Pattern Recognition

Kuan-Wen Chen
2024/9/24

Introduction

- Examples of PR in our daily life:
  - recognize a face
  - read handwritten characters
  - understand spoken words
  - identify car keys in the pocket by feel
  - decide whether a fruit is ripe by its smell
  - etc.

The Goal of PR

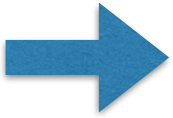
- To design and build machines that can recognize pattern. (as an engineering field)
- To gain deeper understanding and appreciation for PR systems in the natural world – particularly in human. (as a science)

Applications

- Face detection, recognition, and verification
- Speech and speaker recognition
- Fingerprint identification
- OCR and document analysis
- Industrial Inspection
- Medical diagnostics
- DNA sequence analysis
- etc.

An Example

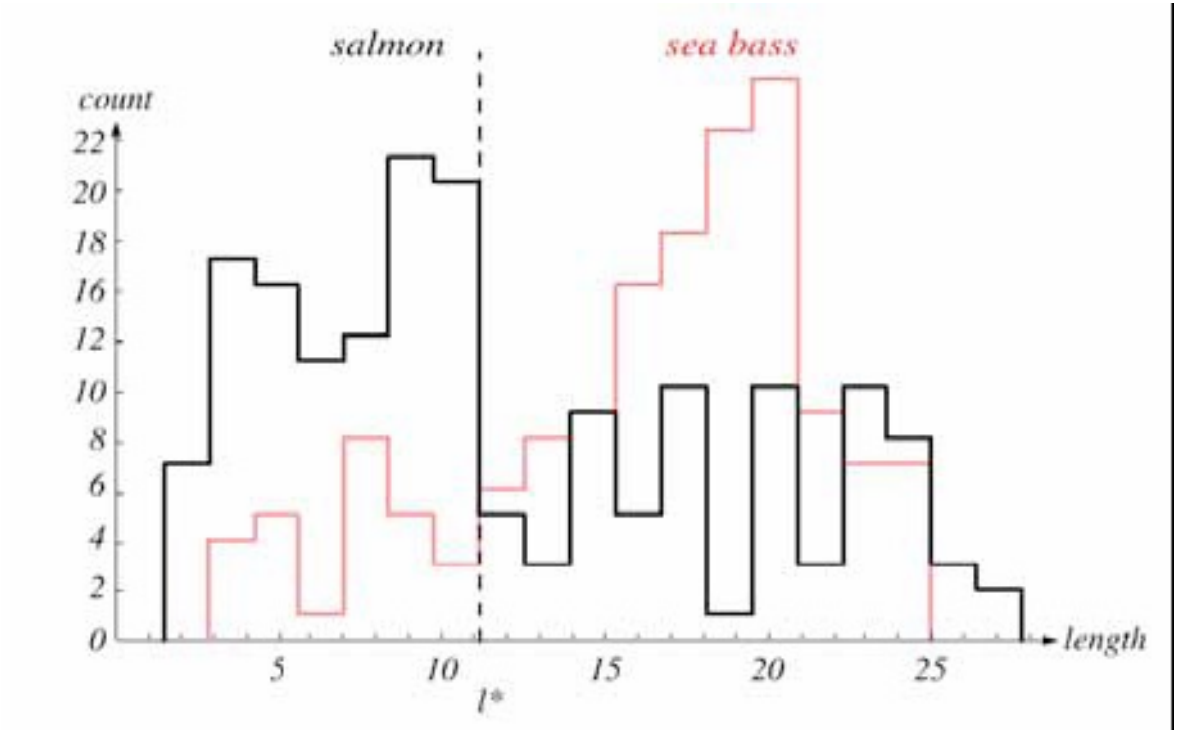
- A pilot project: separate sea bass from salmon.
- Physical differences between the two types of fishes: length, lightness, width, number and shape of fins, position of the mouth, etc.



possible features to be used in the classifier

An Example

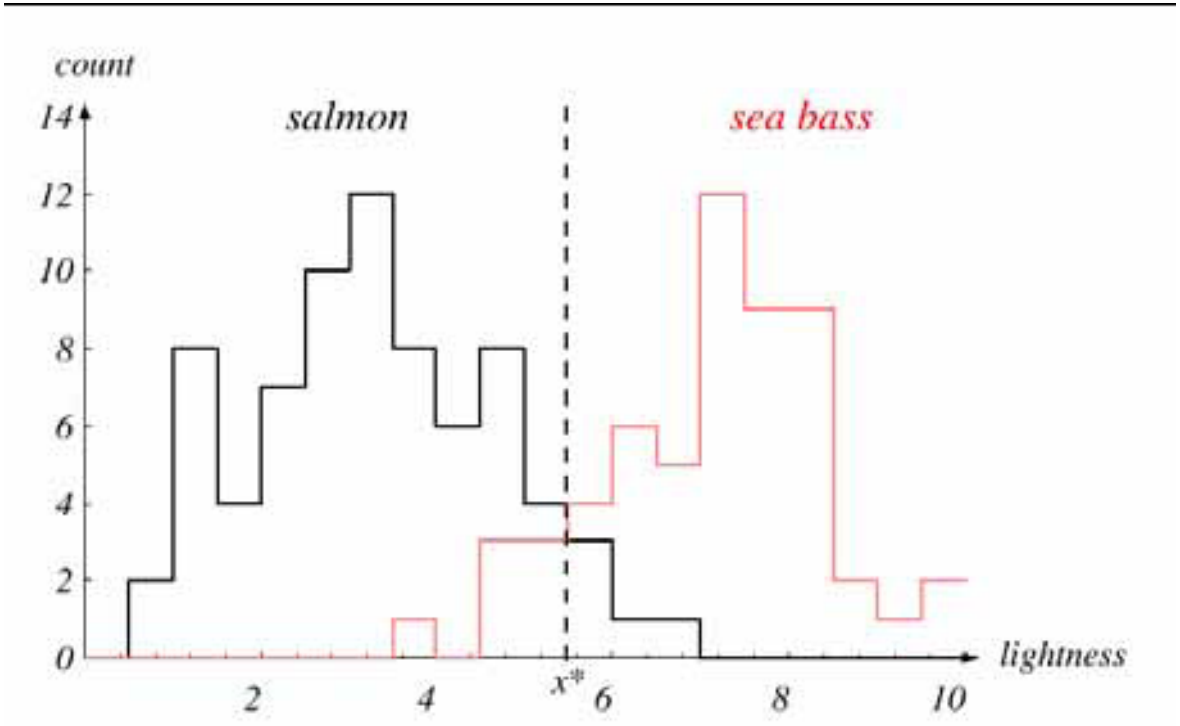
- Histogram for the length feature - obtained with some training samples



difficult to choose a good threshold, *l**

An Example

- Histogram for the lightness feature - average lightness of the fish scales



easier to choose a good threshold, x^*

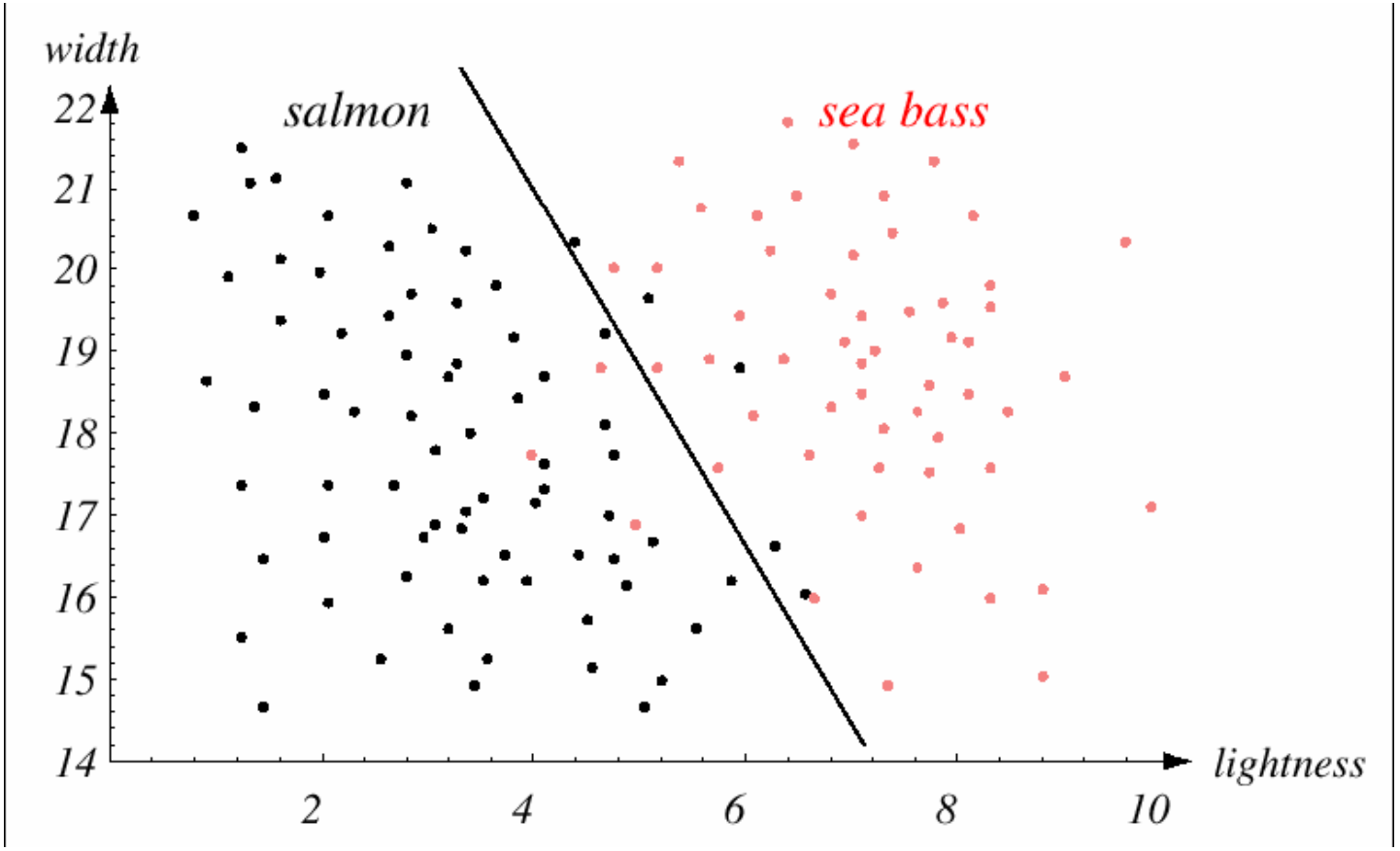
An Example

- Our task is to find the decision rule (or to set the decision boundary) that can minimize an overall cost. decision theory

- To improve the performance, try to use more features simultaneously.
  - e.g., sea bass are typically wider than salmon
  - choose lightness and width as features

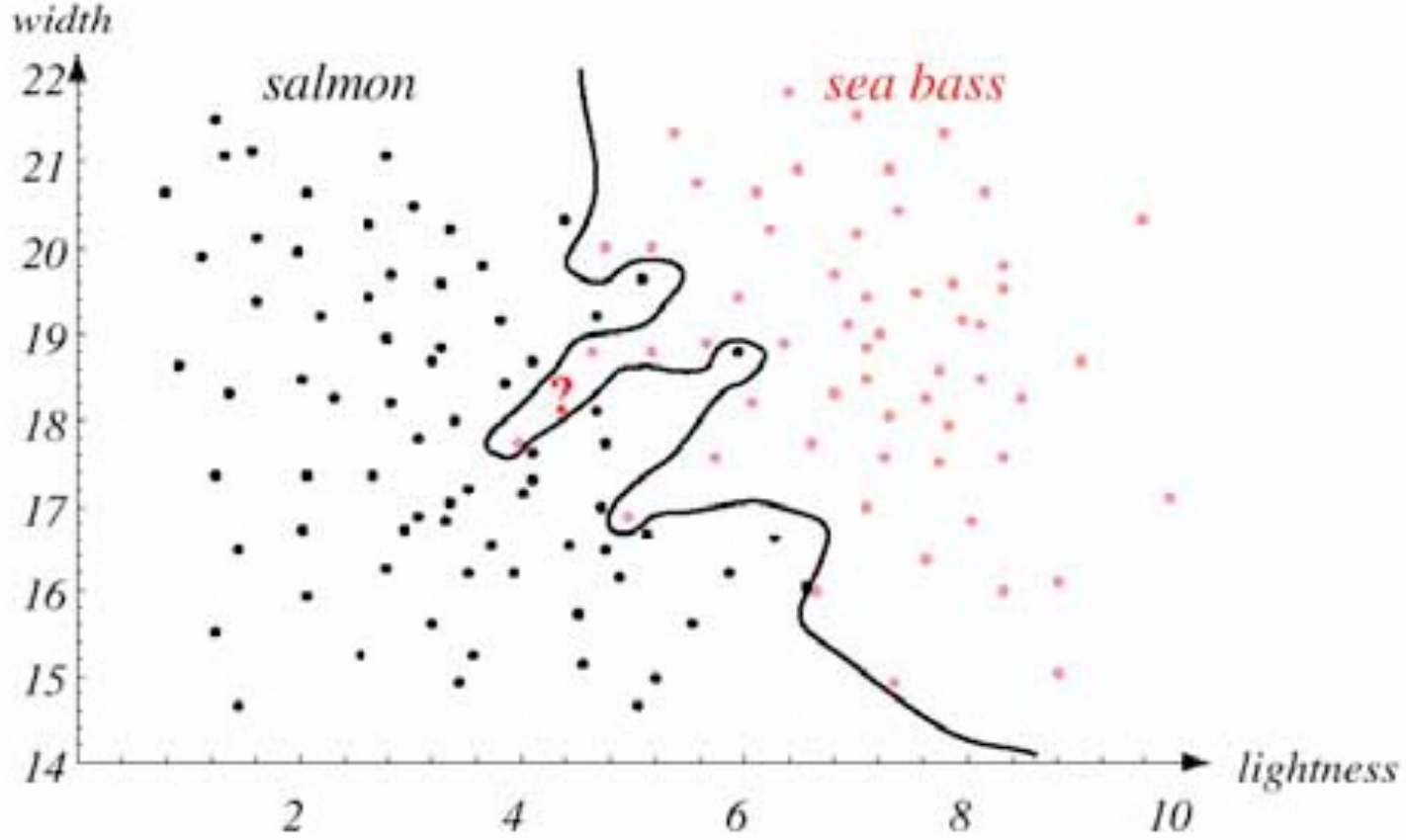
An Example

- Two-dimensional feature space



Generalization

- Our goal is to design a classifier to suggest actions when presented with *novel* patterns, i.e., fish not yet seen.



An Example

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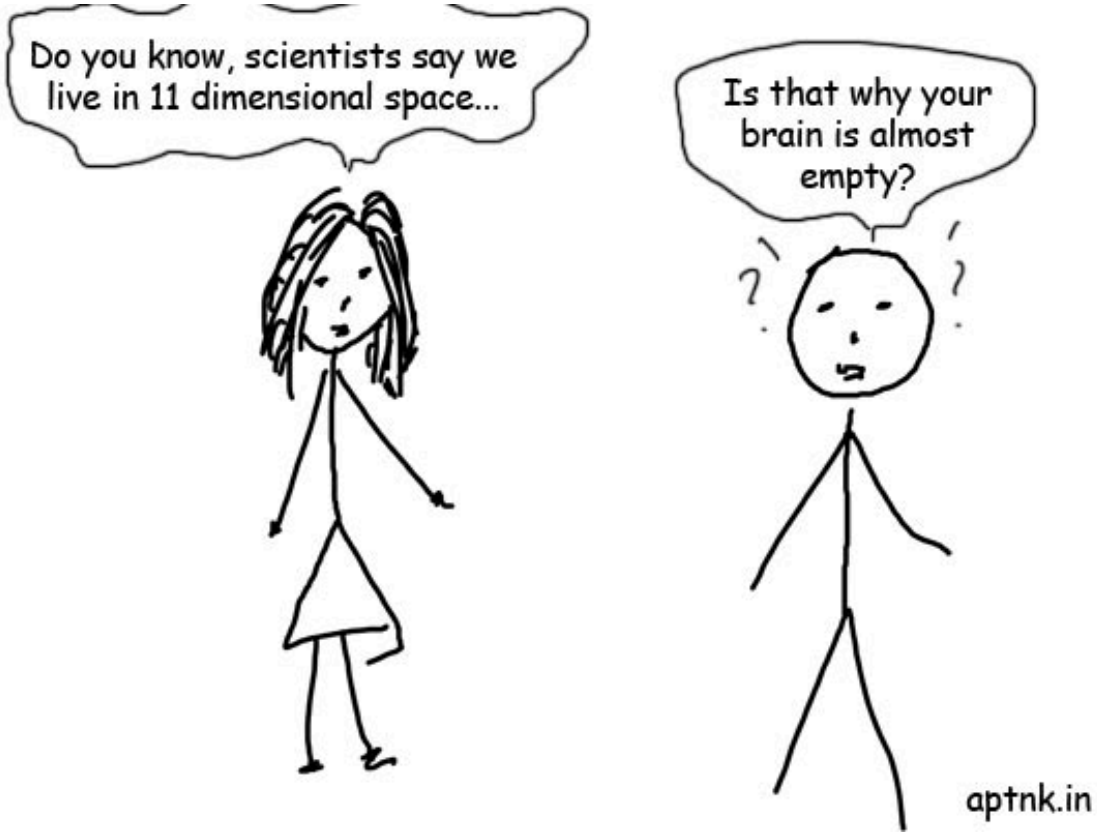
Does it more features always lead to better results?

No!!

"Curse" of dimensionality

Curse of dimensionality



100 x 100

10,000-dimensional vector

Dimension reduction

PR Systems

- A typical PR system consists of the following five components:
  - Sensing (e.g., cameras, microphones.)
  - Preprocessing (Segmentation and Grouping)
  - Feature Extraction
  - Classification
  - Post Processing

The Design Cycle

- Collect Data
- Choose Features
- Choose Model
- Train Classifier
- Evaluate Classifier

How deep learning helps for PR:

- Feature
- Model
- Classifier

Bayesian Decision Theory

- Maximum *a posteriori* probability (M.A.P.) classifier is the minimum-error-rate classifier

The Bayes rule:

$$P(\omega_j \mid x) = P(x \mid \omega_j)\, P(\omega_j) / P(x)$$

$$\text{Posterior} = \frac{\text{Likelihood} * \text{Prior}}{\text{Evidence}}$$

Learning

- Supervised Learning
  - Parametric Approach
  - Non-Parametric Approach
    - Parzen Windows, k-NN Estimation

- Unsupervised Learning *(clustering)*
  - Parametric Approach
  - Non-Parametric Approach
    - Clustering

- Reinforcement Learning (learning with a critic)

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