Introduction To Computer Vision

- Text book
  - Computer Vision
    - Linda G. Shapiro and George C. Stockman
    - Prentice-Hall 2001.
  - Pattern Classification
    - R.O. Duda, P.E. Hart and D.G. Stork
    - Wiley-Interscience Publication, 2001
    - 2nd Edition
  - Pattern Recognition
    - S. Theodoridis and K. Koutroumbas

Introduction To Computer Vision

- Tentative Grading
  - Homework 10%
  - Min-term examination 40%
  - Final-term examination 40%
  - Term project (Implementation) 10%

Introduction To Pattern Recognition

- Tentative Grading
  - Homework 20%
  - Min-term examination 40%
  - Final-term examination 40%

    or Term project (Implementation)

Introduction To Pattern Recognition

- *A basic problem: how to recognize a person ?*

1. Color 2. Weight 3. Shape 4. Texture 5. Height/Weight Ratio

6. Face 7. Fingerprint 8. IRIS 9. DNA

Approaches to do PR:

a. Statistical

b. Syntactic

Concave or Convex ?

Generative and Discriminative methods ?

- Bayesian Rule

x: Unknown data C_k: class to be labeled

Posterior probability Likelihood function Prior probability

$$p(C_k \mid x) = \frac{p(x \mid C_k)\, p(C_k)}{p(x)}$$

Evidence

Generative and Discriminative methods ?

Depend on which model is chosen:

$p(C_k|x)$ *or* $p(x|C_k)$

- Generative approach

$$p(C_k \mid x)$$

- Discriminative approach

$$p(x \mid C_k)$$

Generative vs. Discriminative Models

- 生成方法(generative approach)

1. separately model class-conditional densities $p(x|C_k)$ and priors $p(C_k)$
2. then evaluate posterior probabilities using Bayes' theorem

$$p(\mathcal{C}_k|\mathbf{x}) = \frac{p(\mathbf{x}|\mathcal{C}_k)p(\mathcal{C}_k)}{\sum_j p(\mathbf{x}|\mathcal{C}_j)p(\mathcal{C}_j)}$$

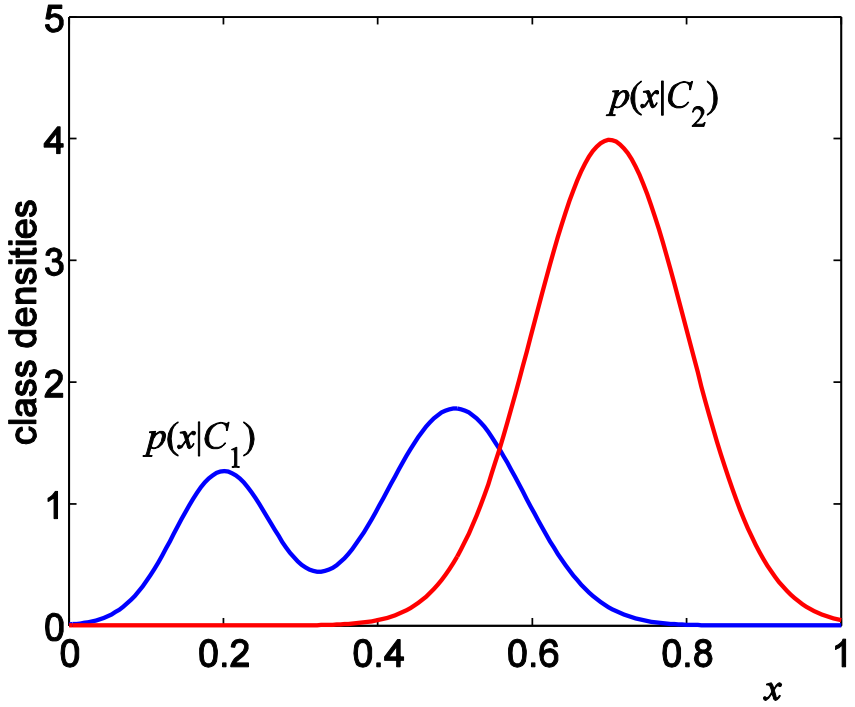
$$where\ p(x) = \sum_i p(x|C_j)p(C_j)$$

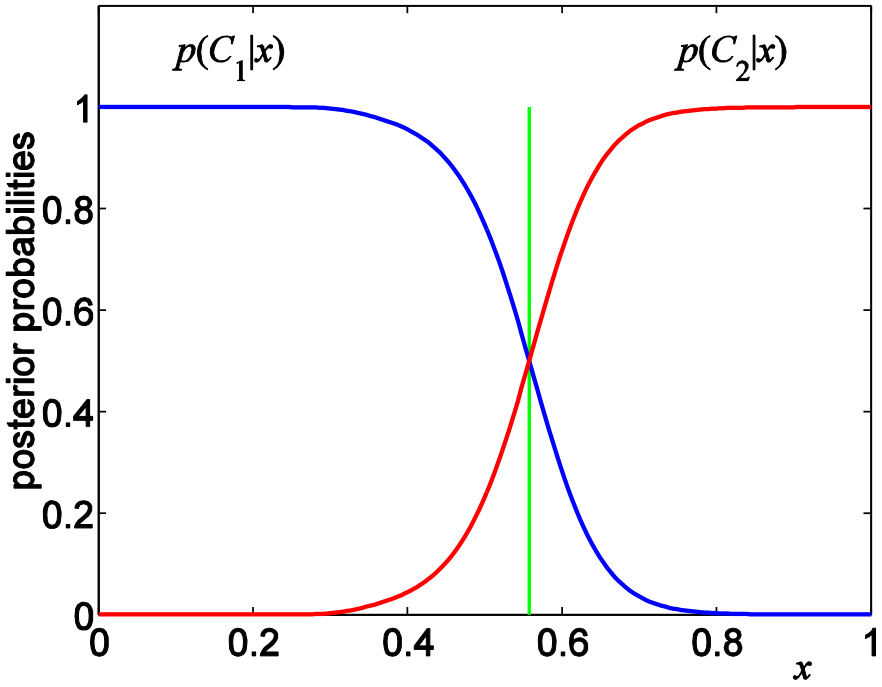
Generative vs. Discriminative Models

- 辨別方法(Discriminative approach): directly model posterior probabilities

$$p(x \mid C_k)$$

Generative vs. Discriminative





Generative Approach

- **Advantage:**
  - Relatively straightforward to characterize invariances
  - They can handle partially labelled data
- **Disadvantage:**
  - Wastefully model variability which is unimportant for classification
  - Scale badly with the number of classes and the number of invariant transformations (slow on test data)

判別方法

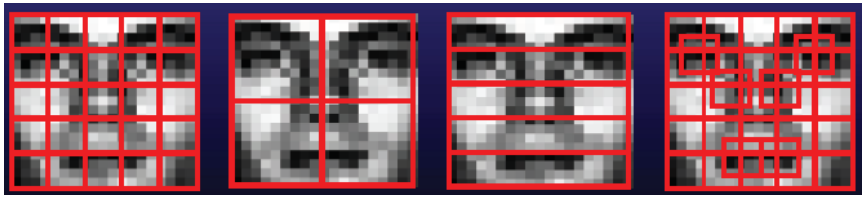
- **Advantage:**
  - Use the flexibility of the model in relevant regions of input space
  - Very fast once trained
- **Disadvantage:**
  - Interpolate between training examples, by assuming all the classes are equally distributed
  - Don’t easily handle variations in the same class (e.g. faces can have glasses and/or moutaches and/or hats)

Object Detection and Tracking

- Face Detection
  - Using Neural Network Algorithm
  - Using SVM Algorithm
  - Using AdaBoosting Algorithm
- Face Feature

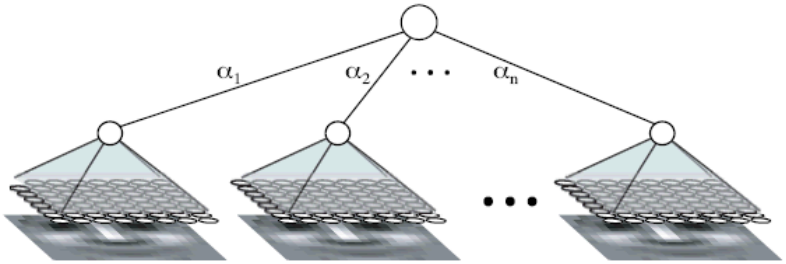
24x24 pixel gray scale images

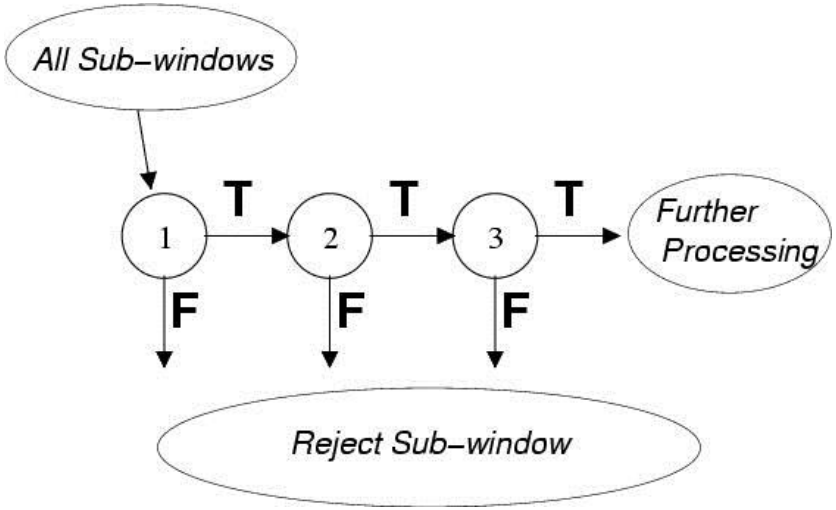
Number of Features = **16233**



Object Detection and Tracking

- Ada Boosting
  - Weak Learner





After learning, a set of weights can be obtained to form a new learner.

Vehicle Detection

- Most methods using image differencing to detect vehicles.
  - We propose a new color-based algorithm to detect vehicles.
- Problem: vehicles have various colors, e.g., red, black, white, yellow,…
- Procedure to find vehicle color model:

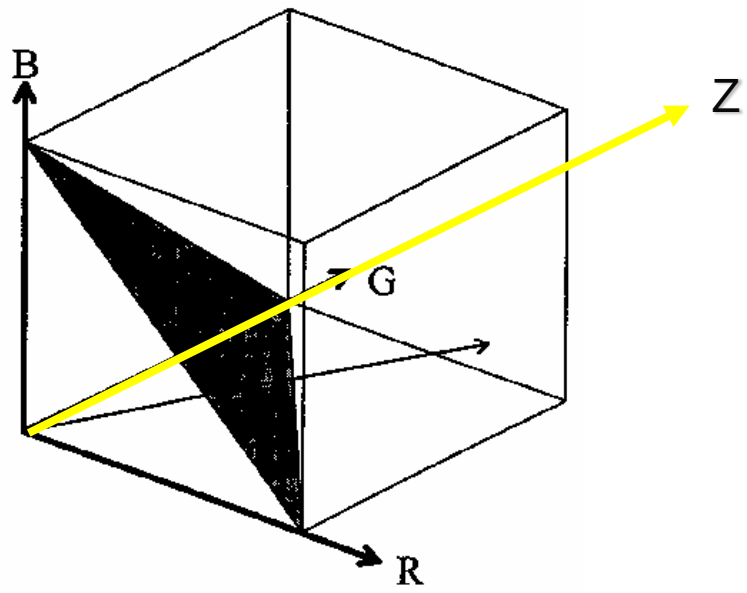
A. Collect a lot of vehicle images.

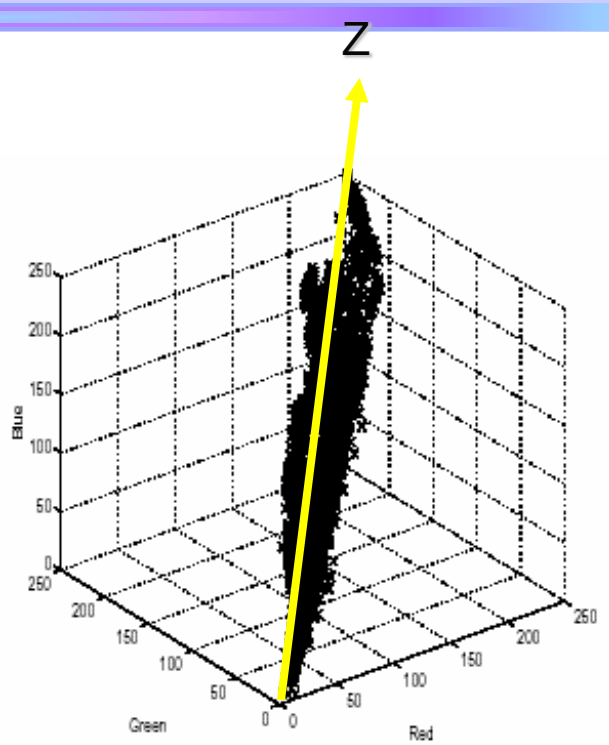
B. Use PCA to find three eigenvectors with the most larger three eigenvalues.

(IEEE ITS, revised)

Vehicle Detection

- Vehicle Detection





Vehicle Detection

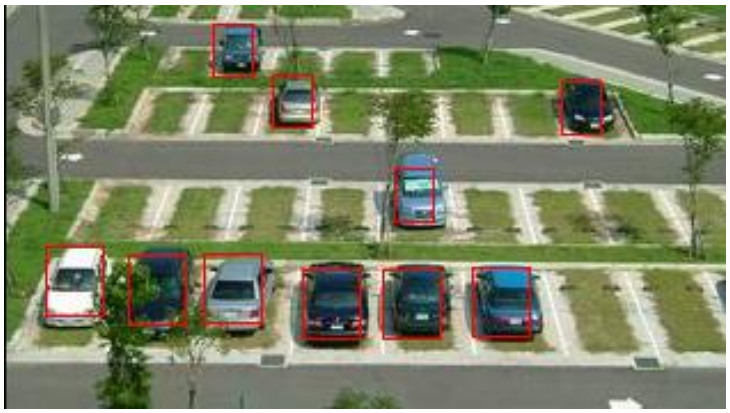
- Detection of vehicle color

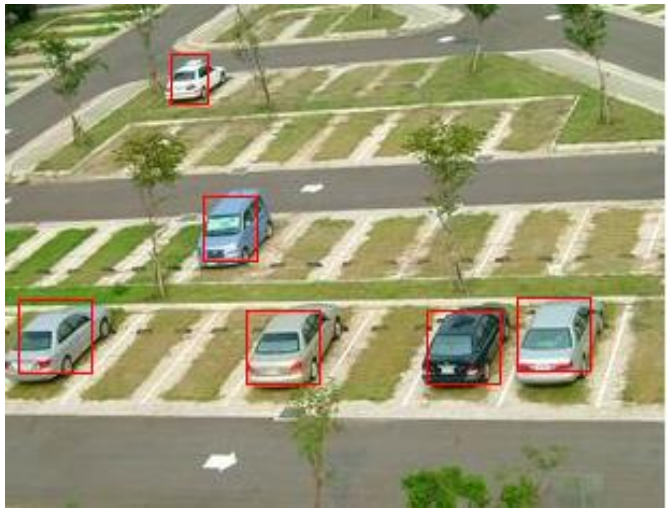
Vehicle Detection

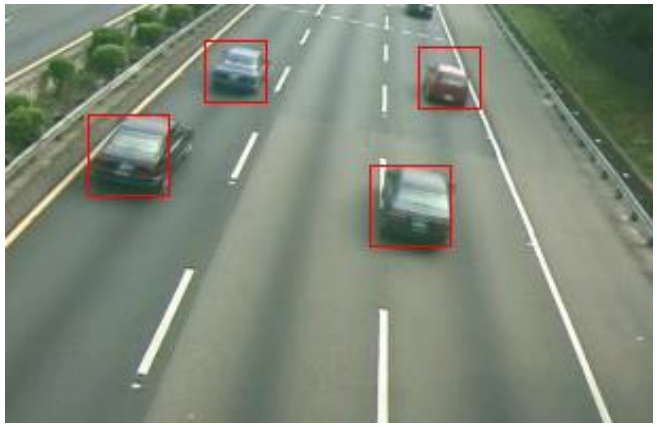
- Detection of vehicle color

Vehicle Detection

- This verification also can be achieved by SVM or Ada-boosting.







Airplane Detection

Plane size is too small

Airplane Detection

- **Using Hausdorff Distance and SVM**

Introduction To Computer Vision

Some Applications

Domain	Data Mining	Document Classification	Computing Biology	Industrial Applications	Speech Recognition
Application	Finding meaningful pattern	Internet Search	Sequence analysis	Printed board inspection	Automatic operator
Input	Points in high-dimen space	Text Document	DNA Protein Sequence	Intensity images	Speech waveform
Classes	Good Cluster	Semantic categories	Known gene protein types	Defective nondefective	Spoken words

Introduction To Computer Vision

- Important academic references
  - Reference journals
    - Pattern Recognition (PR)
    - Pattern Recognition Letters (PRL)
    - IEEE Trans. Pattern Analysis and Machine Intelligence (IEEE PAMI)
    - IEEE Trans. System, Man and Cybernetics (IEEE SMC) (Part A, Part B)
    - IEEE Trans. Image Processing (IEEE IP)

Introduction To Pattern Recognition

- Important academic references
  - Reference journals (Cont.)
    - IEEE Trans. Circuits and Systems for Video Technology
      (IEEE CSVT)
    - Computer Vision and Image Understanding
      (CVIU)
    - Graphical Modeling
      (GM)
      (Graphical Modeling and Image Processing)

Introduction To Computer Vision

- Important academic references
  - Reference journals (Cont.)
    - Image and Vision Computing (IVC)
    - International Journal of Computer Vision (IJCV)
    - Machine Vision and Applications (MVA)

Introduction To Computer Vision

- Important academic references
  - Reference journals (Cont.)
    - IEEE Trans. Information Theory (IEEE IT)
    - IEEE Trans. Neural Networks (IEEE NN)
    - Neural Networks (NN)
    - 影像與識別
中華民國影像處理與圖形識別會刊
(IPPR)

Introduction To Computer Vision

- Important academic references
  - Conferences
    - International Conference on Pattern Recognition (ICPR)
    - International Conference on Image Processing (ICIP)
    - IEEE International Conference on Computer Vision (ICCV)
    - IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR)

Introduction To Computer Vision

- Important academic references
  - Conferences (Cont.)
    - International Joint Conference on Neural Networks (IJCNN)
    - IPPR Conference on Computer Vision, Graphics and Image Processing (國內)
    - International Computer Symposium (ICS or NCS, 國內)

Introduction To Computer Vision

- Course outline
  - Advanced Computer Vision
    - Moments and Thresholding
    - Tracking
    - Region Features
    - Shape Descriptions
    - Face Detection
    - Trademark Indexing
    - Video Coding
    - MPEG4
    - License Plate Detection
    - Object Segmentation
  - Pattern Recognition