

# Digital Image Processing

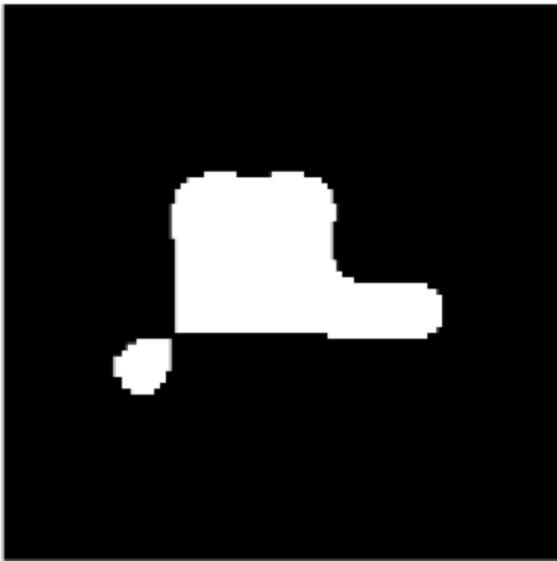
## CS390S

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2018 Spring

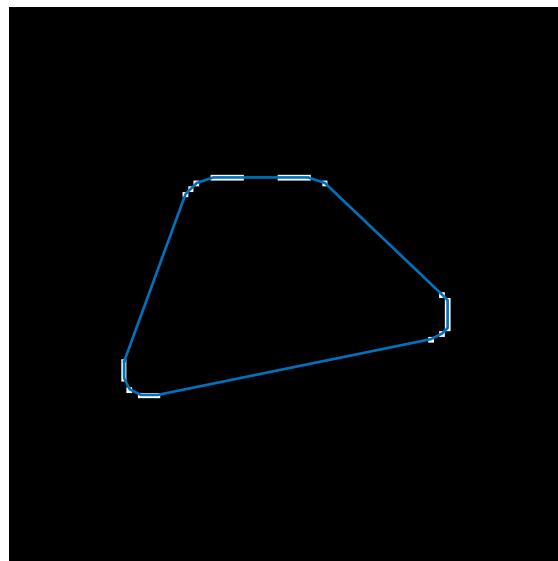


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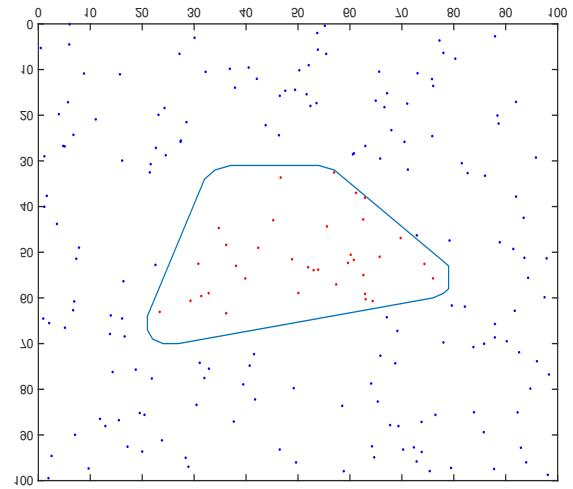
# Exercise-convex hull



A test matrix



Convex hull of the test matrix



Classification result of  
random points

# Exercise-convex hull

- **Test image generation**
  - “convexhull\_input.m”
- **Convex hull calculation “convhull()” function**
  - e.g.  $k=\text{convhull}(xt,yt)$
- **Show pixels on the convex hull**
  - `imshow()` and `plot()`
- **Generate random points and check if they are inside or outside of the hull**
  - `Inpolygon()` function and example code “`PolygonTest.m`”

# Face Recognition



**How do you differentiate these two persons?**

# Face Recognition



**How do you differentiate these two pandas?**

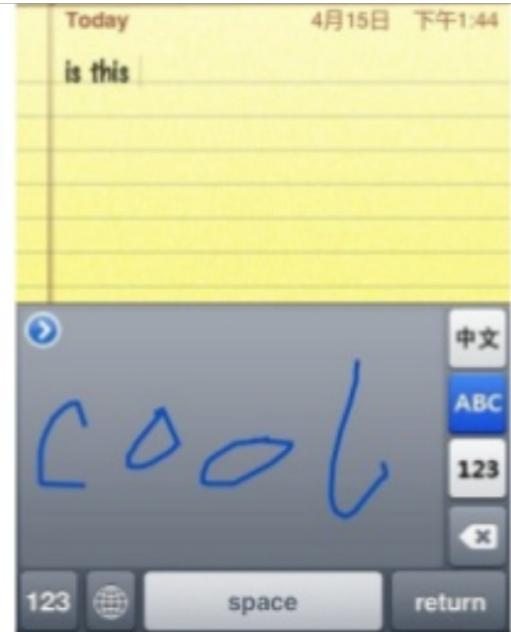
# Face Recognition

- How do you recognize a human face?
- How do you recognize an animal's face?
- How about computer?

# Face Recognition

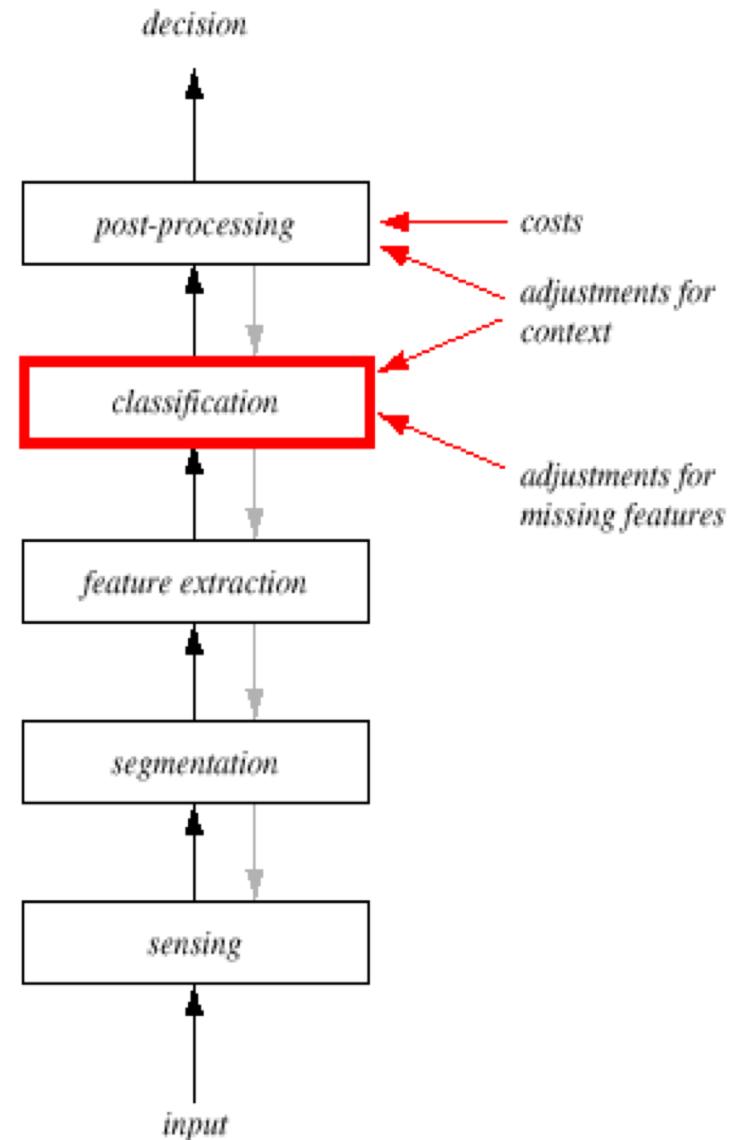
- Pattern recognition

- Task  $T$ : recognizing handwritten words within images
- Performance measure  $P$ : percent of words correctly recognized
- Training experience  $E$ : a database of handwritten words with given classifications



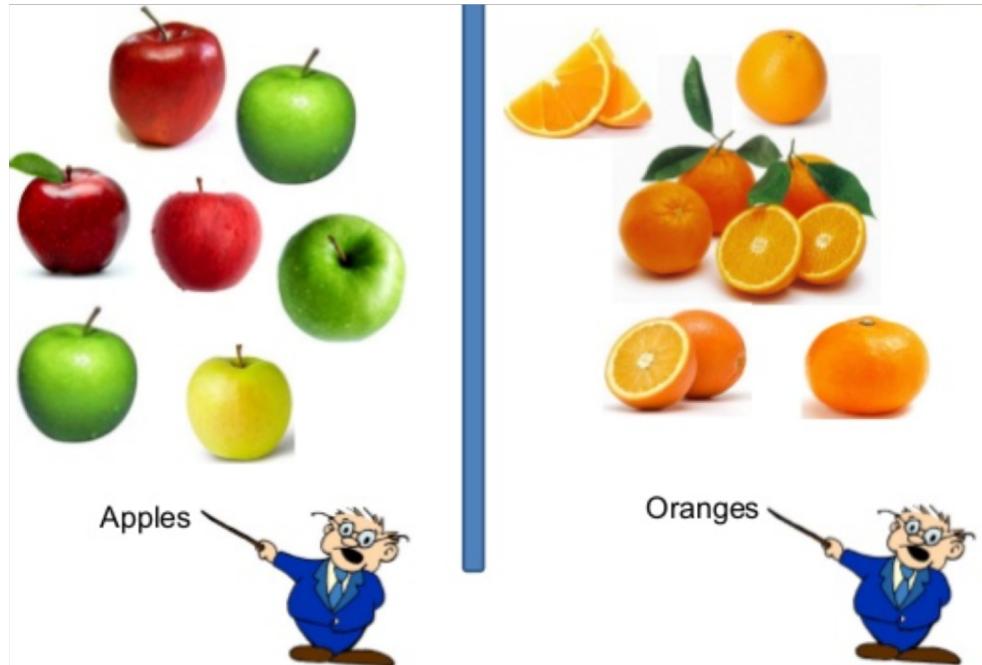
# Face Recognition

- Pattern recognition



# Face Recognition

- Pattern recognition- classification



# Face Recognition

- Pattern recognition – classification
  - Training and testing

Training examples of a person



Test images



AT&T Laboratories, Cambridge UK  
<http://www.uk.research.att.com/facedatabase.html>

# Face Recognition

- Task? Goal?

*Are they faces?*



# Face Recognition

- Task? Goal?

*Are they from same persons?*



# Face Recognition

- The Goal?
- The assumption?
- The approach?

# Face Recognition

- Challenges in face detection



# Face Recognition

- Task
- Detect full nature human face(s) in an image with reasonable resolution
  - Face(s) is (are) not covered or dramatically painted in color (i.e. They are maturely “naked” faces)
  - Frontal face(s) is (are) preferred
  - Face(s) is (are) in certain resolution/size

# Face Recognition



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# Face Recognition

- **Face detection:**
  - Face Skin Detection Approach
  - Other approaches
  - Feature extract approach
  - Neural Network approach
  - others

# Face Recognition

- **Face Skin Detection Approach**
- Use skin color properties to detect the possible skin pixels
- Use Morphology to reduce the noisy pixels
- Use knowledge of the face sizes to reduce the noisy pixels
- Detect the face

# Face Recognition

- Face detection based on skin color:

## Advantage

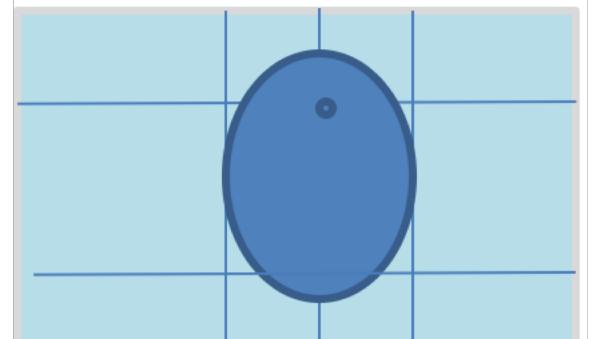
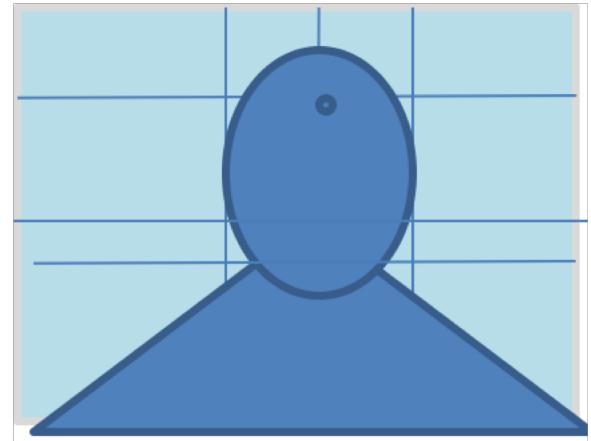
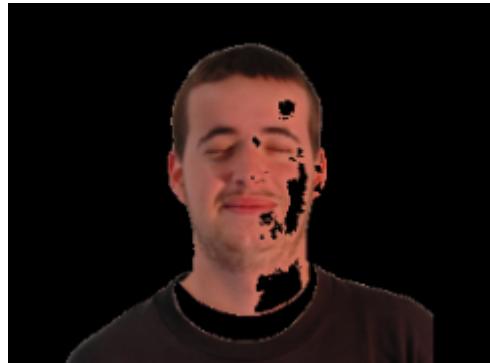
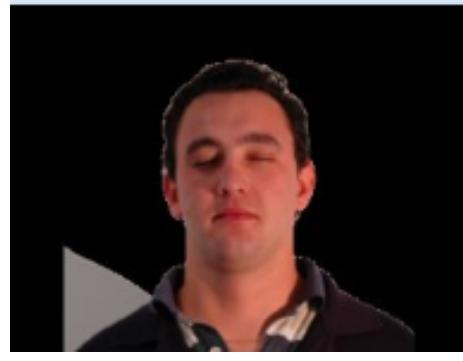
- Straightforward
- Easy to program

## Disadvantage

- Very sensitive to overall illumination
- Sensitive to background

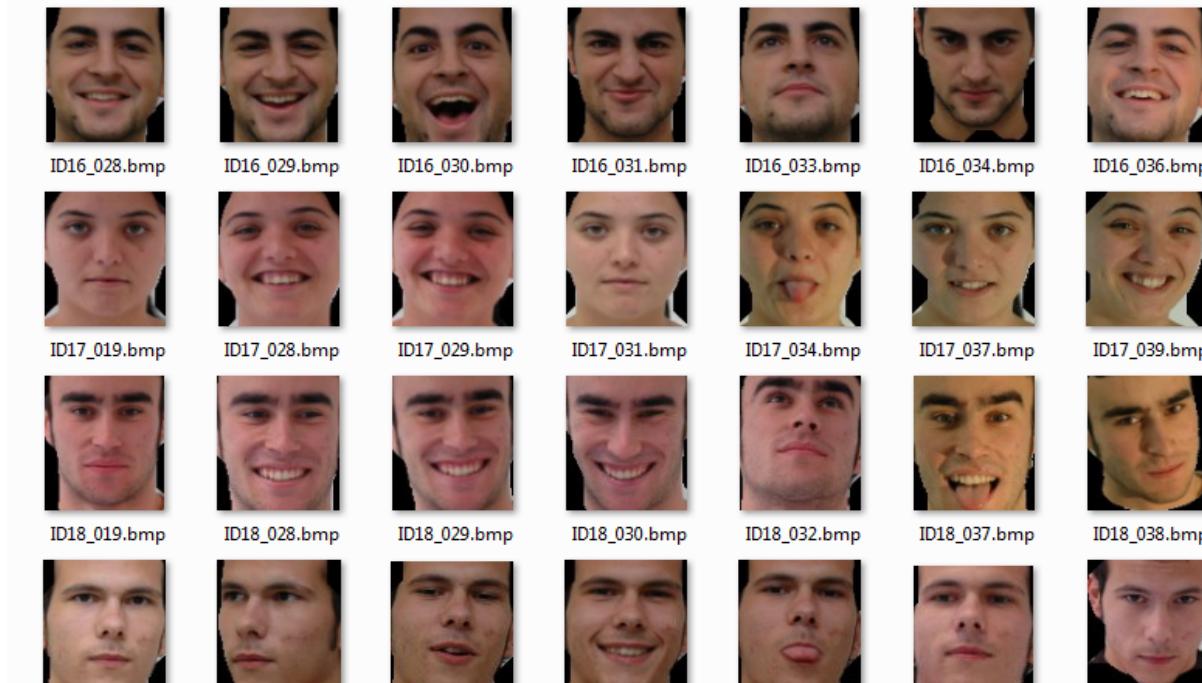
# PCA Face Recognition

- Face detection



# PCA Face Recognition

- Face detection



# Face Recognition

- **Definition:**

- Given a database of facial images with ground truth
  - Recognize an individual from an image formed from new and varying conditions (pose, expression, lighting etc.)

- **Sub-Problems:**

- **Representation:**

- How do we represent images of faces?
    - What information do we store?

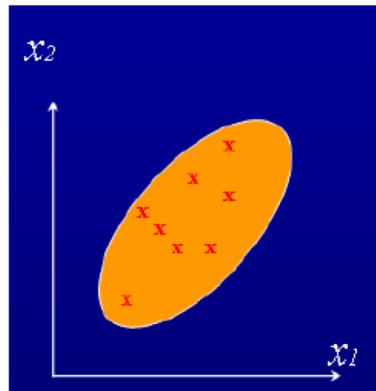
- **Classification:**

- How do we compare stored information to a new sample?
    - Search

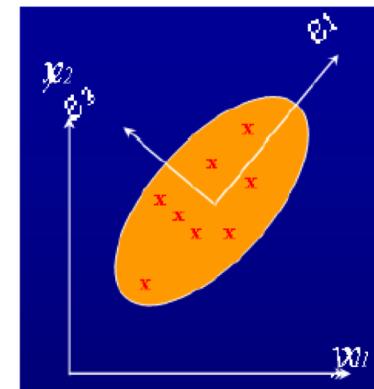
# PCA Face Recognition

- Principal component analysis
  - Eigen Face/Hotteling Transform/Karhunen-Loeve Method
- Principle: find an orthogonal coordinate system such that data is approximated best and the correlation between different axis is minimized.

# PCA Face Recognition



PCA  
→



- Define a new origin as the mean of the data set
- Find the direction of maximum variance in the samples ( $e_1$ ) and align it with the first axis ( $y_1$ ),
- Continue this process with orthogonal directions of decreasing variance, aligning each with the next axis
- Thus, we have a rotation which minimizes the correlation.

# PCA Face Recognition

## Read the two papers!

### **Given:**

M training images from m different persons with same size: row-by-col.

**Mp** = desired number of principal components, usually **Mp=m**

### **Feature Extraction Steps**

1. For each training image, change to 1 column vector, each vector will have row\*col length
2. For each person, calculate the average vector  $X_i$
3. Calculate the mean vector of all the persons in the system  $M_e = (X_1 + X_2 + \dots + X_m)/m$
4. Let  $A_i = X_i - M_e$
5. Calculate the eigen vectors of  $A^*A'$  store it as P
6. Calculate the weight of the training data projected into eigenspace  $wt\_A = P'^*A$

### **Feature Match Steps**

1. For the input image  $I_m$ , change to 1 column vector: Y
2. Calculate  $B = Y - M_e$
3. Calculate weight of the input data projected into eigenspace  $wt\_B = P'^*B$ ;
4. Calculate the euclidean distance for the input image:  $eud(i) = \sqrt{\sum((wt\_B - wt\_A(:,i)).^2)}$ ;
5. Find the smallest euclidean distance j, the input face is from person j.

# PCA Face Recognition

- Read the two papers given
- Explain the steps of PCA FR in slide