人臉特徵抽取和比對

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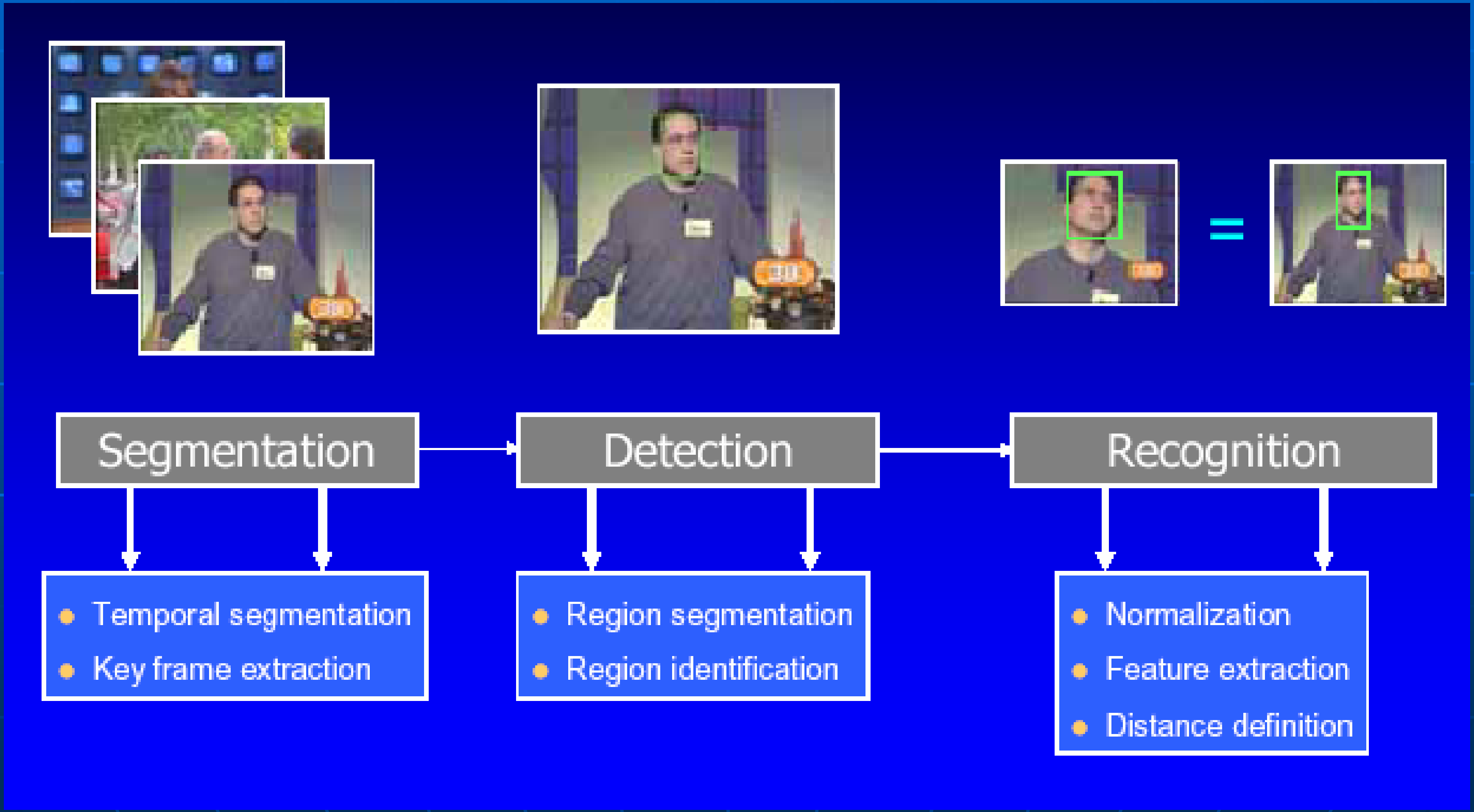
2005 11 08

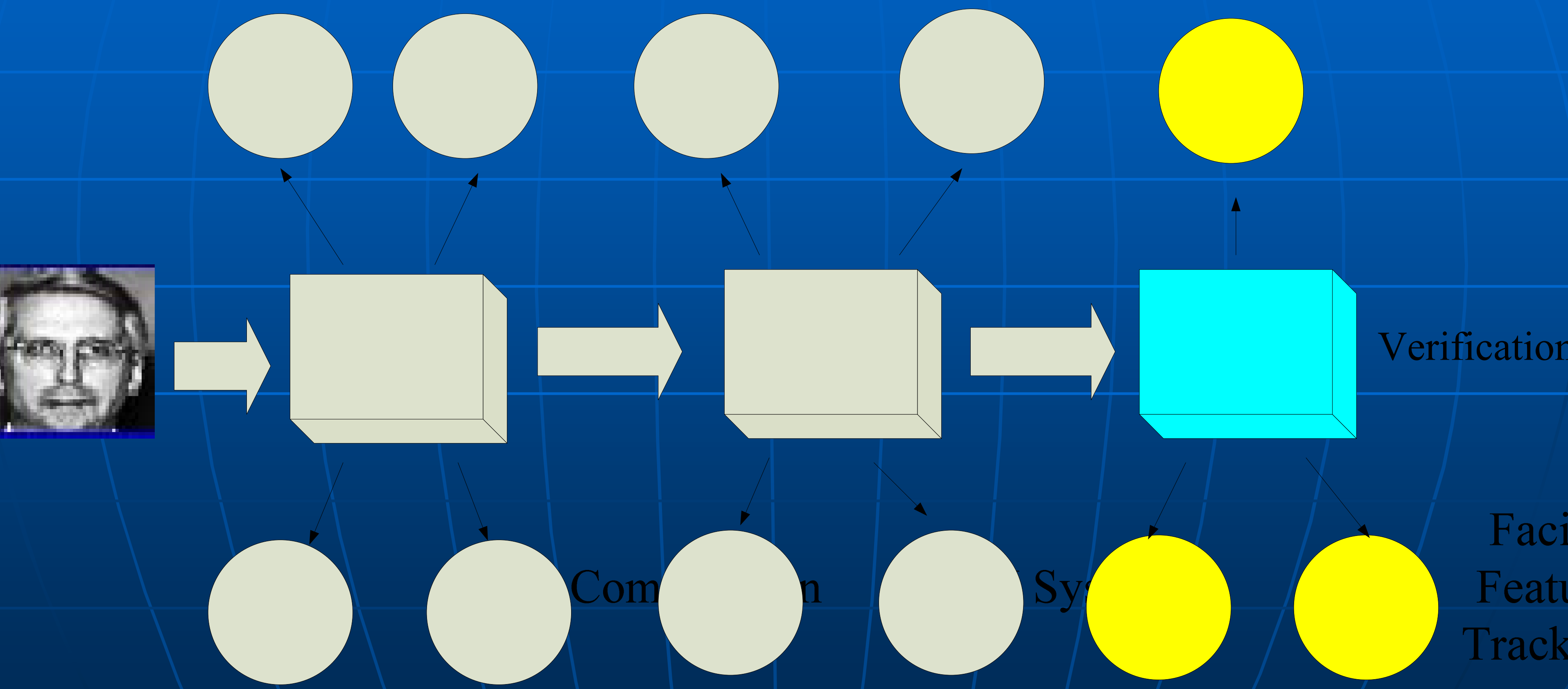
大綱

- 人臉辨識簡介
  - 特徵抽取
  - 特徵比對
- 特徵抽取/比對
  - PCA
  - Fishface
  - EBGM

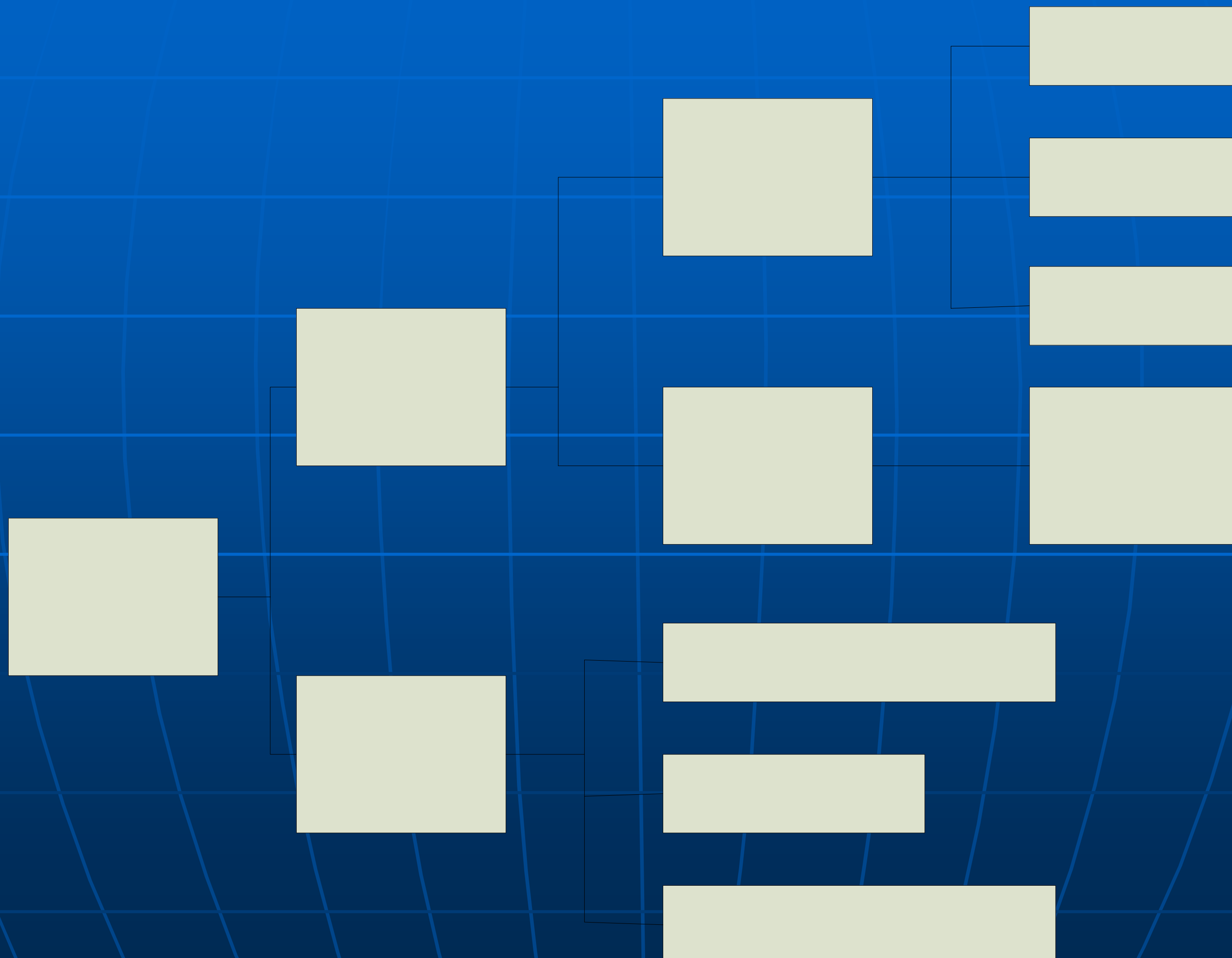
Face detection / recognition



Generic Face Recognition System



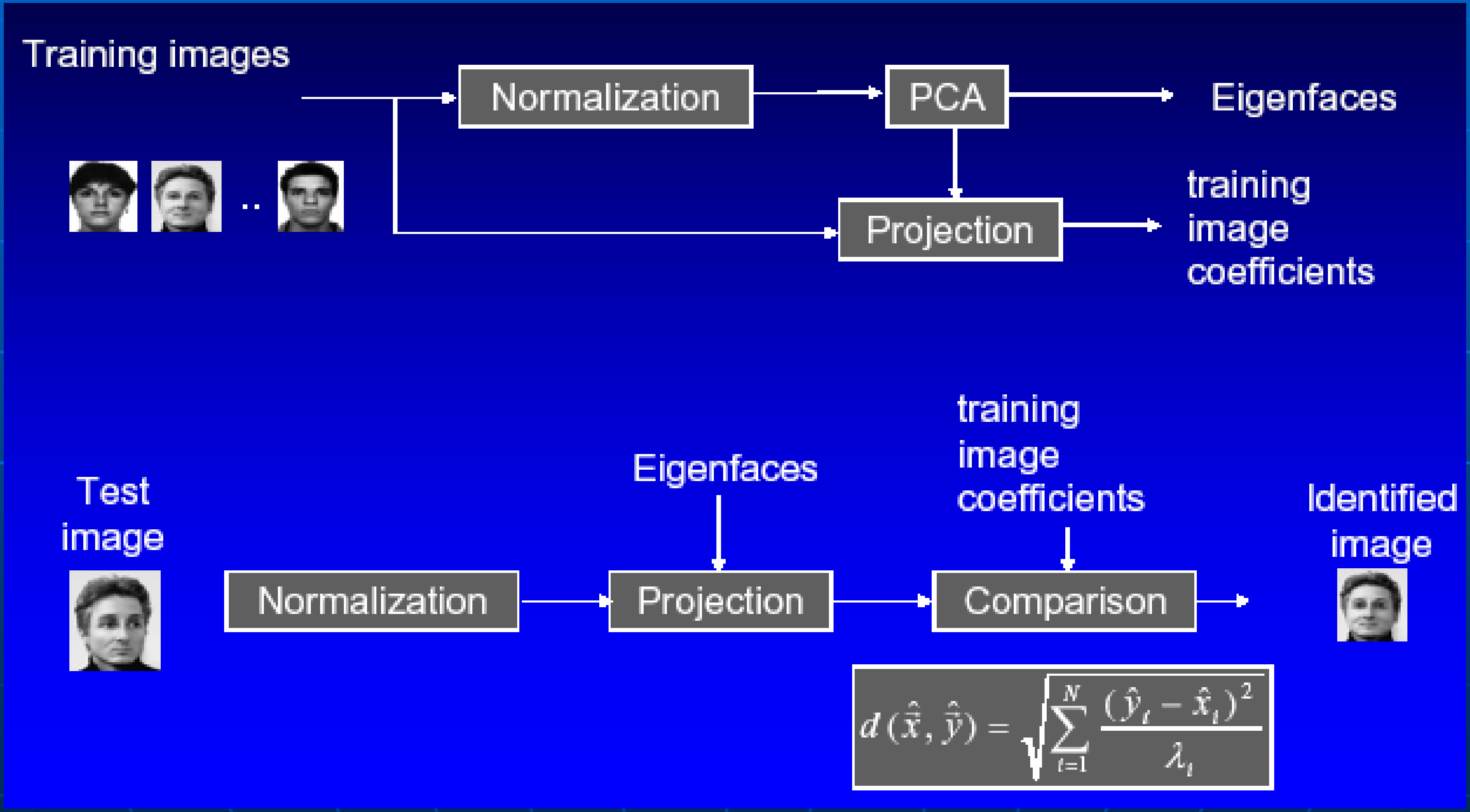
Face Detection Techniques



Face recognition method

- Holistic methods
  - *Principal-component analysis (PCA)*
    - Eigenfaces
    - Probabilistic eigenfaces
    - Fisherfaces/subspace LDA
    - SVM
    - ICA
  - *Other representations*
    - LDA/FLD
    - PDBNN
- Feature-based methods
  - Hidden Markov model
  - EBGM(Elastic Bunch Graph Matching)
- Hybrid methods
  - Modular eigenfaces
  - Hybrid LFA

Principal-component analysis



PCA 特徵

- 建立特徵空間
  - 求平均值：將訓練樣本加總起來除以個數

$$m = \frac{1}{k}\sum_{i=1}^{k} x^i, x^i = [x_1^i, \ldots, x_N^i]^T$$

K 為訓練樣本個數

N 為每一樣本的維度

  - Zero Mean：把所有訓練樣本減掉平均值

$$\overline{x^i} = x^i - m, i = 1 \ldots k$$

  - 計算Covariance Matrix：

$$c = \sum_{i=1}^{k} \overline{x^i}\,\overline{x^i}^T$$

PCA 特徵

- 計算特徵值與特徵向量：由Covariance Matrix 來求得特徵值與特徵向量

$$c\phi_i = \lambda\phi_i$$

ϕ i為特徵向量，λ 為特徵值

- 計算特徵空間：依照計算得到的特徵值由大到小做排序，將所對應的特徵向量組合而成特徵空間，而選取的特徵向量則為所對應的特徵值是非零的特徵向量

$$\phi = [\phi_1, \phi_2, \ldots, \phi_k]$$

其中 $\lambda_i = \phi_i C \phi_i \neq 0$ and $\lambda_i > \lambda_{i+1}$, for $1 \leqq i \leqq k$

PCA 特徵

- 訓練樣本投影到特徵空間，根據上述的步驟可得訓練樣本的特徵

$$\overline{y^i} = \phi^T \overline{x^i} \Leftrightarrow \overline{Y} = \phi^T \overline{X}$$

where i=1…k

- 測試樣本投影到特徵空間
  - 當有一個測試樣本要做辨識時，將其樣本減掉訓練樣本的平均值，接著再投影到特徵向量上，便可以與訓練樣本做比對

$$\overline{x^{test}} = x^{test} - m$$

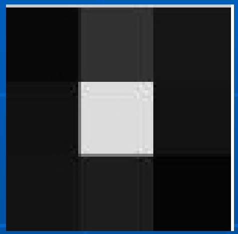
$$\overline{y^{test}} = \phi^T \overline{x^{test}}$$

PCA Example

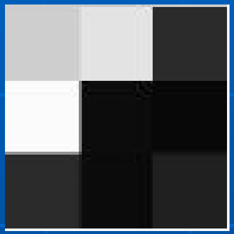
訓練樣本

x1

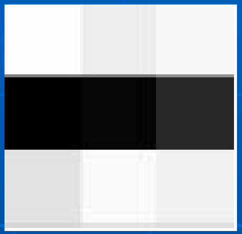
x2



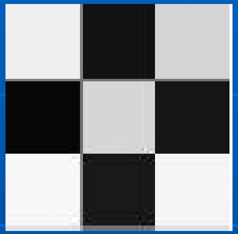
x3



x4



x5



$$x^1 = \begin{bmatrix} 45 \\ 216 \\ 11 \\ 207 \\ 3 \\ 237 \\ 9 \\ 247 \\ 8 \end{bmatrix} \quad x^2 = \begin{bmatrix} 8 \\ 49 \\ 21 \\ 17 \\ 220 \\ 18 \\ 19 \\ 29 \\ 5 \end{bmatrix} \quad x^3 = \begin{bmatrix} 206 \\ 227 \\ 43 \\ 251 \\ 13 \\ 8 \\ 43 \\ 11 \\ 32 \end{bmatrix} \quad x^4 = \begin{bmatrix} 253 \\ 238 \\ 248 \\ 0 \\ 6 \\ 40 \\ 226 \\ 249 \\ 241 \end{bmatrix} \quad x^5 = \begin{bmatrix} 239 \\ 17 \\ 213 \\ 7 \\ 214 \\ 21 \\ 247 \\ 24 \\ 245 \end{bmatrix}$$

PCA Example

$$\overline{x^1} = \begin{bmatrix} -105.2 \\ 66.6 \\ -96.2 \\ 110.6 \\ -88.2 \\ 172.2 \\ -99.8 \\ 135 \\ -98.2 \end{bmatrix} \quad \overline{x^2} = \begin{bmatrix} -142.2 \\ -100.4 \\ -86.2 \\ -79.4 \\ 128.8 \\ -46.8 \\ -89.8 \\ -83 \\ -101.2 \end{bmatrix} \quad \overline{x^3} = \begin{bmatrix} 55.8 \\ 77.6 \\ -64.2 \\ 154.6 \\ -78.2 \\ -56.8 \\ -65.8 \\ -101 \\ -74.2 \end{bmatrix} \quad \overline{x^4} = \begin{bmatrix} 102.8 \\ 88.6 \\ 140.8 \\ -96.4 \\ -85.2 \\ -24.8 \\ 117.2 \\ 137 \\ 134.8 \end{bmatrix} \quad \overline{x^5} = \begin{bmatrix} 88.8 \\ -132.4 \\ 105.8 \\ -89.4 \\ 122.8 \\ -43.8 \\ 138.2 \\ -88 \\ 138.8 \end{bmatrix}$$

$$\overline{x^i} = x^i - m, i = 1 \ldots k$$

$$\Sigma = \begin{bmatrix} 52855 & 8952 & 42665 & -9566 & -11254 & -21069 & 43917 & -1766 & 46764 \\ 8952 & 45917 & -4267 & 30630 & -48681 & 15361 & -10651 & 33276 & -8571 \\ 42665 & -4267 & 51825 & -36752 & 3399 & -17011 & 52689 & 10631 & 56599 \\ -9566 & 30630 & -36752 & 59723 & -34836 & 20286 & -37734 & 567 & -39700 \\ -11254 & -48681 & 3399 & -34836 & 52823 & -20040 & 9367 & -37178 & 6989 \\ -21069 & 15361 & -17011 & 20286 & -20040 & 37603 & -18205 & 33325 & -17382 \\ 43917 & -10651 & 52689 & -37734 & 9367 & -18205 & 55189 & 4521 & 58751 \\ -1766 & 33276 & 10631 & 567 & -37178 & 33325 & 4521 & 61828 & 8890 \\ 46764 & -8571 & 56599 & -39700 & 6989 & -17382 & 58751 & 8890 & 62827 \end{bmatrix}$$

$$c = \sum_{i=1}^{k} \overline{x^i}\,\overline{x^i}^T$$

PCA Example

$\lambda_1 = 2.4660 * 10^5 \quad \lambda_2 = 1.5214 * 10^5 \quad \lambda_3 = 0.6452 * 10^5 \quad \lambda_4 = 0.1733 * 10^5$

$$\phi_1 = \begin{bmatrix} 0.3420 \\ -0.1631 \\ 0.4342 \\ -0.3805 \\ 0.1690 \\ -0.2227 \\ 0.4584 \\ -0.0486 \\ 0.4822 \end{bmatrix} \quad \phi_2 = \begin{bmatrix} 0.2498 \\ 0.4755 \\ 0.1861 \\ 0.1811 \\ -0.5314 \\ 0.2183 \\ 0.1294 \\ 0.5164 \\ 0.1751 \end{bmatrix} \quad \phi_3 = \begin{bmatrix} -0.4677 \\ -0.1880 \\ 0.0324 \\ -0.4731 \\ 0.1907 \\ 0.4079 \\ 0.0078 \\ 0.5629 \\ 0.0366 \end{bmatrix} \quad \phi_4 = \begin{bmatrix} -0.1526 \\ 0.3929 \\ 0.0177 \\ -0.5151 \\ -0.1658 \\ -0.6526 \\ -0.2180 \\ 0.1159 \\ -0.2056 \end{bmatrix}$$

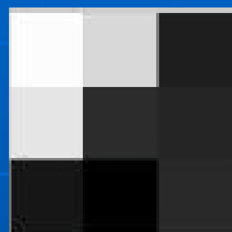
$$c\phi_i = \lambda\phi_i$$

$$\overline{Y} = \left[\overline{y^1} \mid \overline{y^2} \mid \overline{y^3} \mid \overline{y^4} \right]$$

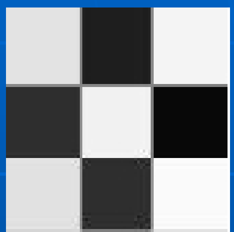
$$= \begin{bmatrix} -283.6066 & -93.2130 & -141.8661 & 221.7076 & 296.9781 \\ 131.5803 & -264.5387 & 22.3806 & 225.9250 & -115.3473 \\ 106.2963 & 74.4875 & -214.0694 & 42.0448 & -8.7592 \\ -56.6104 & 61.5808 & 9.1302 & 64.1966 & -78.2972 \end{bmatrix}$$

PCA Example

測試資料

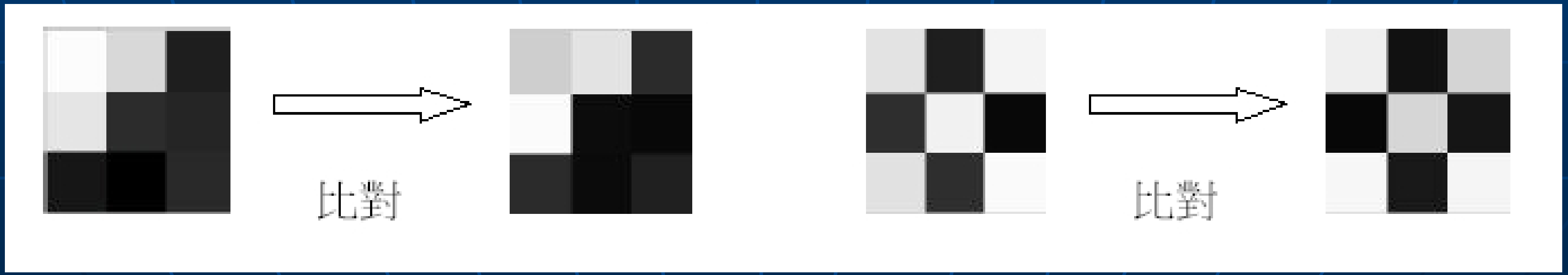


test1



test2

L2 norm	$\overline{y^1}$	$\overline{y^2}$	$\overline{y^3}$	$\overline{y^4}$	$\overline{y^5}$
$\overline{y^{test1}}$	378.0100	402.0206	32.2885	491.0841	490.0995
$\overline{y^{test2}}$	630.9563	444.5817	501.0019	372.9368	12.4843



Fisherface

- 建立 FLD 的轉換空間
  - 求 Within Class 與 Between Class 的平均值:

Class Mean:

$$m_j = \frac{1}{k_j}\sum_{j=1}^{k_j} x_j,\ j \in c$$

kj表示j類別樣本的個數

Total Mean:

$$m = \frac{1}{T}\sum_{i=1}^{c}\sum_{j=1}^{k_i} x_j$$

$$T = \sum_{i=1}^{c} k_i$$

c:類別個數

Fisherface

- 計算 Within Class Scatter：分別計算每個類別裡面的 Covariance Matrix，並且將所有類別的 Covariance Matrix 加總起來

$$s_w = \sum_{i=1}^{c} \sum_{j=1}^{k_i} (x_j - m_i)(x_j - m_i)^T$$

- 計算 Between Class Scatter：對每個類別的平均值與所有訓練樣本的平均值計算 Covariance Matrix

$$s_b = \sum_{i=1}^{c} k_i (m_i - m)(m_i - m)^T$$

Fisherface

- 解特徵值的問題：求得Sw與Sb，解廣義化的特徵值問題

$$s_B = \phi_i = \lambda s_w \phi_i$$

ϕ i為特徵向量

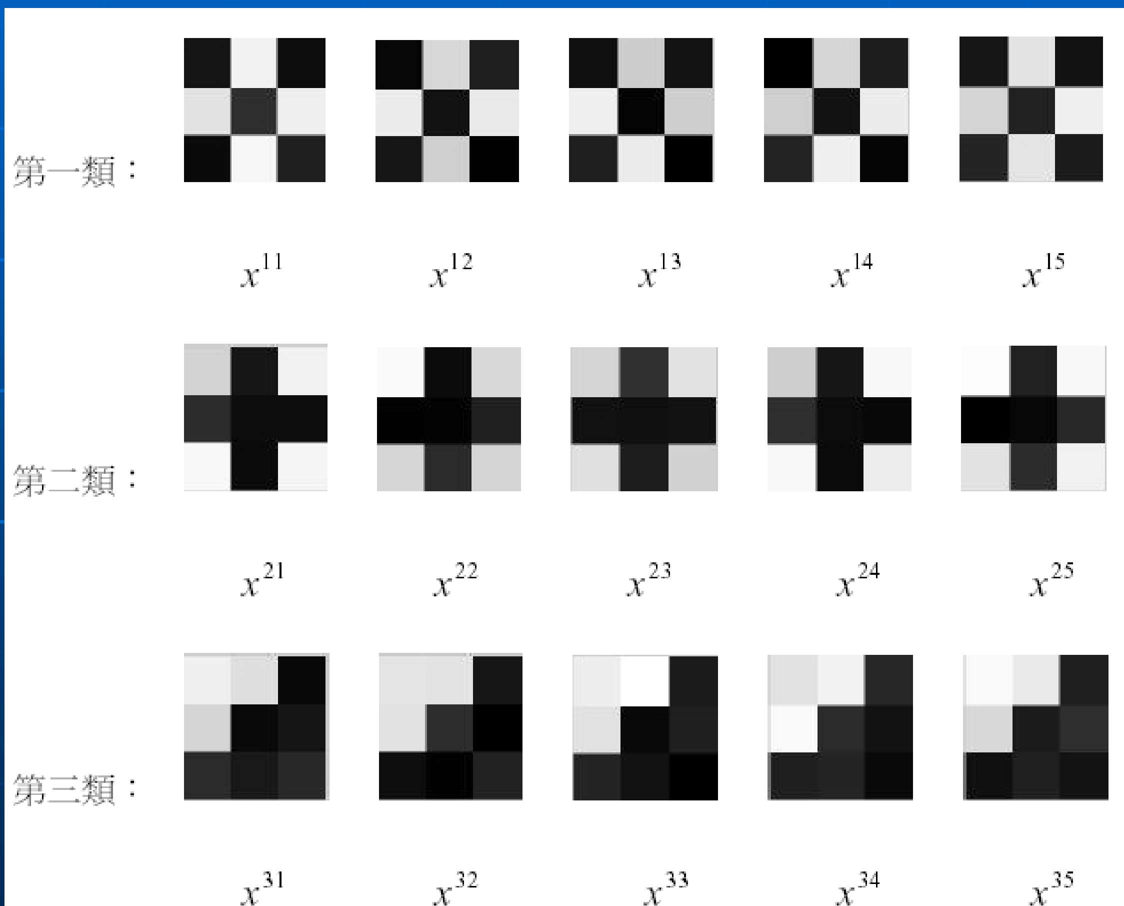
- 求得 FLD 轉換空間：

$$\phi = [\phi_1, \phi_2, \ldots, \phi_m]$$

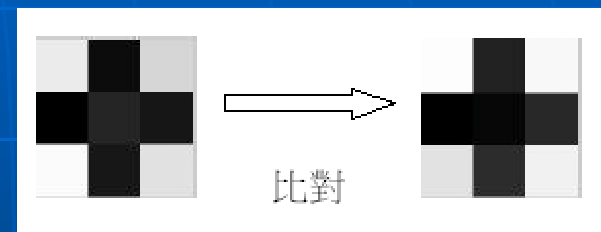
m為選取特徵向量個數，最大c-1

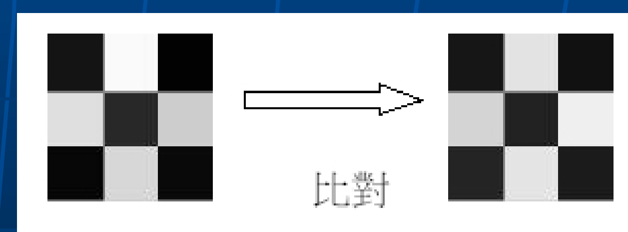
Fisherface Example

測試資料

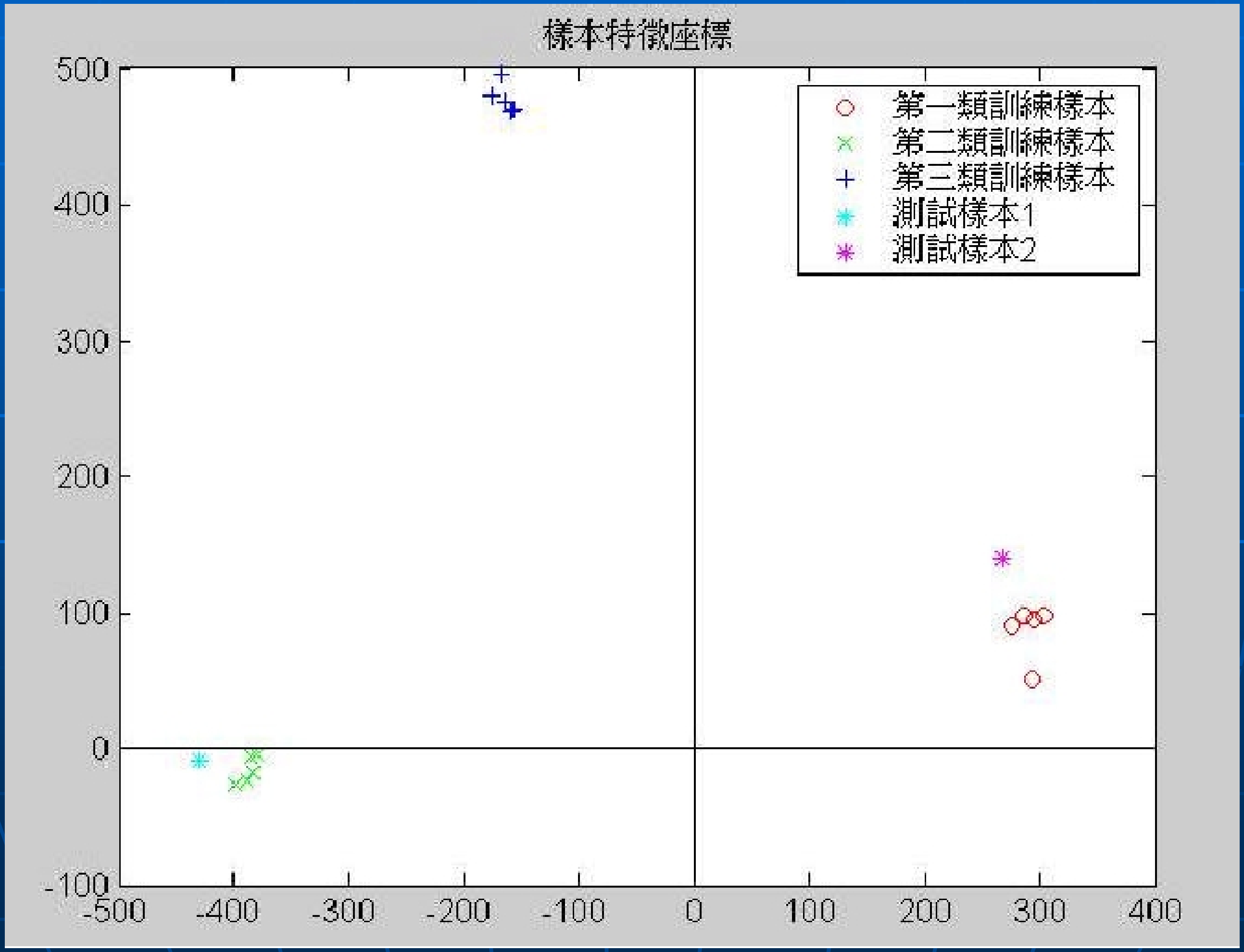


比對資料





Fisherface Example

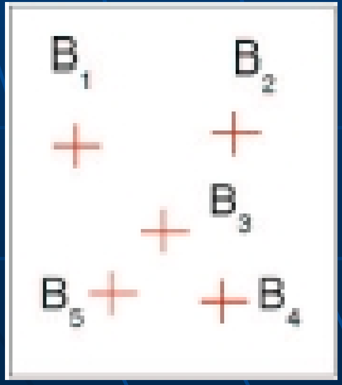


EBGM(Elastic Bunch Graph Matching)

- 抽取臉部特徵點



- 建立bunch graph，每個bunch graph的結點都符合臉部記號位置



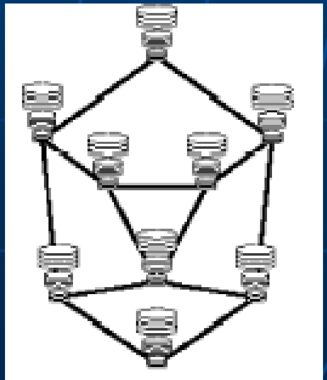
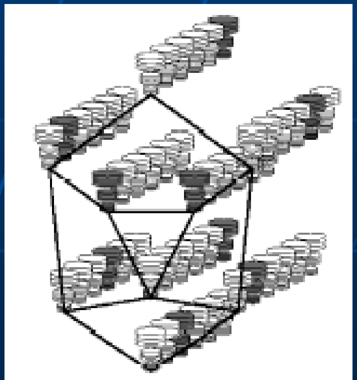
$B_1=\{J_{11},J_{21},J_{31},...\}$

$B_2=\{J_{12},J_{22},J_{32},...\}$

$B_3=\{J_{13},J_{23},J_{33},...\}$

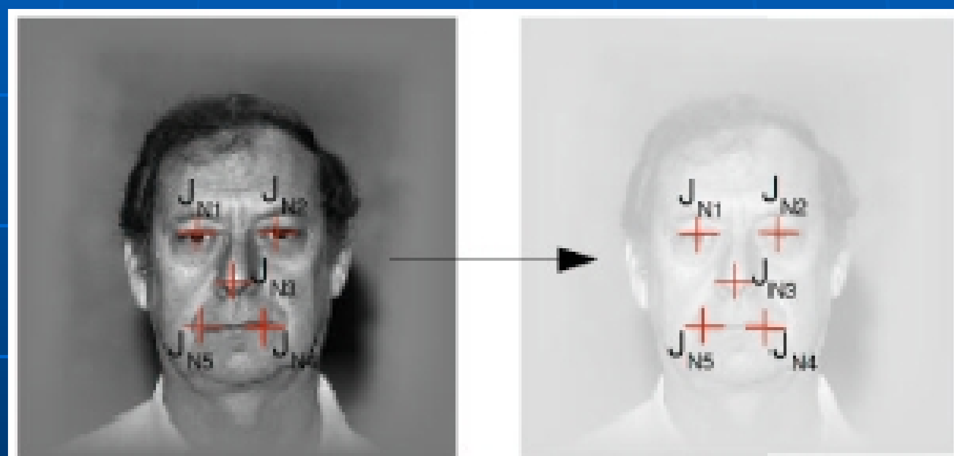
$B_4=\{J_{14},J_{24},J_{34},...\}$

$B_5=\{J_{15},J_{25},J_{35},...\}$

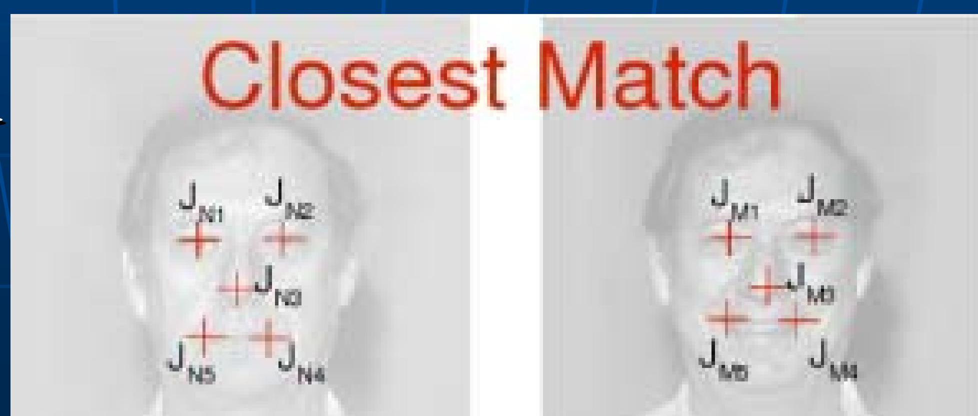



EBGM(Elastic Bunch Graph Matching)

- 在依張新影像重新建立bunch graph，在跟原始bunch graph進行比對



- 輸出比對結果



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