图像处理与机器学习

Digital Image Processing and Machine Learning

主讲人：黄琳琳

电子信息工程学院

中国大学MOOC

第九章　应用实例

复杂背景人脸检测算法

Face detection from cluttered images

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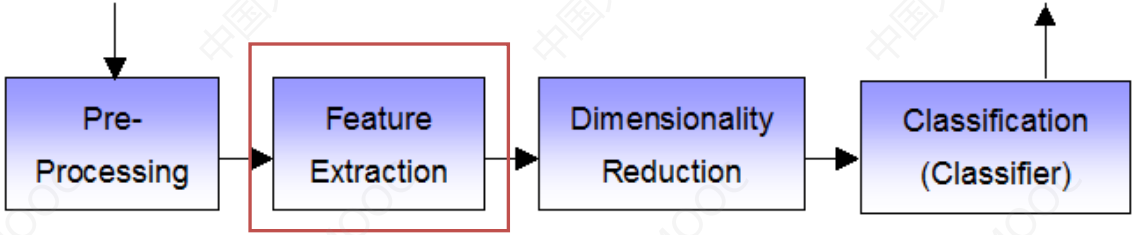
Face Detection from Cluttered images

- System Overview



Face Detection from Cluttered images

- Feature extraction

  -- Gray levels

  -- Gradient features

  -- Gabor features

  -- Harr features

gray levels of 368 pixels

$$\vec{X} = (X_1, X_2 \ldots X_{368})^T$$

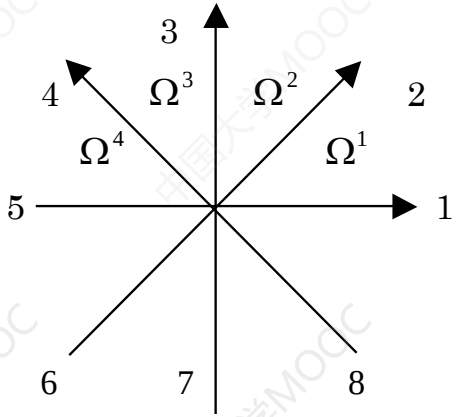
Face Detection from Cluttered images

- Feature extraction

  -- Gradient features

Sobel gradient vector: $u(x, y) = [u_x, u_y]^T$

Eight chain-code directions



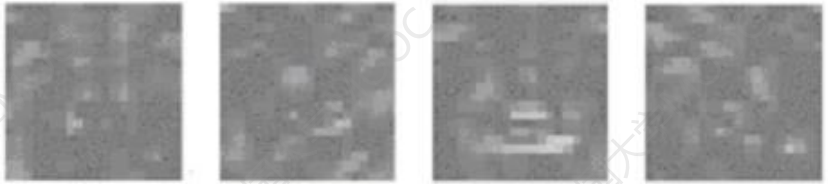
Face Detection from Cluttered images

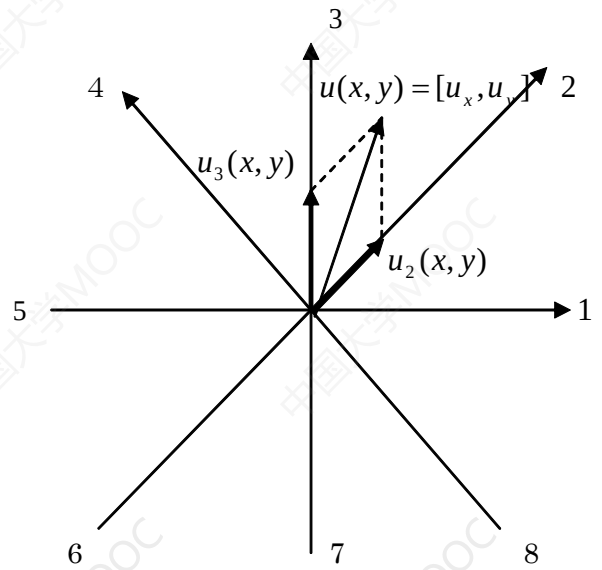
- 8 directional sub-images:

$$f_d(x, y), d = 1, 2, \ldots 8$$

- 4 orientation sub-images:

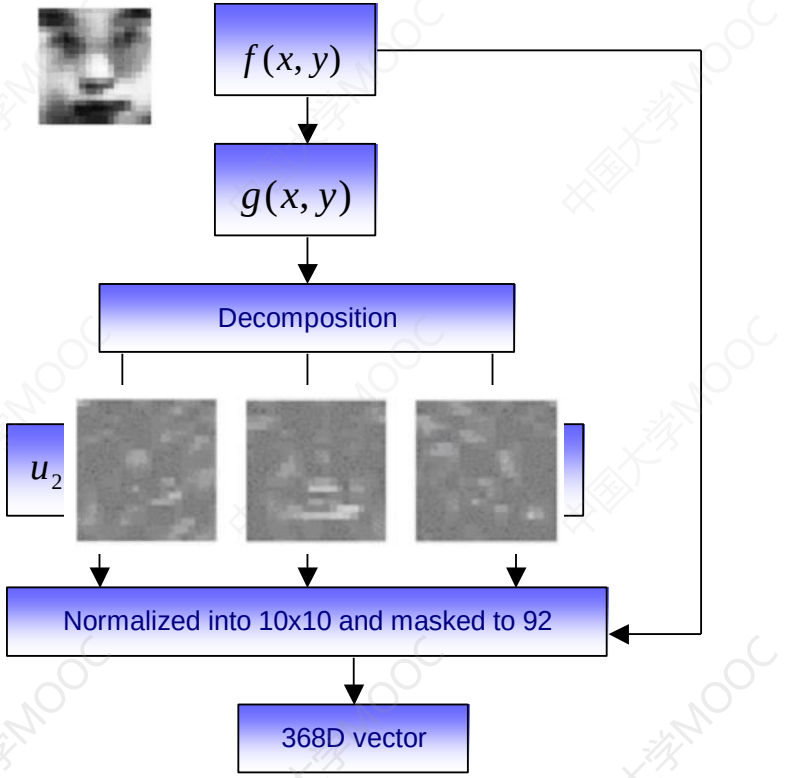
$$Or_d(x, y), d = 1, 2, \ldots 4$$





Face Detection from Cluttered images

- Feature vector construction
  - -- Intensity image
  - -- 3 orientation sub-images
  - -- Down-sampled, masked
- 368D feature vector



Face Detection from Cluttered images

- 2D Gabor Filter

-- Space domain impulse function:

$$h(x,y)=\exp[-(\frac{x^2+y^2}{2\sigma_g^2})]\cos(2\pi(u_0x+v_0y))$$

-- Associated 2D Fourier transform:

$$H(u,v)=A\{\exp[-(\frac{(u-u_0)^2+(v-v_0)^2}{2\sigma_G^2})]+\exp[-(\frac{(u+u_0)^2+(v+v_0)^2}{2\sigma_G^2})]\}$$

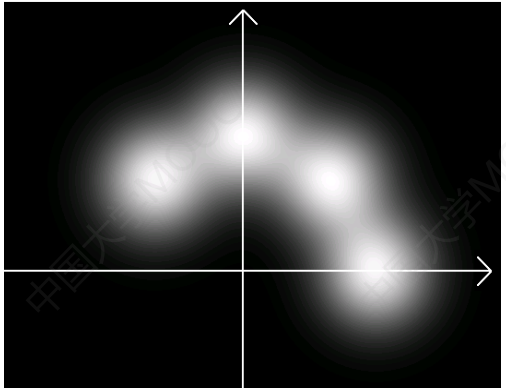
$$A=2\pi\sigma_g^2,\qquad \sigma_G=\frac{1}{2\pi\sigma_g}$$

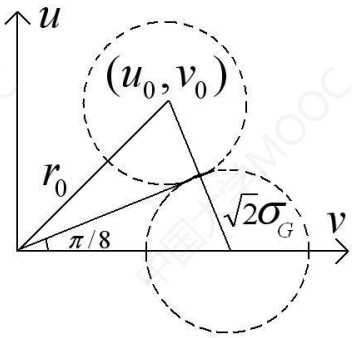
Face Detection from Cluttered images

- Gabor filter design $H(u,v) = A\{\exp[-(\frac{(u-u_0)^2+(v-v_0)^2}{2\sigma_G^2})] + \exp[-(\frac{(u+u_0)^2+(v+v_0)^2}{2\sigma_G^2})]\}$

  -- The parameters of Gabor filter:

$$\begin{cases} \sqrt{2}\sigma_G \le r_0 \sin(\frac{\pi}{8}) \\ r_0 + \sqrt{2}\sigma_G \le r_{\max} \\ r_{\max} = 0.25 \end{cases} \Rightarrow \begin{cases} r_0 = 0.18 \\ \sigma_G = 0.05 \\ \sigma_g = 3.2 \end{cases}$$





Face Detection from Cluttered images

- Gabor filter design

-- Gabor representation of image

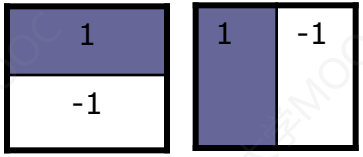
$$O(x, y, u, v) = I(x, y) * h(x, y, u, v)$$

Down-sampled, masked

-- 368D Gabor feature vector

Face Detection from Cluttered images

- Two types of basis 2D Harr functions:



- Harr wavelet coefficients coded in gray levels

Down-sampled, masked

368D Harr feature vector

- Amplitude projections

$$Am_h = \sum_{x=1}^{20} I(x,y), Am_v = \sum_{y=1}^{20} I(x,y); \quad 1 \le x, y \le 20$$

Face Detection from Cluttered images

- Feature extraction

  -- Gray levels $\vec{x}_{intensity}$

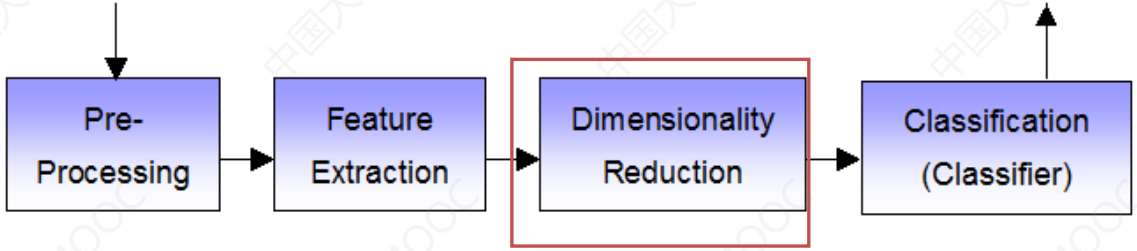
  -- Gradient features $\vec{x}_{gradient}$

  -- Gabor features $\vec{x}_{Gabor}$

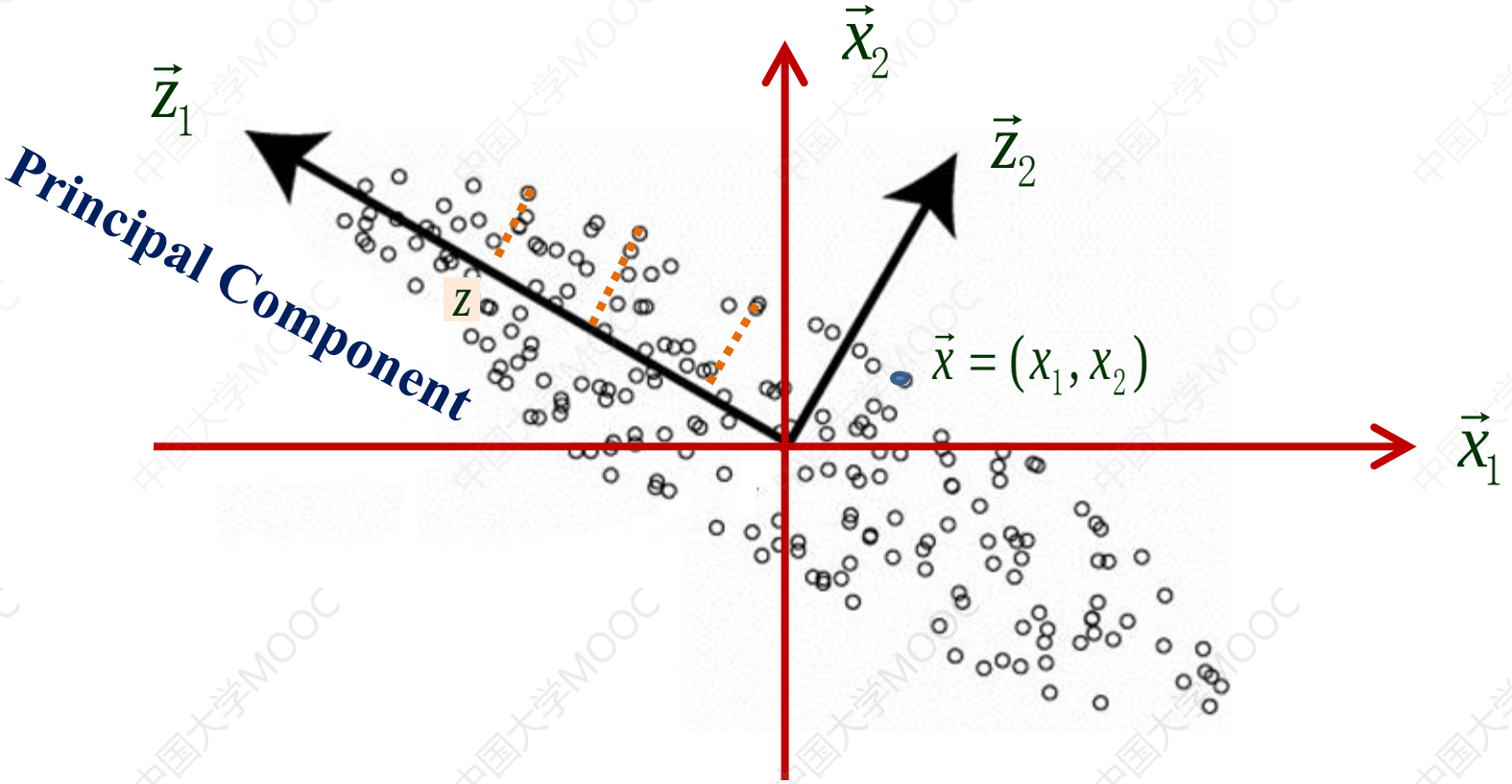
  -- Harr features $\vec{x}_{Harr}$

Face Detection from Cluttered images

- System Overview



Face Detection from Cluttered images

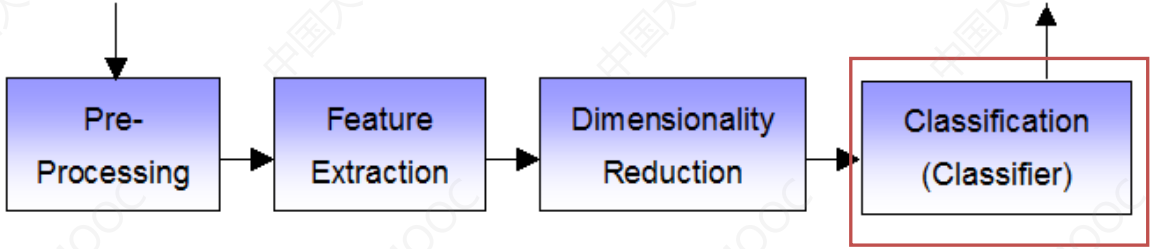


Face Detection from Cluttered images

original face | reconstructed by 1 eigenvector | reconstructed by 10 eigenvectors | resonstructed by 20 eigenvectors

Face Detection from Cluttered images

- System Overview



谢 谢

本课程所引用的一些素材为主讲老师多年的教学积累，来源于多种媒体及同事和同行的交流，难以一一注明出处，特此说明并表示感谢！

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