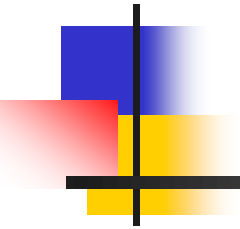
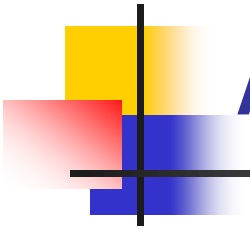


Pattern Recognition

Min Wang

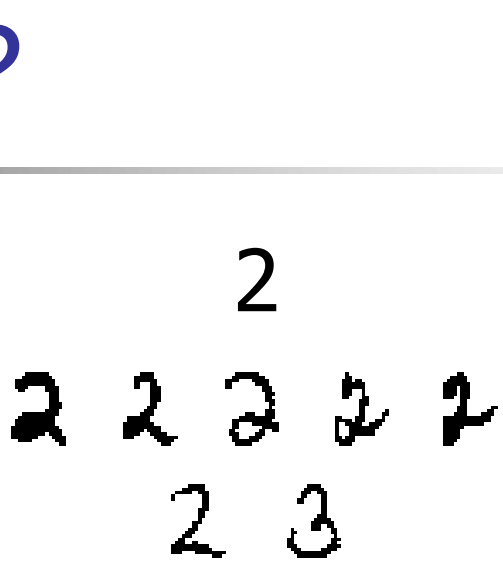


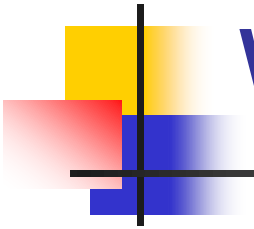
Application Cases

- Character Recognition
  - OCR (Optical Character Recognition)
- Speech Recognition
  - translation machine, identification
- Intelligent Traffic
  - License plate, car model
- Target Recognition
  - ATR (Automatic Target Recognition)
- Many more…

What is PR?

- Pattern
- Sample
- Recognition
- Learning/Training
- Evaluation/Test





What is PR?

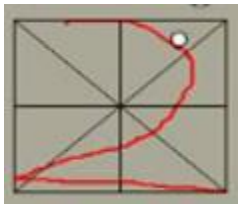
- Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of interest from their background, and make sound and reasonable decisions about the categories of the patterns. (Anil K.Jain)

Structured PR methods (Jingsun Fu, 1960s)

- Also called knowledge-based PR methods
- Structured representation (string, tree, graph)
- Structure (syntax) analysis
- Limited usage
- Difficulty in inference, recursion

Statistical PR methods (T.Pavlidis, 1971)

- A sample->a feature vector $x^T = [x_1,\ldots,x_n]$
- Feature vectors->feature space
- How to divide the feature space
- Widely used
- Less make use of the structure relationship of patterns



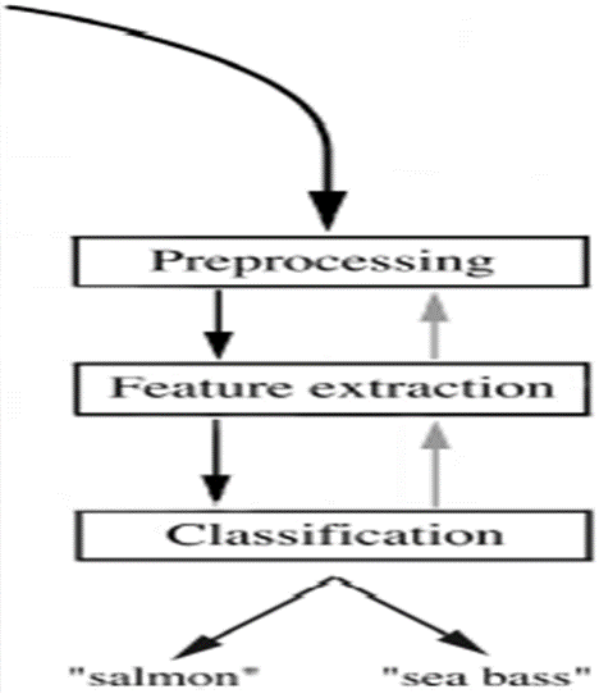
An Example

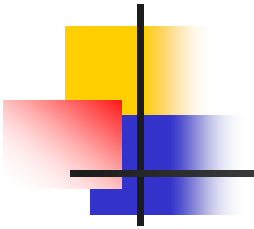
- "Sorting incoming fish on a conveyor according to species using optical sensing"

Species

Sea bass

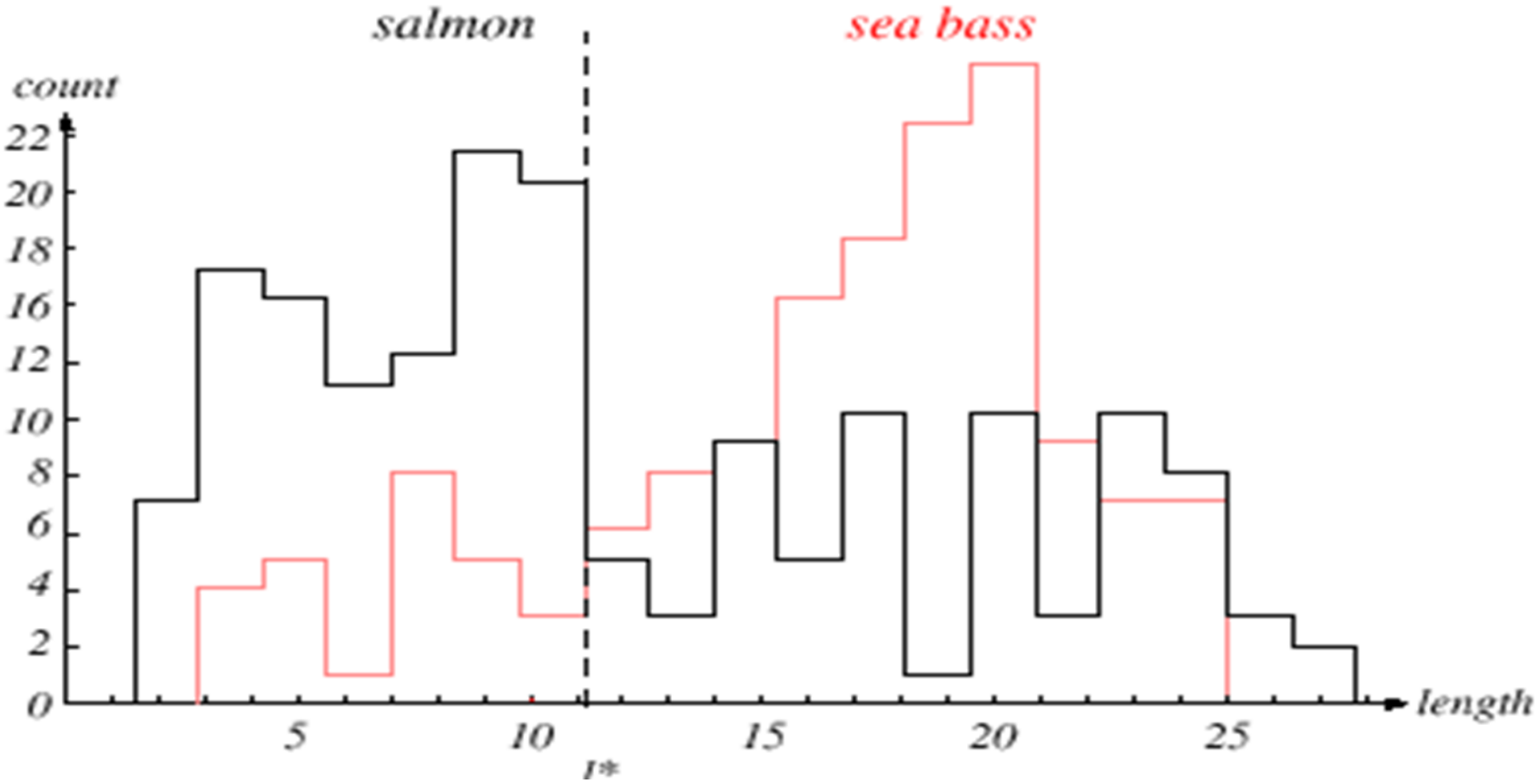
Salmon


Preprocessing
Feature extraction
Classification
"salmon"
"sea bass"



- Preprocessing
  - Use a segmentation operation to isolate fishes from one another and from the background
- Feature extraction
  - Reduce the Information from a single fish by measuring certain features
- Classification
  - Our focus

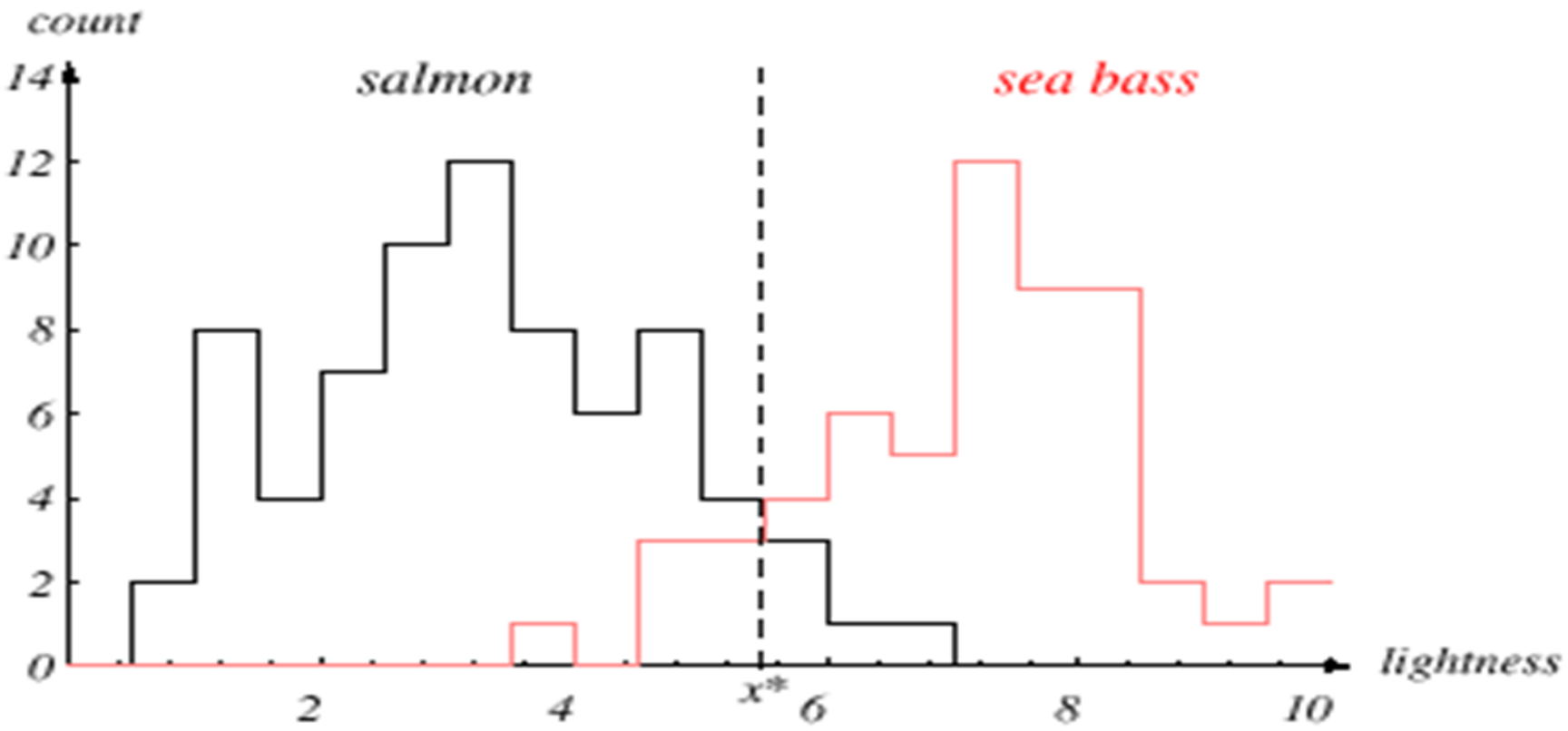
Classification by length



The length is a poor feature alone!

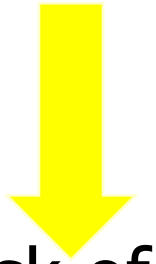
Select the lightness as a possible feature.

Classification by lightness



Decision theory

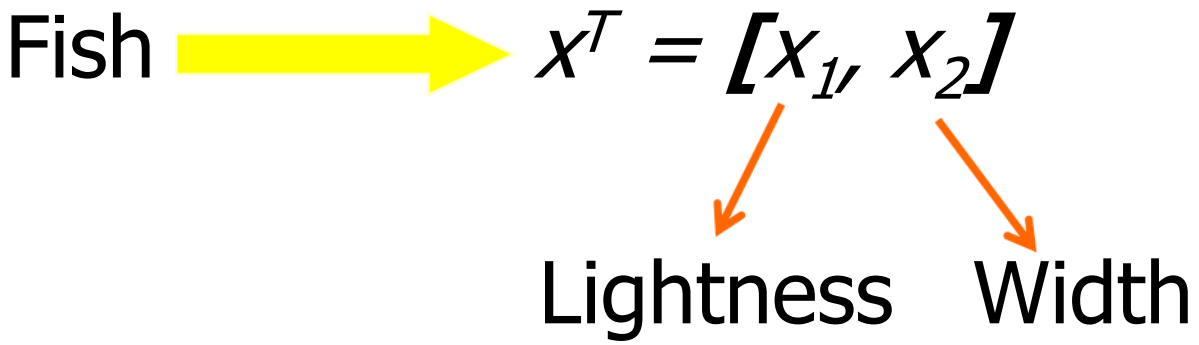
- Threshold decision boundary and cost relationship
  - Move our decision boundary toward smaller values of lightness in order to minimize the cost (reduce the number of sea bass that are classified salmon!)



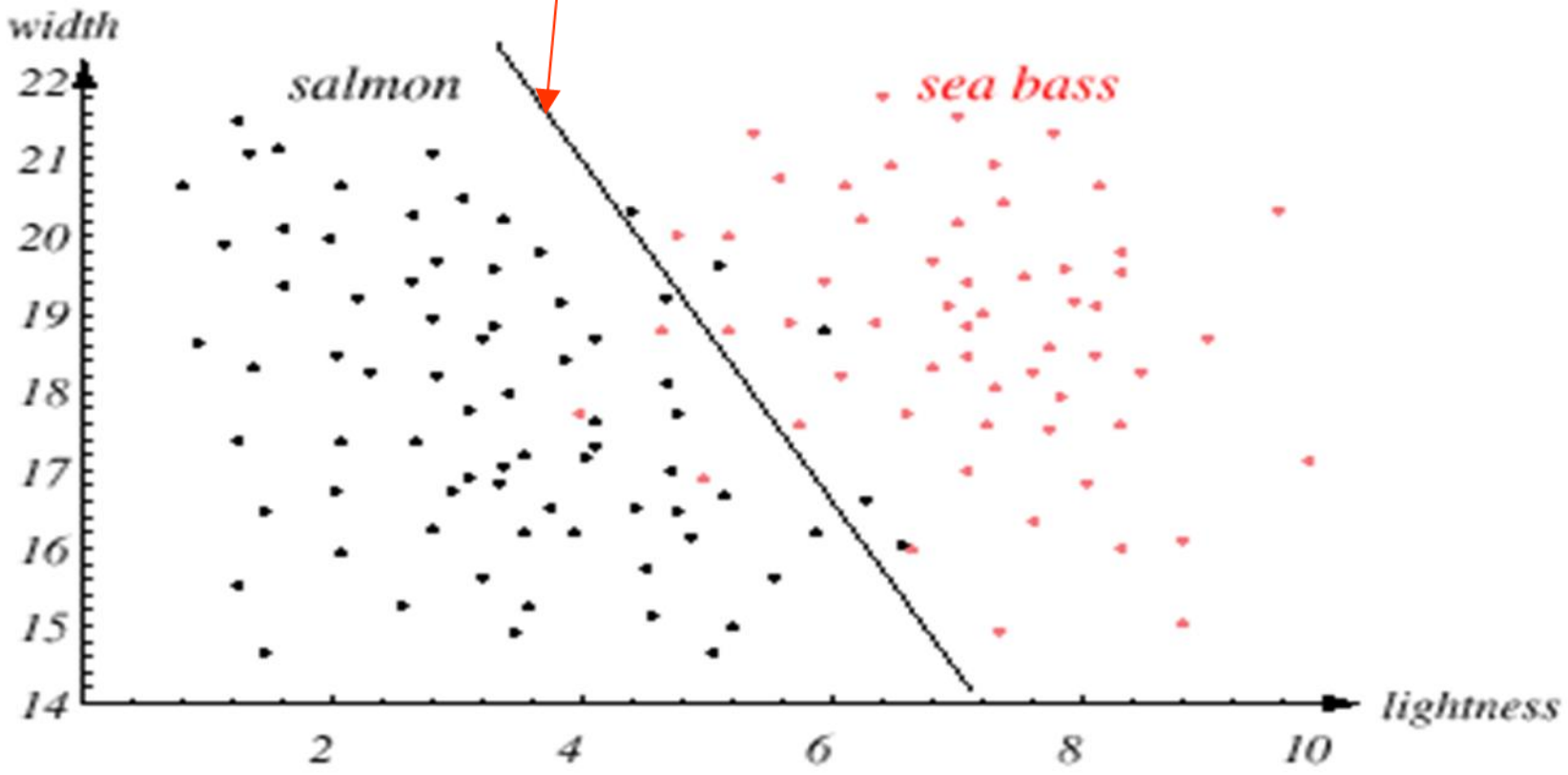
Central task of decision theory

Feature vector

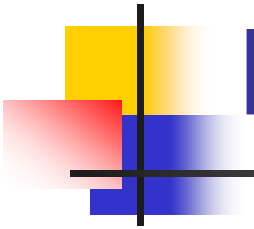
- Adopt the lightness and add the width of the fish



decision boundary

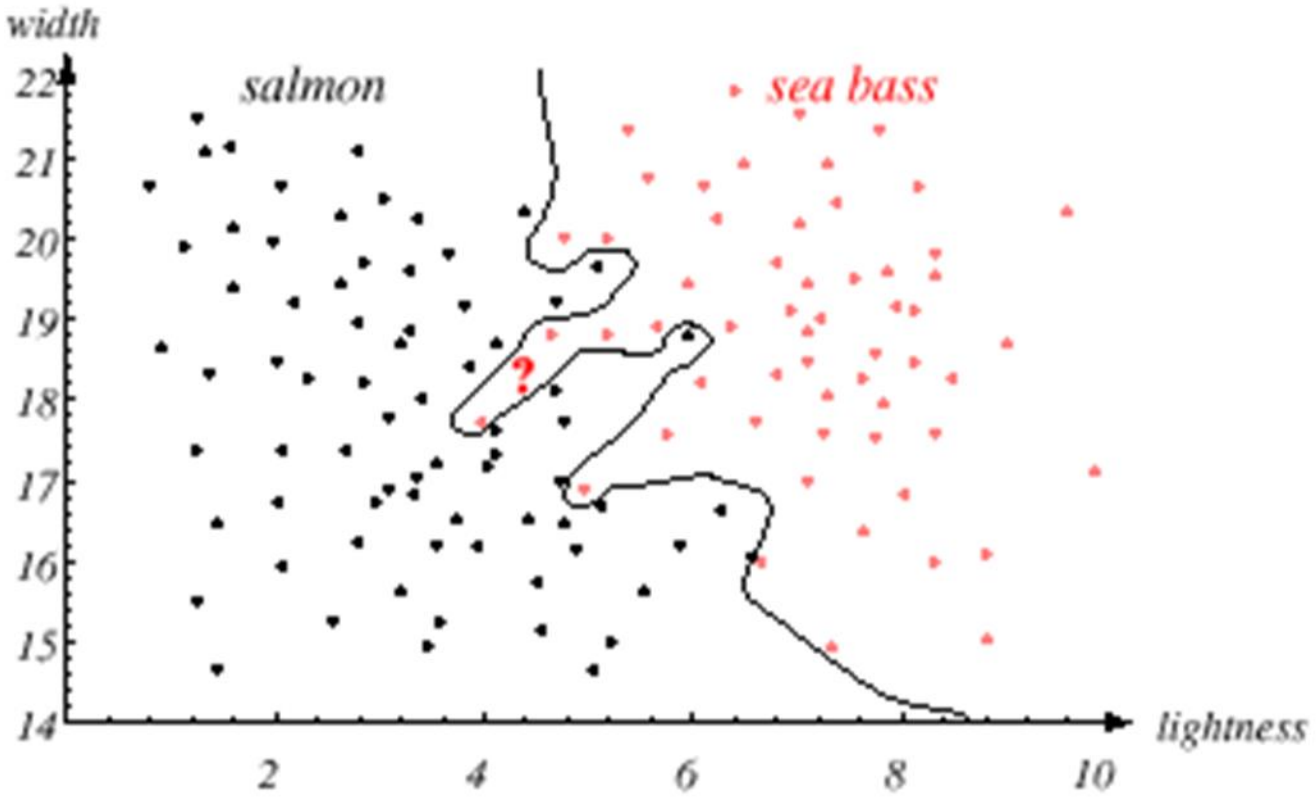


Underfitting!

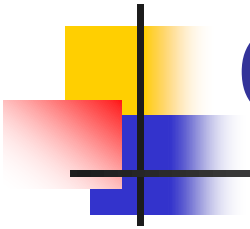


Feature choice

- 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"
- Ideally, the best decision boundary should be the one which provides an optimal performance such as in the following figure:



Overfitting!

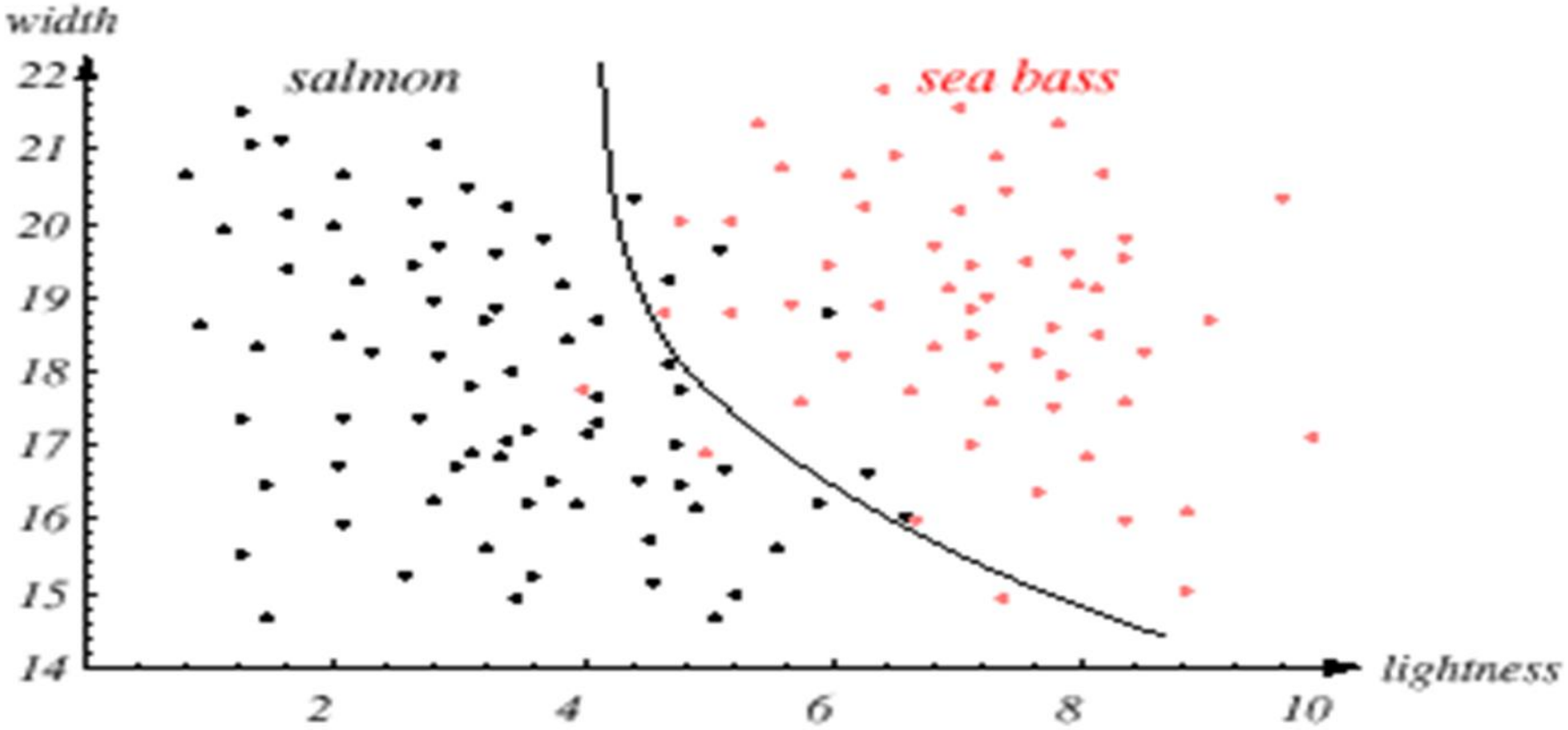


Generalization

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

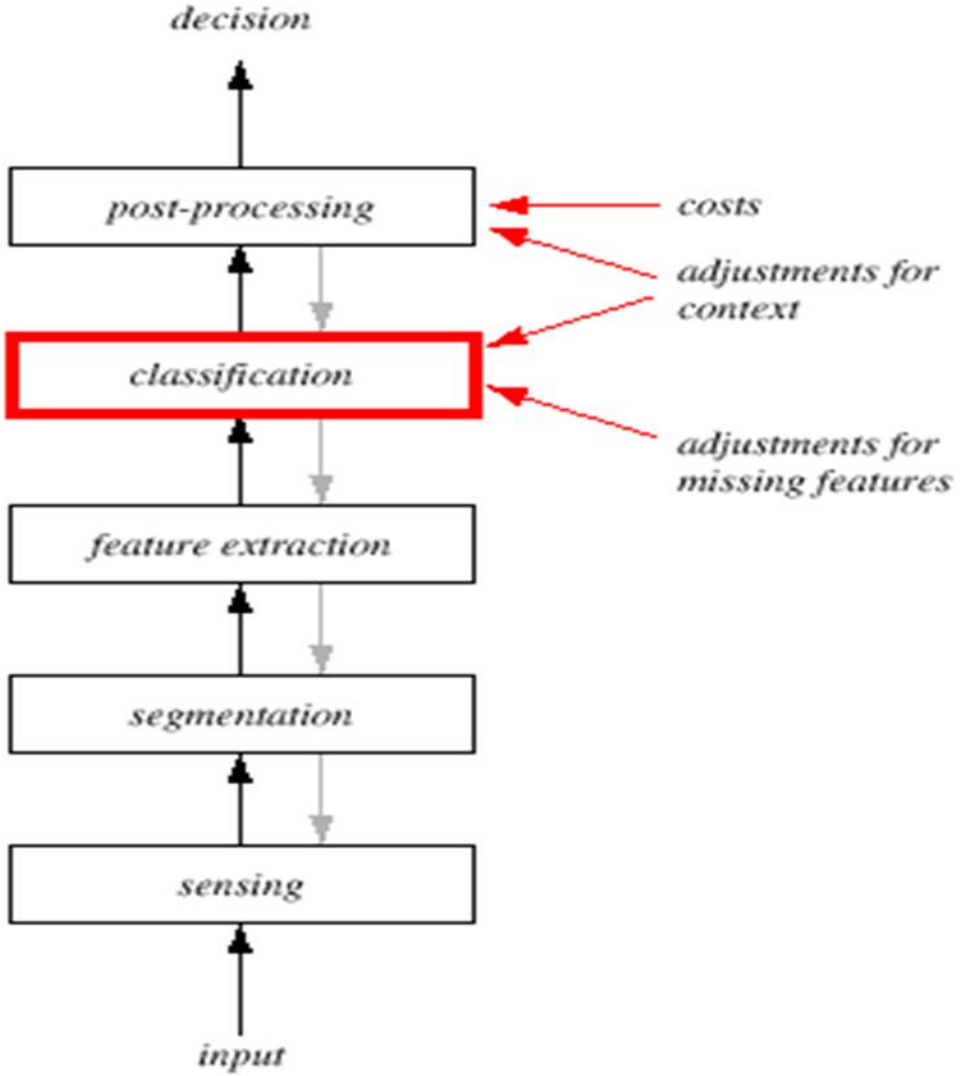
Issue of generalization!

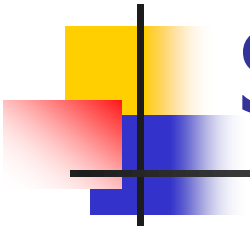
Model choice



Tradeoff!

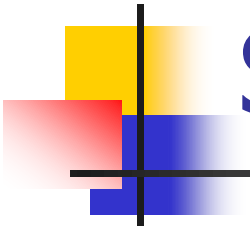
A PR System


decision
post-processing
costs
adjustments for context
classification
adjustments for missing features
feature extraction
segmentation
sensing
input



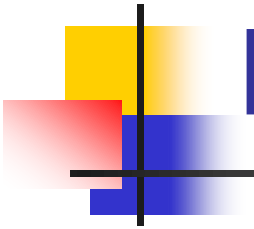
Sensing

- Use of a transducer (camera or microphone)
- PR system depends of the bandwidth, the resolution sensitivity distortion of the transducer
- Data collection. How do we know when we have collected an adequately large and representative set of examples for training and testing the system?
- Out of our scope



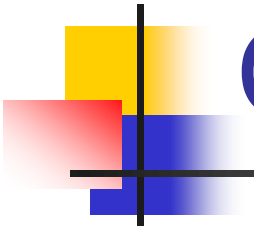
Segmentation

- Samples should be well separated and should not overlap
- Out of our scope



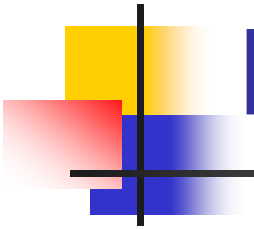
Feature extraction

- Feature choice
  - Discriminative features
  - Insensitive to noise
  - Invariant features with respect to translation, rotation and scale
  - Simple to extract
- Depends on the characteristics of the problem domain



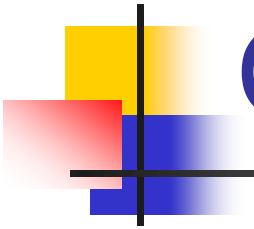
Classification

- Use a feature vector provided by a feature extractor to assign the object to a category
- Model choice. Unsatisfied with the performance of our fish classifier and want to jump to another class of model
- Training. Use data to determine the classifier. Many different procedures for training classifiers and choosing models



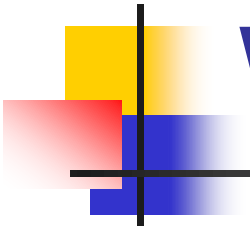
Post-processing

- Measure the error rate (or performance) and switch from one set of features to another one
- Exploit context information other than from the target pattern itself to improve performance
- 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?



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



What you should know…

- pattern,sample,recognition,
  pattern recognition
- feature,feature vector,
  feature space,decision boundary
- components of a PR system