



北京交通大学

图像处理与机器学习

Digital Image Processing and Machine Learning

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电子信息工程学院



第九章 应用实例

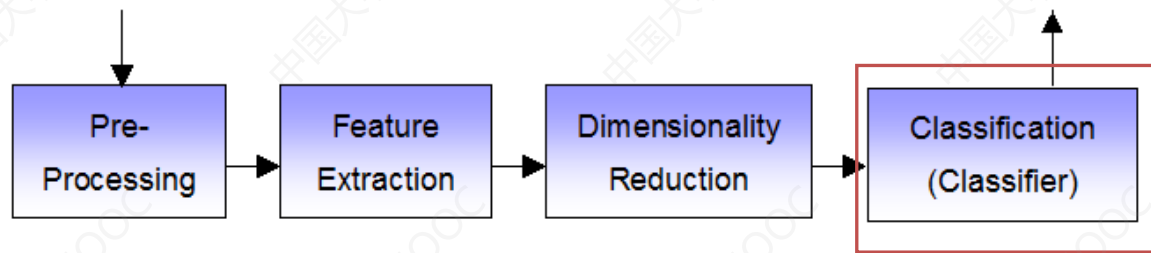
复杂背景人脸检测算法

Face detection from cluttered images



Face Detection from Cluttered images

◆ System Overview





Face Detection from Cluttered images

➤ PNN can be viewed as a generalized linear classifier

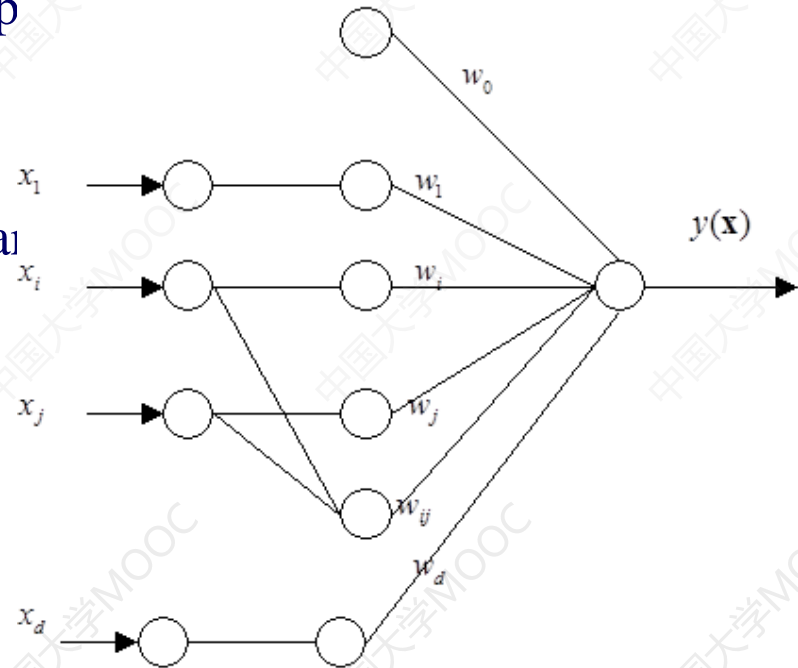
-- Non-linear mapping of polynomial exp

-- the second-order PNN

-- The parameters are optimized from learning

$$y(\mathbf{x}) = g\left(\sum_{i=1}^D w_i x_i + \sum_{j=1}^D \sum_{i=j}^D w_{ij} x_i x_j + w_0\right)$$

$$g(a) = \frac{1}{1 + \exp(a)}$$





Face Detection from Cluttered images

➤ PNN training

$$y(\mathbf{x}) = g\left(\sum_{i=1}^D w_i x_i + \sum_{j=1}^D \sum_{i=j}^D w_{ij} x_i x_j + w_0\right)$$

- ✓ Face samples: 29,900 face samples
- ✓ Non-face samples: non-face samples are collected in three steps



Face Detection from Cluttered images

➤ PNN training
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✓ Face samples: 29,900 face samples

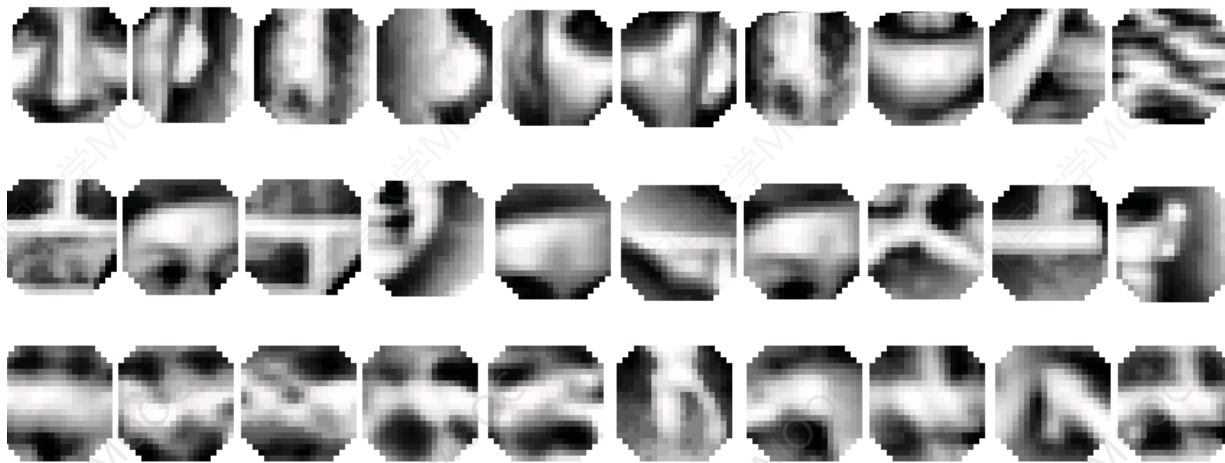




Face Detection from Cluttered images

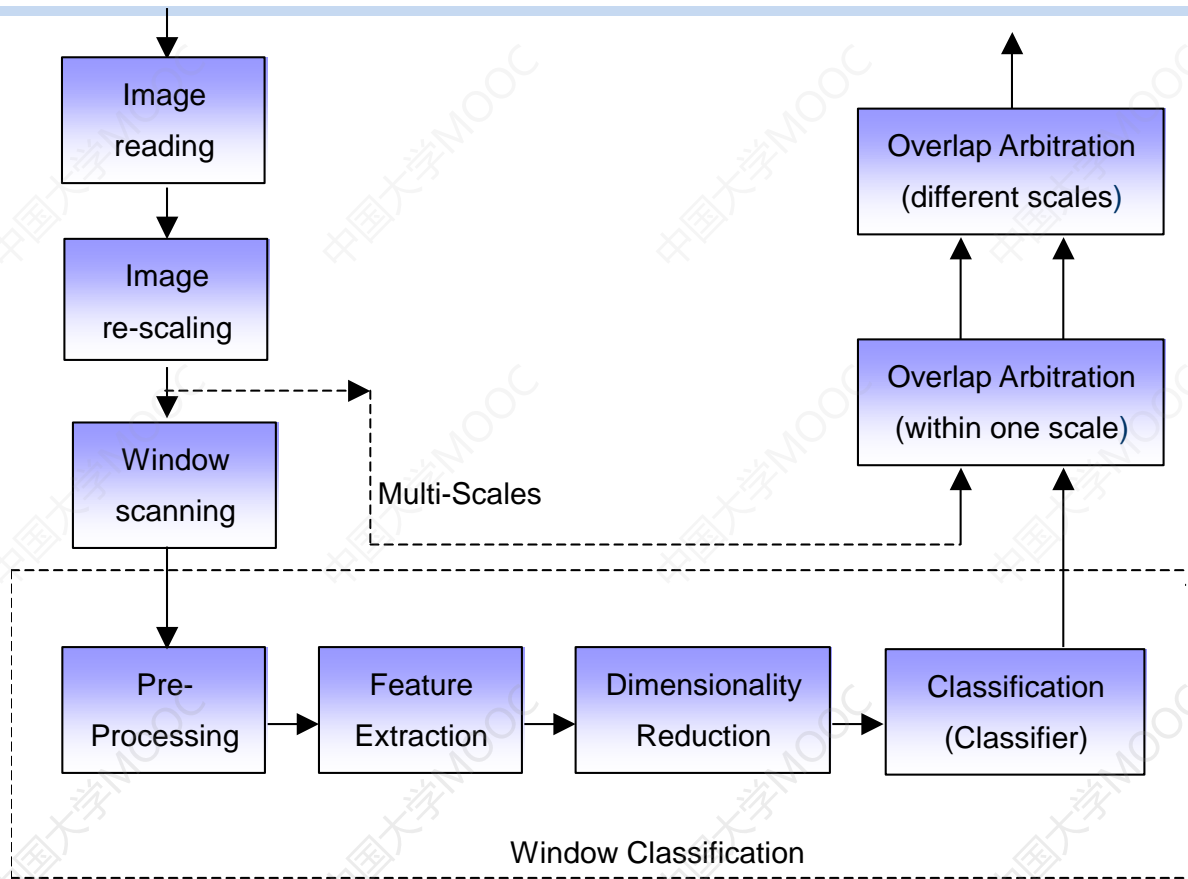
➤ PNN training
$$y(\mathbf{x}) = g\left(\sum_{i=1}^D w_i x_i + \sum_{j=1}^D \sum_{i=j}^D w_{ij} x_i x_j + w_0\right)$$

- ✓ Non-face samples: non-face samples are collected in three steps





Face Detection from Cluttered images





Face Detection from Cluttered images

➤ Detection performance evaluation

- Database: MIT (23images) , CMU (109 images)
- Criteria

$$\text{Detection rate} = \frac{\text{Number of correct detection}}{\text{Total number of faces in testing images}}$$

$$\text{False positive rate} = \frac{\text{Number of false positive}}{\text{Total number of windows in testing images}}$$



Face Detection from Cluttered images

➤ Detection results on different PCA dimensionality

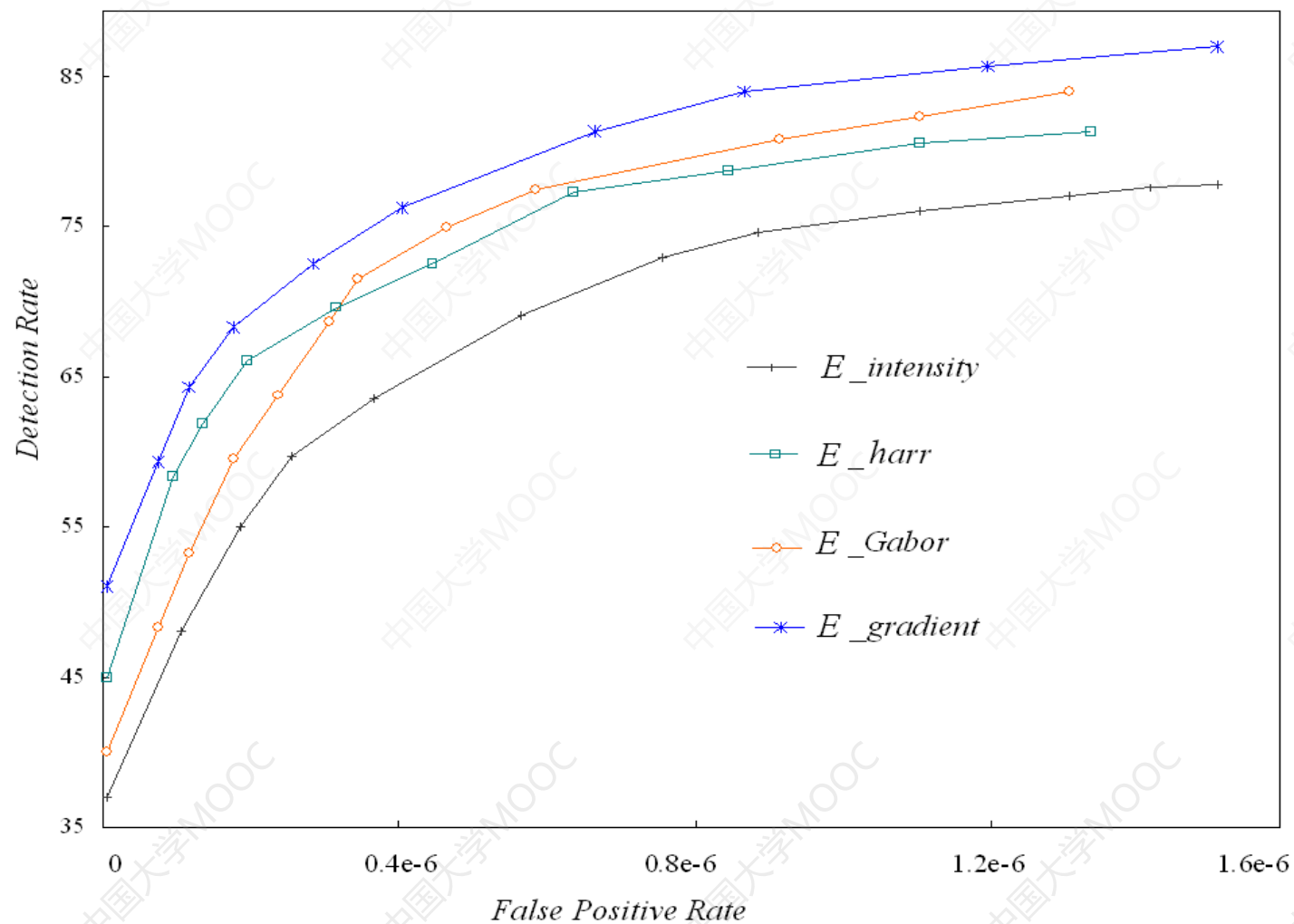
	CMU Testset: 109 images	
Dimensionality	Detection rate	False positives
60	84.2%	385
80	84.6%	276
100	84.6%	251



Face Detection from Cluttered images

➤ Detection results on different features

23 MIT images containing 149 faces		
	Detection rate	False positives
Gray level	84.56%	22
Gradient	84.56%	11
MIT	84.56%	13



T: 11/11/3

**Detection
examples**
Gray



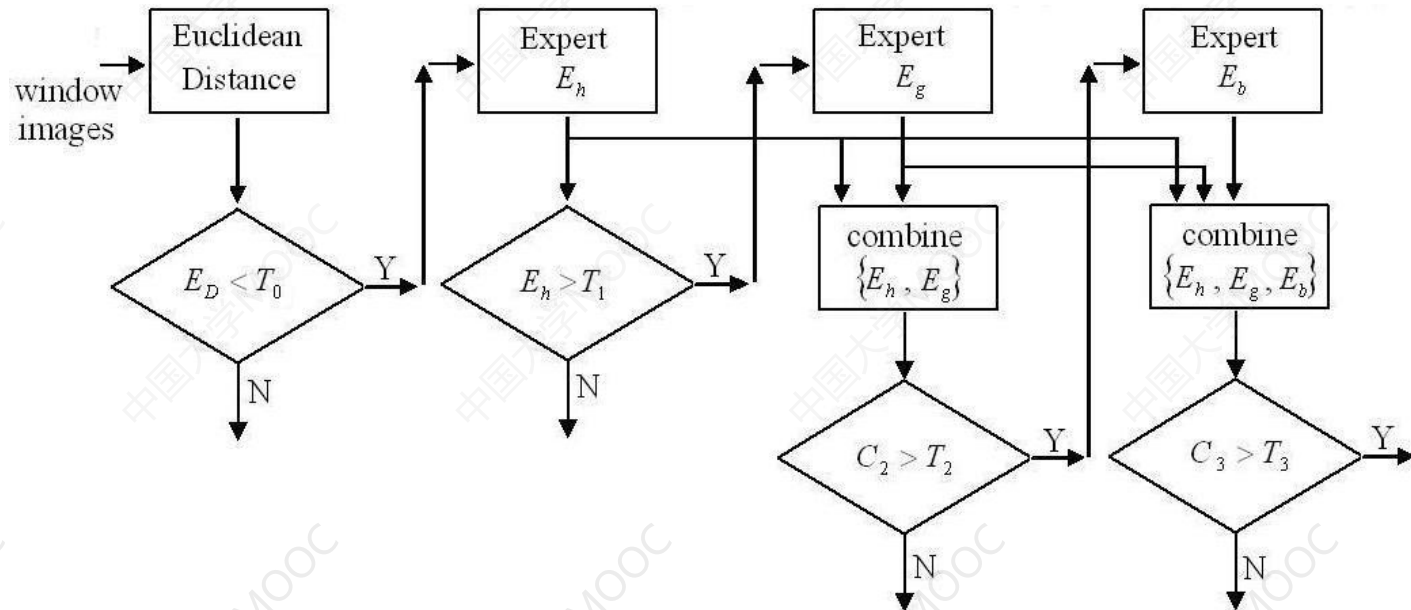
**Detection
examples**
Gradient





Face Detection from Cluttered images

➤ Multi-expert





Face Detection from Cluttered images

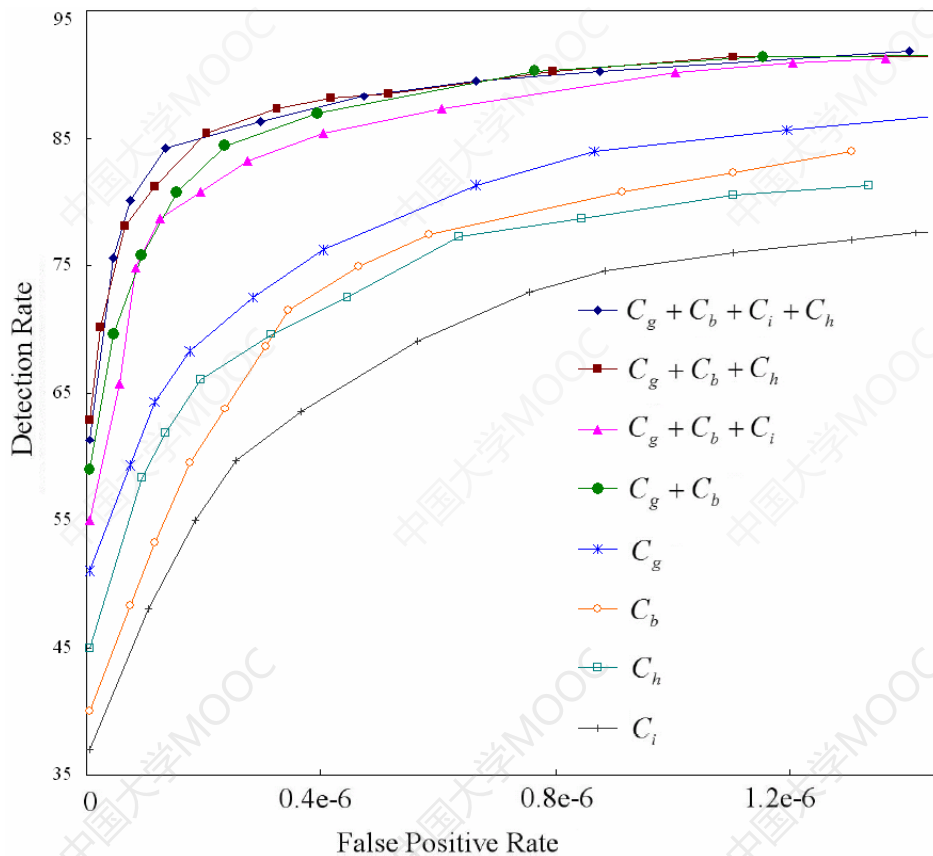
➤ Detection results on multi-experts

23 MIT images containing 149 faces		
	Detection rate	False positives
Multi_expert	92%	0
Gray level	84.56%	22
Gradient	84.56%	11
MIT	84.56%	13



Face Detection from Cluttered images

Multi-expert



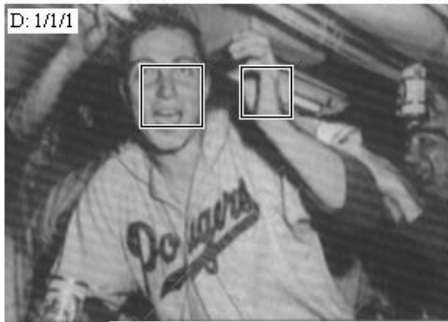
B: 6/6/1



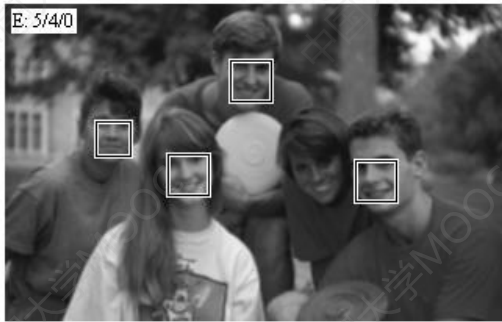
F: 5/5/0



D: 1/1/1



E: 5/4/0



C: 5/4/2



U: 14/11/7

USA 2 ENGLAND 0
June 9th 1993





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！