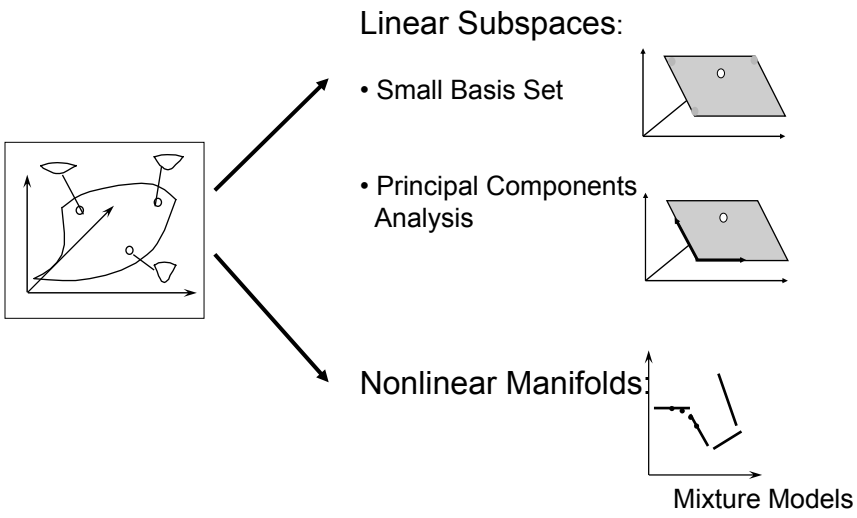
Analytically derived:
Affine, Twist/Exponential Map

Learned:
Linear/non-linear Sub-Spaces

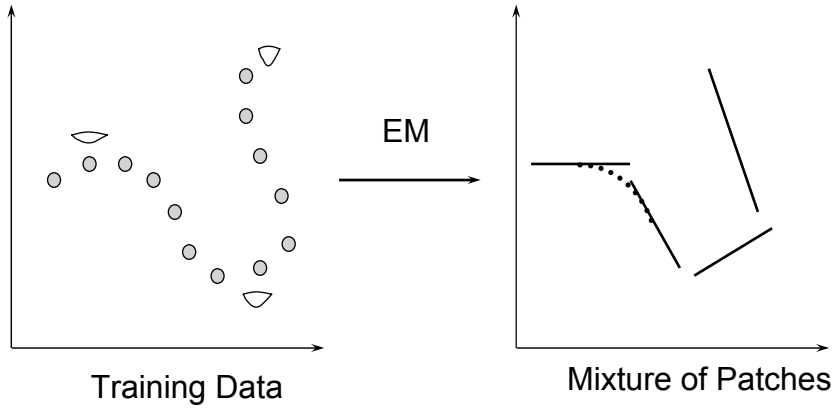
Non-Rigid Constrained Spaces



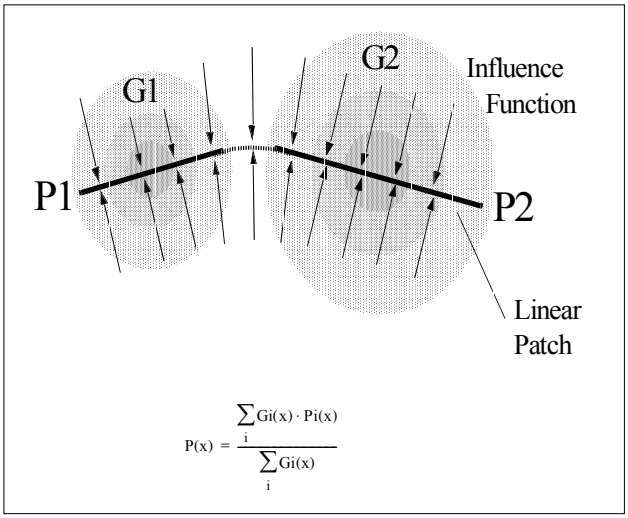
Non-Rigid Constrained Spaces



Manifold Learning

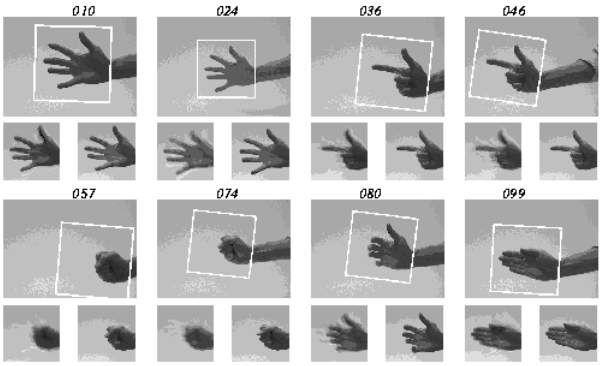


Mixture of Projections



Contoh:

Eigen Tracking
(Black and Jepson)



Contoh:

Shape Models for tracking:

Feature/Shape Models secara umum:

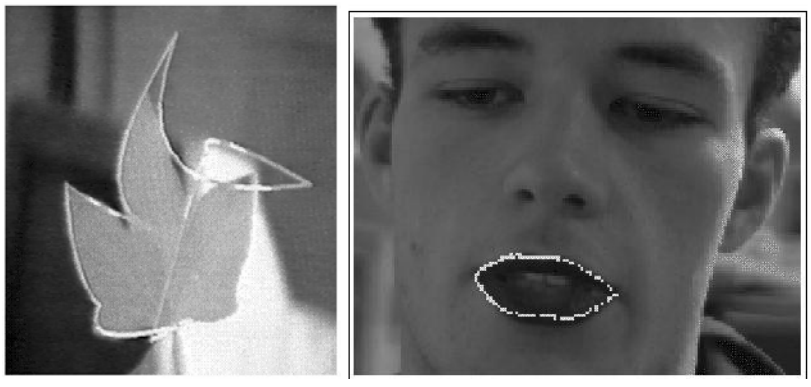
Visual Motion Contours:
Blake, Isard, Reynard

Transformations	**generated by:**	Dimension	no. views
Planar translation	X, Y translation	2	1
Planar similarity	$+X, Y$ rotation, scaling	4	1
Planar affine	3D Euclidean, planar curve	6	1
3D affine	3D Euclidean, space curve	8	2(3)
3D affine+	3D Euclidean, silhouette	11	3(6)
Constrained nonrigid	+ linear deformations	$+n$	$+n$ (key-frames)
Unconstrained nonrigid	B-spline configurations	$2N_c$	

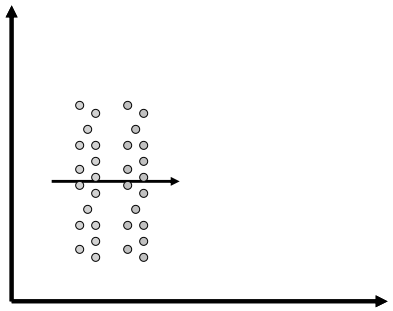
Figure 3: *Configuration sub-spaces — hierarchy for increasing complexity of object and motion.*

Feature/Shape Models secara umum:

Visual Motion Contours:
Blake, Isard, Reynard



Linear Discriminant Analysis:



Fisher's linear discriminant:

$$\mu_k = \frac{1}{N_K} \sum_{n \in C_K} x_n$$

$$S_B = (\mu_2 - \mu_1)(\mu_2 - \mu_1)^T \qquad S_W = \sum_{n \in C_1} (x_n - \mu_1)(x_n - \mu_1)^T + \sum_{n \in C_2} (x_n - \mu_1)(x_n - \mu_1)^T$$

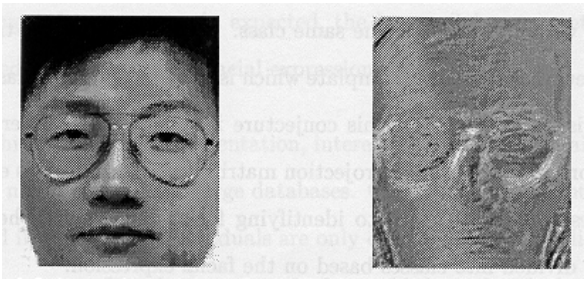
$$J = \frac{w^T S_B W}{w^T S_W w}$$

$$w \propto S_W^{-1}(\mu_2 - \mu_1)$$

Contoh: Eigenfaces vs Fisherfaces

Glasses or not Glasses ?

Contoh: Eigenfaces vs Fisherfaces

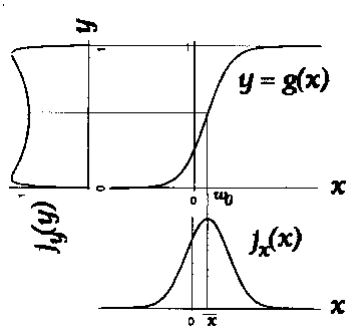


Input New Axis

Belhumeur, Hespanha, Kriegman 1997

Basis Shape Algorithms lainnya:

- ICA (Independent Components Analysis, Bell+Sejnowski)
- Maximize Entropy (or spread of output distribution):



Basis Shape Algorithms lainnya:

- NMF (non-negative matrix factorization, Lee+Seung)
- LNMF (local NMF, Li et al)