

上海交通大学硕士学位论文答辩

实用人脸识别系统初探

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主要内容

- 研究背景
- 本文主要工作
- 工作总结与展望

研究背景

□ 研究意义

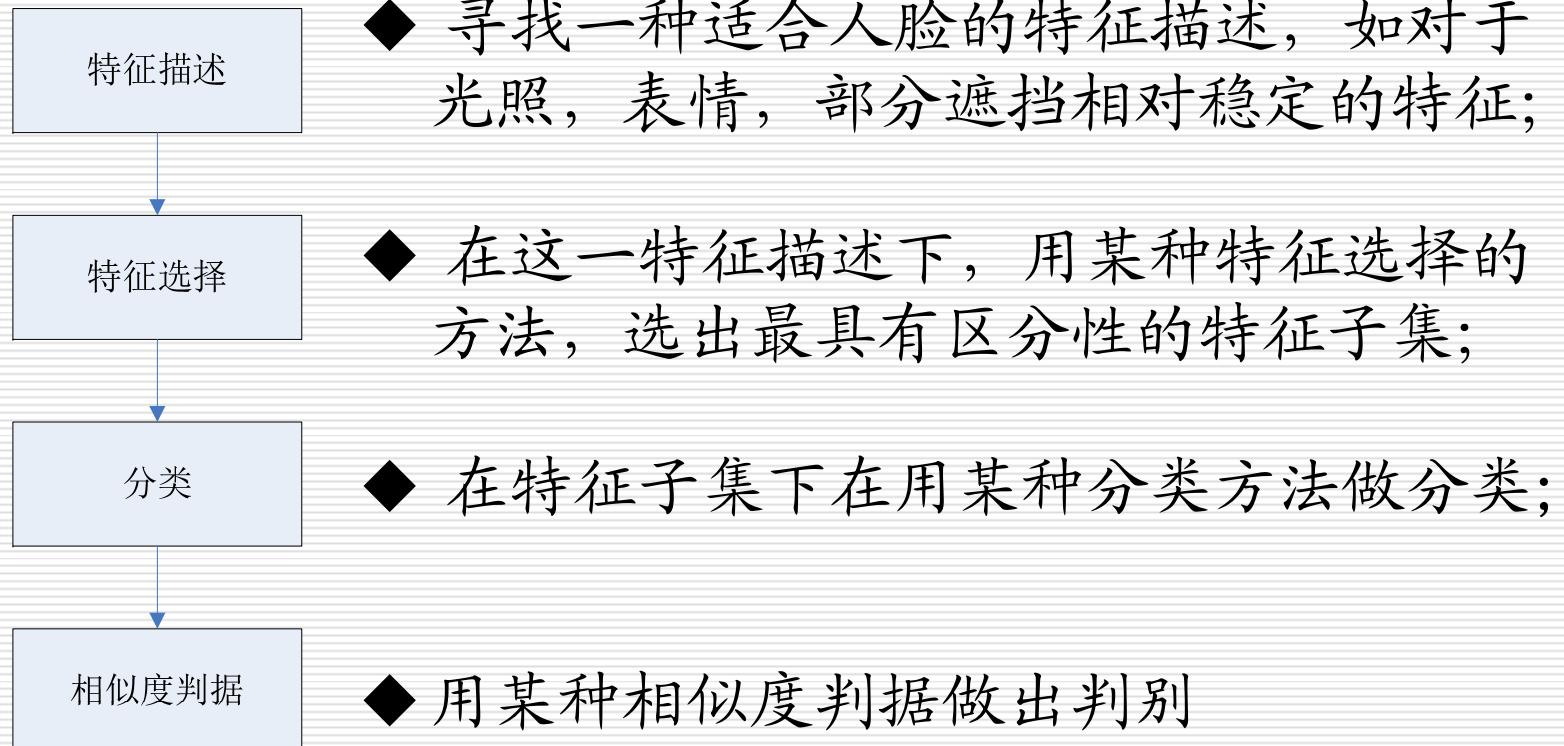
- 人脸识别研究可以极大地促进多门相关学科的发展
- 作为生物特征识别技术的人脸识别具有巨大的潜在应用前景

□ 应用优势

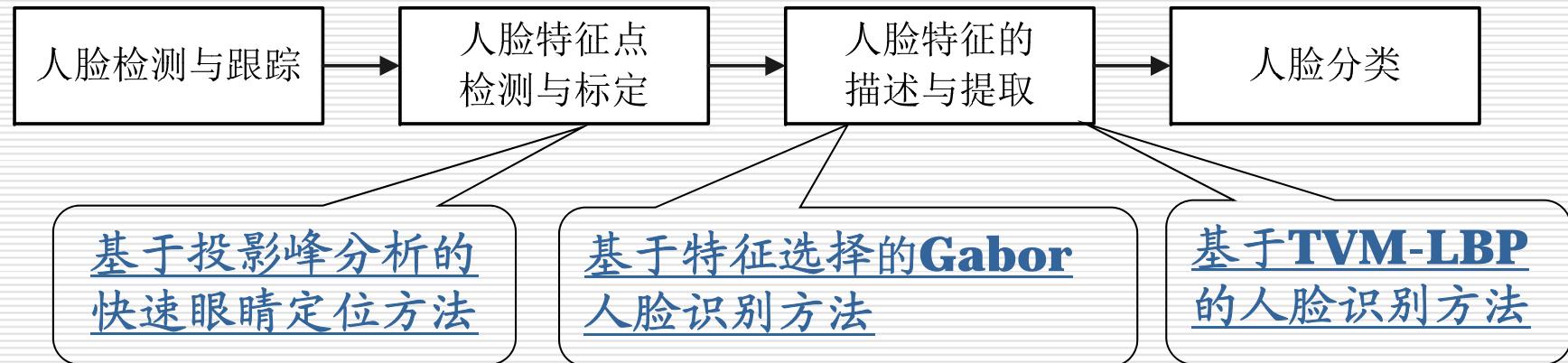
- 隐蔽操作，适用于安全监控
- 非接触式，容易被接受
- 事后追踪能力
- 图像采集设备成本低

研究背景

□ 研究热点与难点



本文主要工作



开放式人脸识别体系框架

基于人脸识别的考勤系统

工作总结

■ 基于投影峰分析眼睛定位方法

(去除眼镜，额发，鬓角，眉毛干扰，通过简单投影运算实现眼睛快速定位)

■ 特征选择Gabor识别方法

(加快Gabor特征提取速度，降低Gabor特征维数)

■ 全变分模型LBP识别方法

(提高光照变化条件下LBP方法的识别率)

■ 开放式人脸识别体系框架

(为人脸识别实用系统设计提供参考模型)

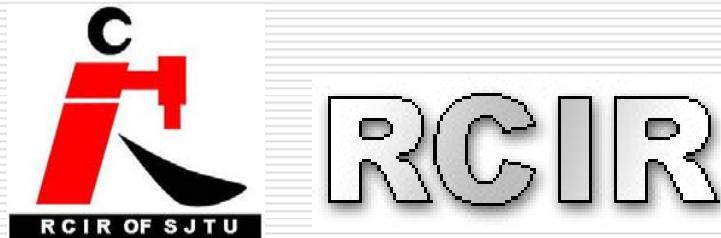
工作展望

□ 特殊情况下人脸识别

- 姿态
- 光照
- 配饰遮挡

□ 特征选择

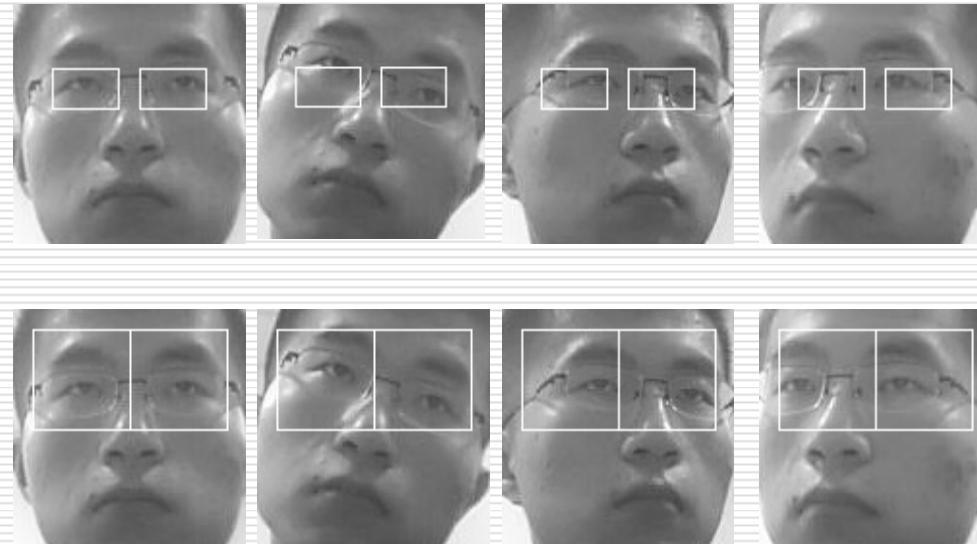
谢谢！



Research Center of Intelligent Robotics

基于投影峰分析的快速眼睛定位方法

□ 传统投影方法



基于投影峰分析的快速眼睛定位方法

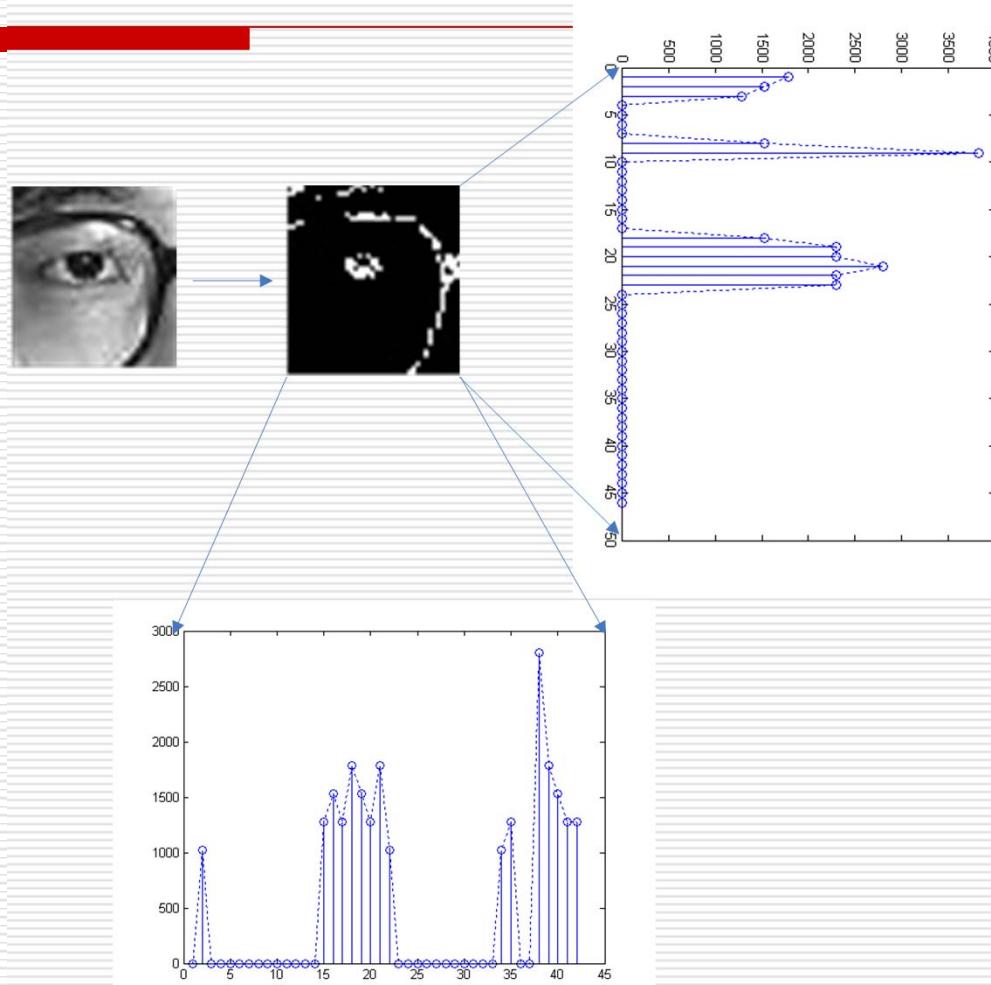
□ 投影峰分析

$$U_n = \alpha W_n + \beta S_n + \gamma D_n$$

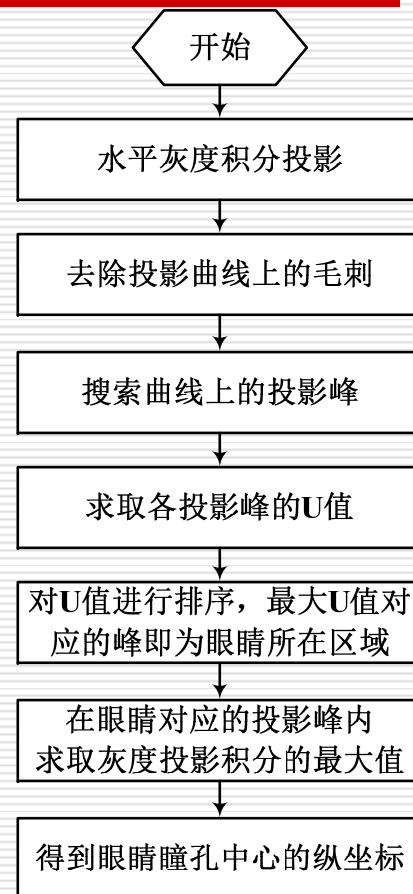
$$W_n = y_{n2} - y_{n1}$$

$$S_n = \sum_{y=y_{n1}}^{y_{n2}} P(y)$$

$$D_n = \left| \frac{y_{n2} - y_{n1}}{2} - Y_c \right|$$



基于投影峰分析的快速眼睛定位方法



实验结果

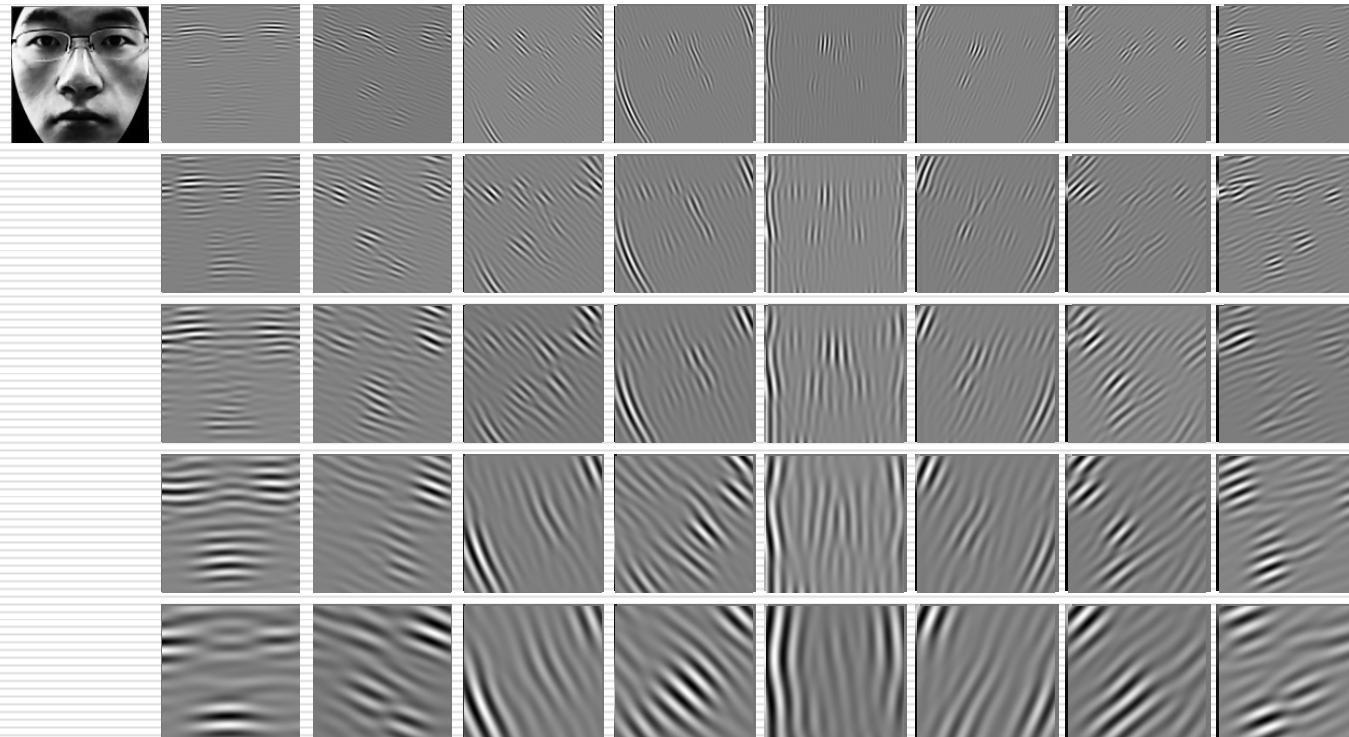


	FERET(%)	BioID(%)	JAFFE(%)	Time(ms)
Our Method	98.92	95.87	99.26	0.56
Adaboost	98.93	96.03	99.47	10.36
HPF	—	94.81	97.18	0.49

基于特征选择的Gabor人脸识别方法

□ Gabor人脸描述

$$\psi_{\mu,\nu}(z) = \frac{\|k_{\mu,\nu}\|^2}{\sigma^2} e^{\left(-\|k_{\mu,\nu}\|^2 \|z\|^2 / 2\sigma^2\right)} \left[e^{ik_{\mu,\nu} z} - e^{-\sigma^2/2} \right]$$

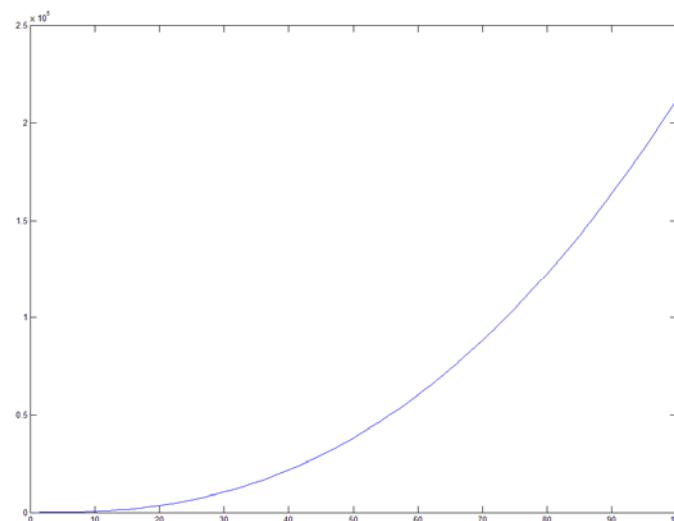


GFC方法

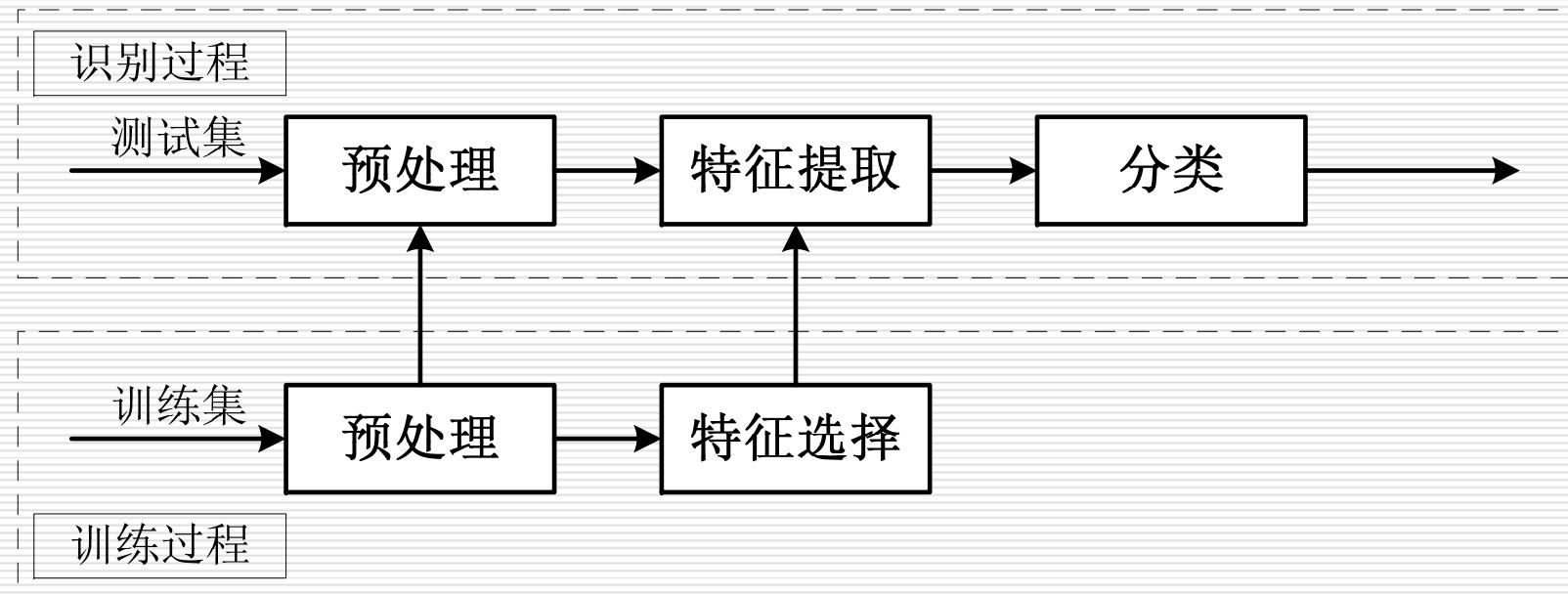
C. Liu 02年在IEEE Trans. Image Processing中一文提出GFC (Gabor Fisher Classifier)，在FERET人脸库上达到95 % 左右的识别率。

实际系统中，GFC识别一幅 128×128 人脸图片需要耗时240ms。

耗时原因：二维卷积的算法复杂度为 $O((n\log n)^2)$



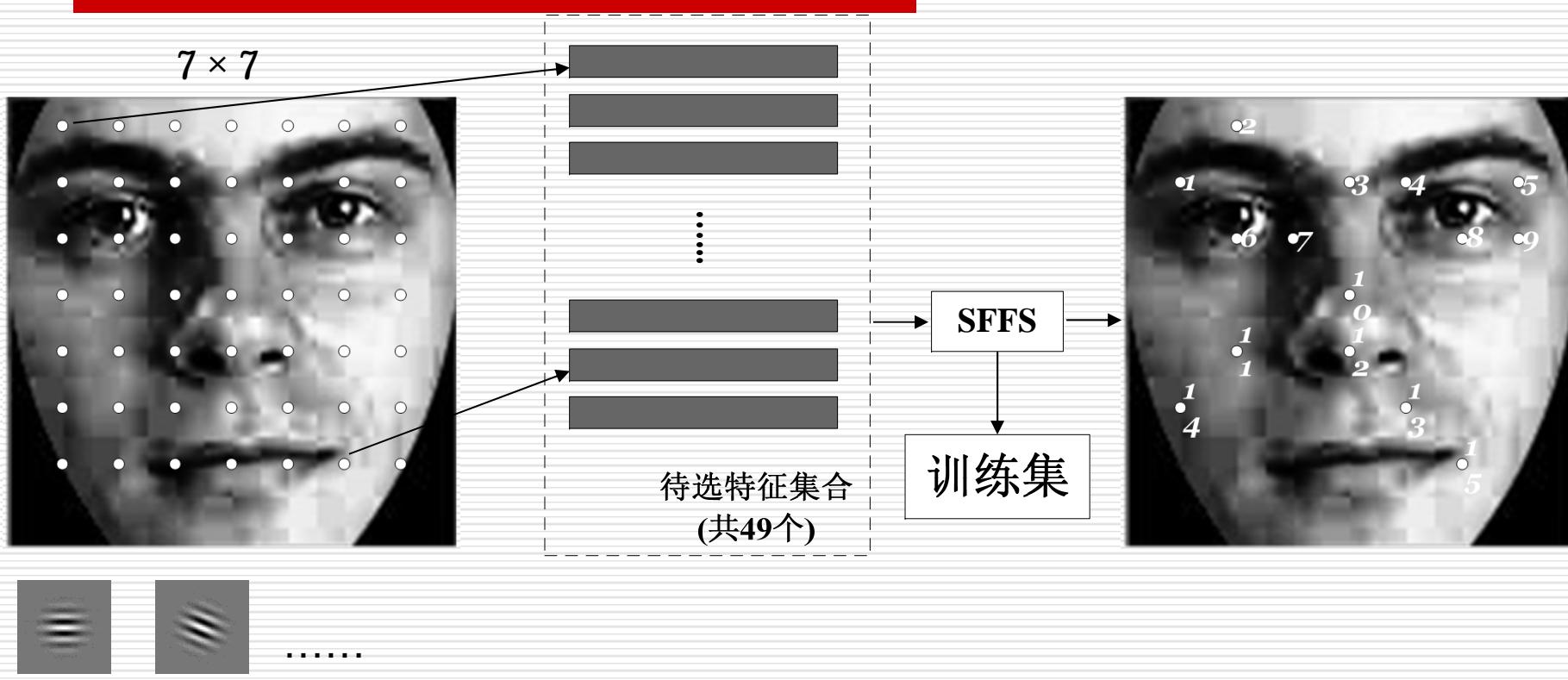
基于特征选择的Gabor人脸识别方法



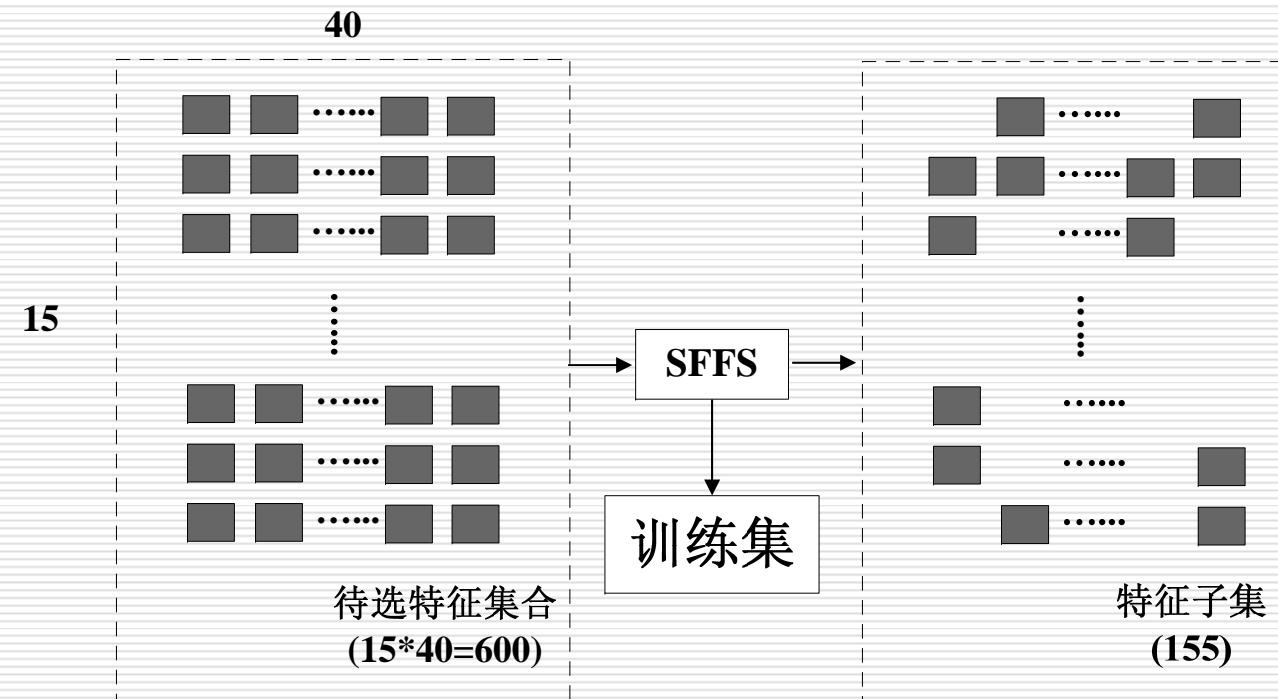
Gabor核位置选择



Gabor核位置选择



Gabor尺度和方向选择



位置	(v, μ)
1#	(0, 0) (1, 0) (1, 1) (2, 1) (1, 3) (2, 3) (0, 4) (1, 4) (2, 4) (2, 5) (0, 6) (1, 7) (2, 7)
2#	(2, 0) (1, 1) (2, 1) (0, 3) (1, 4) (3, 4) (4, 4) (0, 5) (3, 5) (4, 5) (1, 6) (2, 7)
3#	(0, 0) (3, 0) (4, 0) (3, 1) (4, 1) (2, 2) (4, 3) (3, 4) (4, 4) (4, 5) (2, 7) (3, 7)
4#	(2, 1) (3, 1) (4, 1) (3, 2) (2, 3) (1, 4) (2, 4) (3, 4) (1, 5) (2, 5) (2, 7)
5#	(2, 1) (4, 1) (0, 3) (1, 3) (4, 3) (0, 4) (1, 4) (2, 4) (3, 4) (4, 4) (1, 5)
6#	(2, 0) (3, 0) (4, 0) (0, 1) (2, 1) (3, 1) (4, 1) (4, 3) (2, 4) (2, 4) (0, 5) (1, 5) (3, 5)
7#	(2, 0) (3, 0) (1, 2) (3, 2) (0, 3) (1, 3) (2, 4) (0, 5) (1, 5) (4, 5) (1, 6) (0, 7) (2, 7)
8#	(0, 0) (0, 1) (3, 0) (4, 0) (2, 1) (3, 2) (0, 4) (3, 4) (4, 4) (2, 5) (3, 5) (2, 7)
9#	(0, 0) (2, 0) (4, 0) (4, 2) (2, 3) (3, 3) (0, 4) (2, 4) (3, 4) (4, 4) (4, 6)
10#	(0, 0) (3, 0) (1, 3) (2, 3) (3, 3) (1, 4) (2, 4) (3, 4) (2, 5) (3, 5) (4, 5) (0, 7) (1, 7)
11#	(2, 0) (3, 0) (1, 1) (2, 1) (3, 1) (0, 4) (1, 4) (1, 5) (1, 6) (0, 7)
12#	(0, 0) (1, 1) (2, 3) (1, 4) (0, 5) (2, 5) (3, 5) (4, 6) (0, 7)
13#	(1, 1) (1, 4) (3, 5) (3, 6)
14#	(1, 2) (4, 3) (3, 4) (3, 5)
15#	(1, 1) (3, 1) (1, 2) (0, 3) (2, 3) (1, 5) (2, 5) (4, 6)
总计	155

基于SFFS-Gabor的人脸识别方法

经过特征选择之后，特征提取时

SFFS-Gabor: 155个 16×16 的二维卷积

GFC: 40个 128×128 的二维卷积

在FERET人脸库上实验结果

	识别率 (%)	平均耗时 (ms)
GFC	96.60	2400
SFFS-Gabor	95.43	50



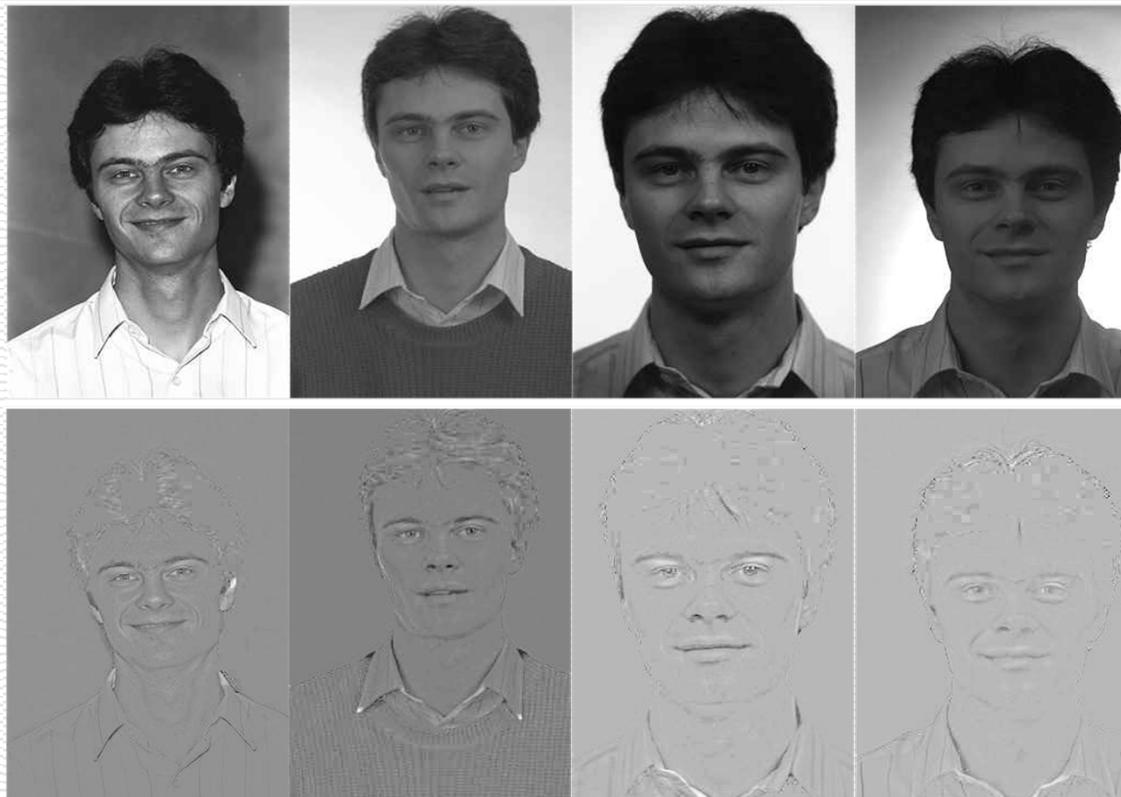
基于TVM-LBP的人脸识别方法

局部二值模式(Local Binary Pattern, LBP)是一种有效的纹理描述。

T. Ojala在ECCV04中用LBP描述人脸特征，通过直方图分析的方法作人脸识别取得良好实验效果但当环境光照变化时，识别效果变差。

全变分模型 (Total Variation Model, TVM)

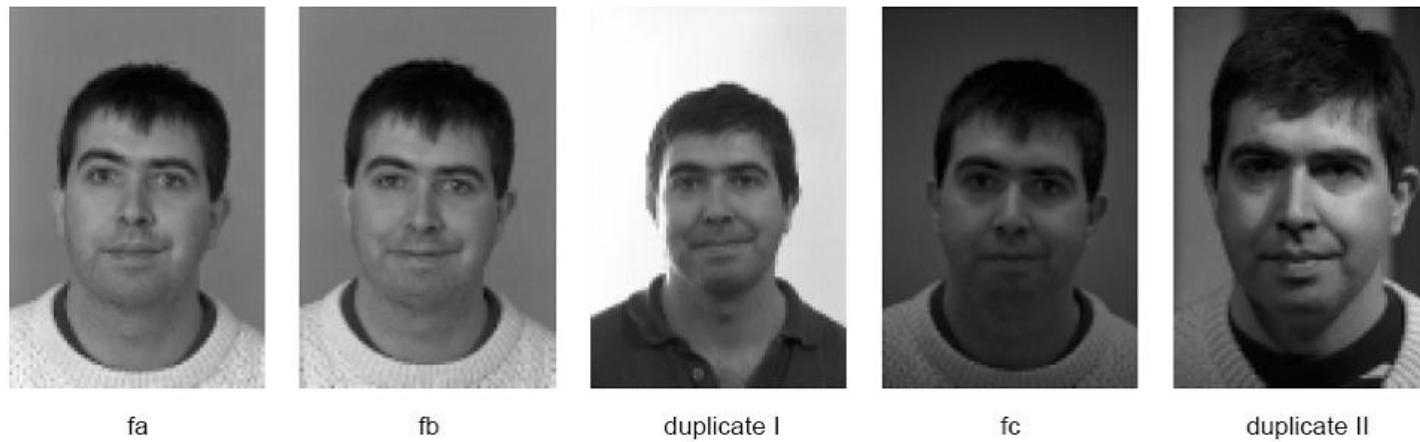
图像的纹理：肤色背景纹理 + 及精细的轮廓纹理



TVM-LBP特征提取过程



FERET人脸库



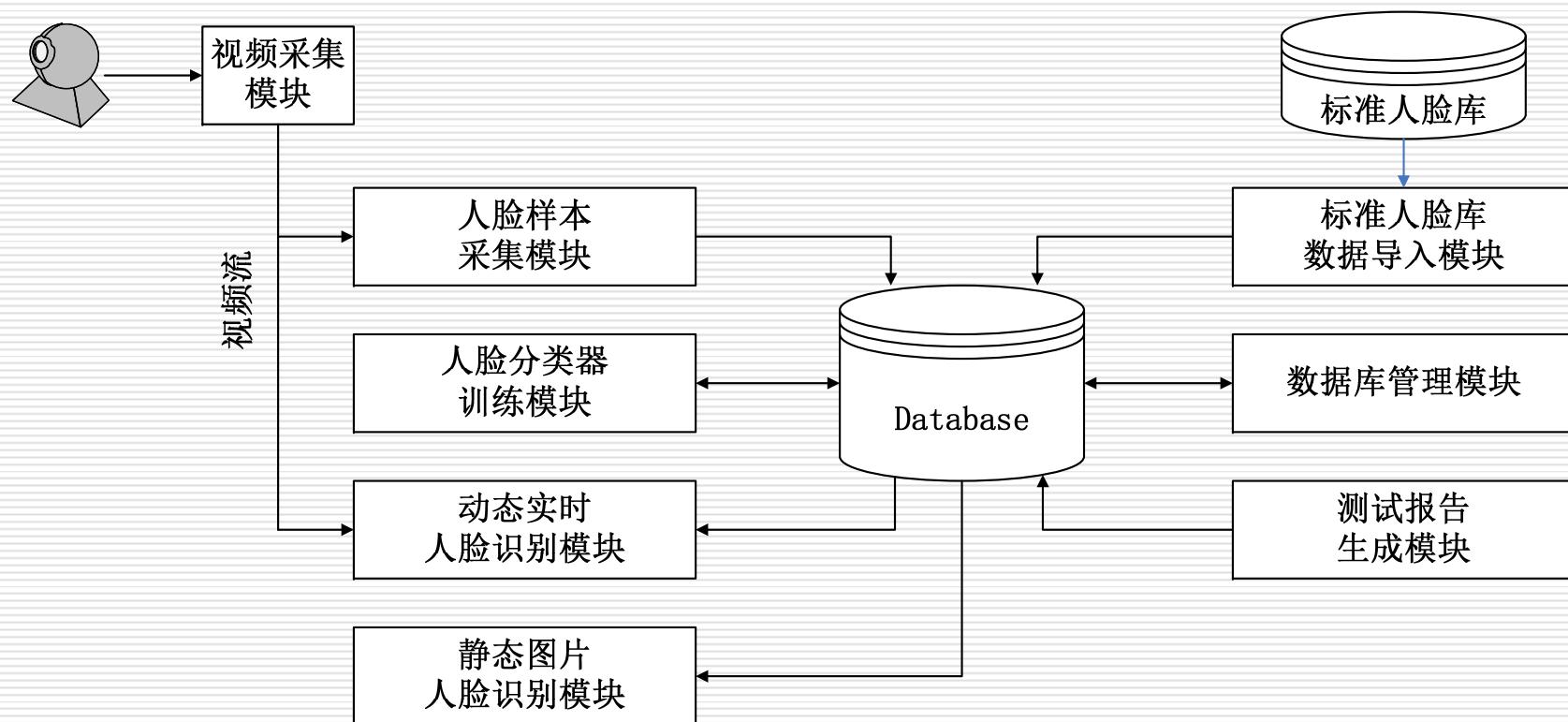
Gallery (fa)	fb	fc	Dup I	Dup II
1196	1195	194	722	234

实验比较

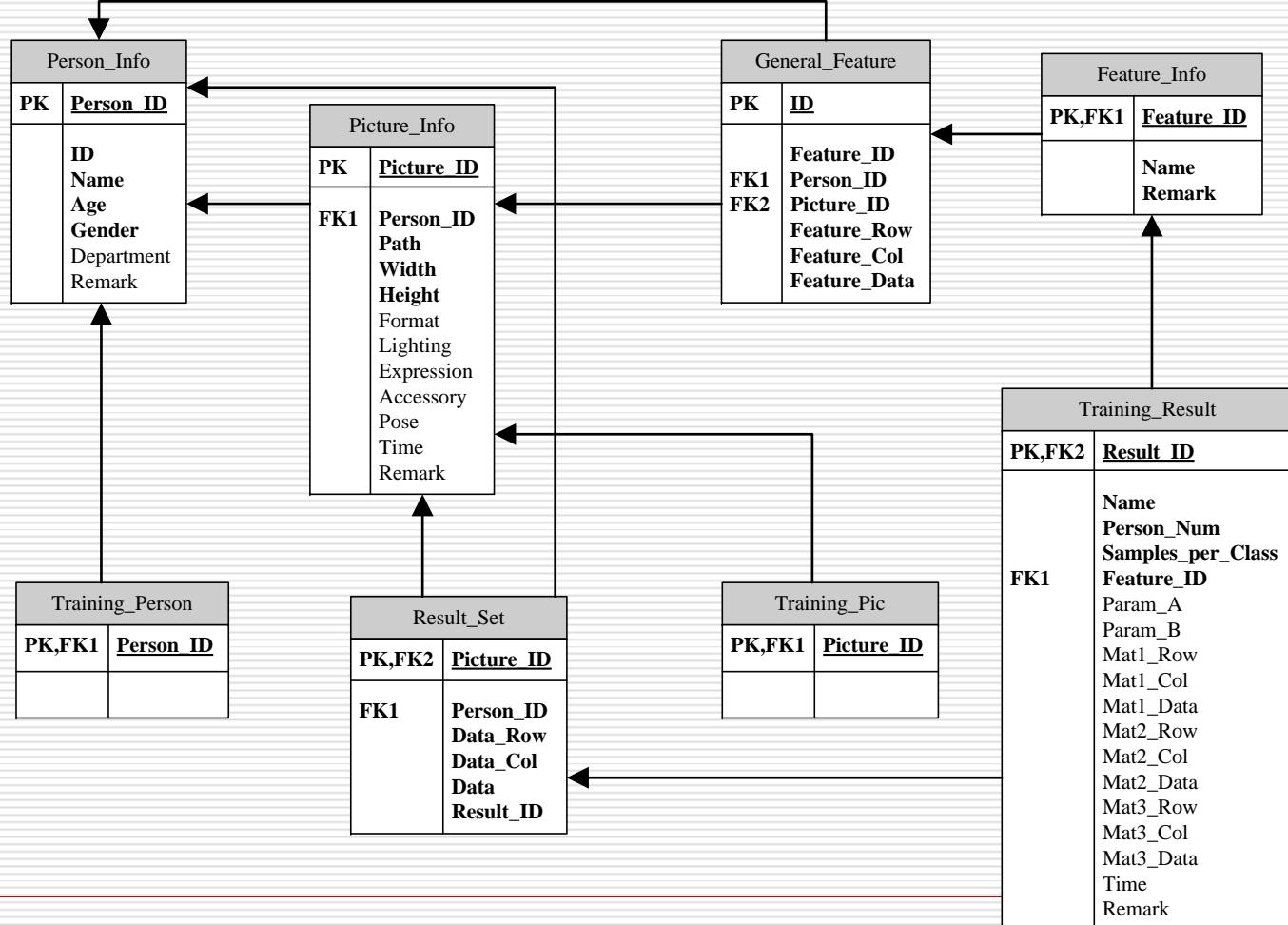
	fb(%)	fc(%)	Dup I(%)	Dup II(%)
Original-LBP	91.3	50.0	50.0	31.1
TVM-LBP	<u>92.6</u>	<u>78.5</u>	<u>52.2</u>	30.7



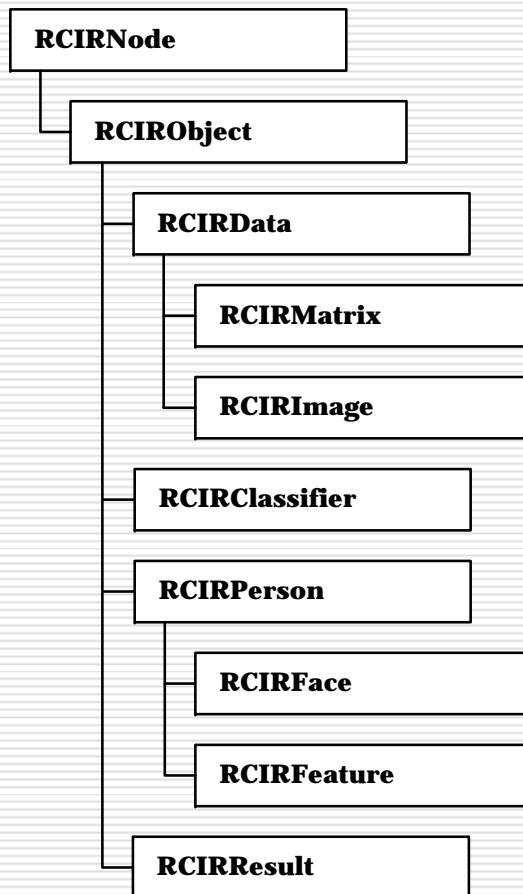
开放式人脸识别体系框架



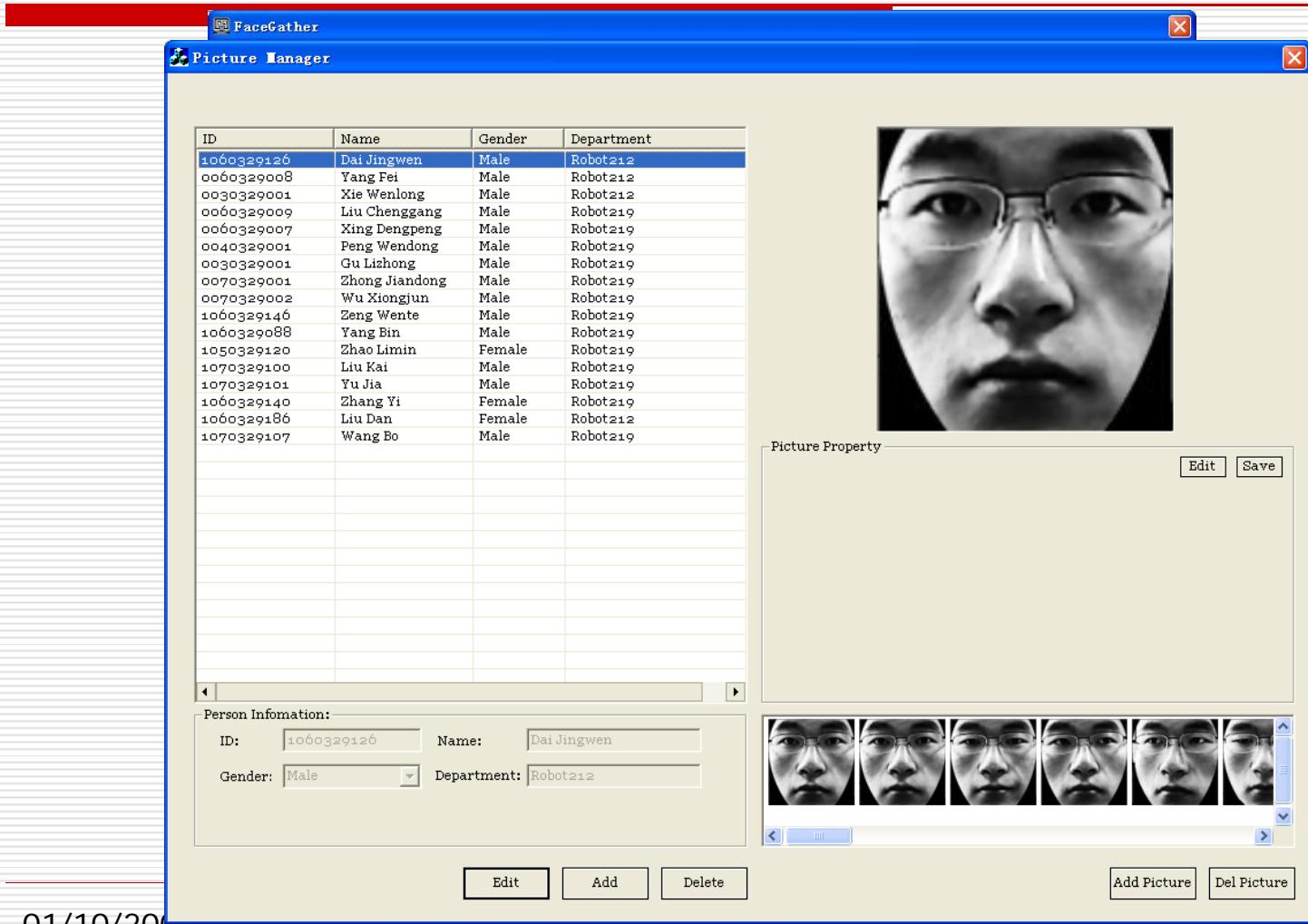
开放式人脸识别体系框架



开放式人脸识别体系框架



样本采集与管理模块



01/10/2008

KOTKE-SOTO

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Training Wizard (Step 1 of 2)

Training Wizard (Step 2 of 2)

ID	Name
1060329126	Dai Jingwen
0060329008	Yang Fei
0030329001	Xie Wenlong
0060329009	Liu Chenggang
0060329007	Xing Dengpeng
0040329001	Peng Wendong
0030329001	Gu Lizhong
0070329001	Zhong Jiaodong
0070329002	Wu Xiongjun
1060329146	Zeng Wente
1060329088	Yang Bin
1050329120	Zhao Limin
1070329100	Liu Kai
1070329101	Yu Jia
1060329140	Zhang Yi
1060329166	Liu Dan
1070329107	Wang Bo

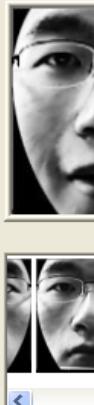
General Info

Sample Numbers per Person: 6 Person Number:

- Training Samples
 - 1@Dai Jingwen
 - 1@1\\Dai Jingwen_0001.jpg
 - 2@1\\Dai Jingwen_0002.jpg
 - 3@1\\Dai Jingwen_0003.jpg
 - 4@1\\Dai Jingwen_0004.jpg
 - 5@1\\Dai Jingwen_0005.jpg
 - 6@1\\Dai Jingwen_0006.jpg
 - 2@Yang Fei
 - 3@Xie Wenlong
 - 4@Liu Chenggang
 - 5@Xing Dengpeng
 - 6@Peng Wendong
 - 7@Gu Lizhong
 - 10@Zeng Wente
 - 11@Yang Bin

01/10/2009

Picture Property



Training

Training Mode

New

Update

Prepare Samples

Start Training

Refresh

Finish

--> Training Parameters:

Class Number: 10

Samples Number Per Class: 6

PC Number: 60

Feature: GaborFace

--> Training Samples have been prepared, please press BTN(Start Training)

~~~~~Start Training@21:21:19~~~~~

INFO: The memory space allocation is accomplished.

INFO: Prepare the training samples.....

Loading the feature matrix of Picture: 1

Loading the feature matrix of Picture: 2

Loading the feature matrix of Picture: 3

Loading the feature matrix of Picture: 4

Loading the feature matrix of Picture: 5

Loading the feature matrix of Picture: 7

Loading the feature matrix of Picture: 41

Loading the feature matrix of Picture: 42

Loading the feature matrix of Picture: 43

Loading the feature matrix of Picture: 44

Loading the feature matrix of Picture: 45

Loading the feature matrix of Picture: 47

Loading the feature matrix of Picture: 86

Loading the feature matrix of Picture: 89

Loading the feature matrix of Picture: 105

Loading the feature matrix of Picture: 106

Loading the feature matrix of Picture: 108

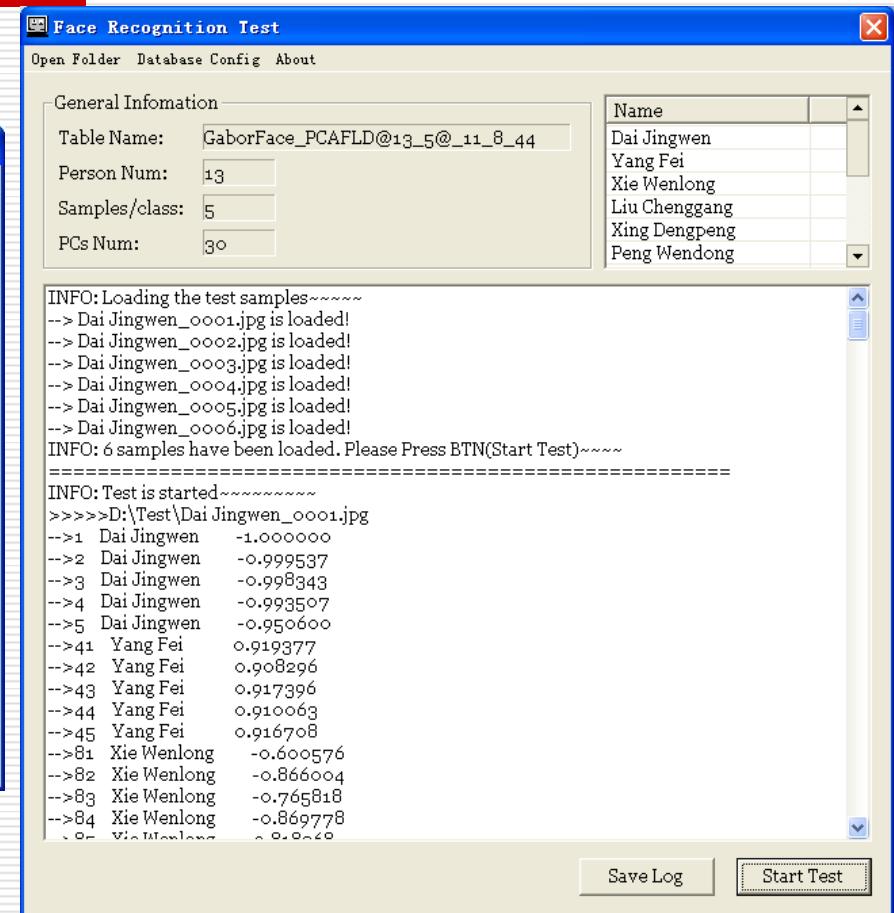
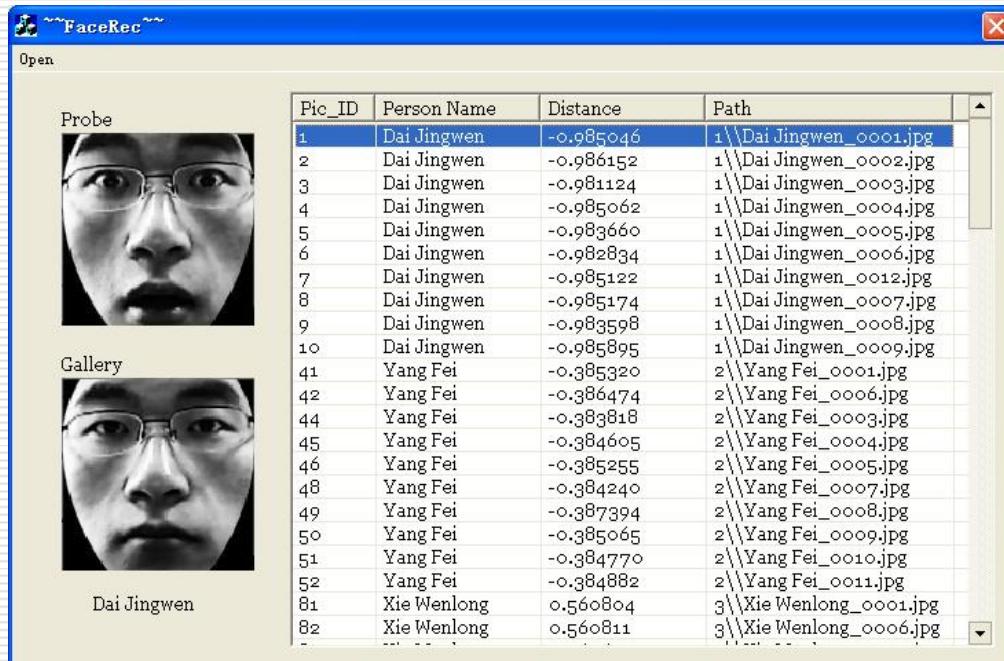
Loading the feature matrix of Picture: 109

Loading the feature matrix of Picture: 125

Loading the feature matrix of Picture: 126

Loading the feature matrix of Picture: 127

# 静态图片人脸识别模块



# 实时识别模块



# 基于人脸识别的考勤系统



Microsoft Excel - Report.xls

文件(F) 编辑(E) 视图(V) 插入(I) 格式(O) 工具(T) 帮助(H) 窗口(W) 帮助(H)

826 A B C D E F G H I J K L M N O

|    | A        | B              | C                  | D            | E                          | F                  | G               | H                  | I                   | J                  | K                | L                  | M               | N                  | O                  |
|----|----------|----------------|--------------------|--------------|----------------------------|--------------------|-----------------|--------------------|---------------------|--------------------|------------------|--------------------|-----------------|--------------------|--------------------|
| 1  | Name     | Monday Morning | Monday Afternoon   | Monday Night | Tuesday Morning            | Tuesday Afternoon  | Tuesday Night   | Wednesday Morning  | Wednesday Afternoon | Wednesday Night    | Thursday Morning | Thursday Afternoon | Thursday Night  | Friday Morning     | Friday afternoon   |
| 2  | Wang Lei |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 3  | xuliqing |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 4  | yfj      |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 5  | 戴景文      |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    | A:12:13<br>L:12:14 |
| 6  | 顾立忠      |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 7  | 顾林麟      |                | A:13:53<br>L:17:04 |              |                            | A:13:37 L:17:06    |                 | A:09:56            |                     |                    |                  |                    |                 |                    |                    |
| 8  | 刘成刚      | A:09:04        |                    |              | A:08:19                    |                    |                 |                    |                     |                    |                  |                    |                 |                    | A:08:36            |
| 9  | 刘丹       |                |                    |              | A:11:24                    |                    |                 |                    |                     |                    | A:22:03          |                    | A:17:36         | A:23:58            | A:09:39            |
| 10 | 刘凯       | A:09:08        | A:17:10            |              | A:08:51                    | A:16:43            | A:18:47 L:21:33 | A:09:16            |                     | A:20:28            | A:09:53          |                    |                 |                    | A:12:41            |
| 11 | 郭文东      |                | A:13:46            |              |                            | A:13:31 L:17:15    | A:19:27 L:21:38 |                    |                     |                    | A:09:11          | A:13:23            |                 |                    | A:09:01 A:13:39    |
| 12 | 王博       |                | A:18:22            |              | A:08:58<br>L:11:24         | A:12:00 L:17:17    | A:18:13 L:21:02 |                    | A:13:55<br>L:17:30  |                    | A:09:44          |                    |                 | A:23:01            |                    |
| 13 | 谢元北      |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 14 | 邢莹麟      |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    | A:17:17            |
| 15 | 杨斌       | A:09:29        | A:17:10            |              | A:08:34<br>L:11:20         | A:11:58            |                 | A:09:04            | A:17:13             |                    | A:09:07 L:11:19  | A:17:17            |                 |                    | A:09:15            |
| 16 | 杨飞       | A:09:05        | A:14:46            | A:18:05      | A:08:04<br>L:11:15 L:17:22 | A:12:25 L:17:17    | A:18:26 L:22:35 | A:07:32<br>L:11:27 | A:11:58<br>L:17:44  | A:19:21<br>L:21:16 | A:08:30 L:11:20  | A:11:46 L:17:14    | A:18:08 L:22:04 | A:08:24<br>L:09:46 | A:12:27<br>L:17:10 |
| 17 | 于佳       |                |                    |              |                            | A:08:45<br>L:11:23 | A:17:16         | A:18:13 L:21:33    | A:09:36<br>L:11:28  | A:11:57<br>L:17:43 | A:09:06 L:11:20  | A:11:45 L:17:17    | A:23:01         | A:09:15 A:12:01    |                    |
| 18 | 曾遇特      | A:09:29        | A:17:10            |              | A:08:33                    |                    |                 | A:09:05<br>A:17:13 |                     |                    | A:09:07          | A:17:16            |                 |                    | A:09:16            |
| 19 | 孙凯       |                | A:17:20            | A:21:02      | L:11:13                    | A:15:50 L:17:17    | A:18:54 L:21:02 | A:09:16<br>L:11:26 |                     | A:11:03 L:11:03    | A:14:23 L:17:17  | A:19:05 L:21:20    |                 |                    |                    |
| 20 | 张怡       |                |                    |              | A:08:26                    |                    |                 | A:09:02            |                     |                    |                  |                    |                 |                    |                    |
| 21 | 钟建东      |                |                    |              |                            |                    |                 |                    | A:12:13             |                    |                  |                    |                 |                    |                    |
| 22 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 23 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 24 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 25 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 26 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 27 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 28 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 29 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 30 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 31 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 32 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 33 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 34 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 35 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 36 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 37 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 38 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 39 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 40 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 41 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 42 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 43 |          |                |                    |              |                            |                    |                 |                    |                     |                    |                  |                    |                 |                    |                    |

# 统计分析

