MLRF Lecture 01

J. Chazalon, LRDE/EPITA, 2025

More definitions

Lecture 01 part 02

Computer Vision

Computer Vision: a definition

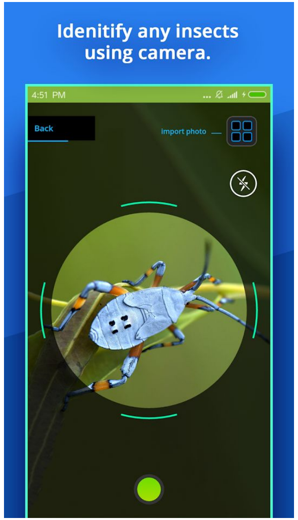
Computer Vision: *the automation of visual tasks with the goal of producing results directly or indirectly usable by humans.* ⇐ *Engineer definition*

Input: image(s) in machine format (image acquisition is a subpart of CV)

Output: some pieces of information about the image, new image(s)…

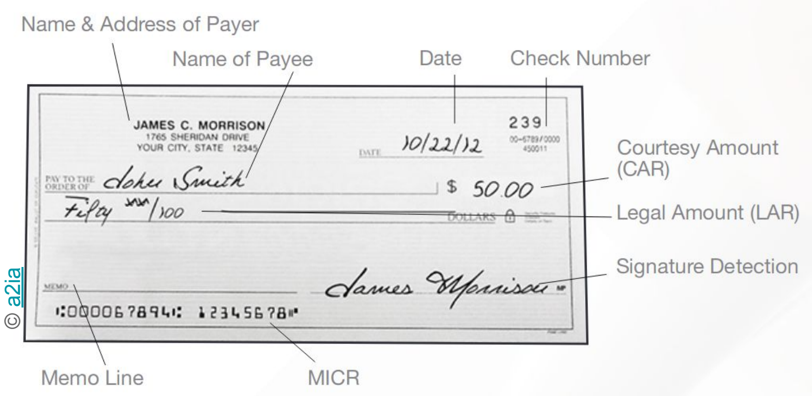
Computer Vision: some examples (1/4)

How would you process image pixels to get those results?



© Happimoji

© NASA



© a2ia

Input: still picture of insect
Output: insect name
Application: farming, …

Classification

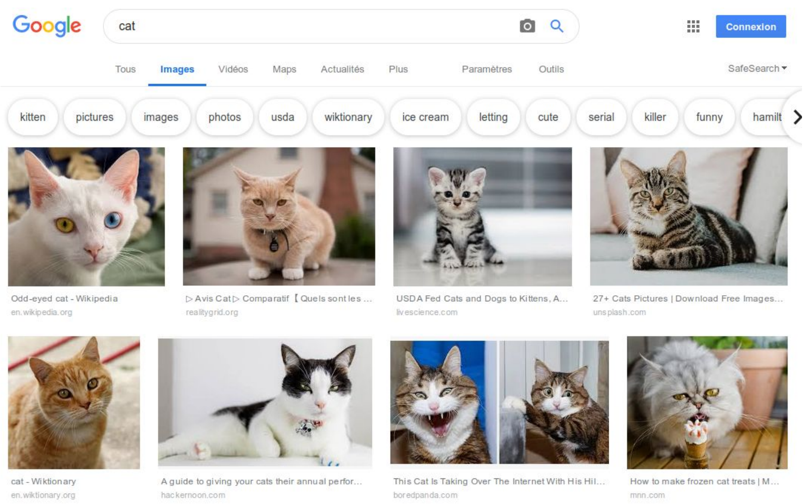
Input: satellite image (near visible range)
Output: crop maturity
Application: farming, trading…

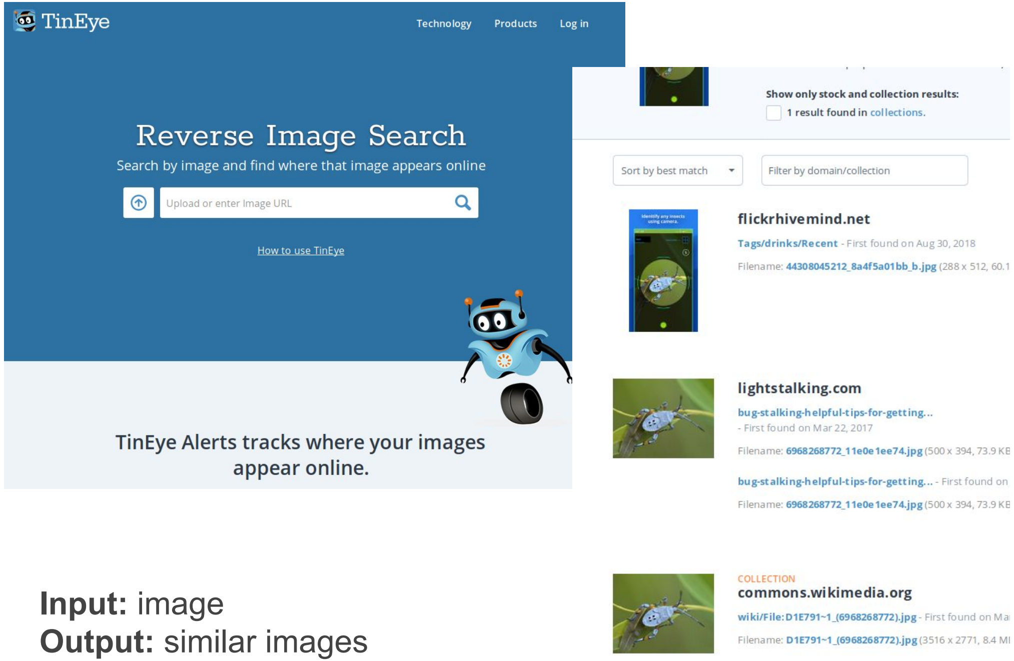
Regression

Input: bank check image (greylevel)
Output: account number, amount…
Application: banks

Detection, Classification, …

Computer Vision: some examples (2/4)





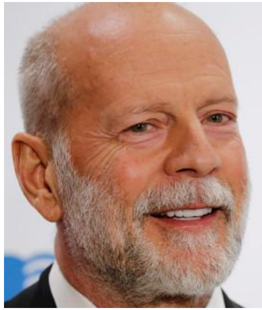
Input: text
Output: list of relevant images
Application: look for cats, …

Indexing, …

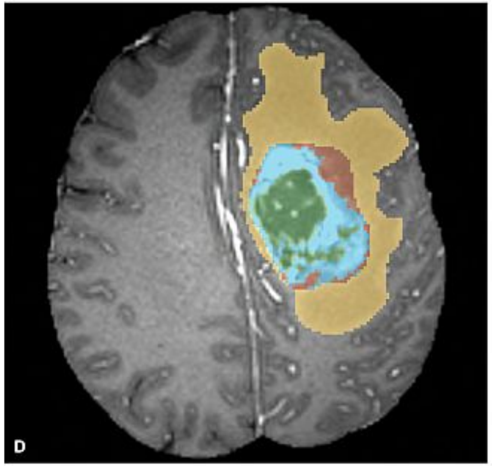
Input: image
Output: similar images
Application: duplicate detection, copyright, …

Content-based Image retrieval, …

Computer Vision: some examples (3/4)



vs



Input: two images of face
Output: same/different person
Application: authentication, …

Distance/similarity learning, …

Input: brain 3D scan
Output: regions with high tumor probability
Application: assisted diagnosis, …

Segmentation, classification, …

Computer Vision: some examples (4/4)

Some applications are direct (like the insect recognition app):
    a human reads and uses the output

Some applications are indirect (like bank check reading):
    the output is fed to a business system

Some applications extend what humans can naturally do:
    either by extending our range of visible colors (satellite example)
    or by simply being more efficient (face verification)

And there are many many many more examples…

Pattern Recognition

Pattern Recognition: a definition

Pattern Recognition: *The field of pattern recognition is concerned with the automatic discovery of regularities in data through the use of computer algorithms and with the use of these regularities to take actions such as* ***classifying*** *the data into different categories.* *— Bishop 2006*

The International Association for Pattern Recognition (IAPR) is an international association [...] concerned with **pattern recognition**, **computer vision**, and **image processing** in a broad sense.

Pattern Recognition: examples

OCR Computer Vision

Pedestrian detection Computer Vision

Credit card fraud detection NOT Computer Vision

…

$\Rightarrow$ $CV \cap PR \neq \varnothing$, “recognition” used to mean “classification”

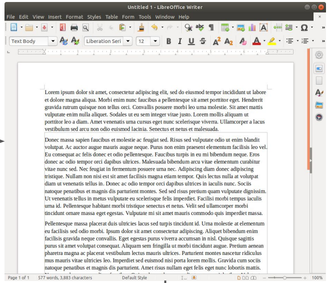
Pattern Recognition is an <u>inverse</u> problem

OCR example – Why Pattern Recognition is hard

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Phasellus nulla ...

Type some text

Forward

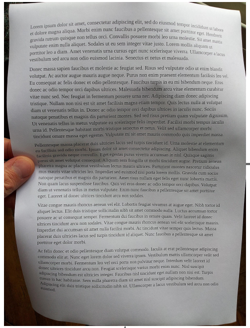


Print it

...

“Scan” it

Reverse



Loren gypsum dolor sit mate, consecrate disciplining lit. Phallus nulls ...

Try to guess was the original text was

“Shapes”

“Shapes”

Sometimes used to describe “visual percepts” (image patterns) which exhibit a “large [deviation] from randomness”. See *Cao et al. 2008*.

A way to designate meaningful visual patterns.

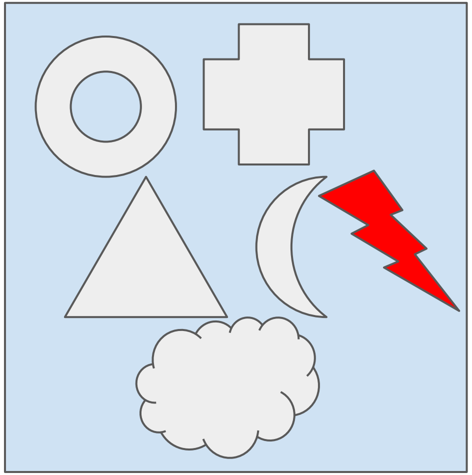
An interesting mathematical foundation to compare them:

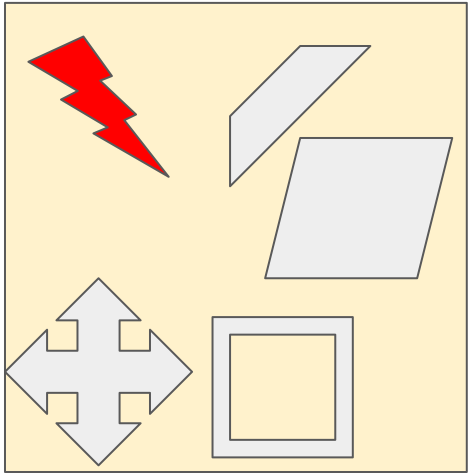
Let S and S’ be two shapes observed in two different images and which happen to be similar. Denote their (small) Hausdorff distance after registration by $\delta = d(S, S')$. Assume we know enough of the background model to compute the probability $Pr(S, \delta) = Pr(d(S, \Sigma) \leq \delta)$ that some shape in the background, Σ be as similar to S as S ' is. If this probability is very small one can deduce that S ' does not look like S just by chance. Then S and S ' will be identified as the same shape.

We can check whether two shapes are <u>significantly</u> close.

“Shapes”

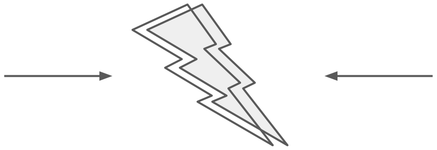
Let S and S’ be two shapes observed in two different images and which happen to be similar.

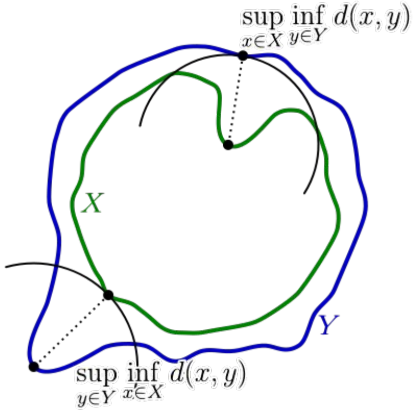




“Shapes”

Let S and S’ be two shapes observed in two different images and which happen to be similar. Denote their (small) Hausdorff distance after registration by δ = d(S, S').





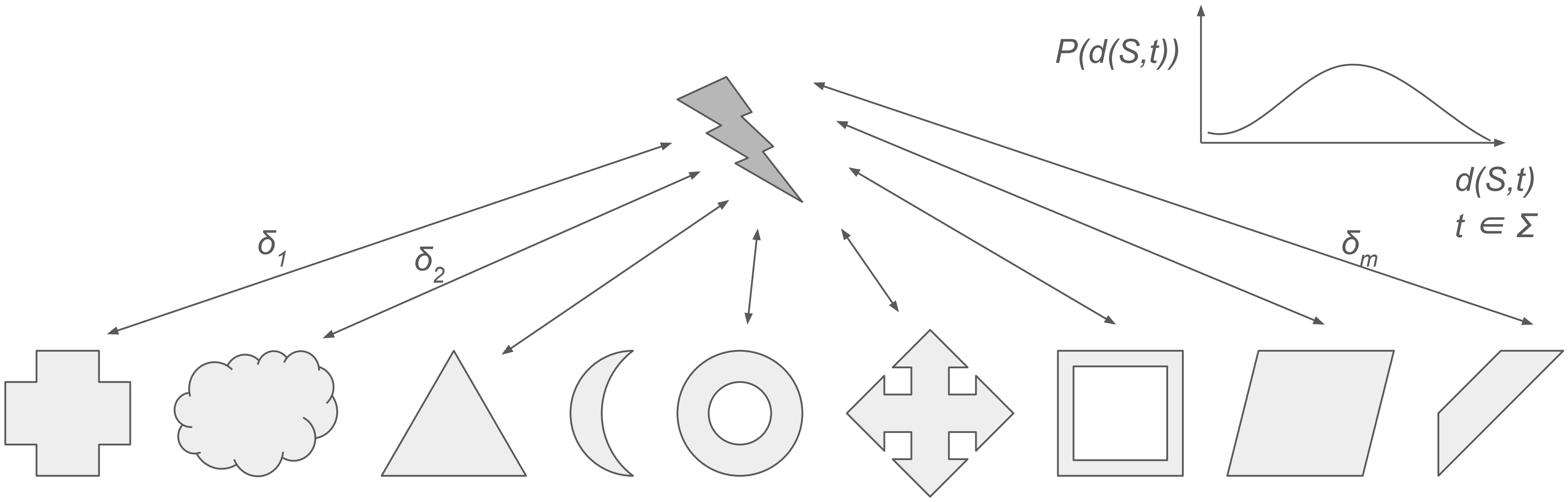
© Rocchini

Hausdorff distance = max of min distances between points on the contours of two shapes.

$$d_{\mathrm{H}}(X,Y) = \max\{\,\sup_{x\in X} \inf_{y\in Y} d(x,y),\ \sup_{y\in Y} \inf_{x\in X} d(x,y)\,\}.$$

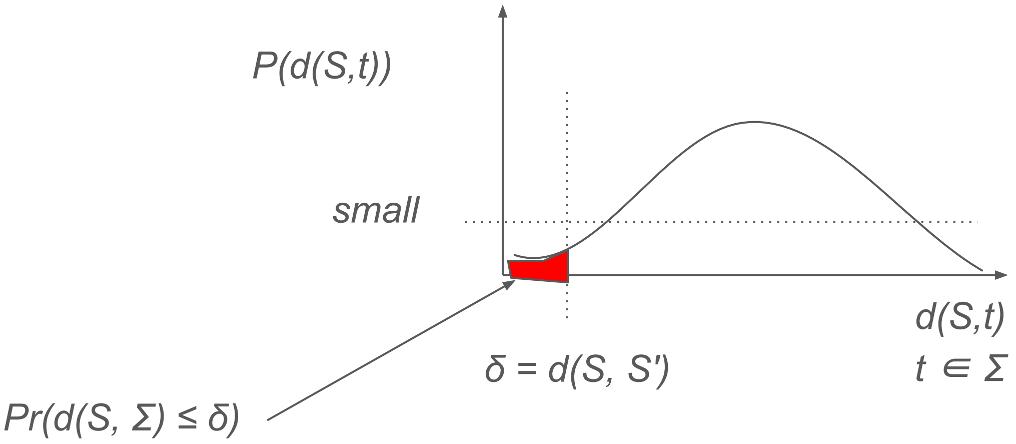
"Shapes"

Let S and S' be two shapes observed in two different images and which happen to be similar. Denote their (small) Hausdorff distance after registration by δ = d(S, S'). <u>Assume we know enough of the background model to compute the probability Pr(S, δ) = Pr(d(S, Σ) ≤ δ) that some shape in the background, Σ be as similar to S as S ' is.</u>



“Shapes”

Let S and S’ be two shapes observed in two different images and which happen to be similar. Denote their (small) Hausdorff distance after registration by δ = d(S, S'). Assume we know enough of the background model to compute the probability Pr(S, δ) = Pr(d(S, Σ) ≤ δ) that some shape in the background, Σ be as similar to S as S ' is. <u>If this probability is very small one can deduce that S ' does not look like S just by chance. Then S and S ' will be identified as the same shape.</u>



So, some **statistics** can help us making better decisions…

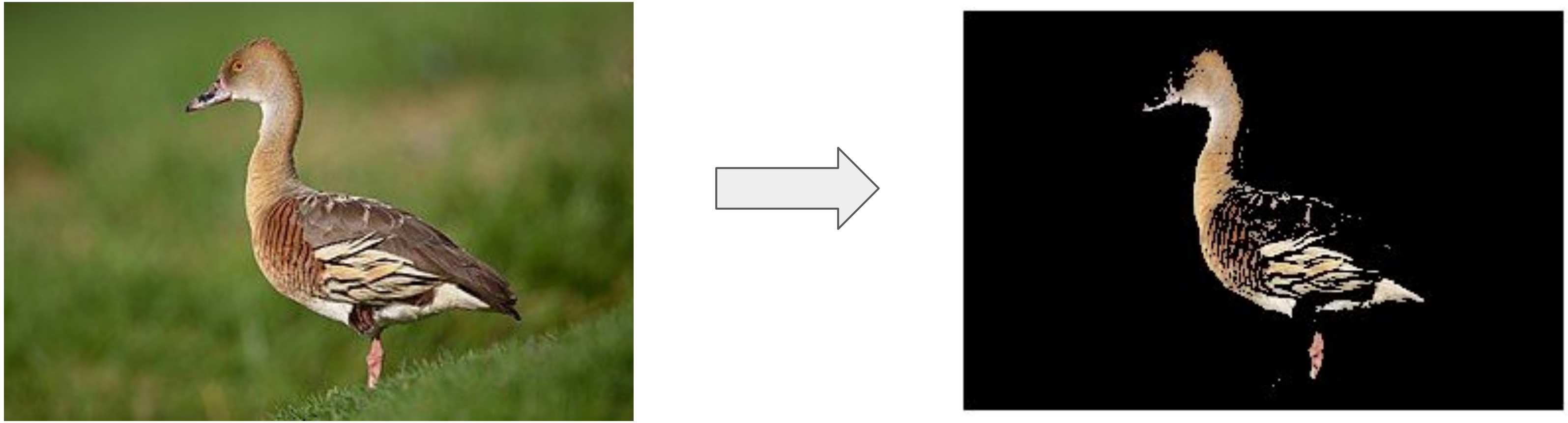
Idea: **learn** the distance threshold under which shapes can be deemed identical.

<u>***A contrario*** approach.</u>

Benefits of ML for CV/PR

A duck example

How to filter the grass to keep only the duck shape, using thresholds in the color domain?

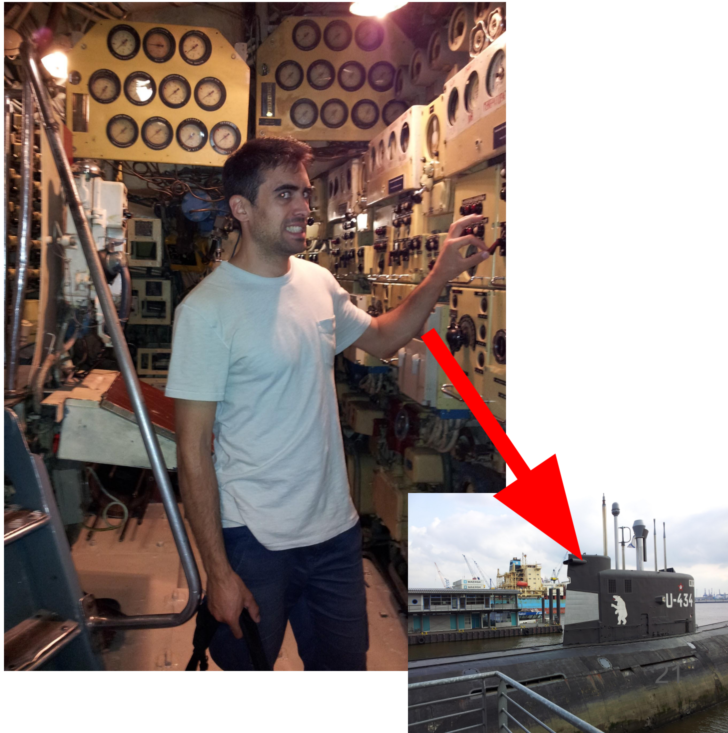


Try it during practice session!
How boring is it to tune the parameters by hand?

Why using Machine Learning in Computer Vision?

To avoid knob tuning. It's complex. It's unsafe.

Photo by jc.winkler

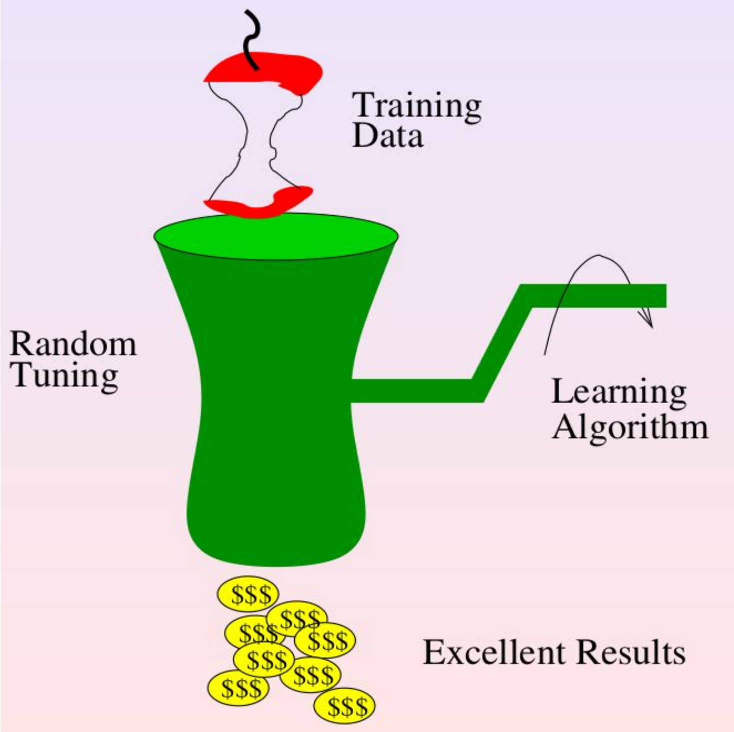


Computer Vision / Pattern Recognition

from S. Bengio 2005

But Beware of the Machine Learning Magic

What they sell you…



But most often…