

# 上海交通大学硕士学位论文答辩

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## 实用人脸识别系统初探

作者：戴景文

导师：苏剑波 教授

# 主要内容

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- 研究背景
- 本文主要工作
- 工作总结与展望

# 研究背景

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## □ 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

特征描述

◆ 寻找一种适合人脸的特征描述，如对于光照，表情，部分遮挡相对稳定的特征；

特征选择

◆ 在这一特征描述下，用某种特征选择的方法，选出最具有区分性的特征子集；

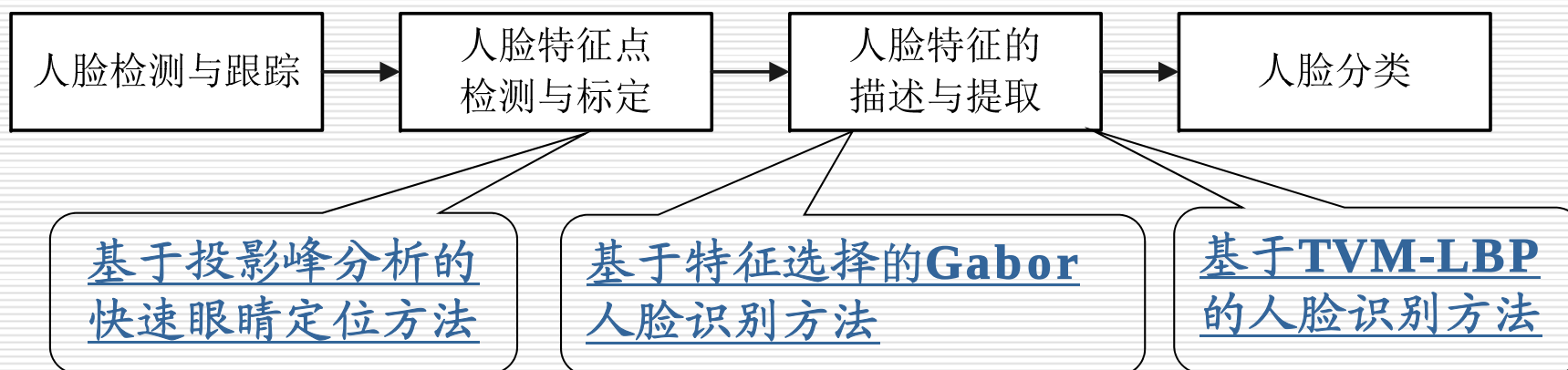
分类

◆ 在特征子集下在用某种分类方法做分类；

相似度判据

◆ 用某种相似度判据做出判别

# 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

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- 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

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## ☐ 特殊情况下人脸识别

- 姿态

- 光照

- 配饰遮挡

## ☐ 特征选择

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# 谢谢！



# RCIR

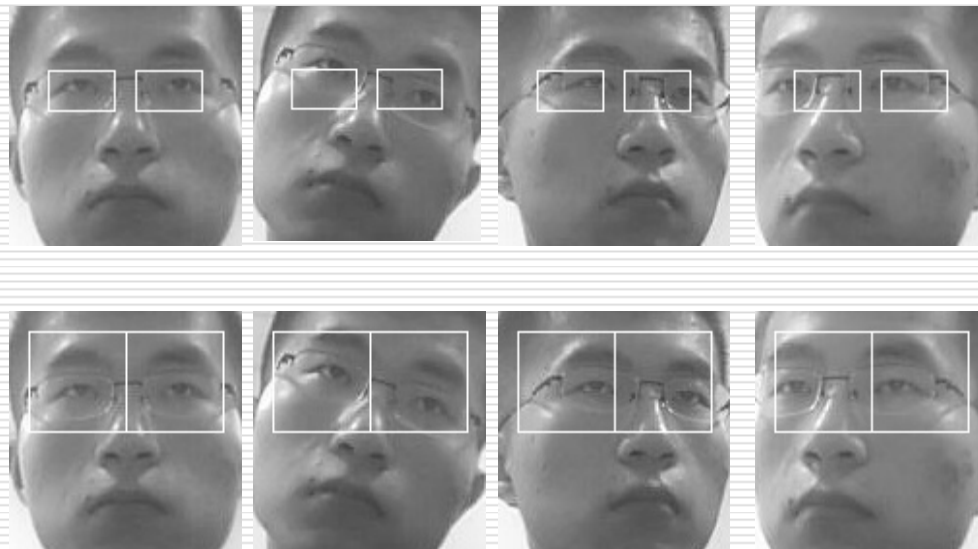
Research Center of Intelligent Robotics



# 基于投影峰分析的快速眼睛定位方法

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## □ 传统投影方法



# 基于投影峰分析的快速眼睛定位方法

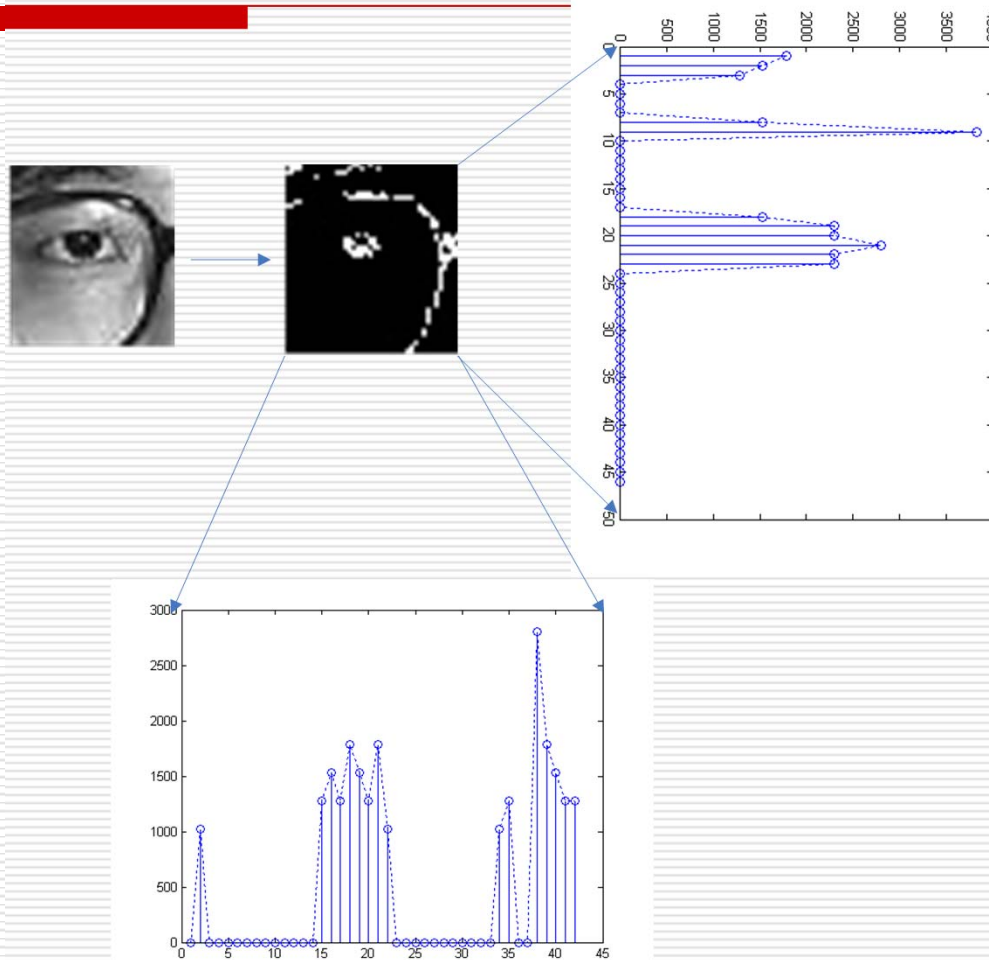
## □ 投影峰分析

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

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

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

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



# 基于投影峰分析的快速眼睛定位方法



# 实验结果



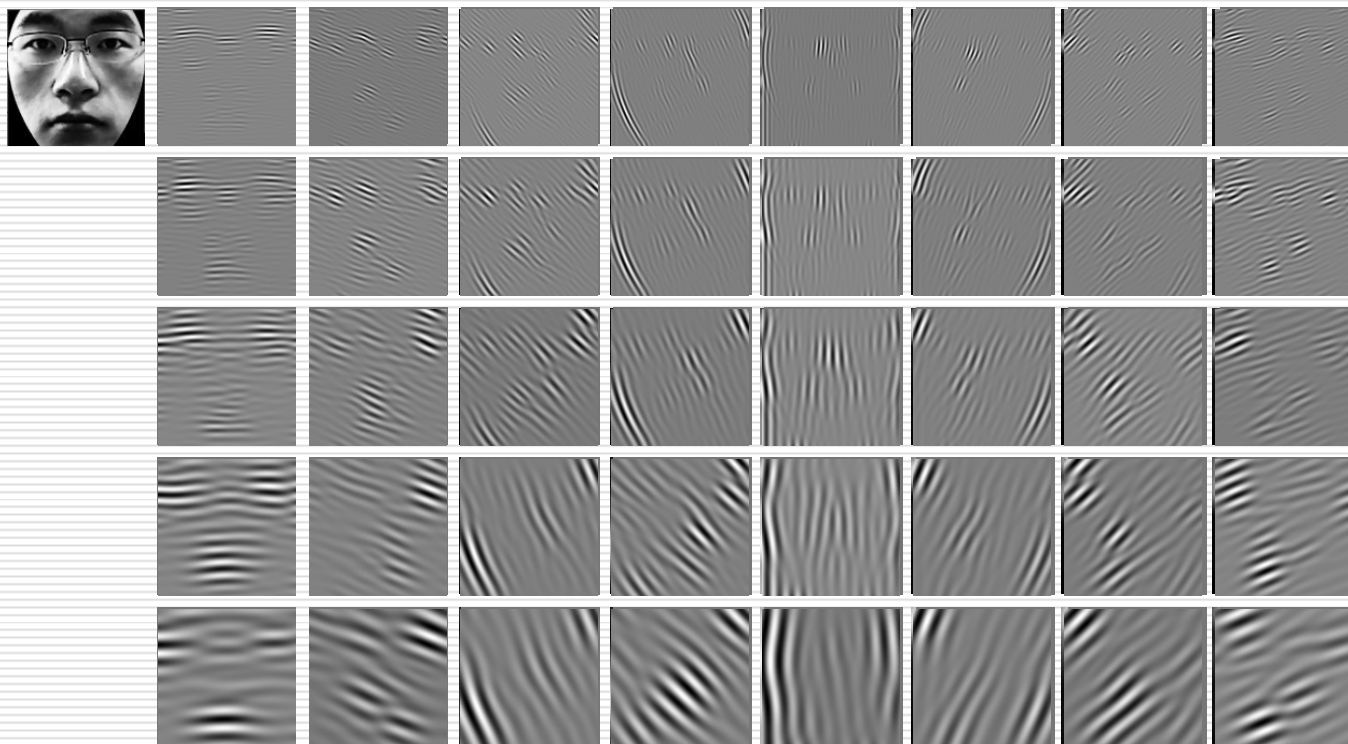
|            | FERET(%) | BioID(%) | JAFFE(%) | Time(ms) |
|------------|----------|----------|----------|----------|
| Our Method | 98.92    | 95.87    | 99.26    | 0.56     |
| Adaboost   | 98.93    | 96.03    | 99.47    | 10.36    |
| HPF        | —        | 94.81    | 97.18    | 0.49     |



# 基于特征选择的Gabor人脸识别方法

□ Gabor人脸描述

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

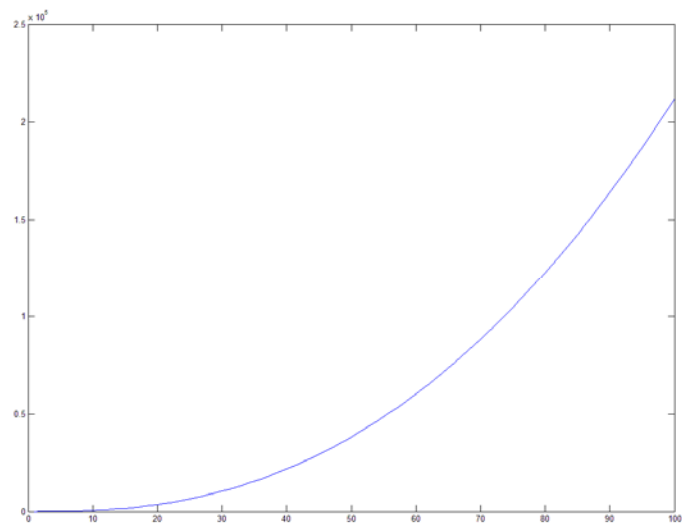


# GFC方法

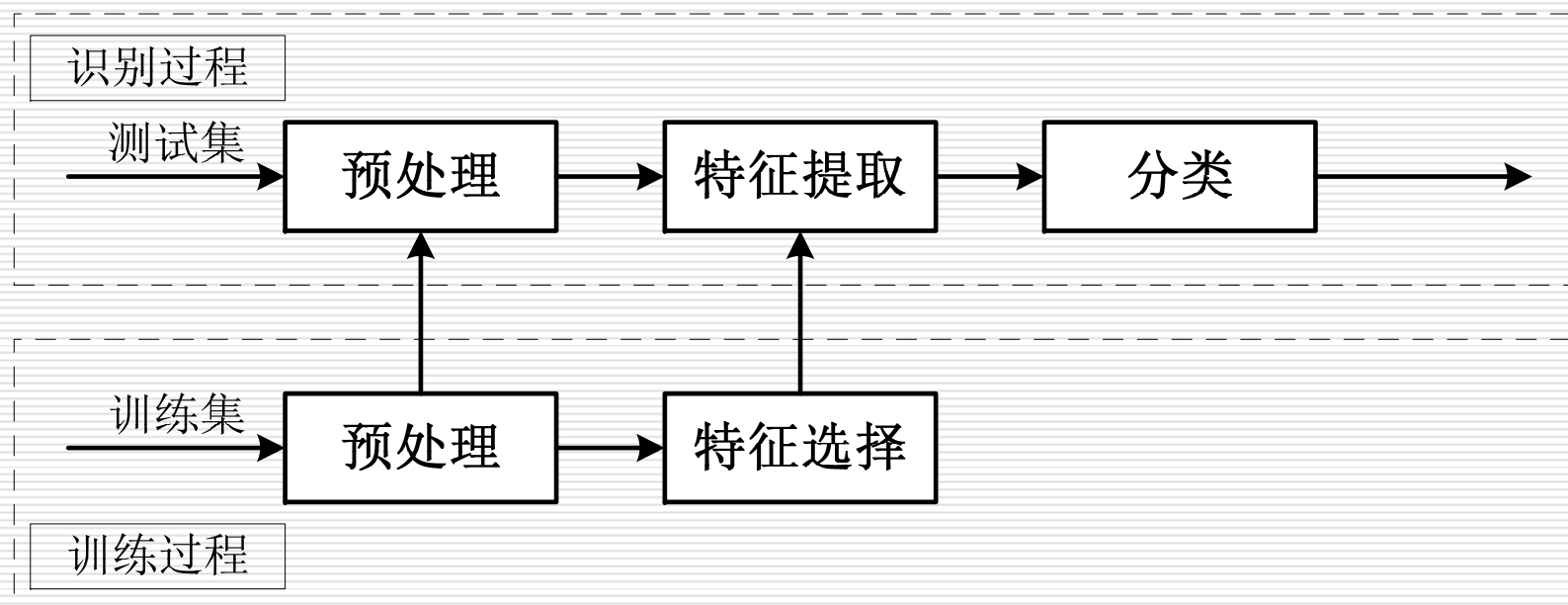
C. Liu 02年在IEEE Trans. Image Processing中一文提出GFC (Gabor Fisher Classifier), 在FERET人脸库上达到95%左右的识别率。

实际系统中, GFC识别一幅 $128 \times 128$ 人脸图片需要耗时2400ms。

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



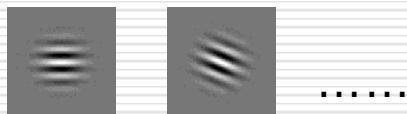
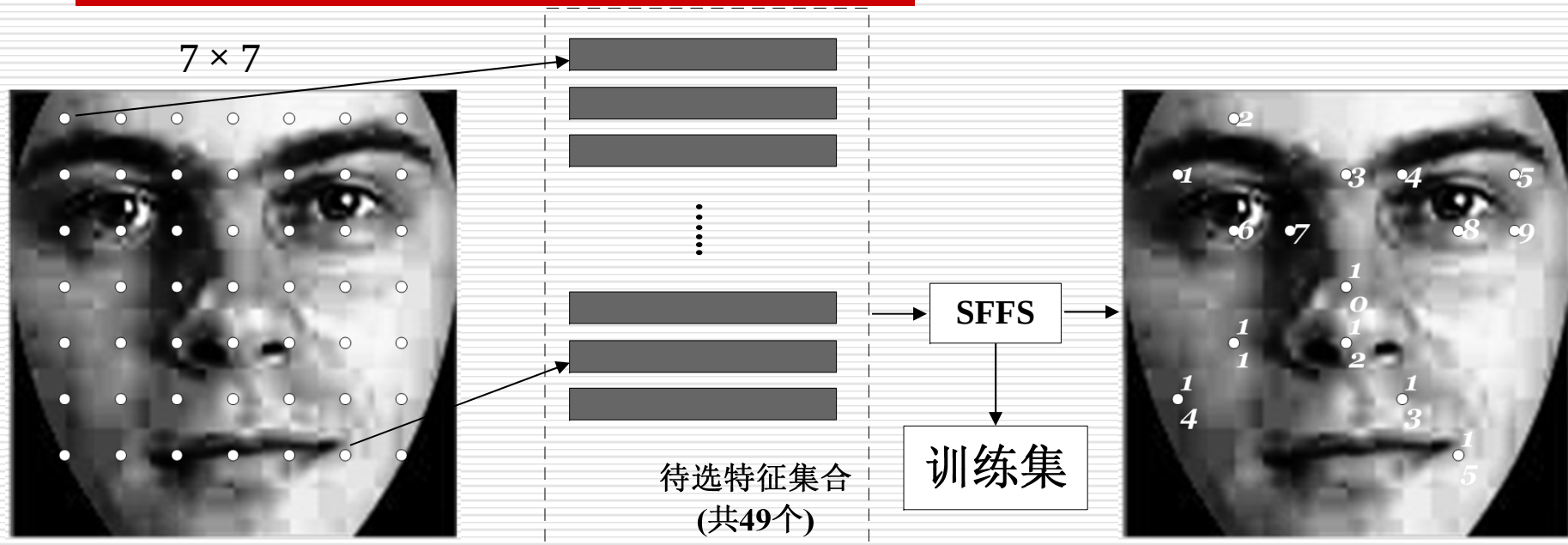
# Gabor核位置选择

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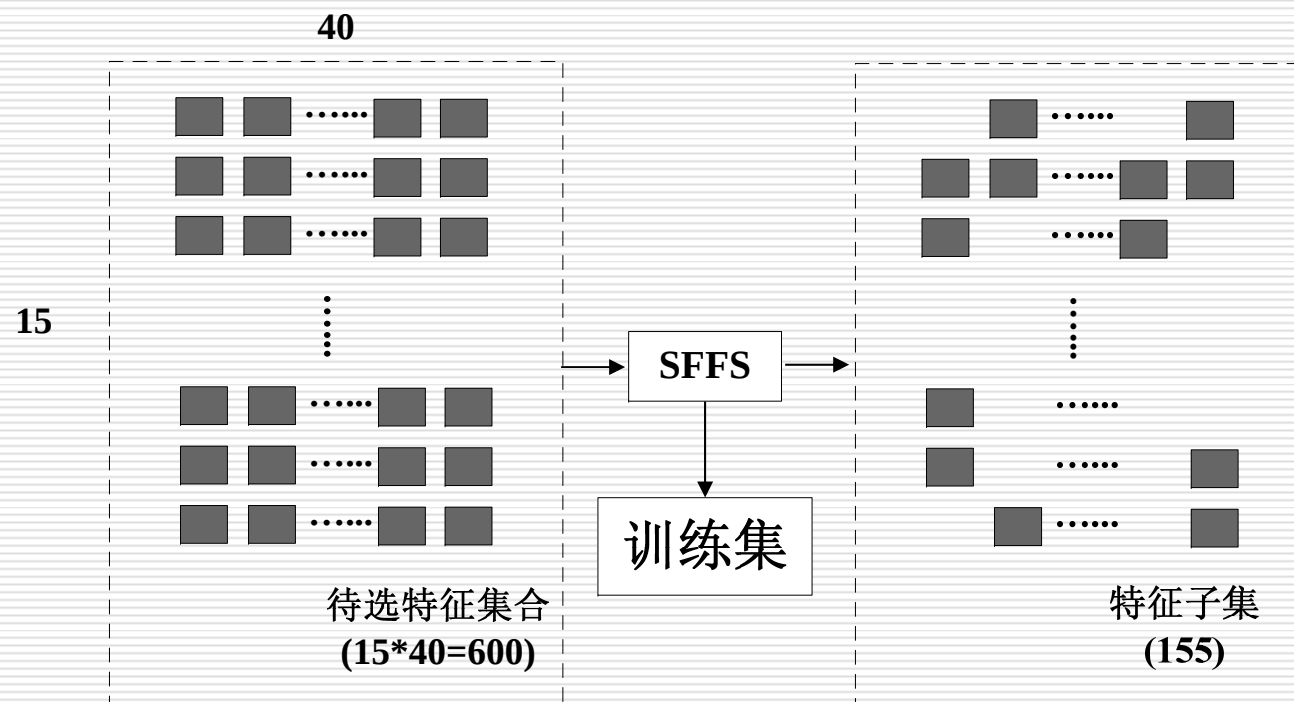


# Gabor核位置选择



40个 $16 \times 16$  Gabor核

# Gabor尺度和方向选择



| 位置  | $(v, \mu)$                                                                                 |
|-----|--------------------------------------------------------------------------------------------|
| 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 $16 \times 16$ 的二维卷积

GFC: 40个 $128 \times 128$ 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

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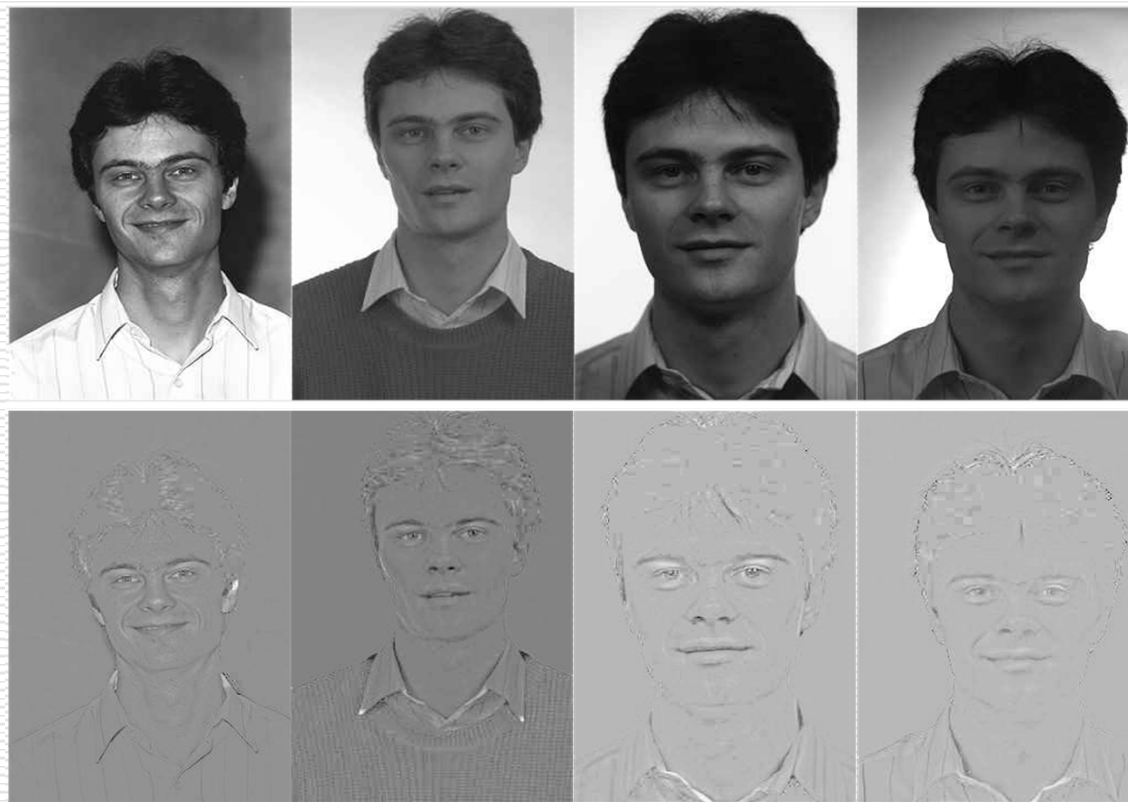
局部二值模式(Local Binary Pattern, LBP)是一种有效的纹理描述。

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)

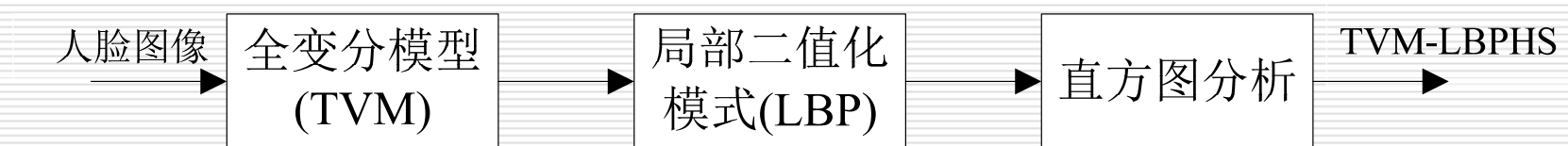
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图像的纹理：肤色背景纹理 + 及精细的轮廓纹理



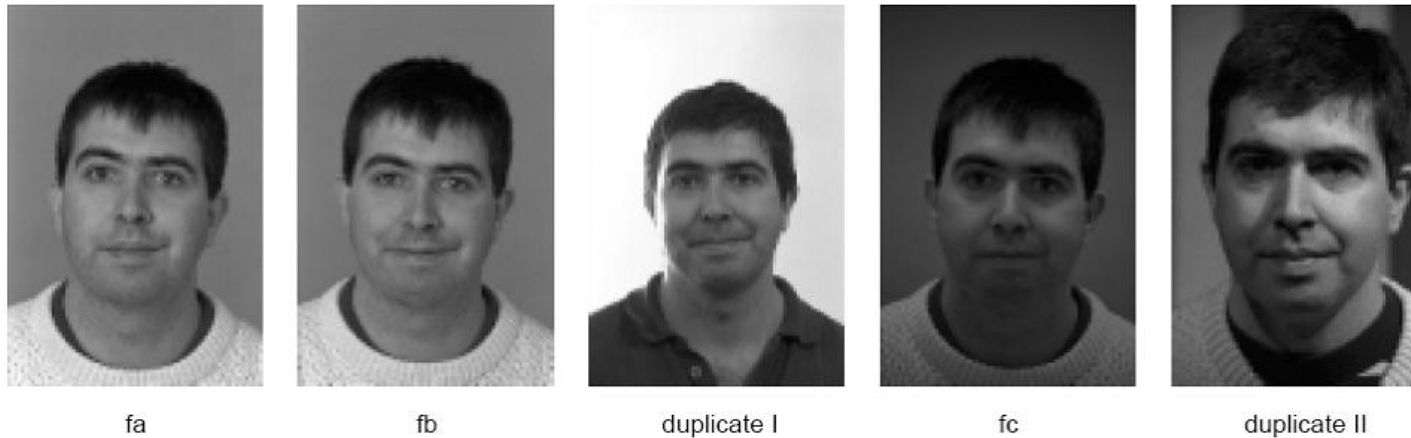
# TVM-LBP特征提取过程

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# FERET人脸库

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



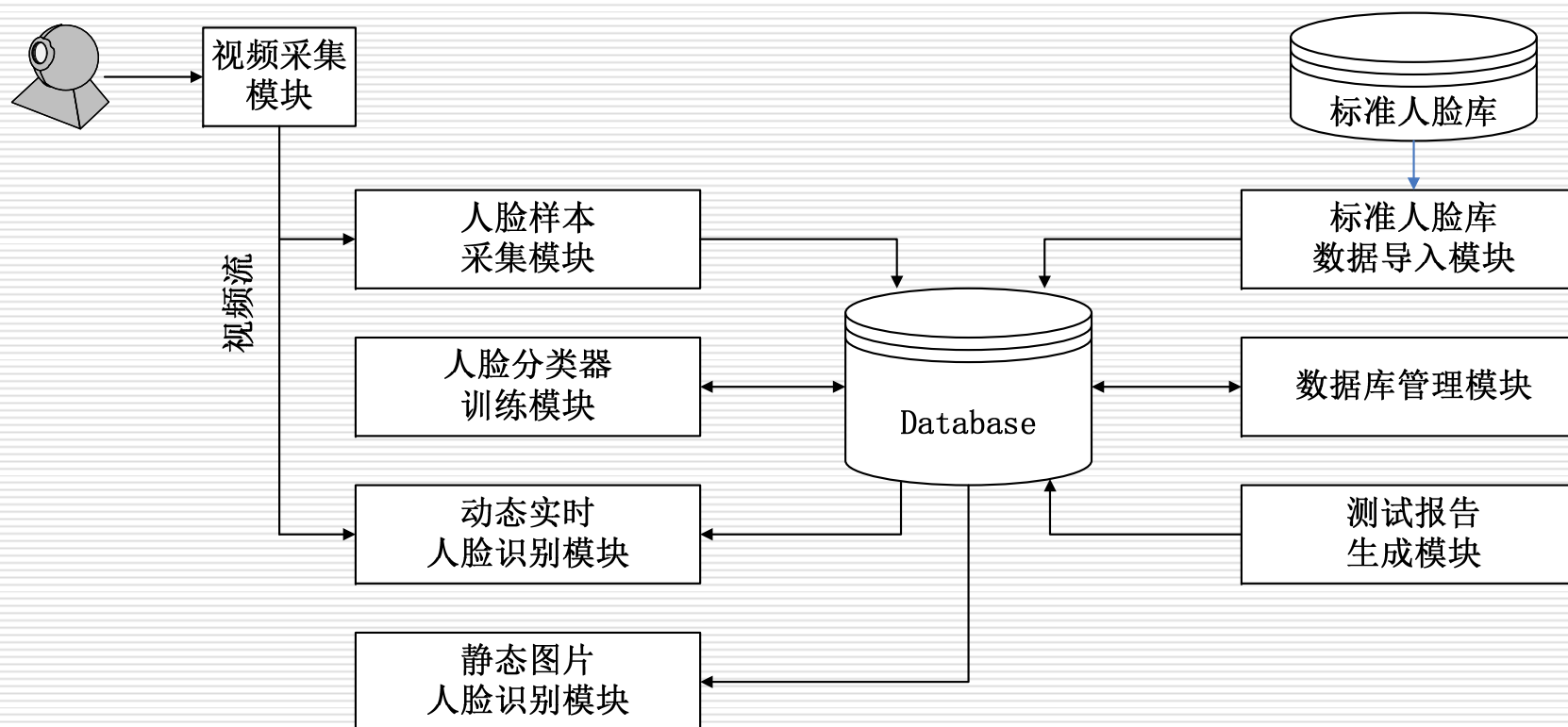
## 实验比较

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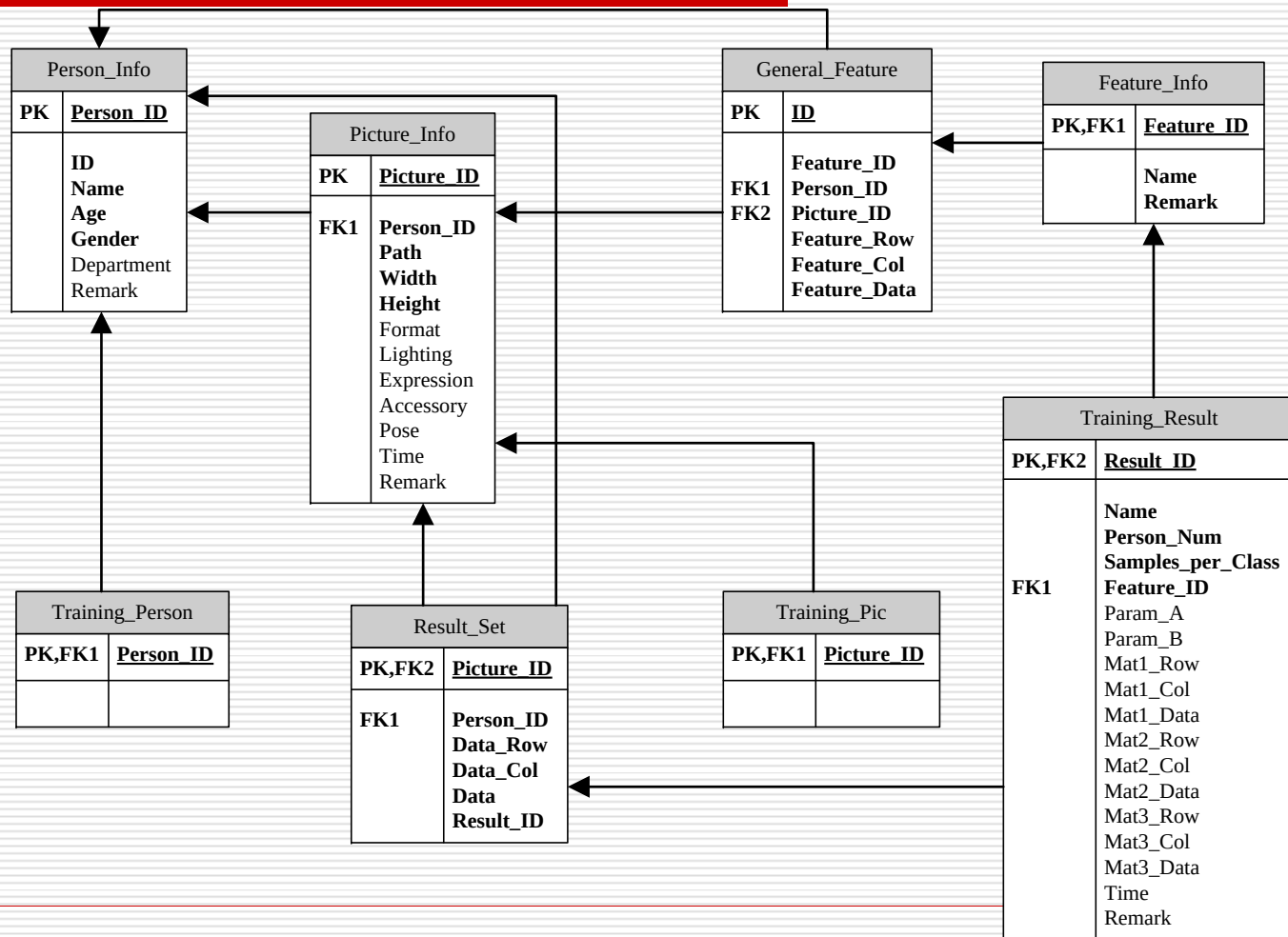
|              | fb(%)              | fc(%)              | Dup I(%)           | Dup II(%) |
|--------------|--------------------|--------------------|--------------------|-----------|
| Original-LBP | 91.3               | 50.0               | 50.0               | 31.1      |
| TVM-LBP      | <b><u>92.6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



# 开放式人脸识别体系框架

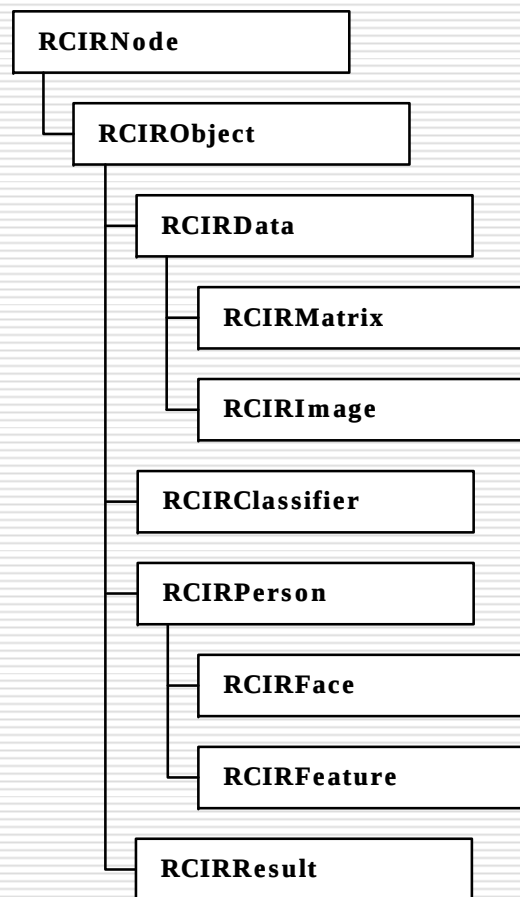


# 开放式人脸识别体系框架

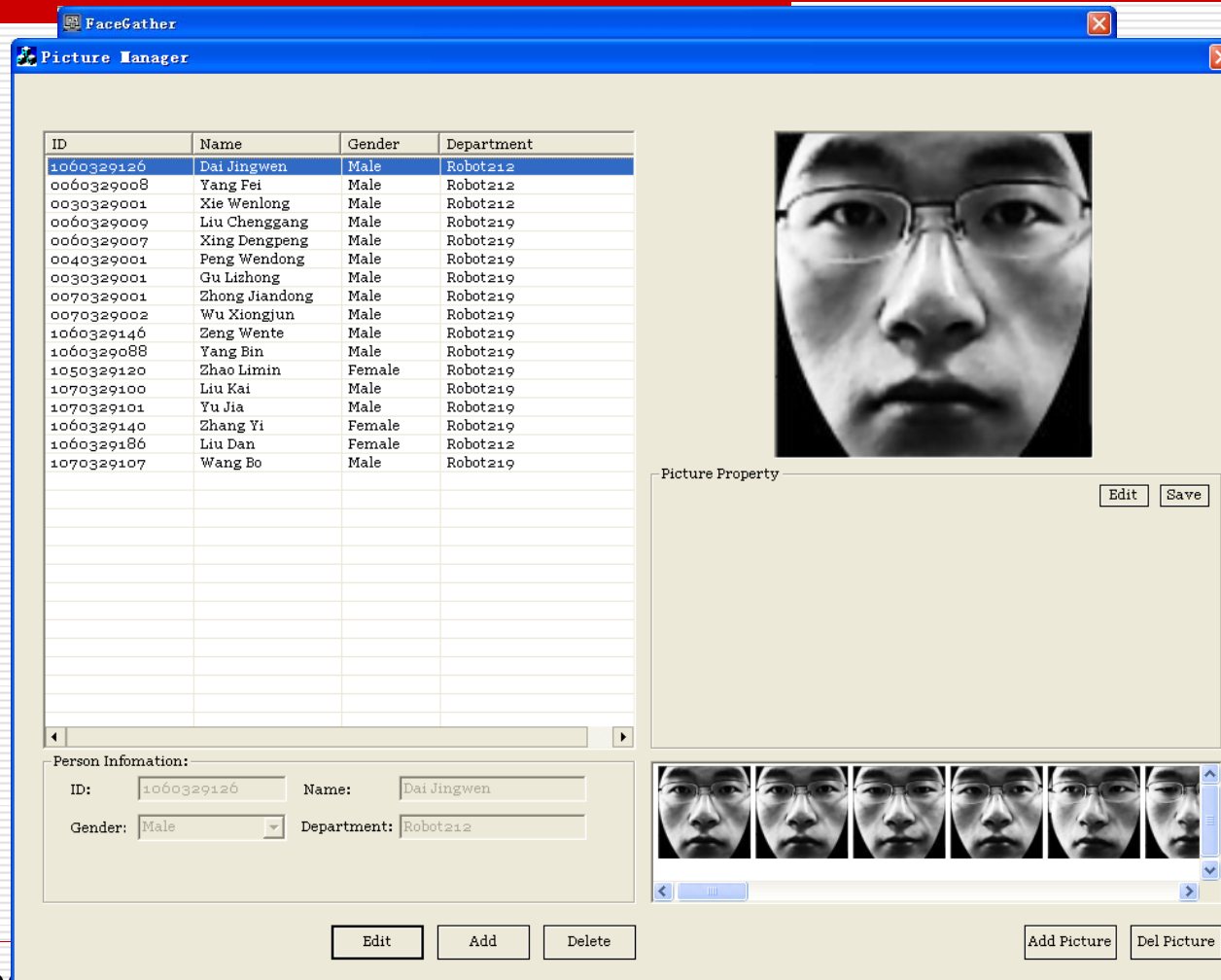


# 开放式人脸识别体系框架

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# 样本采集与管理模块



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 Jiandong |
| 0070329002 | Wu Xiongjun    |
| 1060329146 | Zeng Wentu     |
| 1060329088 | Yang Bin       |
| 1050329120 | Zhao Limin     |
| 1070329100 | Liu Kai        |
| 1070329101 | Yu Jia         |
| 1060329140 | Zhang Yi       |
| 1060329186 | Liu Dan        |
| 1070329107 | Wang Bo        |



Picture Property



General Info

Sample Numbers per Person: 6      Person Number

Training Samples

- 10 Dai Jingwen
  - ... 101\Dai Jingwen\_0001.jpg
  - ... 201\Dai Jingwen\_0002.jpg
  - ... 301\Dai Jingwen\_0003.jpg
  - ... 401\Dai Jingwen\_0004.jpg
  - ... 501\Dai Jingwen\_0005.jpg
  - ... 601\Dai Jingwen\_0006.jpg
- + 20 Yang Fei
- + 30 Xie Wenlong
- + 40 Liu Chenggang
- + 50 Xing Dengpeng
- + 60 Peng Wendong
- + 70 Gu Lizhong
- + 100 Zeng Wentu
- + 110 Yang Bin

**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

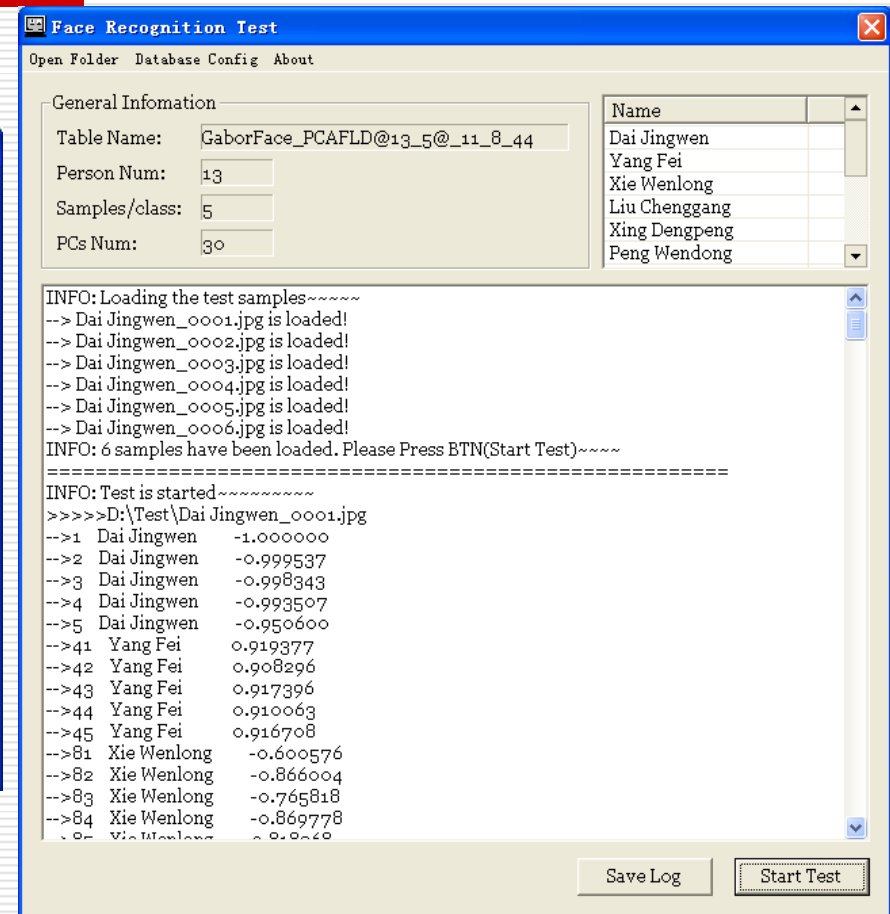
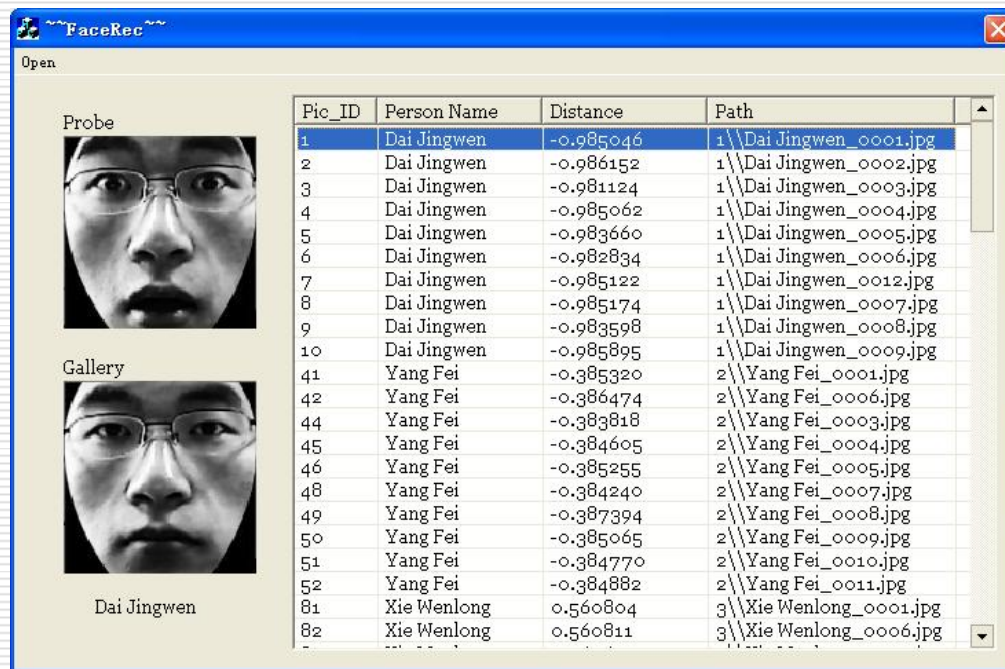
Loading the feature matrix of Picture: 125

Loading the feature matrix of Picture: 126

Loading the feature matrix of Picture: 127

01/10/2009

# 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 - Reports.xls                         |          |                    |                    |                    |                    |                   |                 |                    |                     |                    |                  |                    |                 |                    |                    |
|-------------------------------------------------------|----------|--------------------|--------------------|--------------------|--------------------|-------------------|-----------------|--------------------|---------------------|--------------------|------------------|--------------------|-----------------|--------------------|--------------------|
| 文件(F) 编辑(E) 视图(V) 插入(I) 格式(O) 工具(T) 数据(D) 窗口(W) 帮助(H) |          |                    |                    |                    |                    |                   |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| E26      宋体      10      B      I      U      100%    |          |                    |                    |                    |                    |                   |                 |                    |                     |                    |                  |                    |                 |                    |                    |
|                                                       | 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                                                     | 顾立志      |                    |                    |                    |                    |                   |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 7                                                     | 顾佳麒      |                    | 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                                                    | 彭文东      |                    | 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                                                    | 谢文龙      |                    |                    |                    |                    |                   |                 |                    |                     |                    |                  |                    |                 |                    |                    |
| 14                                                    | 邢登麟      |                    |                    |                    |                    |                   |                 |                    |                     |                    |                  | 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<br>L:11:15 | A:14:46<br>L:17:22 | A:18:05<br>L:22:57 | A:08:04<br>L:11:04 | 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:11:46 L:17:17    | A:23:01         | A:09:15            | A:12:01            |
| 18                                                    | 曾温特      | A:09:29            | A:17:10            |                    | A:08:33            |                   |                 | A:09:05            | A:17:13             |                    | A:09:07          | A:17:16            |                 | A:09:16            |                    |
| 19                                                    | 张凯       |                    | A:17:20            | A:21:02            | A:08:45<br>L:11:13 | A:18:50 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                                                    |          |                    |                    |                    |                    |                   |                 |                    |                     |                    |                  |                    |                 |                    |                    |

11/10/2005

REK@5510

数字

34

# 统计分析

