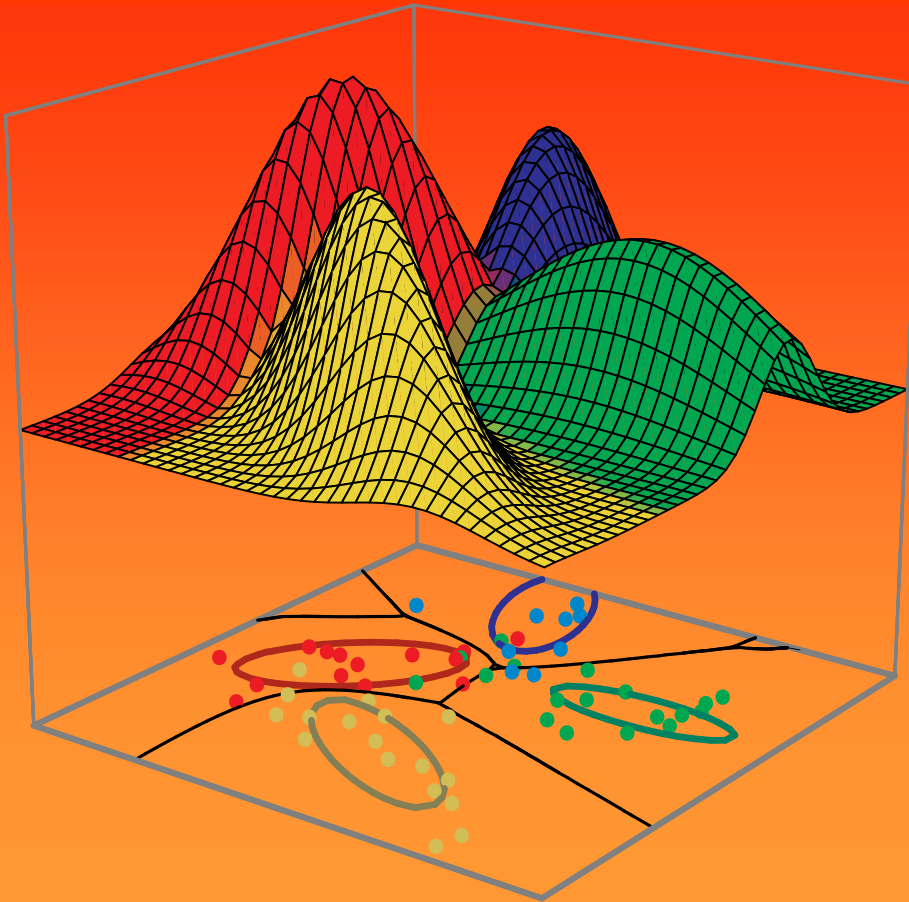


CpE 646 Pattern Recognition and Classification

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Course Text



Pattern Classification

Many materials in these slides were taken from **Pattern Classification (2nd ed)** by R. O. Duda, P. E. Hart and D. G. Stork, John Wiley & Sons, 2000 with the permission of the authors and the publisher

Introduction to Pattern Recognition

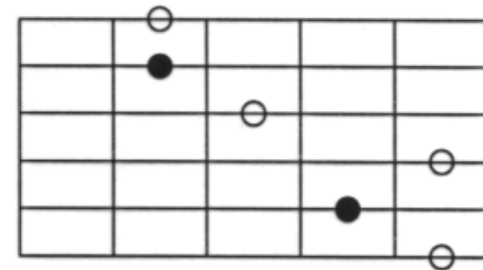
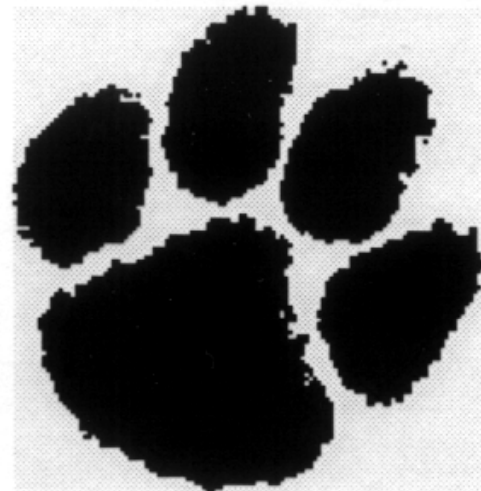
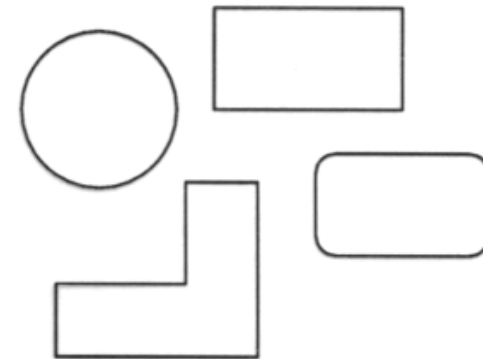
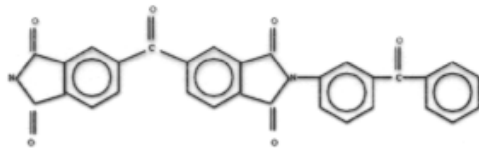
Chapter 1 (Section 1.1 – 1.6) outline:

- Machine Perception
- An Example
- Pattern Recognition Systems
- The Design Cycle
- Learning and Adaptation
- Conclusion

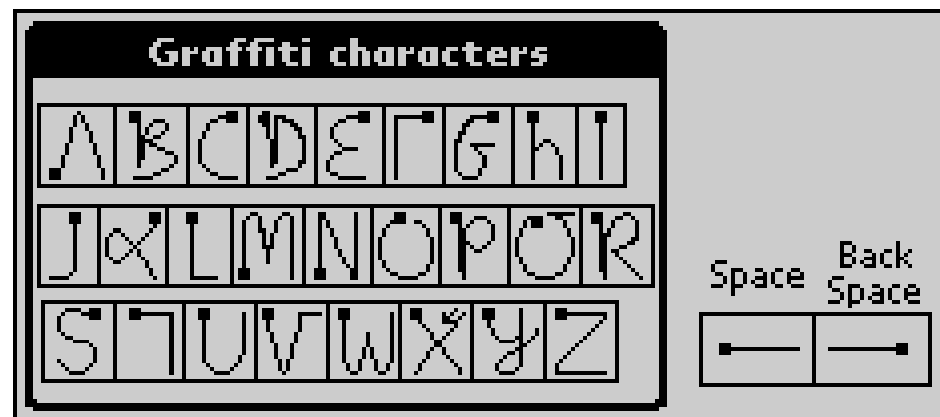
Examples of Patterns



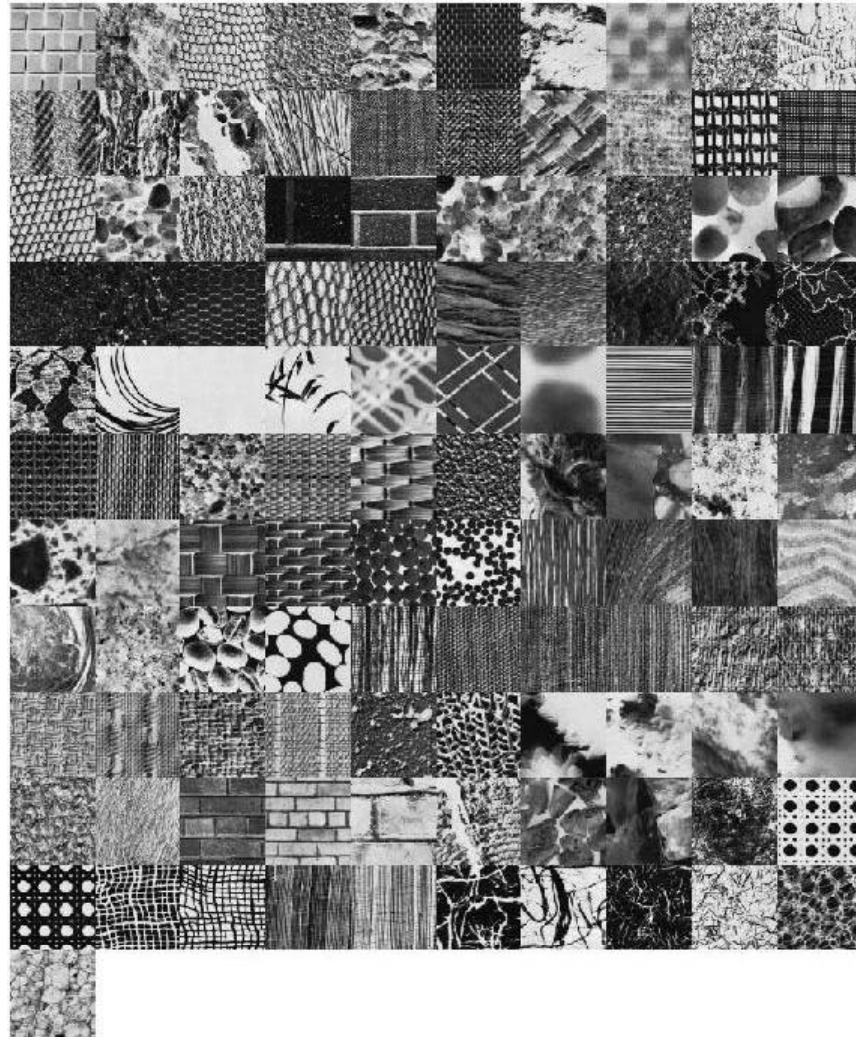
Examples of Patterns



Examples of Patterns



Examples of Patterns



Examples of Patterns



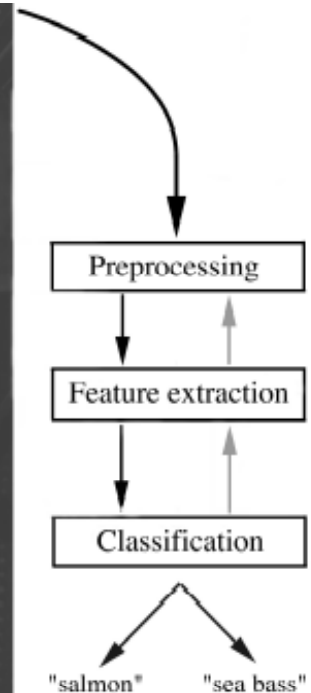
Machine Perception

- Build a machine that can recognize patterns:
 - Speech recognition
 - Fingerprint identification
 - OCR (Optical Character Recognition)
 - DNA sequence identification
 -

An Example

“Sorting incoming Fish
on a conveyor
according to species
using optical sensing”

Species $\begin{cases} \text{Sea bass} \\ \text{Salmon} \end{cases}$



An Example (cont'd)

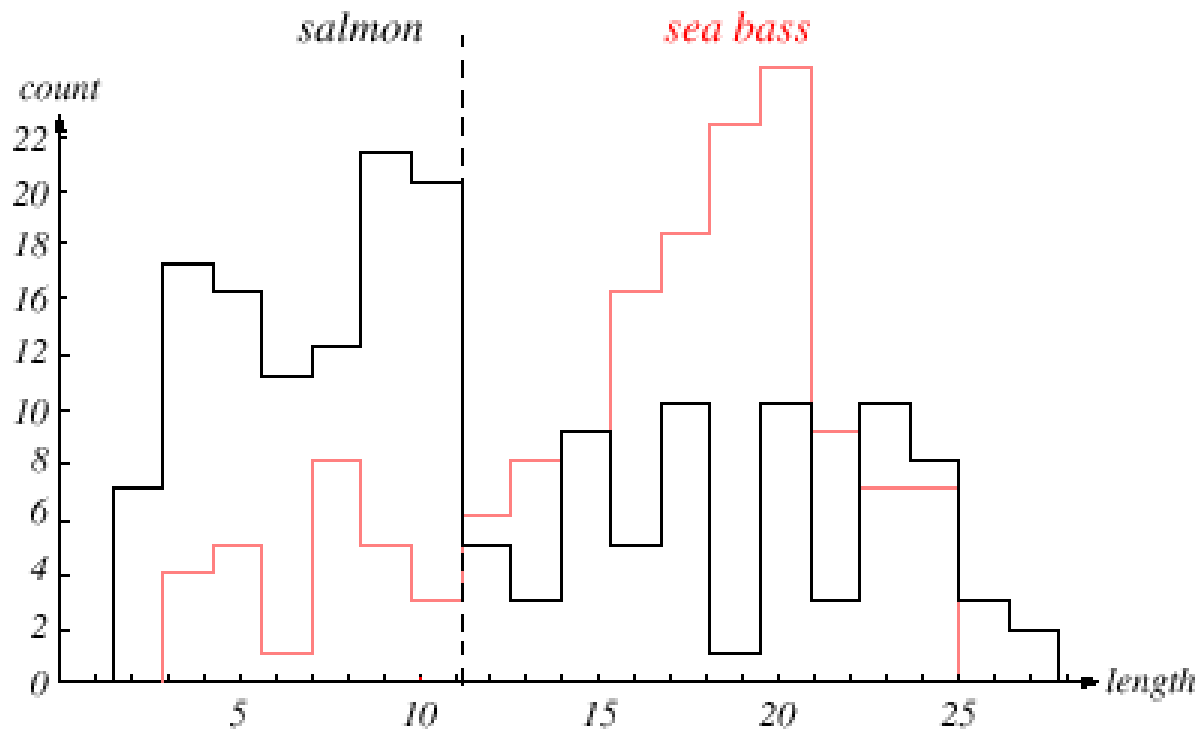
- Problem Analysis
 - Set up a camera and take some sample images to extract features
 - Length
 - Lightness
 - Width
 - Number and shape of fins
 - Position of the mouth, etc...
 - This is the set of all suggested features to explore for use in our classifier!

An Example (cont'd)

- Preprocessing
 - Use a segmentation operation to isolate fishes from one another and from the background
- Information from a single fish is sent to a feature extractor whose purpose is to reduce the data by measuring certain features
- The features are passed to a classifier

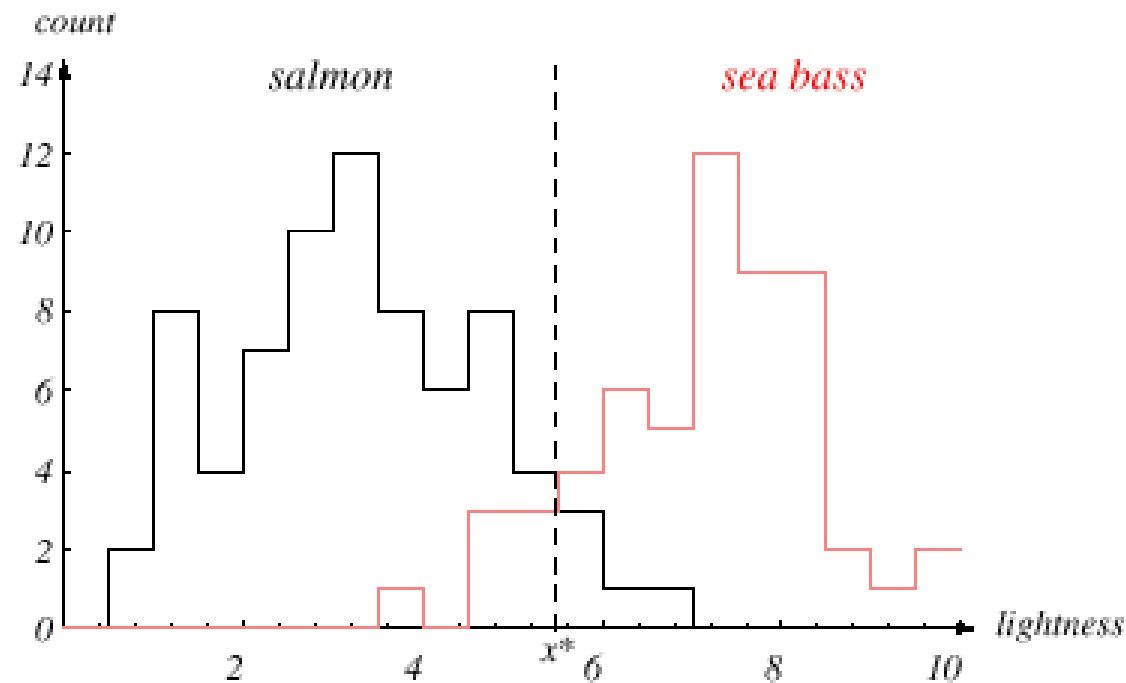
An Example (cont'd)

- Classification
 - Select the length of the fish as a possible feature for discrimination



An Example (cont'd)

- The length is a poor feature alone!
- Select the lightness as a possible feature.



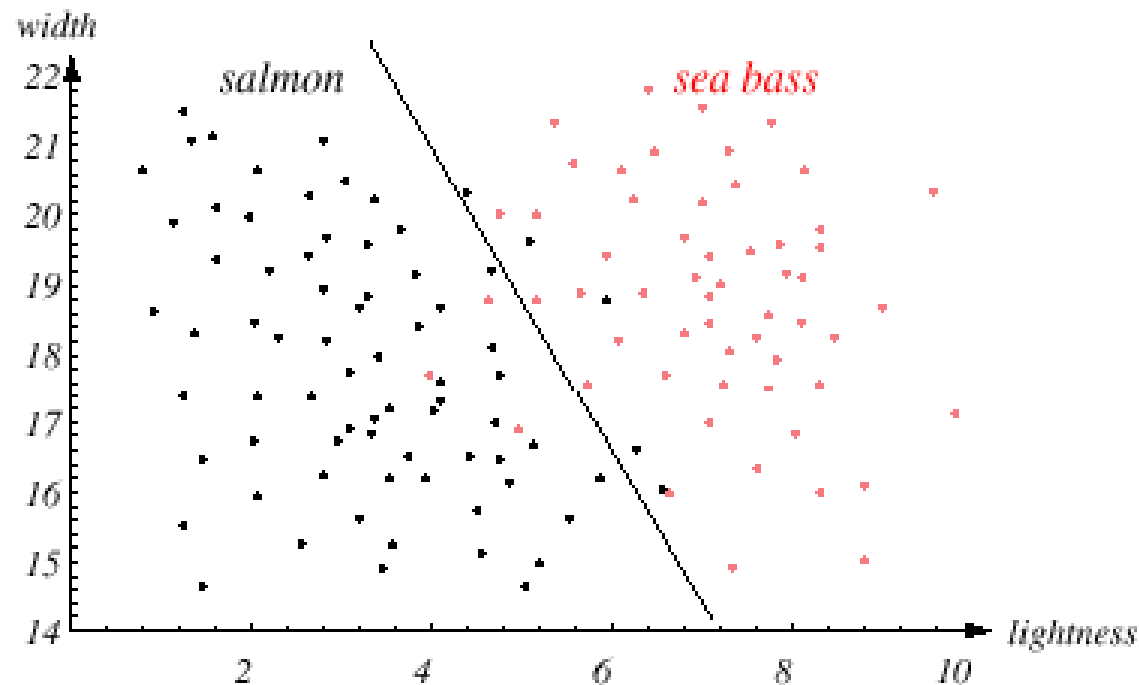
An Example (cont'd)

- Threshold decision boundary and cost relationship
 - Move our decision boundary toward smaller values of lightness in order to minimize the cost (reduce the number of sea bass that are classified salmon!)
 - This is a task of decision theory

An Example (cont'd)

- Adopt the lightness and add the width of the fish

Fish: $\mathbf{x}^T = [x_1, x_2]$,
 x_1 : lightness, x_2 : width

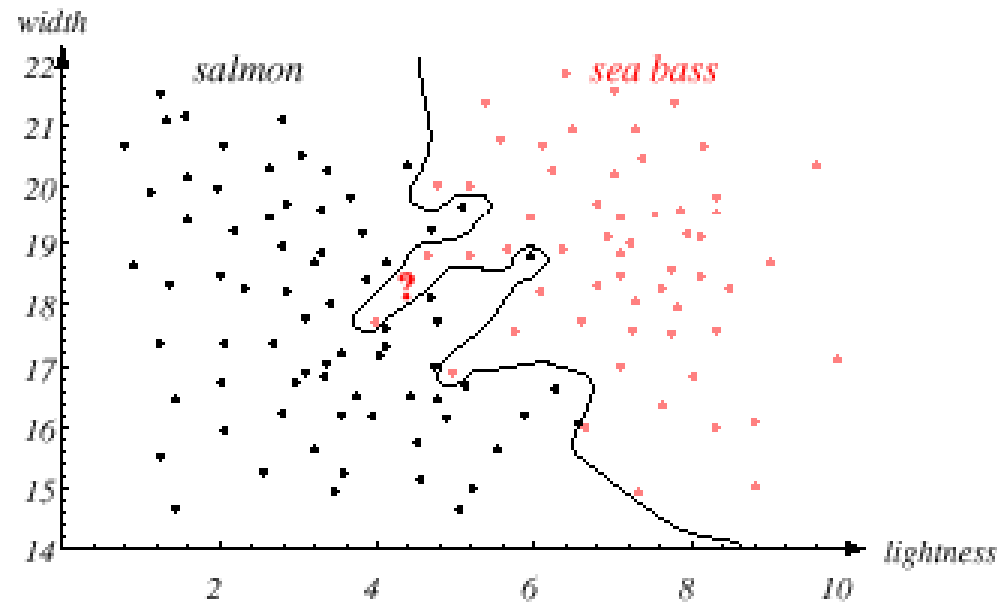


An Example (cont'd)

- We might add other features that are not correlated with the ones we already have. A precaution should be taken not to reduce the performance by adding such “noisy features”

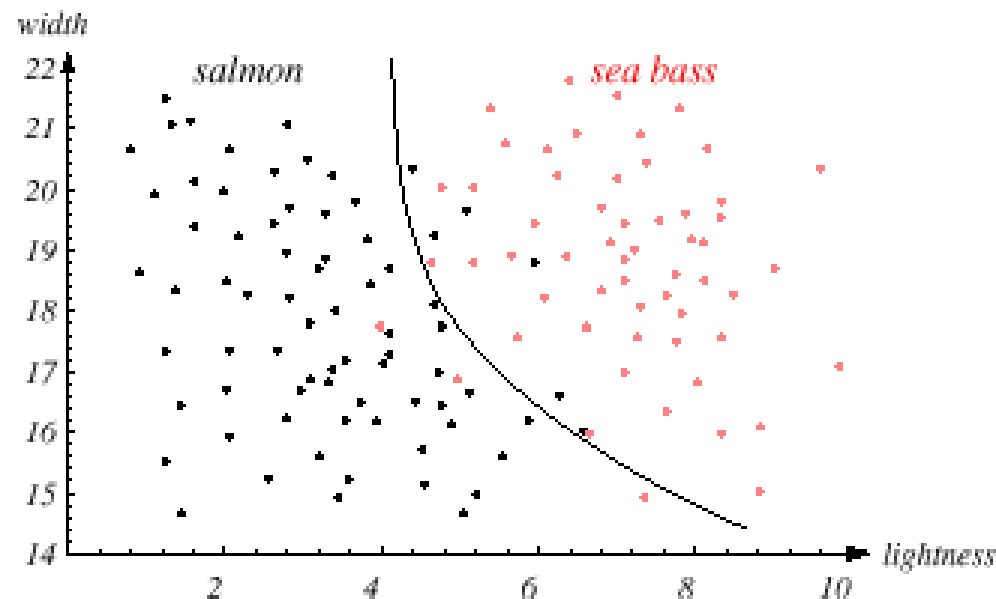
An Example (cont'd)

- Ideally, the best decision boundary should be the one which provides an optimal performance:



An Example (cont'd)

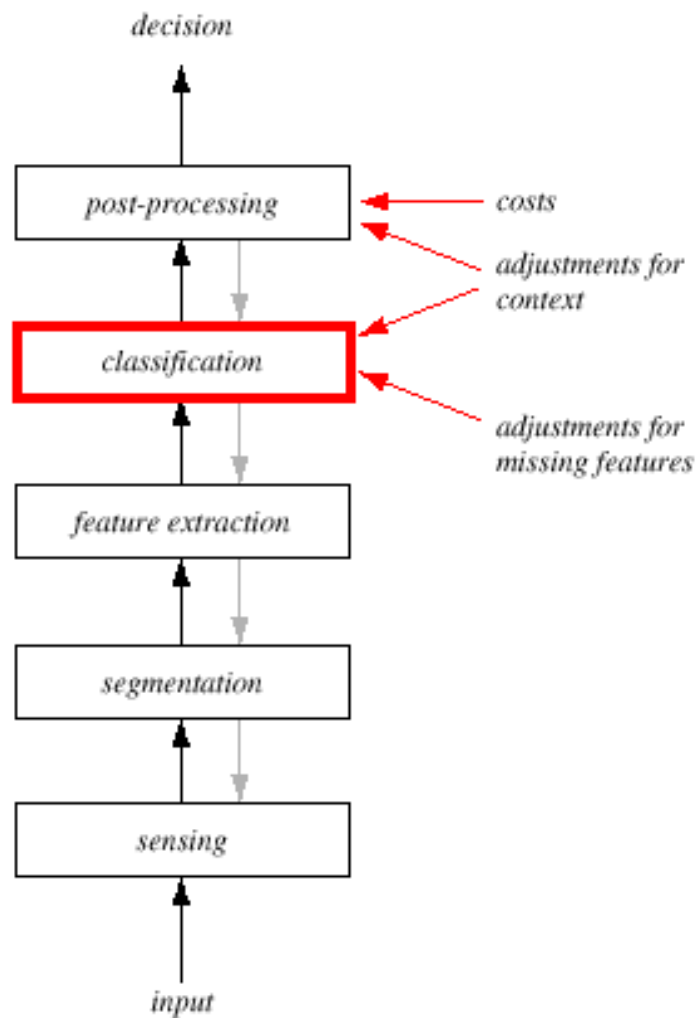
- However, our satisfaction is premature because the central aim of designing a classifier is to correctly classify novel input \Rightarrow issue of generalization!



Pattern Recognition Systems

- Sensing
 - Use of a transducer (camera or microphone)
 - PR system depends of the bandwidth, the resolution sensitivity distortion of the transducer
- Segmentation and grouping
 - Patterns should be well separated and should not overlap

Pattern Recognition Systems (cont'd)



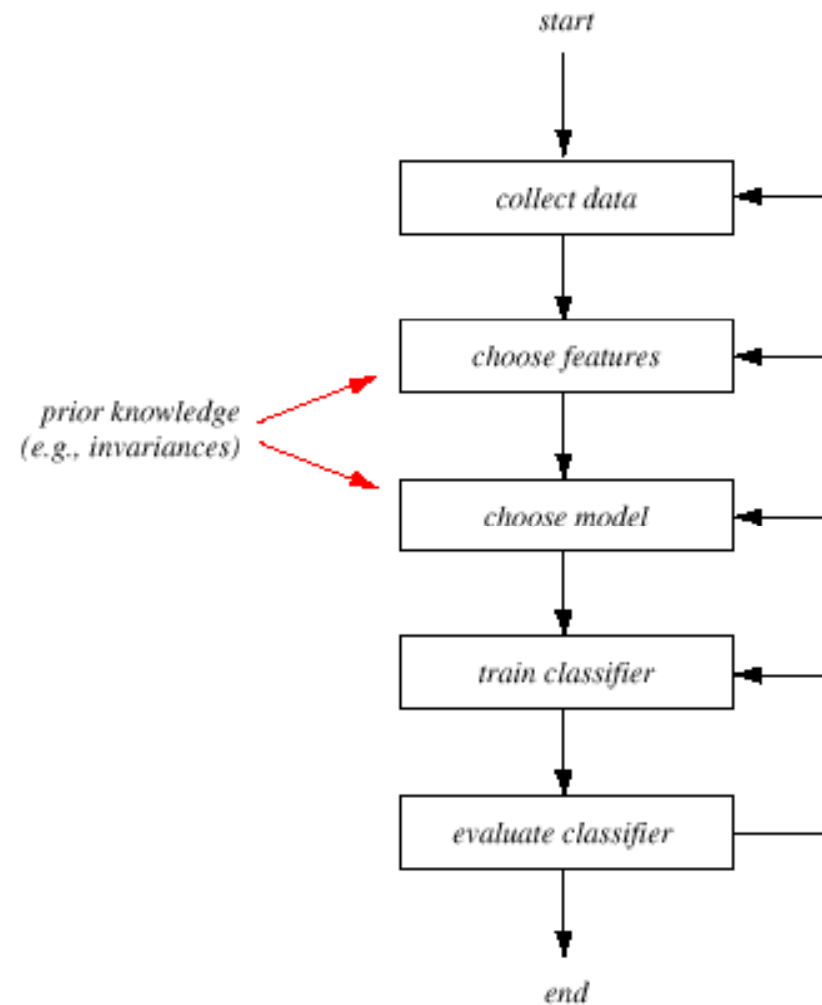
Pattern Recognition Systems (cont'd)

- Feature extraction
 - Discriminative features
 - Invariant features with respect to translation, rotation and scale.
- Classification
 - Use a feature vector provided by a feature extractor to assign the object to a category
- Post Processing
 - Exploit context input dependent information other than from the target pattern itself to improve performance

The Design Cycle

- Data collection
- Feature Choice
- Model Choice
- Training
- Evaluation
- Computational Complexity

The Design Cycle (cont'd)



The Design Cycle (cont'd)

- Data Collection
 - How do we know when we have collected an adequately large and representative set of examples for training and testing the system?
- Feature Choice
 - Depends on the characteristics of the problem domain. Simple to extract, invariant to irrelevant transformation insensitive to noise.
- Model Choice
 - Unsatisfied with the performance of our fish classifier and want to jump to another class of model

The Design Cycle (cont'd)

- Training
 - Use data to determine the classifier. Many different procedures for training classifiers and choosing models
- Evaluation
 - Measure the error rate (or performance and switch from one set of features to another one
- Computational Complexity
 - What is the trade-off between computational ease and performance?
 - (How an algorithm scales as a function of the number of features, patterns or categories?)

Learning and Adaptation

- Supervised learning
 - A teacher provides a category label or cost for each pattern in the training set
- Unsupervised learning
 - The system forms clusters or “natural groupings” of the input patterns

Conclusion

- Reader seems to be overwhelmed by the number, complexity and magnitude of the sub-problems of Pattern Recognition
- Many of these sub-problems can indeed be solved
- Many fascinating unsolved problems still remain