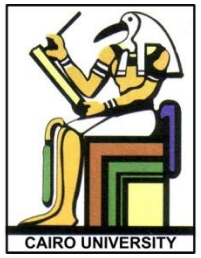
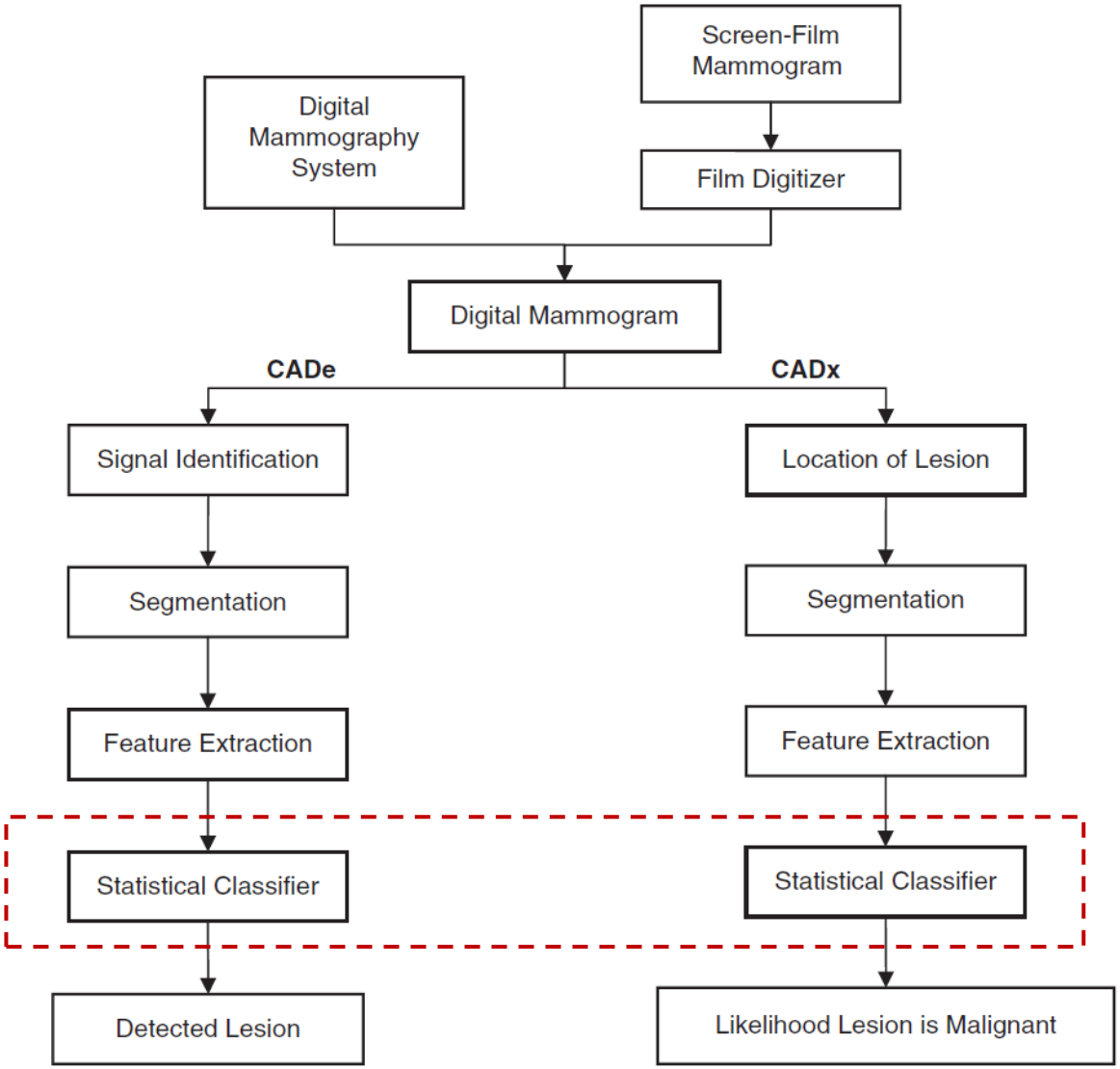


ADVANCED TOPICS IN BIOMEDICAL ENGINEERING

Topic 6: Classification

Prof. Yasser Mostafa Kadah

CAD


Screen-Film Mammogram
Digital Mammography System
Film Digitizer
Digital Mammogram
CADe
CADx
Signal Identification
Location of Lesion
Segmentation
Segmentation
Feature Extraction
Feature Extraction
Statistical Classifier
Statistical Classifier
Detected Lesion
Likelihood Lesion is Malignant

Classification Assumptions

- There is a visible difference between normal and abnormal images
  - If you cannot see consistent differences, you cannot program a CAD system to see them
  - Training set with normal and abnormal cases of interest
- Features selected describe such difference effectively
  - Irrelevant features will only confuse and misguide the CAD system
- Normal and abnormal cases form distinct clusters that are somewhat apart according to a distance measure
  - Cases from the same pathology are represented by points in feature space that with smaller distance separation than with cases from other pathologies
  - “Intra-cluster” distance is significantly smaller than “Inter-cluster” distance

Classifiers: Model

- Parametric classification
  - Assumed a certain distribution for data clusters (e.g., Gaussian)
  - Estimates model parameters from the data
  - Uses this a priori information to design the classification method and estimate its parameters
  - Good if model is correct but bad if not (difficult to know ahead)
- Non-Parametric classification
  - Does not assume or impose any model on the data
  - "Model-Free" or "Data-Dependent"

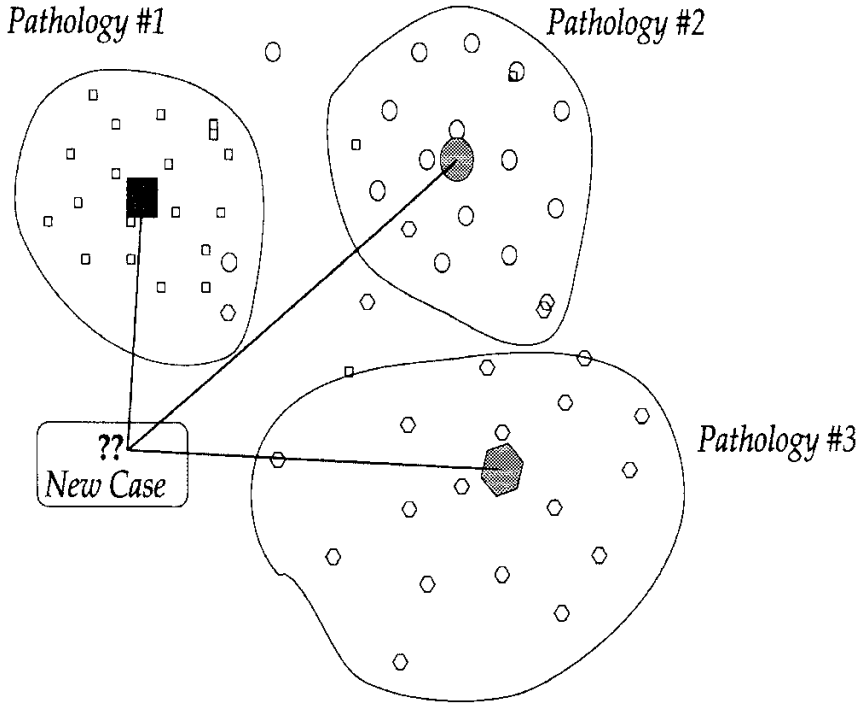
Classifiers: Learning

- Supervised classifiers
  - Classifiers are trained with data samples of known labels
  - Number of clusters known a priori and cannot be changed
  - Relies on “trainer” to provide the correct information

- Unsupervised classifiers
  - Classifiers are trained with data samples with unknown labels
  - Discover underlying clusters according to particular criteria
  - Interesting to identify new clusters representing sub-classes within large normal or pathological classes

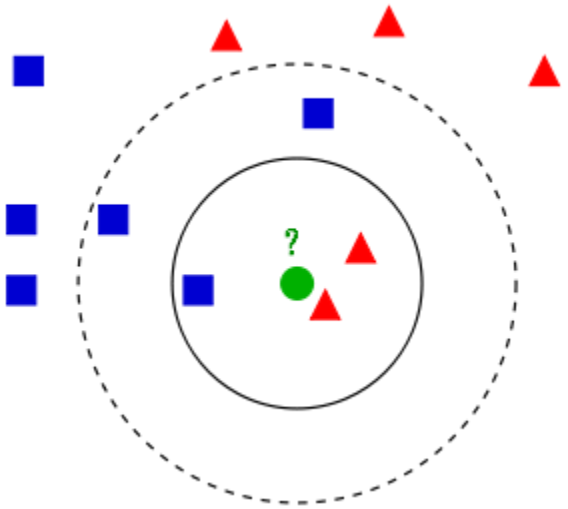
Minimum Distance Classifier

- Idea: Compute the distance between unknown case and the center of known clusters and assign the case to the closest cluster
  - How to compute cluster centers
  - Distance computation
  - Simple but not good in many cases



K-Voting Nearest Neighbor

- Assumption: an unknown case is likely to belong to the class of its neighbors in space
- Idea: Find the K neighbors of the unknown case and make a majority vote among them and assign the case to the pathology of the majority
  - Select K in such a way to avoid "ties": e.g., odd number for binary classification
  - Special case: K=1 – Nearest Neighbor Classifier
  - Matlab function "knnclassify"

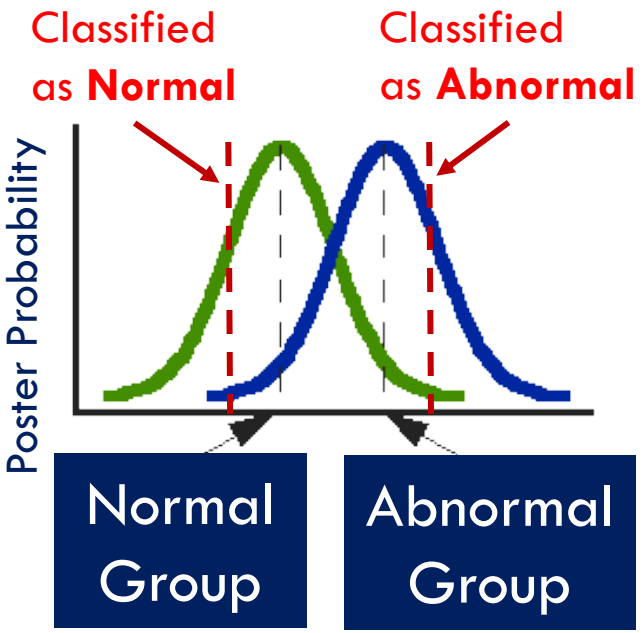


Naïve Bayesian Classifer

- Idea: Assign the unknown case to the class of largest posterior probability

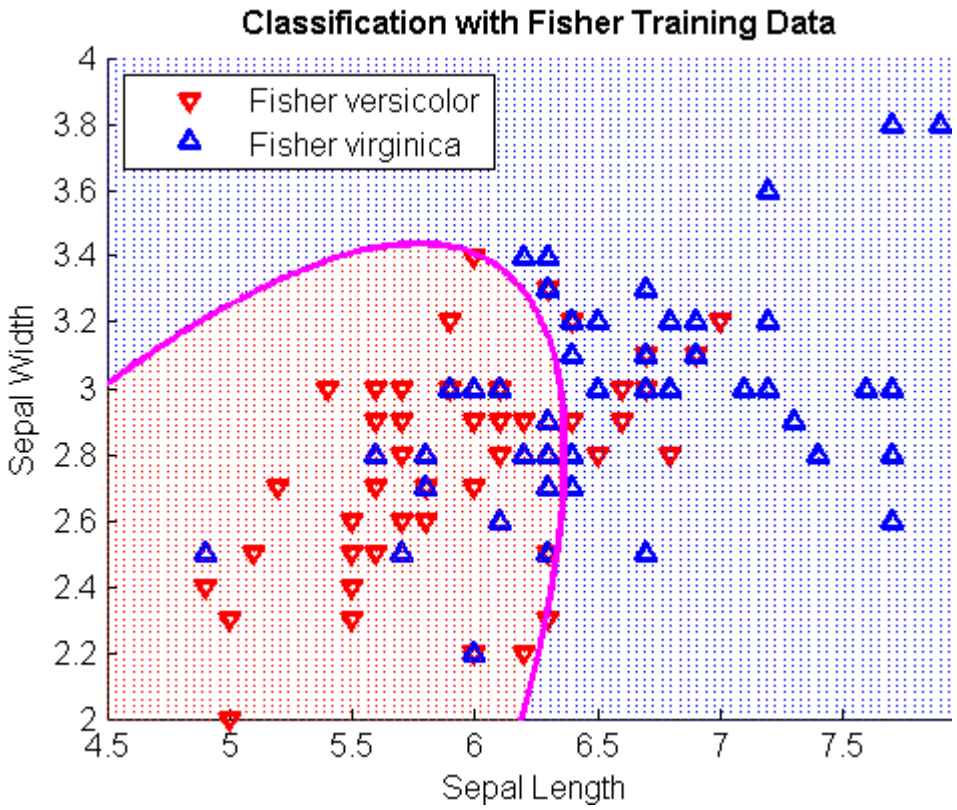
$$P(y \mid x) = \frac{P(x \mid y)P(y)}{P(x)}$$

  - P(y) is the *a priori* probability of y
  - P(x | y) is the likelihood function;
  - P(x) is the marginal probability
  - P(y | x) is the *a posteriori* probability



Discriminant Analysis

- Idea: Find the best separation surface between clusters based
- Generalization of Naïve Bayesian classifier which is a linear version of it
  - Linear: LDA
  - Quadratic: QDA
  - Matlab function "classify"



Things to Watch for

- Feature normalization is important and can improve training and classification results
- Independent training and testing data is a must
  - Half and half for example
  - Leave-one-out cross validation can be used for small data sets

Assignments

- Apply 2 classification methods to the selected features obtained from previous tasks and compare their results