Project 1: face classification and detection

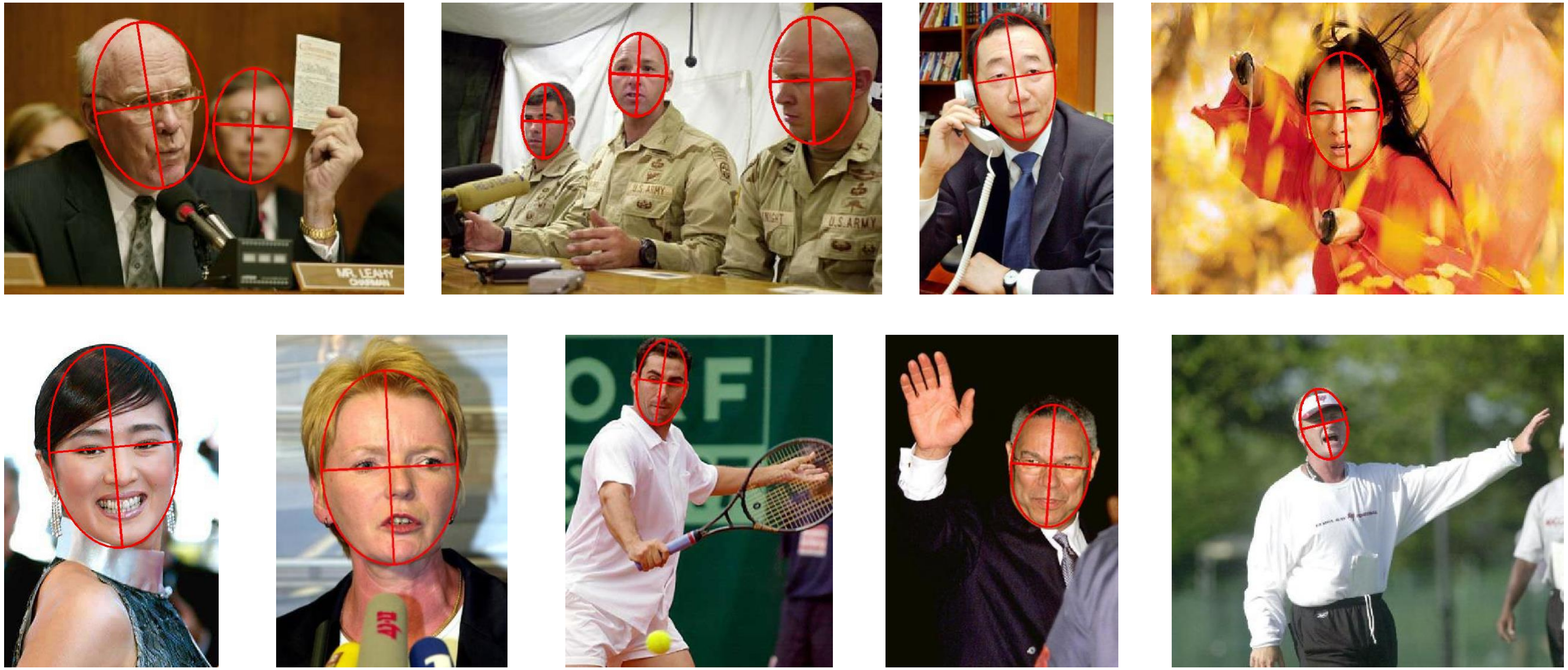
CS 385

Objective

- The objective is to help you have an deep insight of current models, including the intuition about the feature and the model, and the discrimination power of different models.
  - Implement face classification using different models
  - Implement face detection
    - Combining face classification and the sliding window
  - Visualize face features
  - Visualize models
  - Write a report

Dataset: FDDB: Face Detection Data Set and Benchmark

- A dataset before the era of deep learning
  - Relatively easy samples
- You need to download the data from http://vis-www.cs.umass.edu/fddb/
  - Training images
  - Face annotations

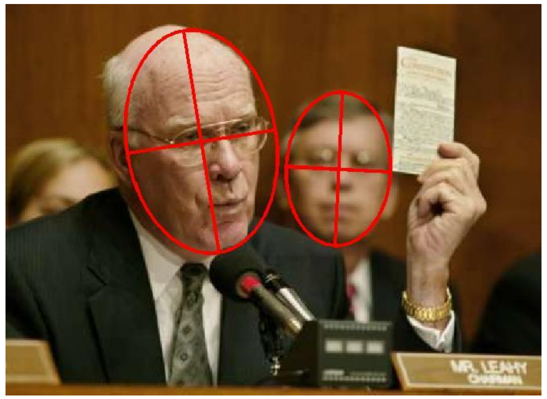


Most faces are captured from a frontal view without a significant rotation.

Face classification

- Given training samples and their labels $\{x_i, y_i\}$
- For the input face image x_i
  - 5171 faces in a set of 2845 images taken from the Faces in the Wild data set.
  - There are ten annotation folders
    - FDDB-fold-01, FDDB-fold-02, ⋯, FDDB-fold-10
  - **Please use face images in the first eight folders as training samples, and use face images in the last two folders as testing samples.**

Face classification

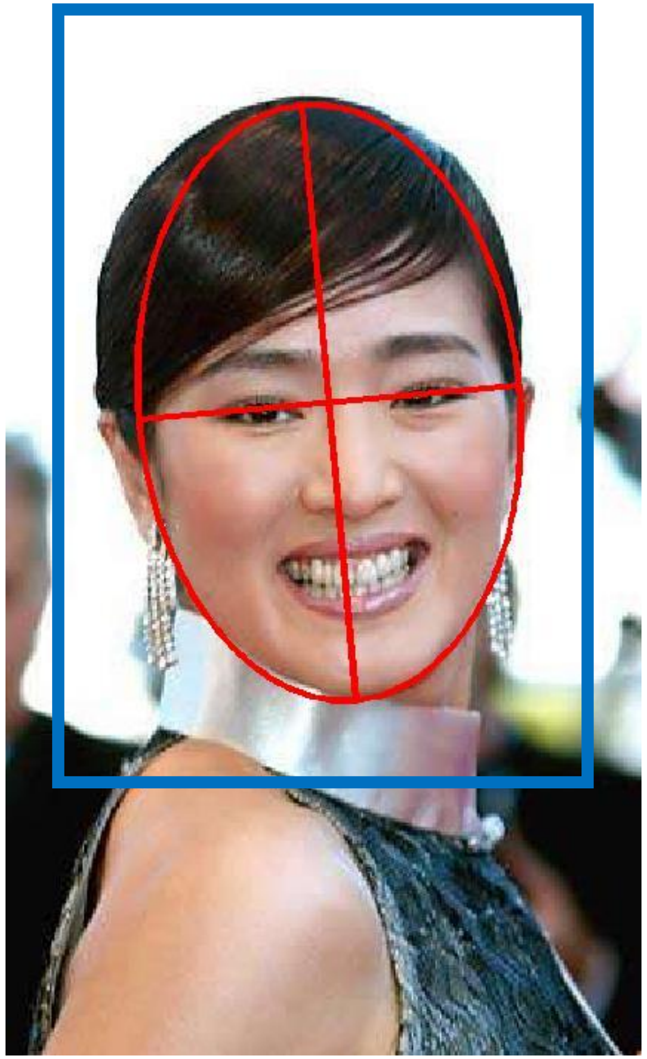


- For the input face image x_i
  - Annotations on each image are represented as follows
    - <image name i>
    - <number of faces in this image =im>
    - <face i1>
    - <face i2>
    - …
    - <face im>
  - Each face <face im> is annotated as
    - <major_axis_radius minor_axis_radius angle center_x center_y 1>

```
2002/07/28/big/img_416
3
60.933903 44.468305 -1.530098 98.276900 82.268230  1
52.564676 35.774346 -1.460712 321.103651 63.475043  1
23.958142 18.064426 1.553739 364.859591 103.521632  1
2002/08/07/big/img_1393
2
163.745742 109.136126 1.236962 132.225074 172.180404  1
134.196339 96.693777 -1.276447 204.178610 271.741124  1
2002/08/26/big/img_292
1
163.778521 101.169600 1.543931 148.203875 181.913193  1
```

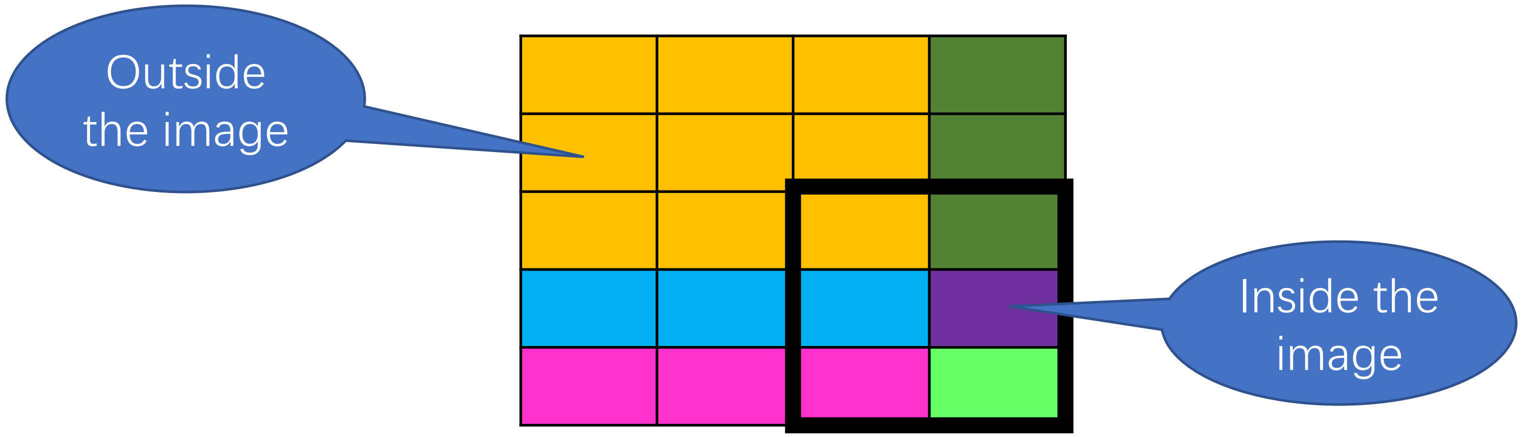
Face classification

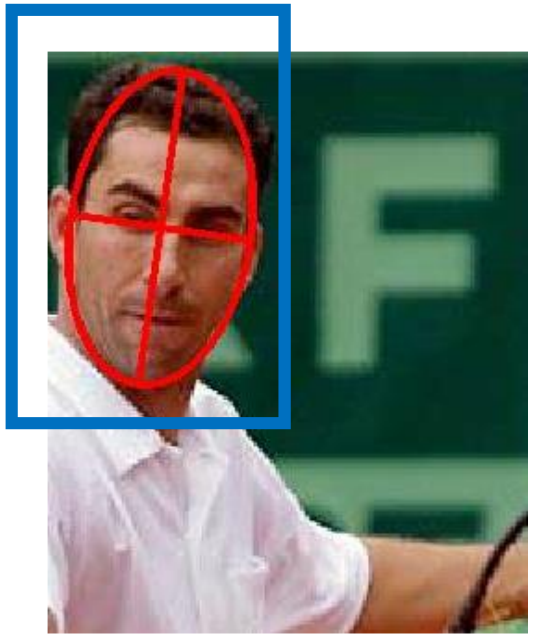
- For the input face image x_i, we need to simplify the data input
  - Use a rectangle **without** any rotations
  - We extend the scale of the bounding box by 1/3
    - Width = (horizontal axis $*$ 2) $*$ (1+1/3)
    - Height = (horizontal axis $*$ 2) $*$ (1+1/3)
  - Crop the face within the bounding box as a positive sample.



Face classification

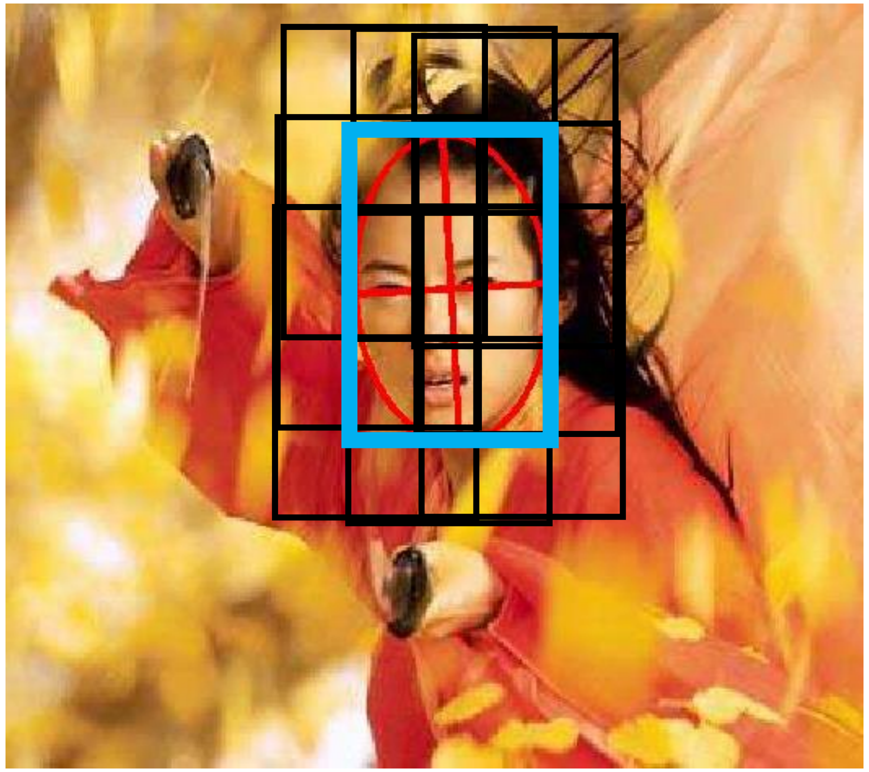
- What if the face is on the border of the image?
  - Please fill the empty space using the nearest pixel.





Face classification

- Given training samples and their labels $\{x_i, y_i\}$.
  - For each face image, i.e., a positive image, $y_i = +1$
  - For each negative image, $y_i = -1$
- How to generate negative images?
  - 1. Resize original images into 96 x 96 pixels
  - 2. For simplicity, please generate eight negative images based on each face by sliding the bounding box by 1/3
  - Using face images in the first four folders to generate negative images for training.
  - Using face images in the last one folders to generate negative images for testing.



Face detection

- Enumerate all potential bounding boxes of faces
  - At all locations
  - Using all scales
- Use the face classifier to identify the true face from the background.

To do

- Resize all samples (including clipped faces and negative samples) into 96 pixels x 96 pixels
- Extract HOG features from each sample using Matlab
    - Paper for HOG features
        - http://www.cs.toronto.edu/~fleet/courses/2503/fall11/Handouts/cvpr05.pdf
    - Extract HOG features using Matlab
        - https://www.mathworks.com/help/vision/ref/extracthogfeatures.html
        - Block size = 2 x 2
        - Cell size = 16 x 16
        - Number of bins = 9
        - Block overlap =1 x 1
        - → in this way, you may extract a 900-d feature vector from each sample.
    - You may also select other platform to extract HOG features
    - You may save and transfer the extracted HOG features to another platform, if the platform for feature extraction is different from that for model learning.

To do

- Visualize bounding boxes of positive and negative samples on images.
- Visualize the extracted HOG features
    - Please see https://www.mathworks.com/help/vision/ref/extracthogfeatures.html if you extract HOG features using Matlab
    - Show the original image on the left and the HOG feature on the right
- Learning a logistic model for classification
    - Optimizing the model via SGD
    - Optimizing the model via Langevin dynamics
    - Report the accuracy
    - Do not use off-the-shelf codes

To do

- Learning a fisher model for classification
  - Report the accuracy, the intra-class variance and the inter-class variance
  - Do not use off-the-shelf codes
- Learning SVMs for classification
  - Learning a linear SVM
  - Learning an RBF SVM (with RBF kernel) for classification
  - Learning a SVM with another kernel
  - Report the accuracy
  - List samples of support vectors (i.e., the samples whose the margin =1)
  - You may use off-the-shelf codes to train the SVM
- Learning convolutional neural networks for classification
  - I will introduce this in several weeks
- Visualize face detection results and feature distribution
  - Based on logistic model, linear SVM, RBF SVM, CNN
  - Visualization of the feature distribution will be introduced later.

Submit

- A report for this project
- Code
  - **Do not copy others' codes**
    - **The teaching assistant will check the code.**
  - **Make sure your code can run**
    - **I will randomly run codes of 30% students.**
  - **Do not create numbers without writing a code**