Deep Learning for Computer Vision

Lecture 2: An Introduction to Old-School Machine Learning

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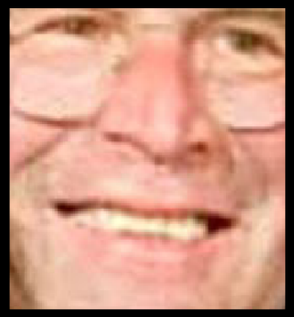
Who are these people?

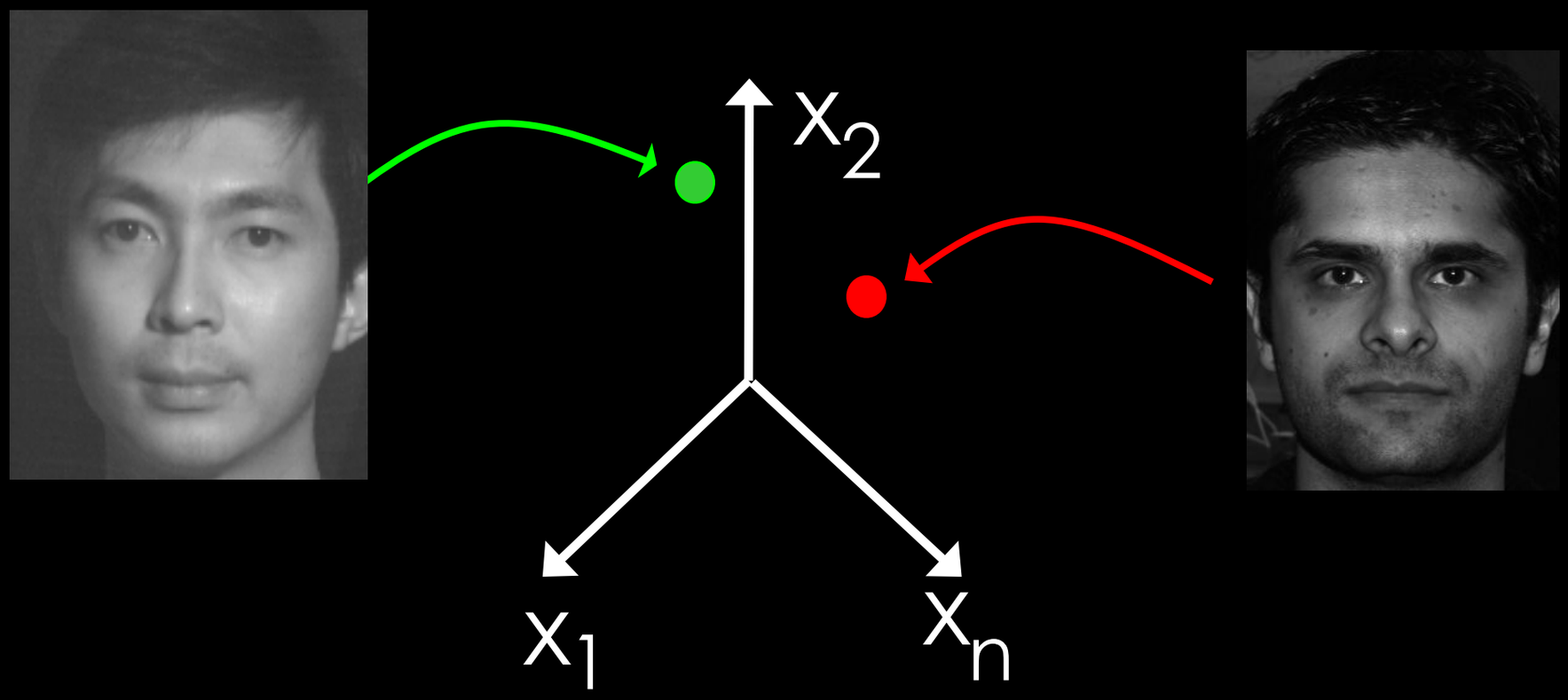
[Sinha and Poggio 1996]

Who are these people?



[Sinha and Poggio 2002]

Images as Points in Euclidean Space



- Let an n-pixel image to be a point in an n-D space, $\mathbf{x} \in \mathbf{R}^n$.

- Each pixel value is a coordinate of **x**.

Image Recognition: Euclidean Distances

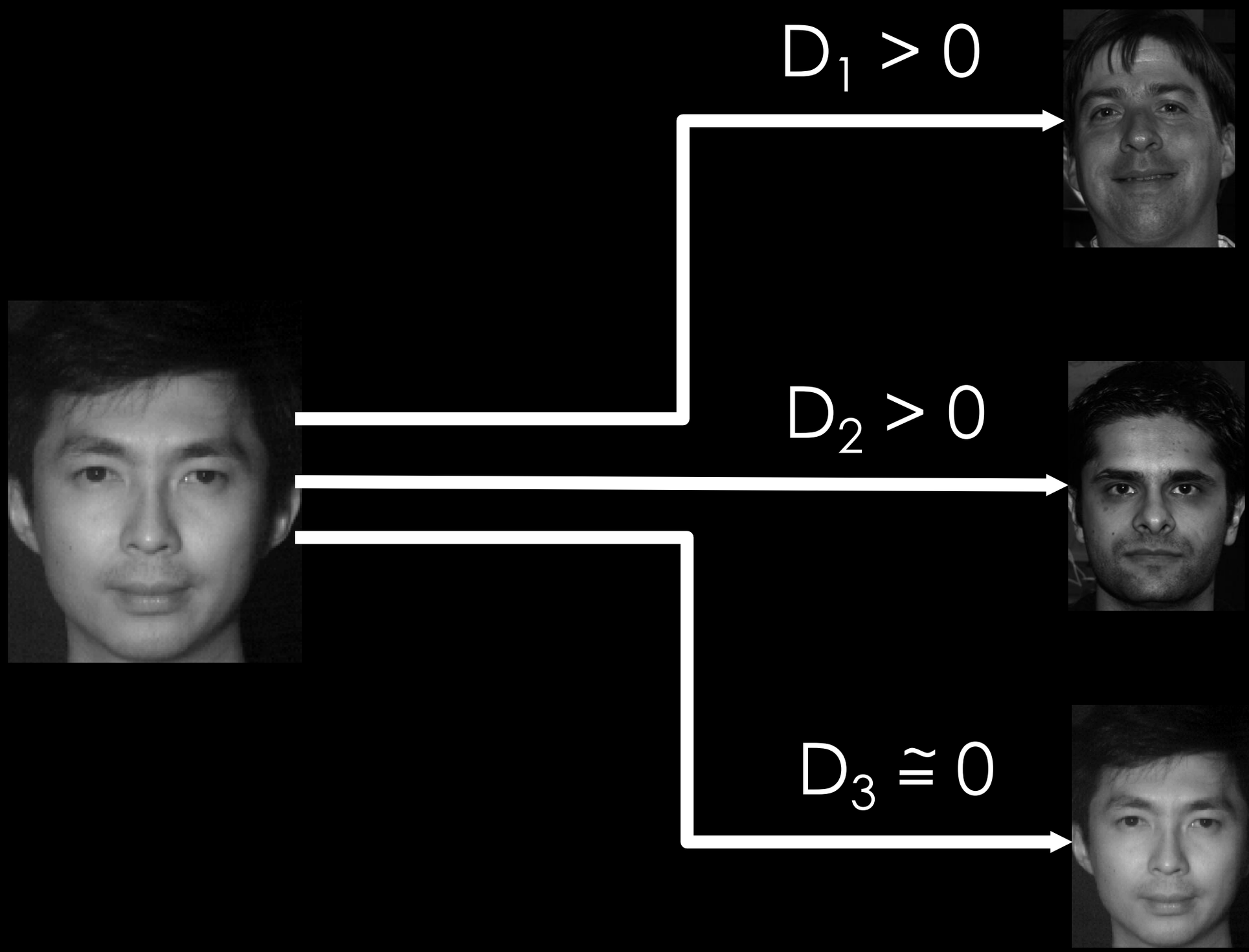
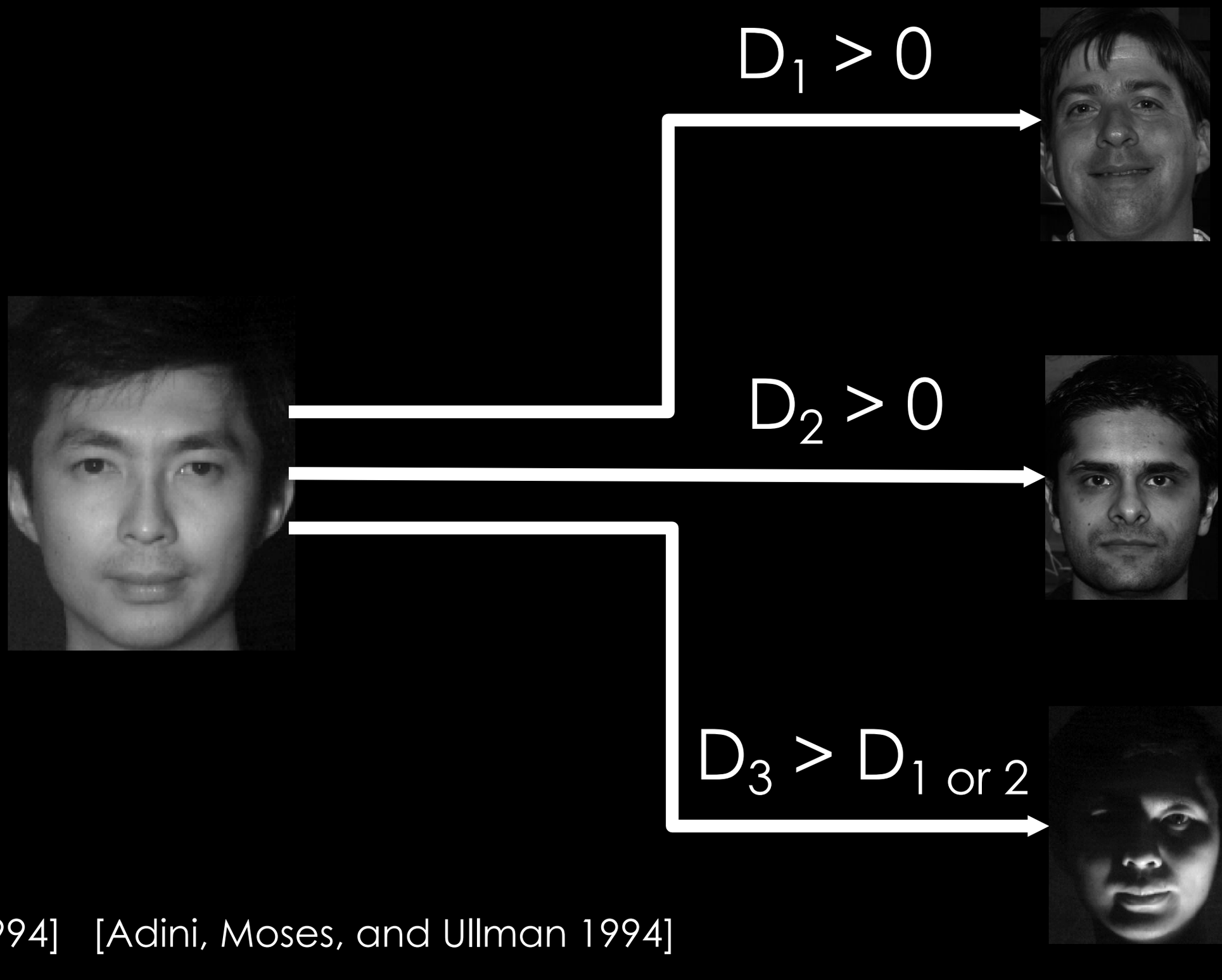


Image Recognition: Euclidean Distances



[Hallinan 1994] [Adini, Moses, and Ullman 1994]

Same Person

or

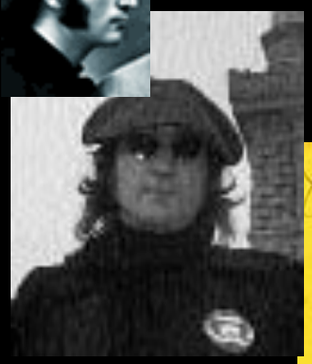
Different People

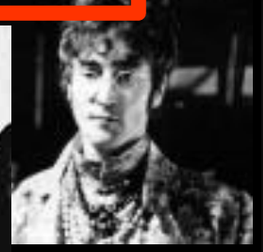
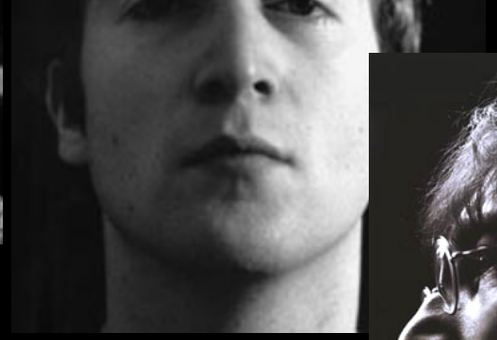
Same Person

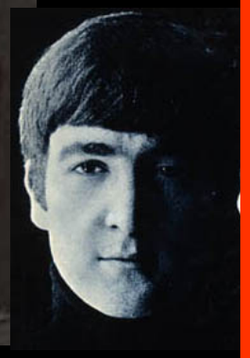
or

Different People

Why is Object Recognition Hard?





Non-Existence Theorem for Geometric Invariants

Geometric invariants for rigid transformations of 3-D objects viewed under perspective projective projection do not exist.

[Burns, Weiss, and Riseman 1992]

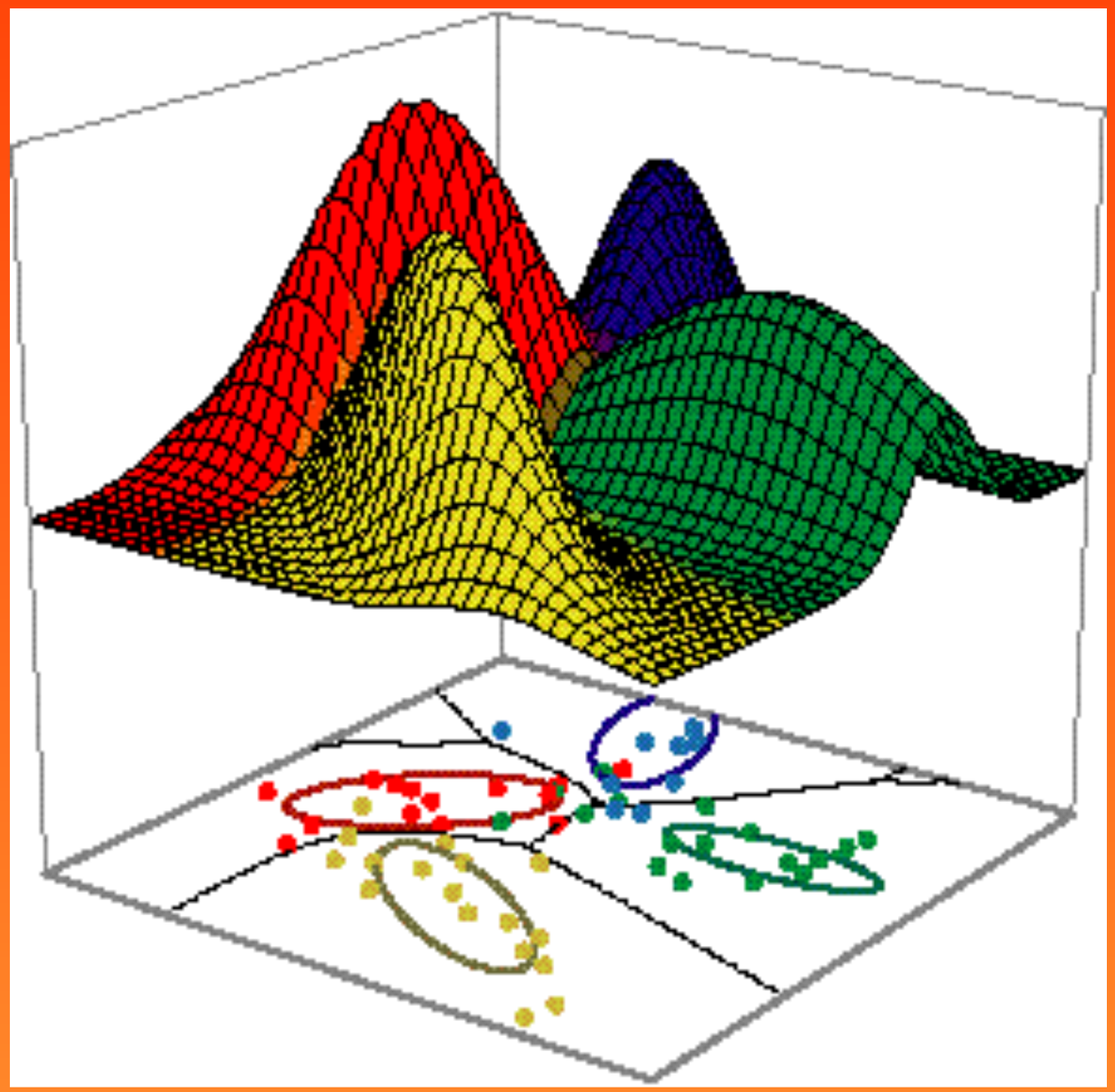
Non-Existence Theorem for Illumination Invariants

Illumination invariants for 3-D objects do not exist.

This result ***does not ignore*** attached and cast shadows, as well as surface interreflection.

[Chen, Belhumeur, and Jacobs 2000]

Classifiers

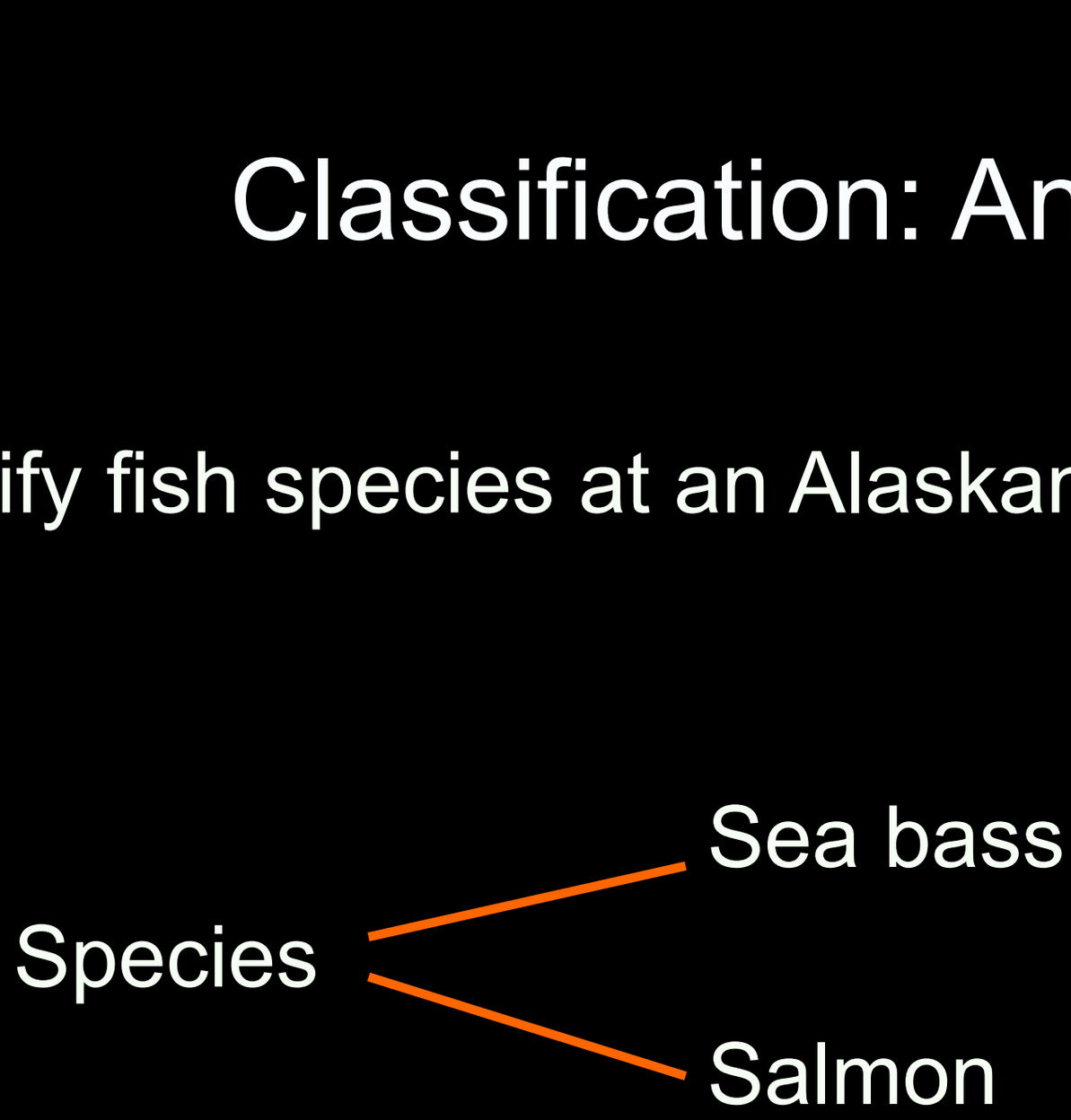


Pattern Classification

Duda, Hart, and Stork

Classification: An Example

Classify fish species at an Alaskan Canning Factory

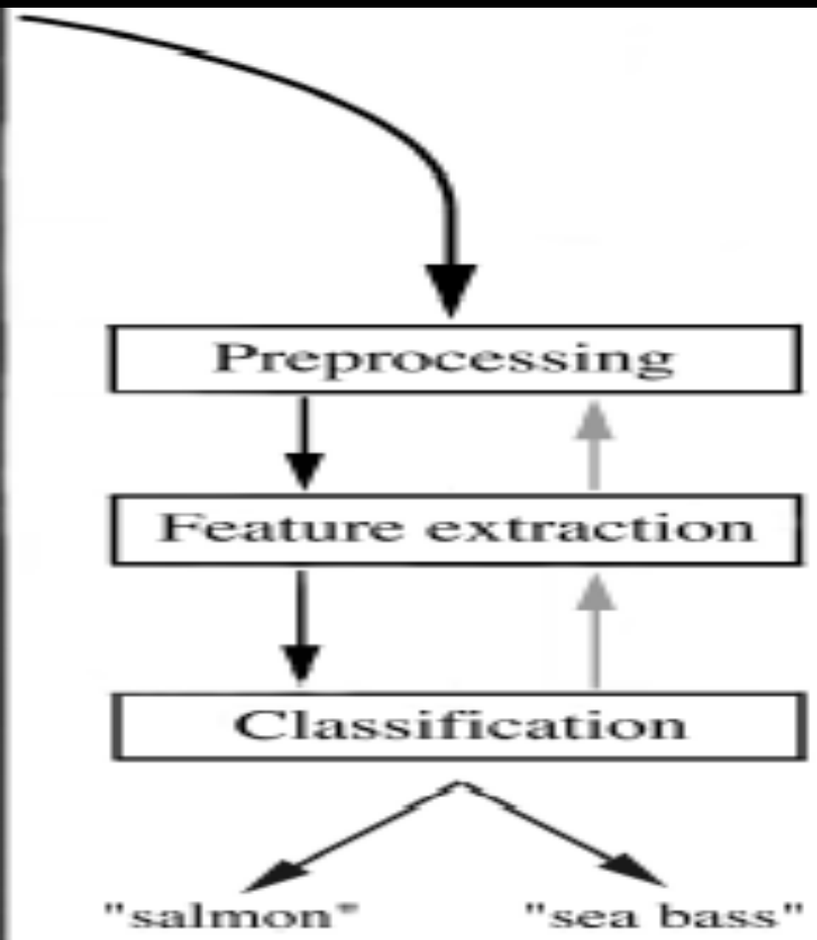


Building a classifier

Use a camera and take some sample images to extract features

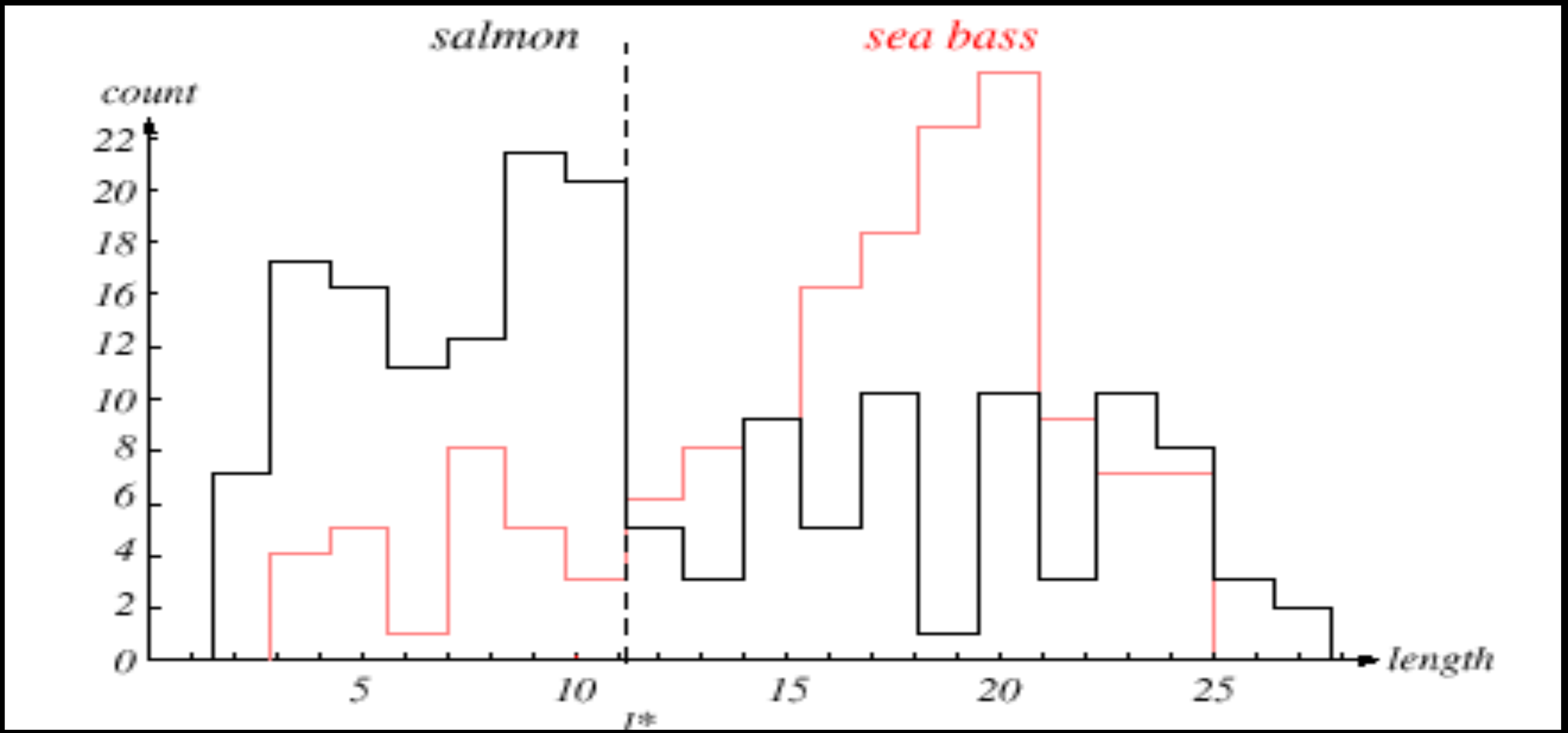
- Length
- Lightness
- Width
- Number and shape of fins
- Position of the mouth, etc…

- This is the set of all suggested features to explore for use in our classifier!


Preprocessing
Feature extraction
Classification
"salmon"
"sea bass"

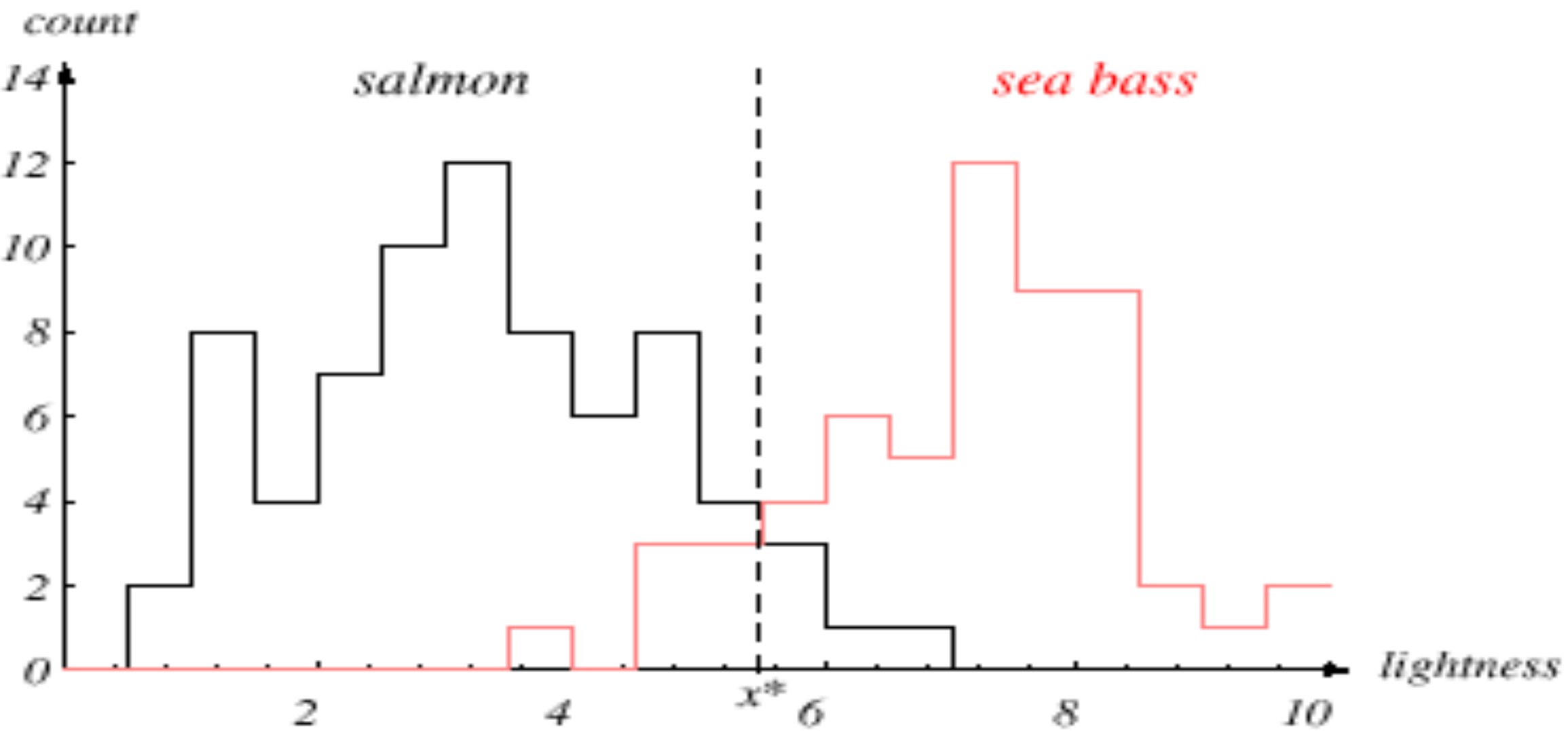
Manual Feature Selection

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


salmon
sea bass
count
22
20
18
16
12
10
8
6
4
2
0
5
10
15
20
25
length
l*

The length is a **poor** feature alone!

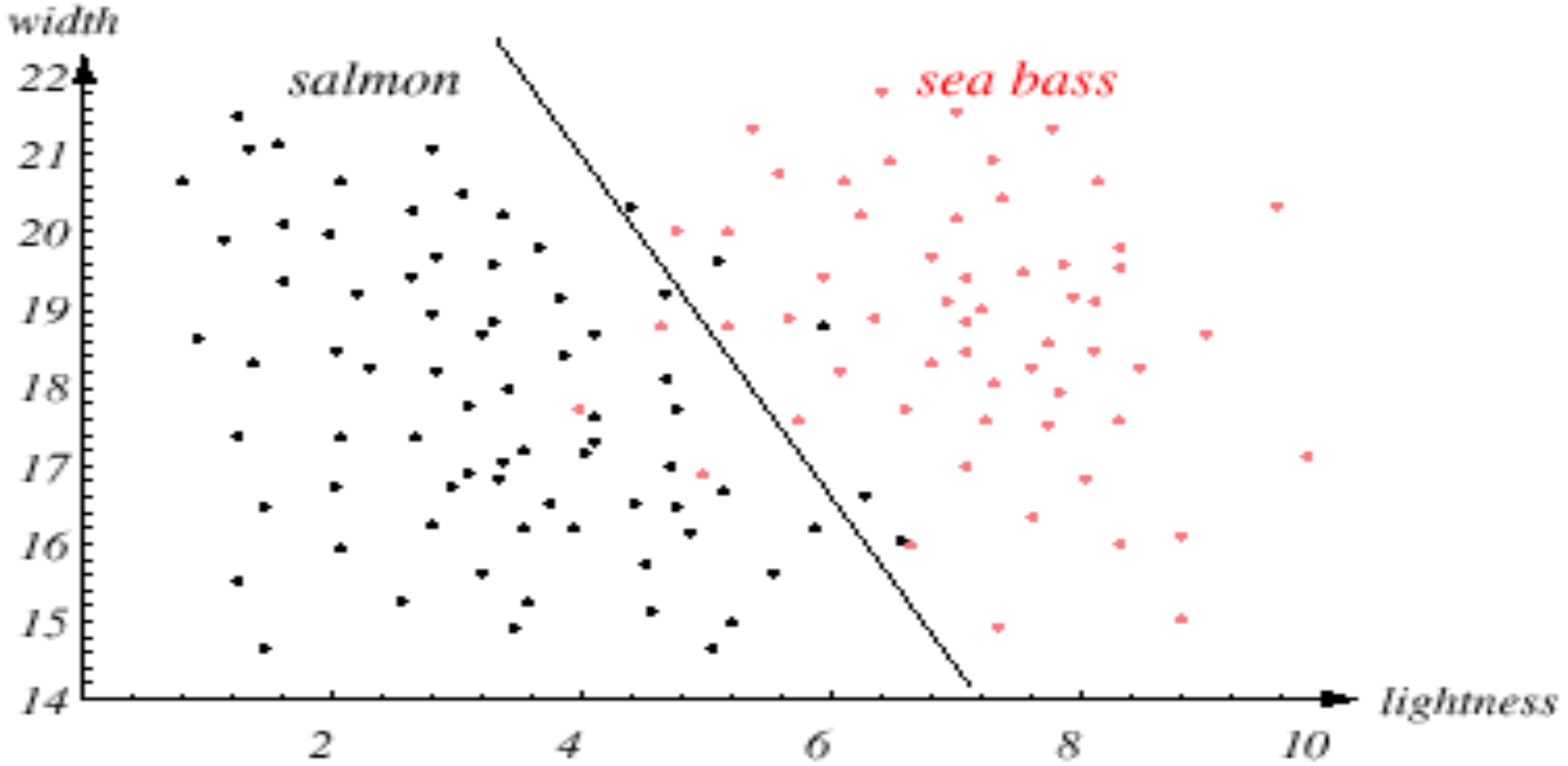
Select the lightness as a possible feature.


count
14
12
10
8
6
4
2
0
salmon
sea bass
2
4
x*
6
8
10
lightness

Adopt the lightness and add the width of the fish

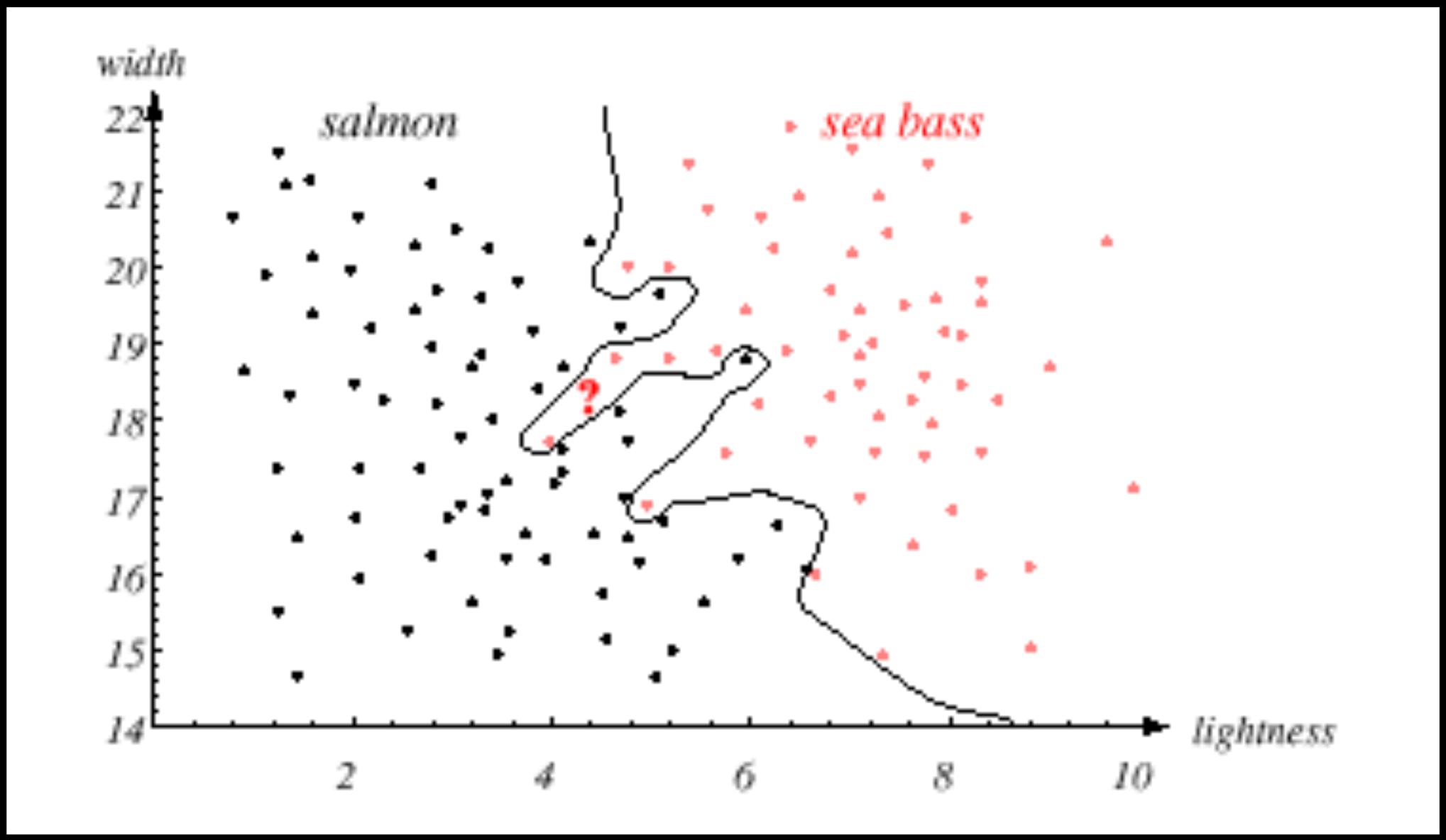
Fish → $x^T = [x_1, x_2]$

- x_1: **Lightness**
- x_2: **Width**

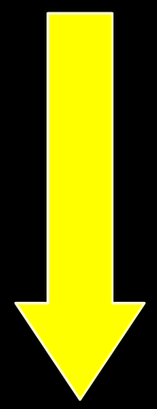

width
22
21
20
19
18
17
16
15
14
salmon
sea bass
2
4
6
8
10
lightness

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 "noisy features"

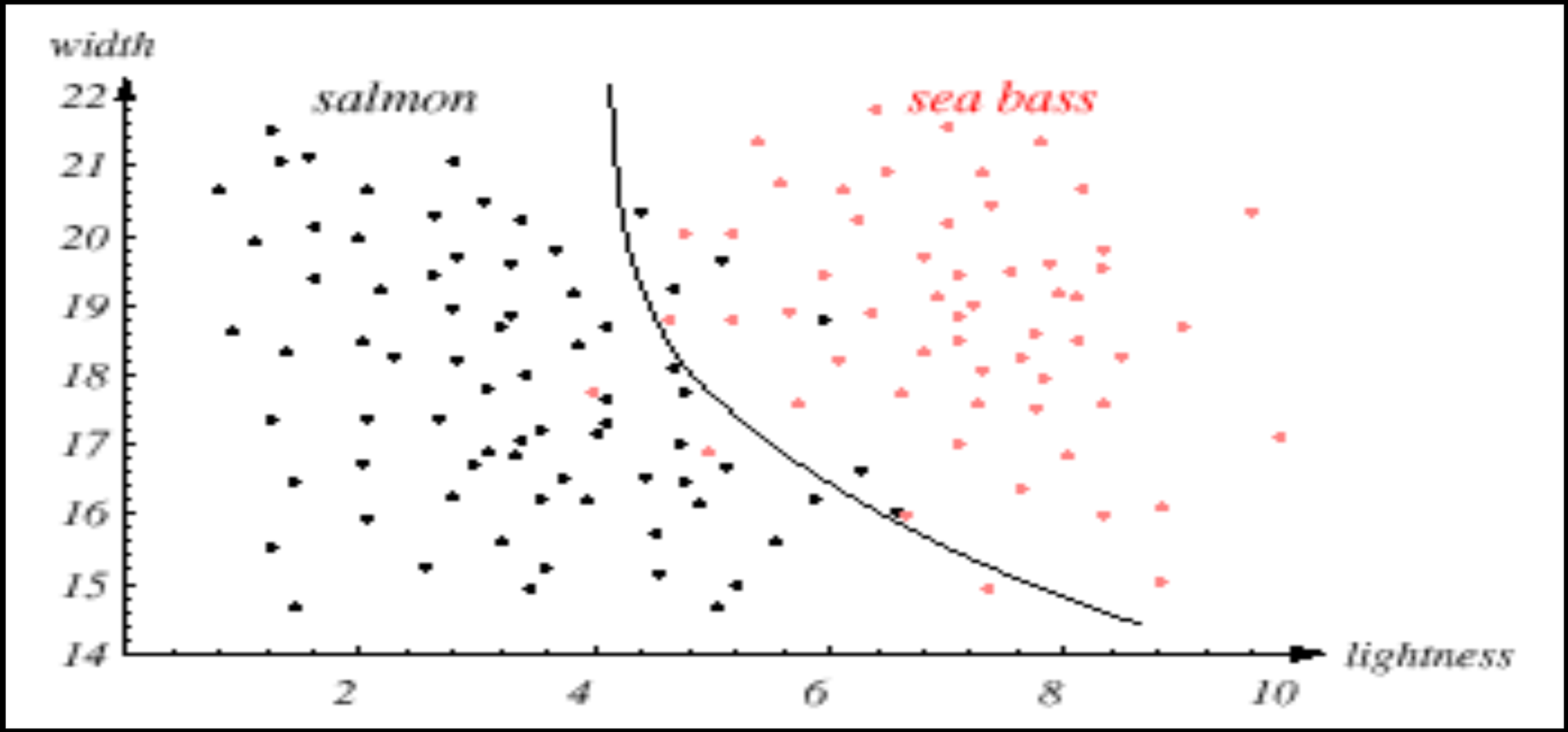
Ideally, the best decision boundary should be the one which provides an optimal performance.


width
22
21
20
19
18
17
16
15
14
salmon
sea bass
?
2
4
6
8
10
lightness

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



Issue of generalization!


width
22
21
20
19
18
17
16
15
14
salmon
sea bass
2
4
6
8
10
lightness