

Lecture 15 – Classifying images

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Agenda

- Digital images
- A classification problem
- Classification pipelines
- Learning models
- Cross-validation
- Classification evaluation

A CLASSIFICATION PROBLEM

A classification problem

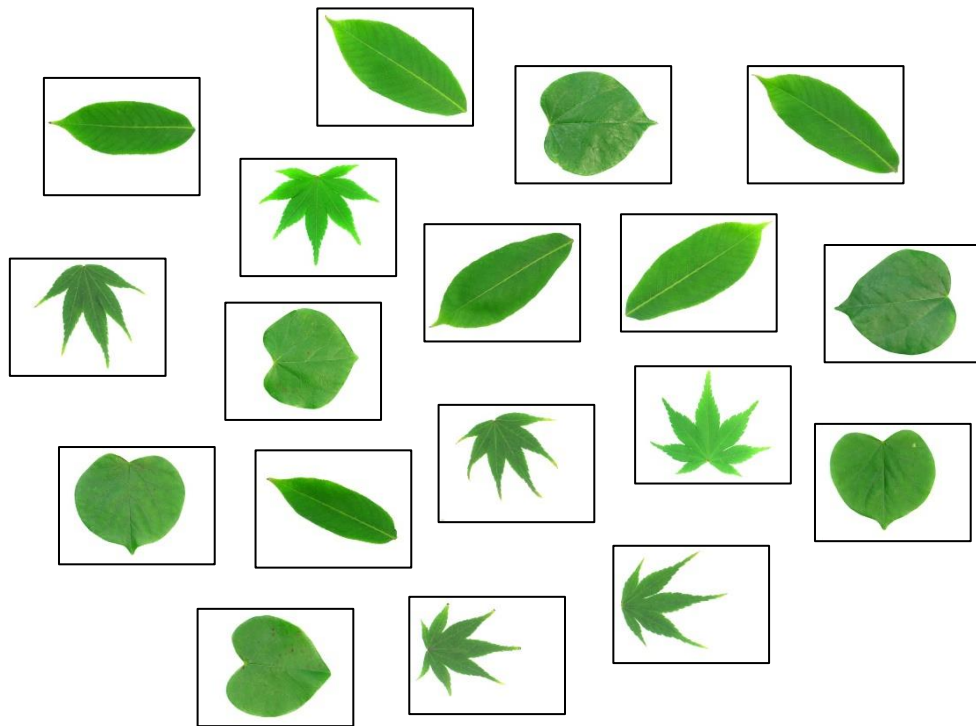
- Learning to classify three types (classes) of leaves from images.

- Flavia leaf dataset:

- <http://flavia.sourceforge.net/>
- 1,907 images
- 33 classes

- We selected 3 classes:

- *aesculus chinensis*
- *acer palmatum*
- *cercis chinensis*



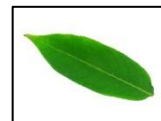
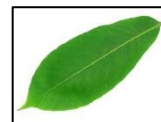
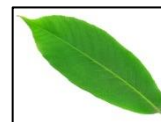
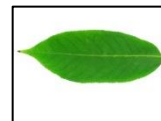
A classification problem

- Learning to classify three types (classes) of leaves from images.

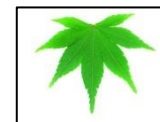
- Feature extraction:
 - Select features from the images that can be used to distinguish between the classes.

- Features can be:
 - Shapes
 - Colors
 - Textures
 - Histogram of gradients (HoG)
 - Bag of Visual Words*
 - Fisher Vectors*
 - ...

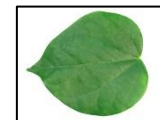
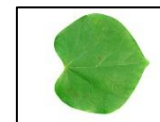
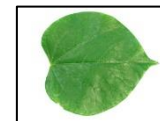
aesculus chinensis



acer palmatum



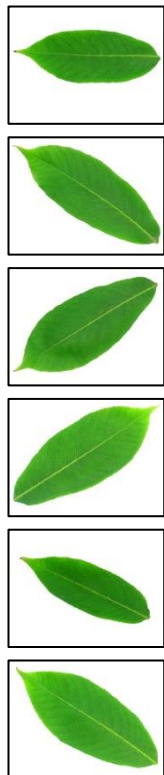
cercis chinensis



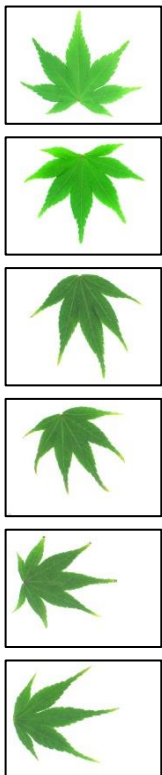
A classification problem

- Some feature shapes:

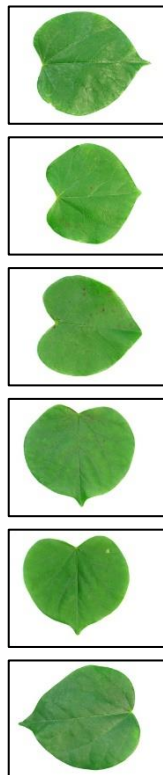
aesculus chinensis



acer palmatum



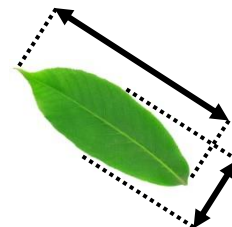
cercis chinensis



Area:

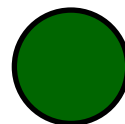


Axis:



Roundness:

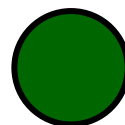
1,0



0,0

Excentricity:

0,0



1,0

Solidity:



÷



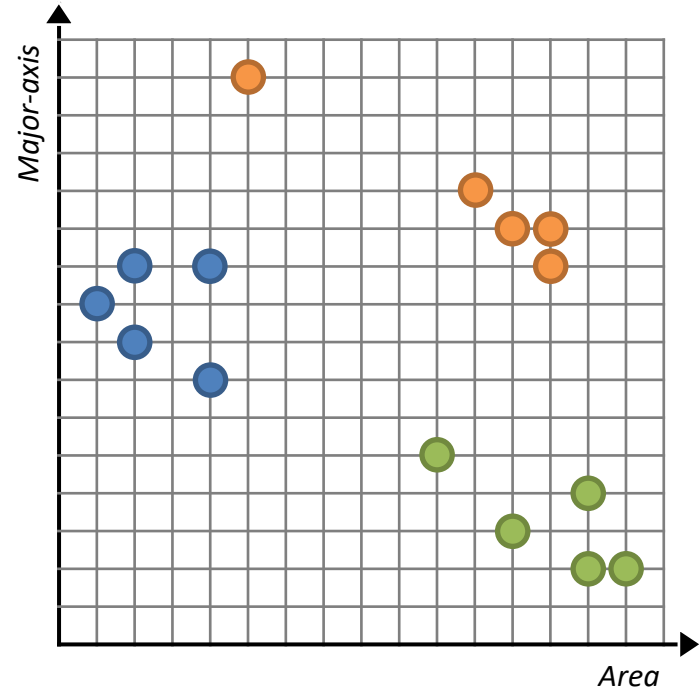
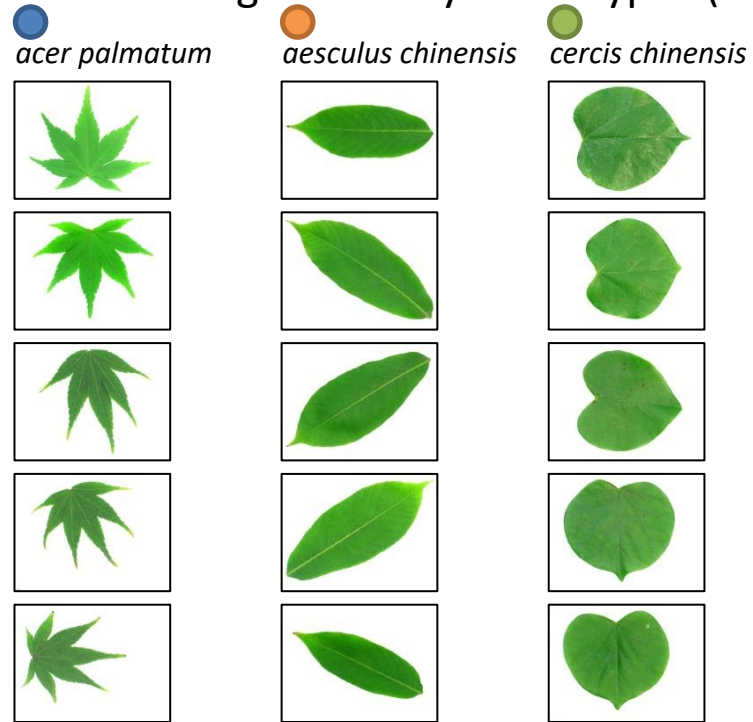
÷



<https://scikit-image.org/docs/stable/api/skimage.measure.html#skimage.measure.regionprops>

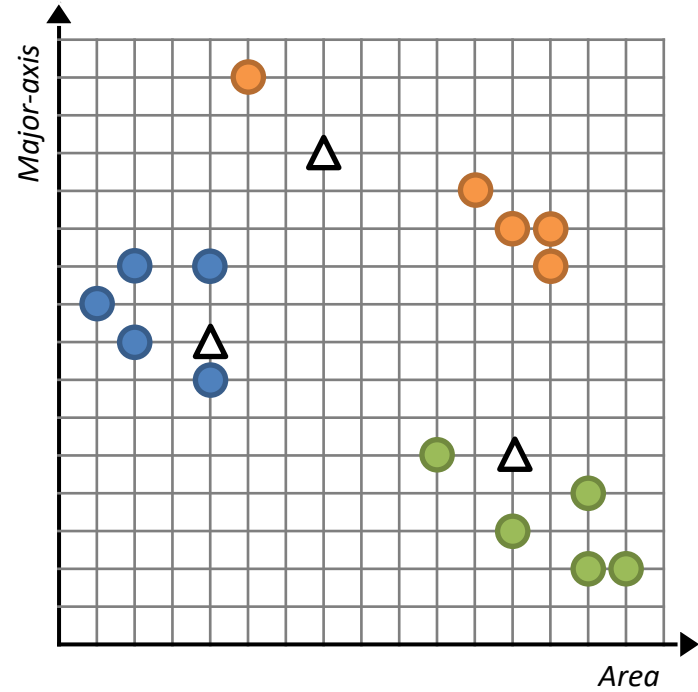
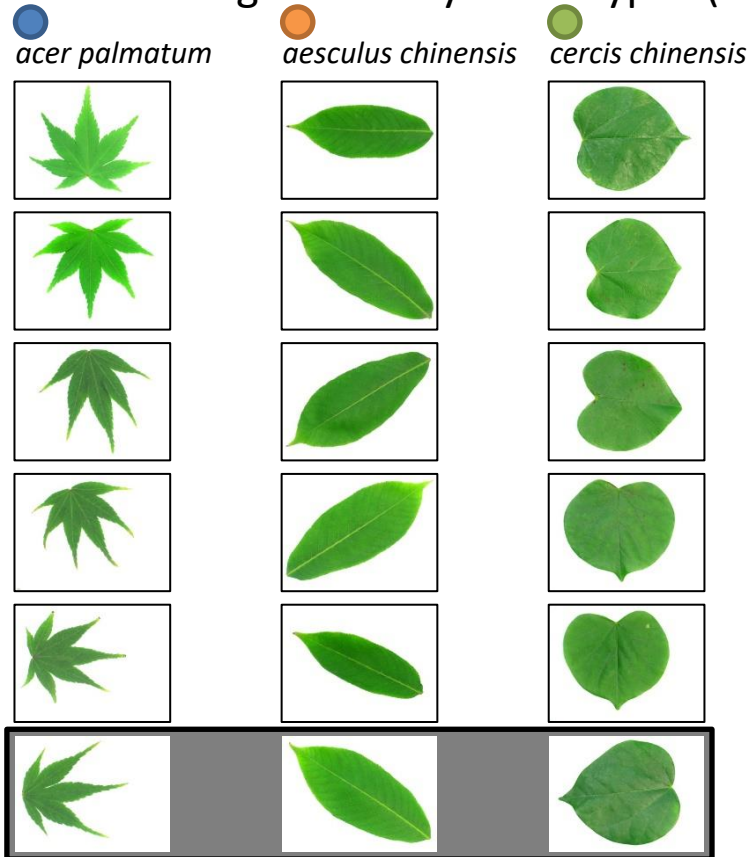
A classification problem

- Learning to classify three types (classes) of leaves from images.

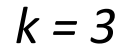


A classification problem

- Learning to classify three types (classes) of leaves from images.

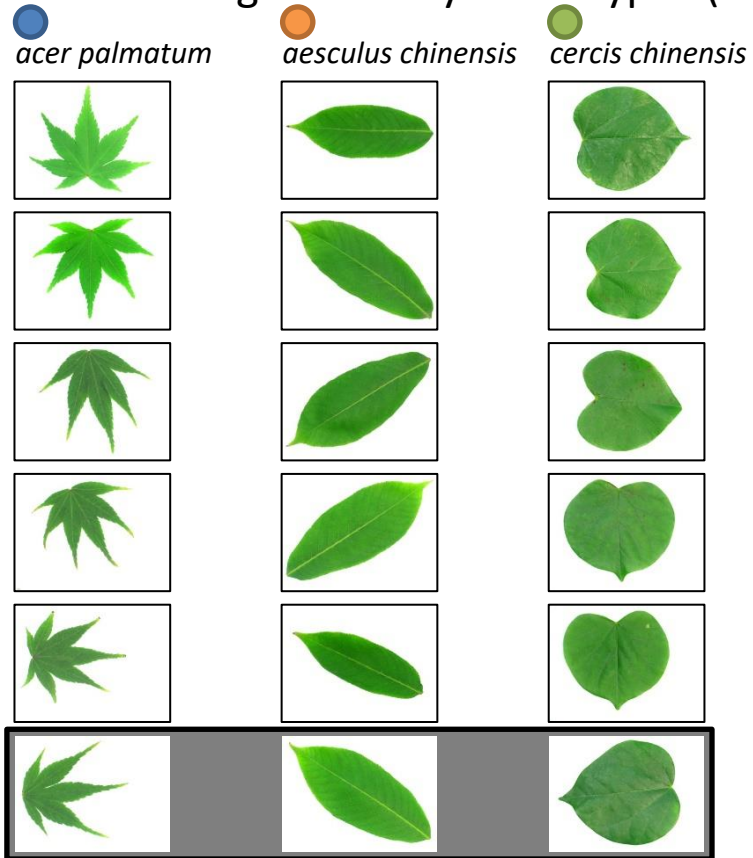


- *acer palmatum* ● *aesculus chinensis* ● *cercis chinensis*

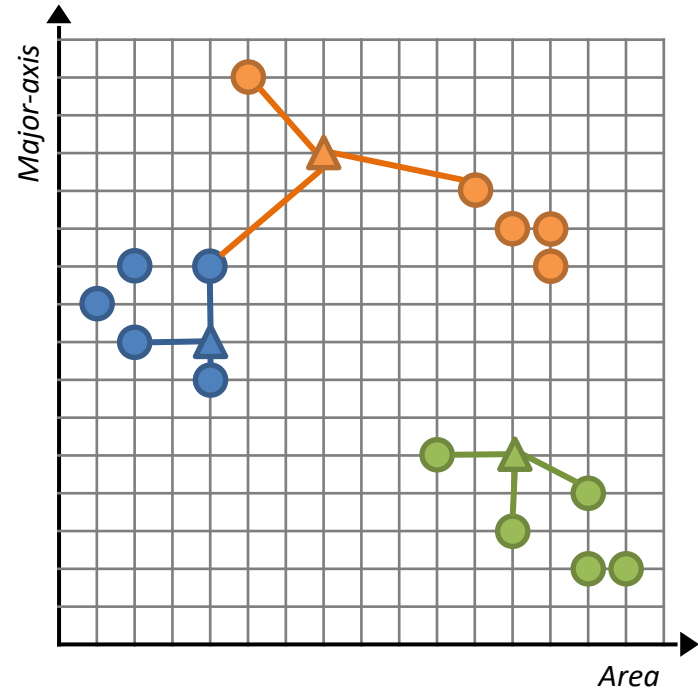


K-nearest neighbors – K-NN

- Learning to classify three types (classes) of leaves from images.






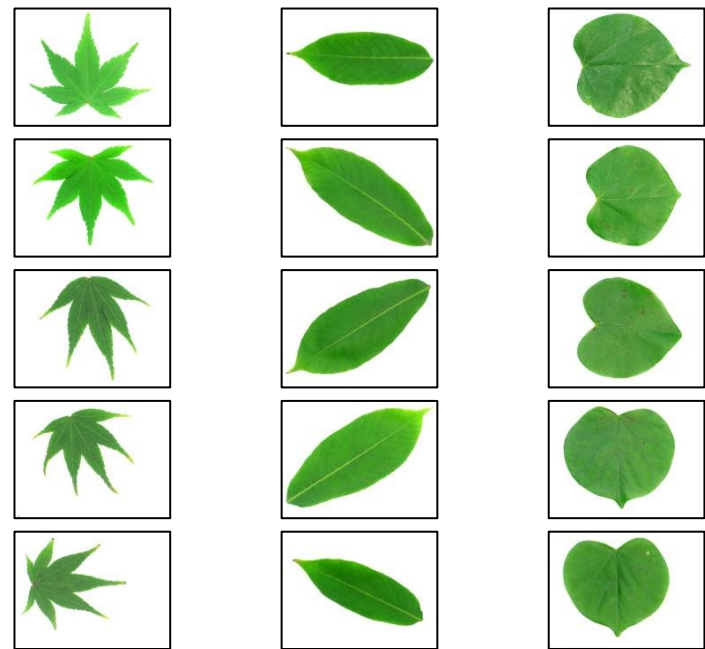
$k = 3$



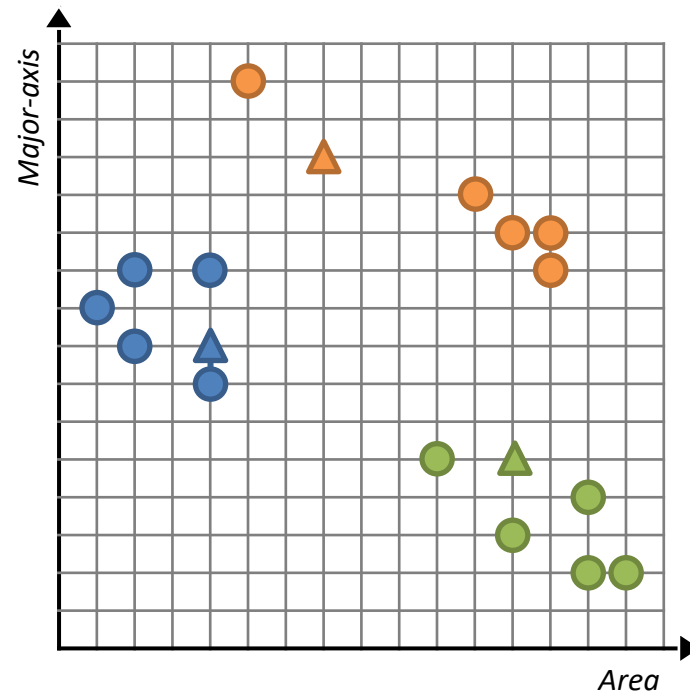
K-nearest neighbors – K-NN

- Learning to classify three types (classes) of leaves from images.

 *acer palmatum*
 *aesculus chinensis*
 *cercis chinensis*

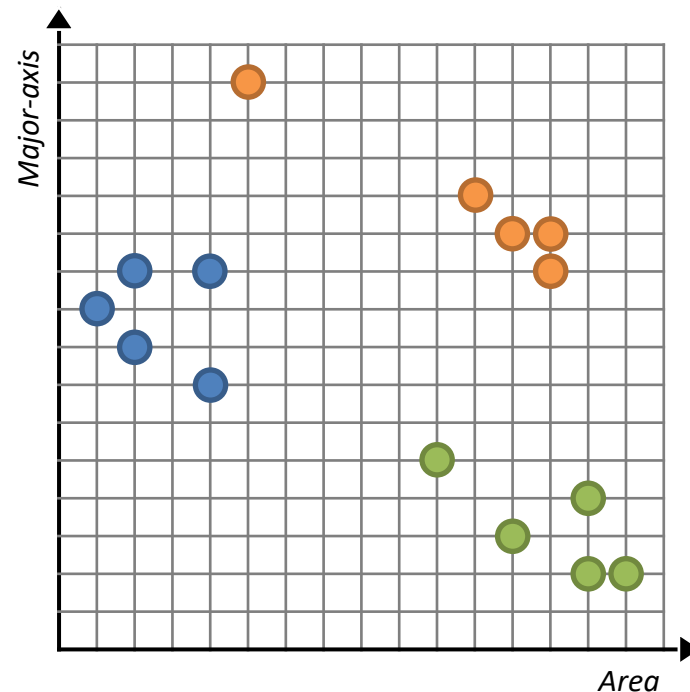
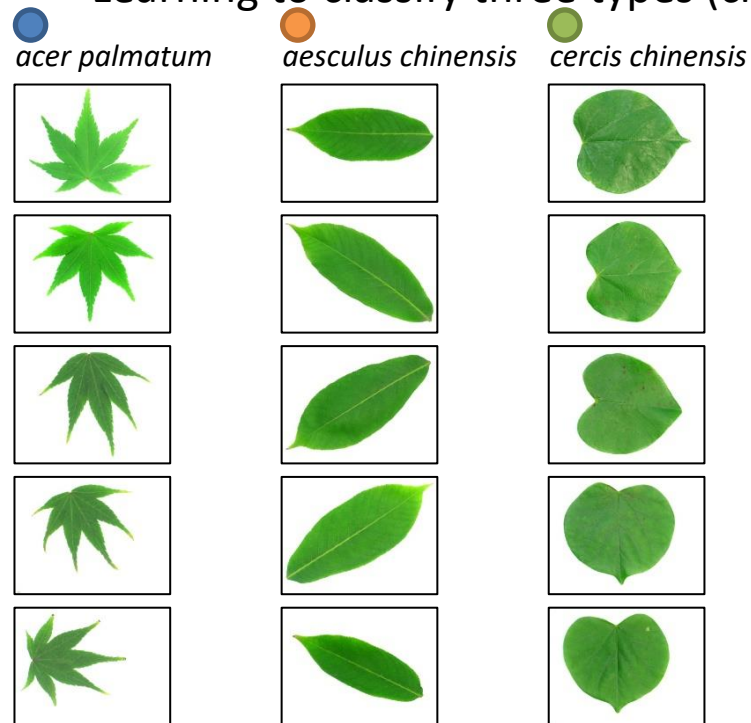


$k = 3$



Linear functions (Perceptrons)

- Learning to classify three types (classes) of leaves from images.

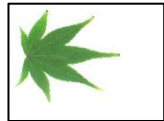


Linear functions (Perceptrons)

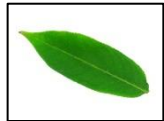
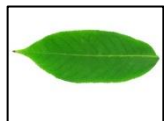
- Learning to classify three types (classes) of leaves from images.



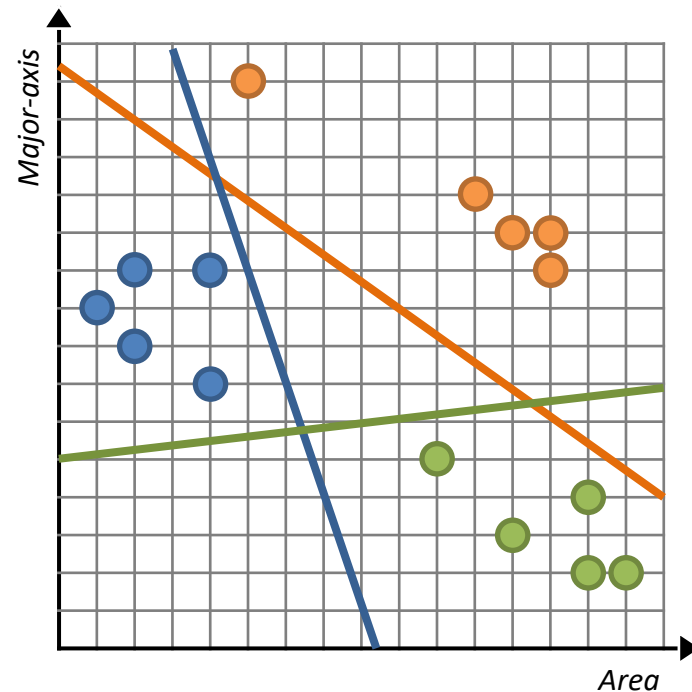
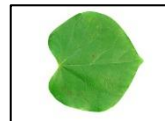
acer palmatum



aesculus chinensis



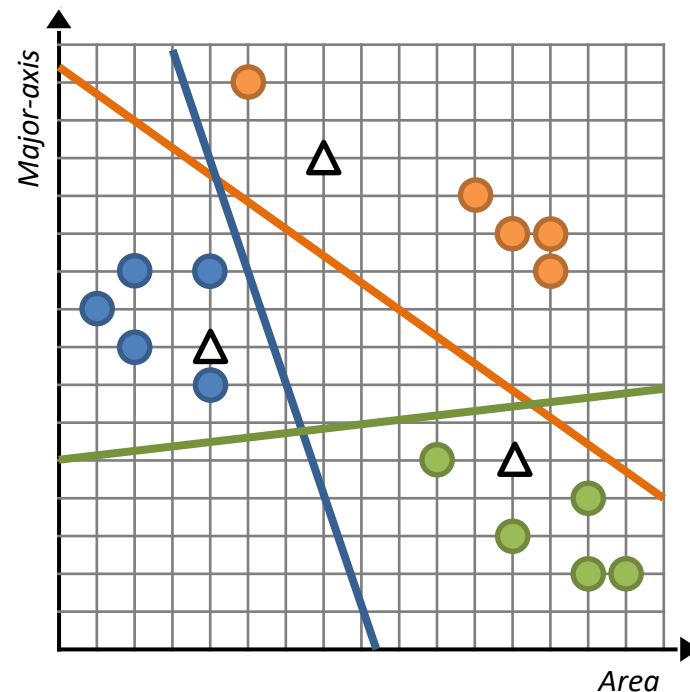
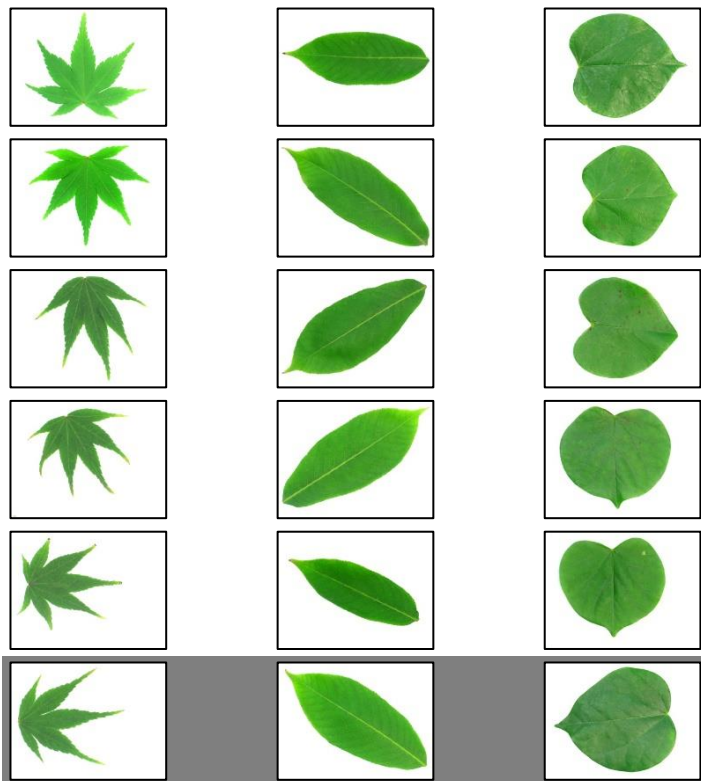
cercis chinensis



Linear functions (Perceptrons)

- Learning to classify three types (classes) of leaves from images.

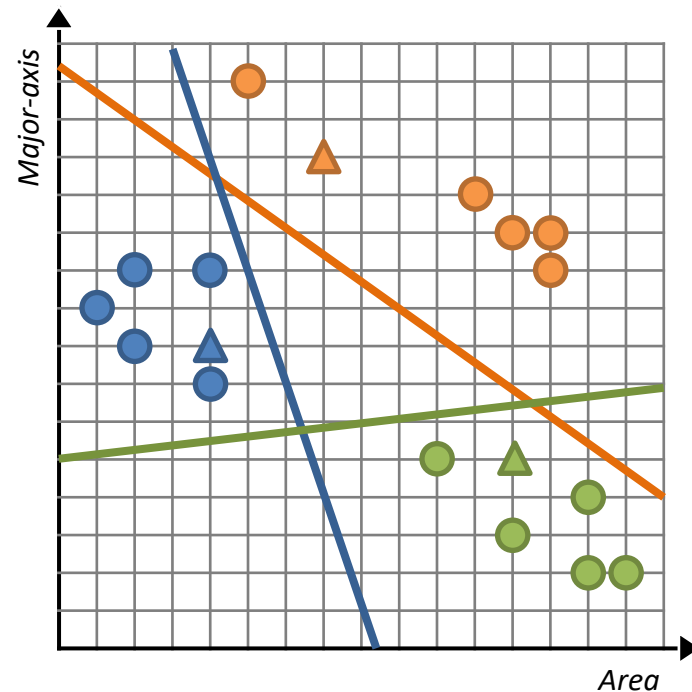
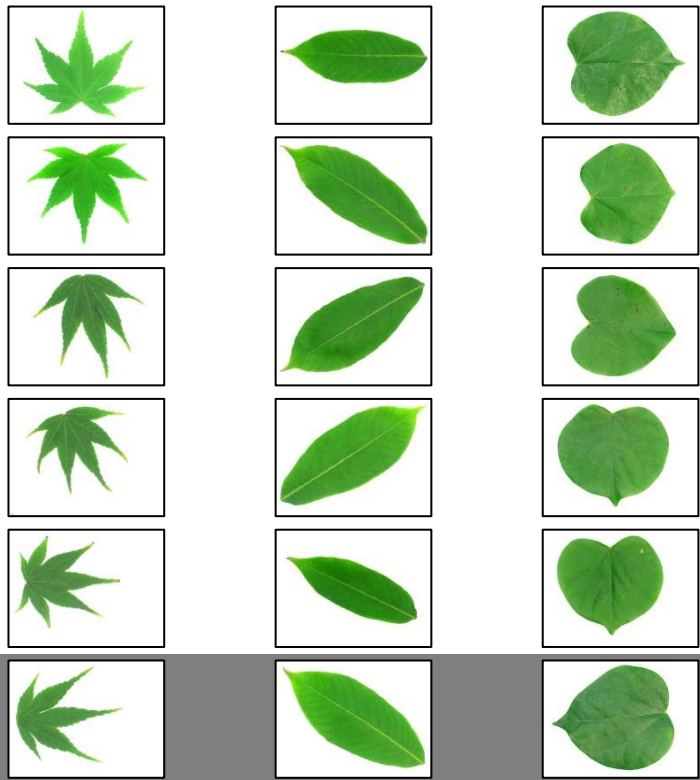
● *acer palmatum*
● *aesculus chinensis*
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Linear functions (Perceptrons)

- Learning to classify three types (classes) of leaves from images.

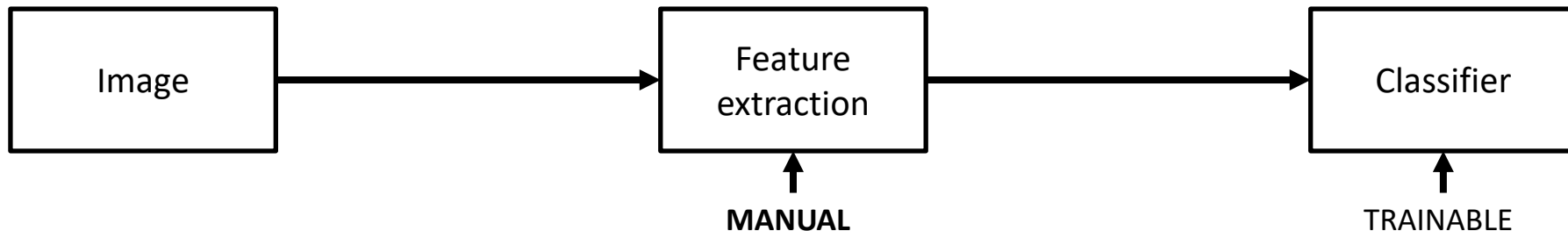
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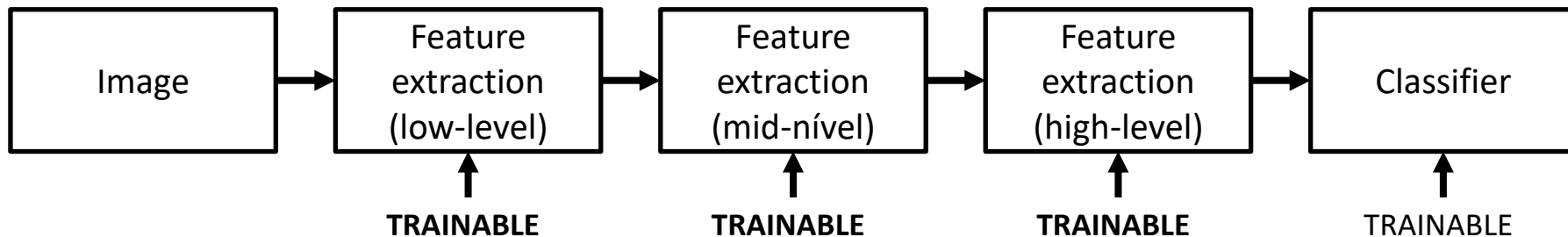
CLASSIFICATION PIPELINES

Classification pipelines

The classic image classification pipeline



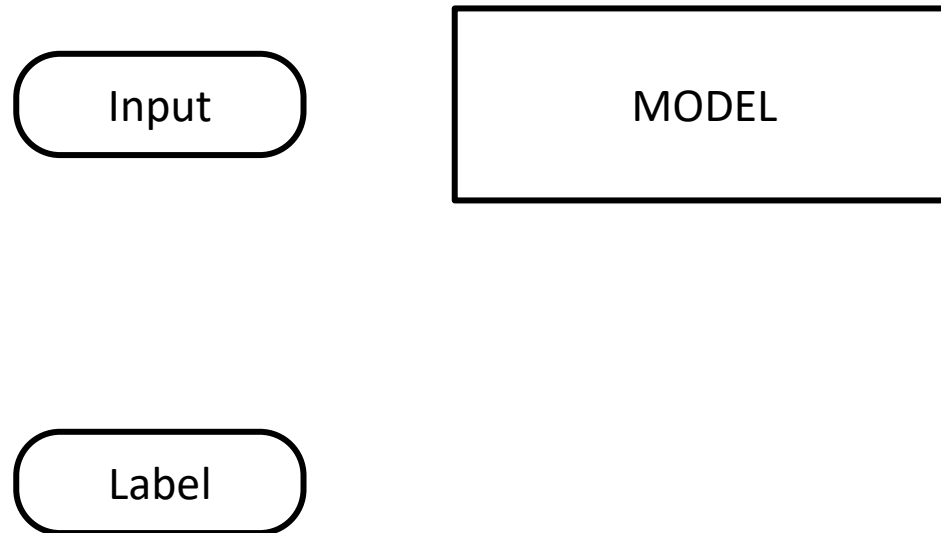
Deep Learning

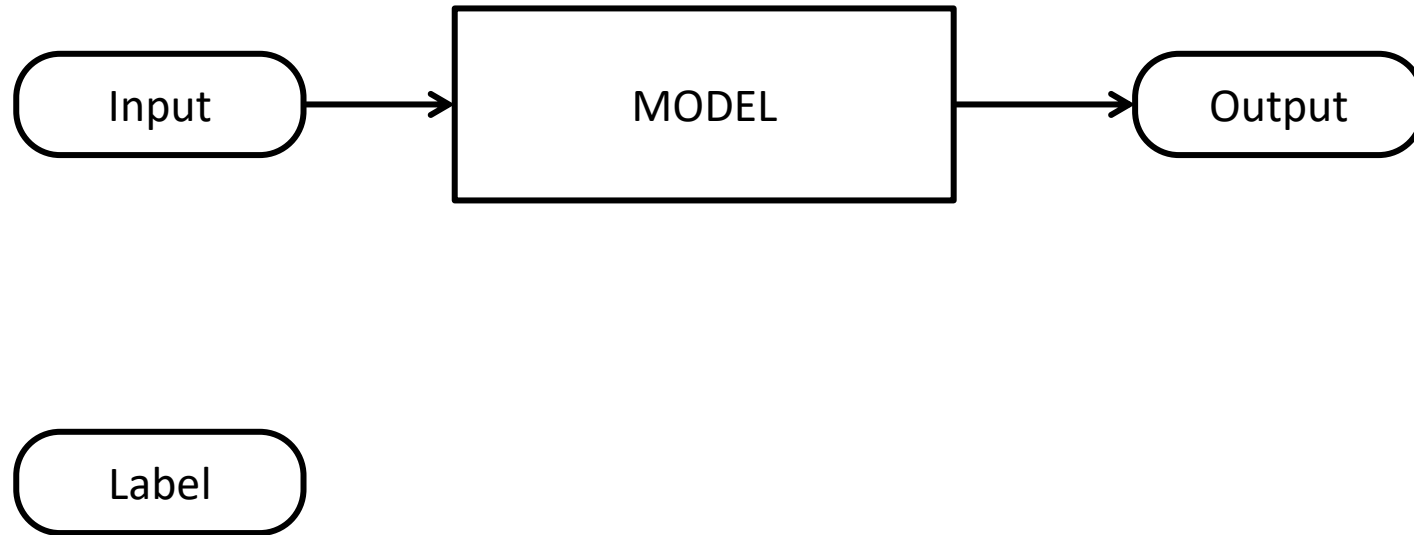


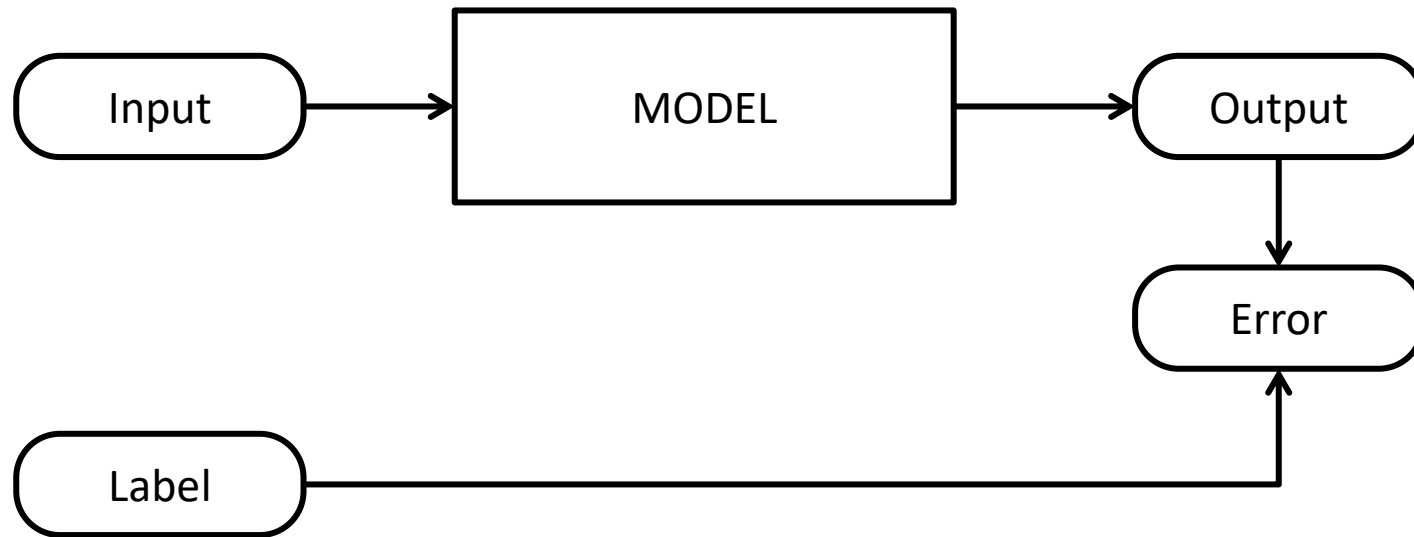
LEARNING MODELS

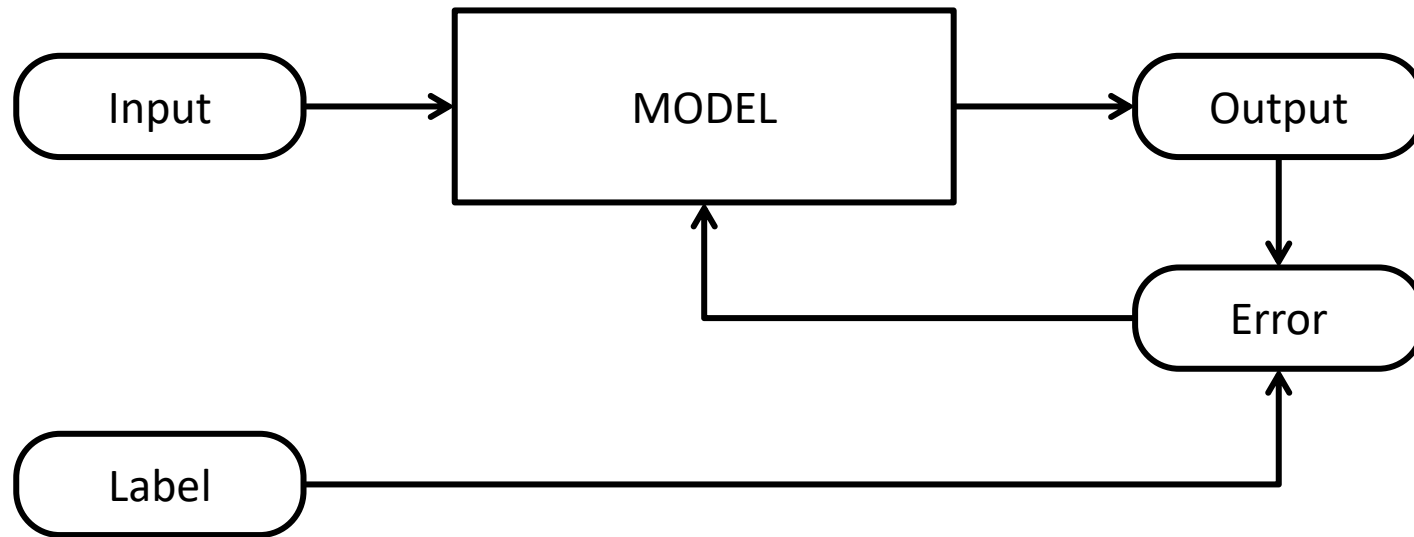
Learning models

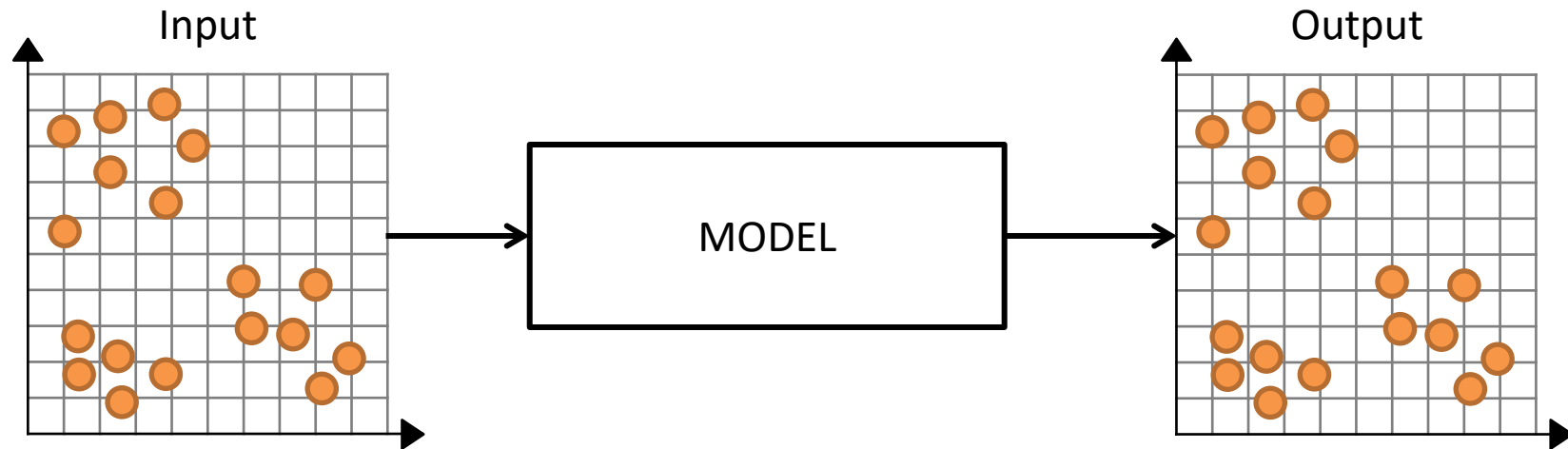
- Supervised learning
- Unsupervised learning
- Reinforcement learning
- Semi-supervised learning

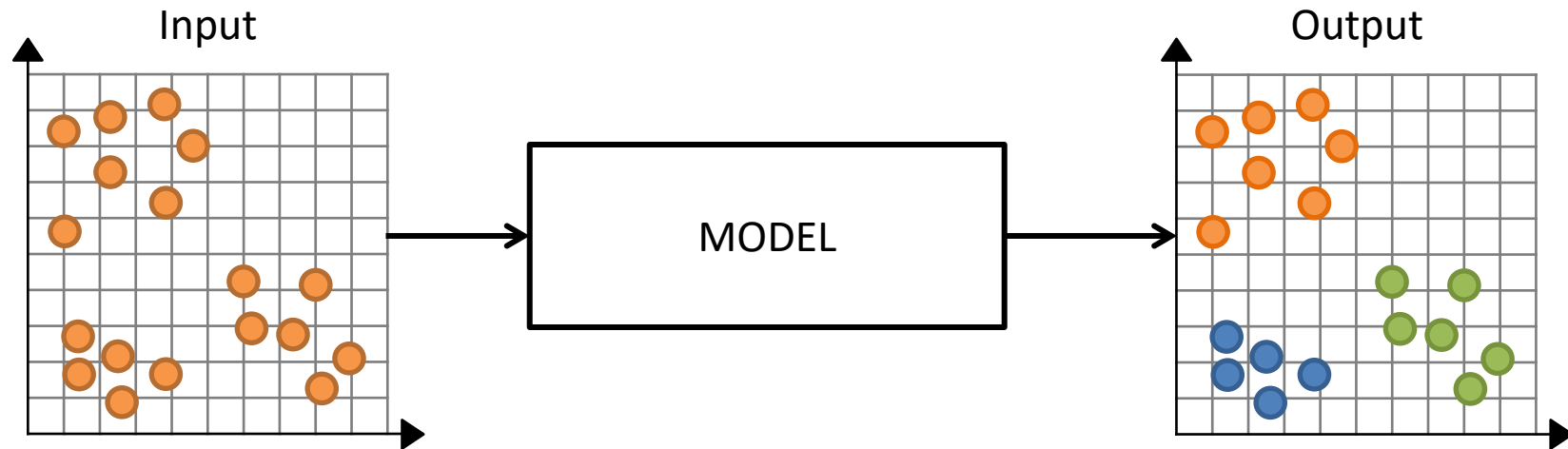


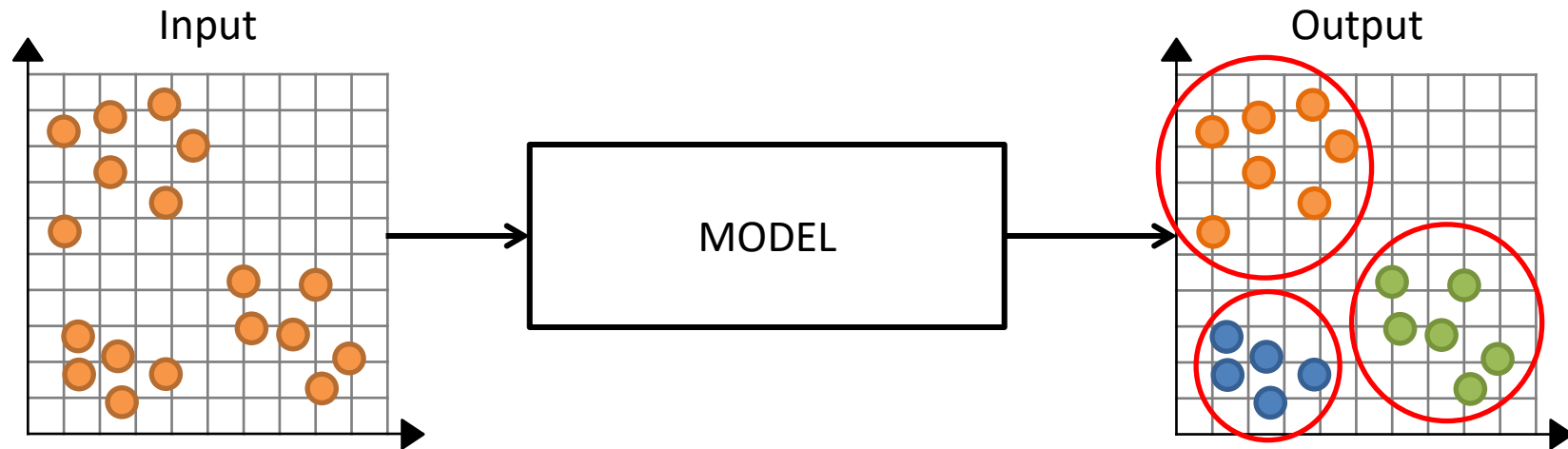




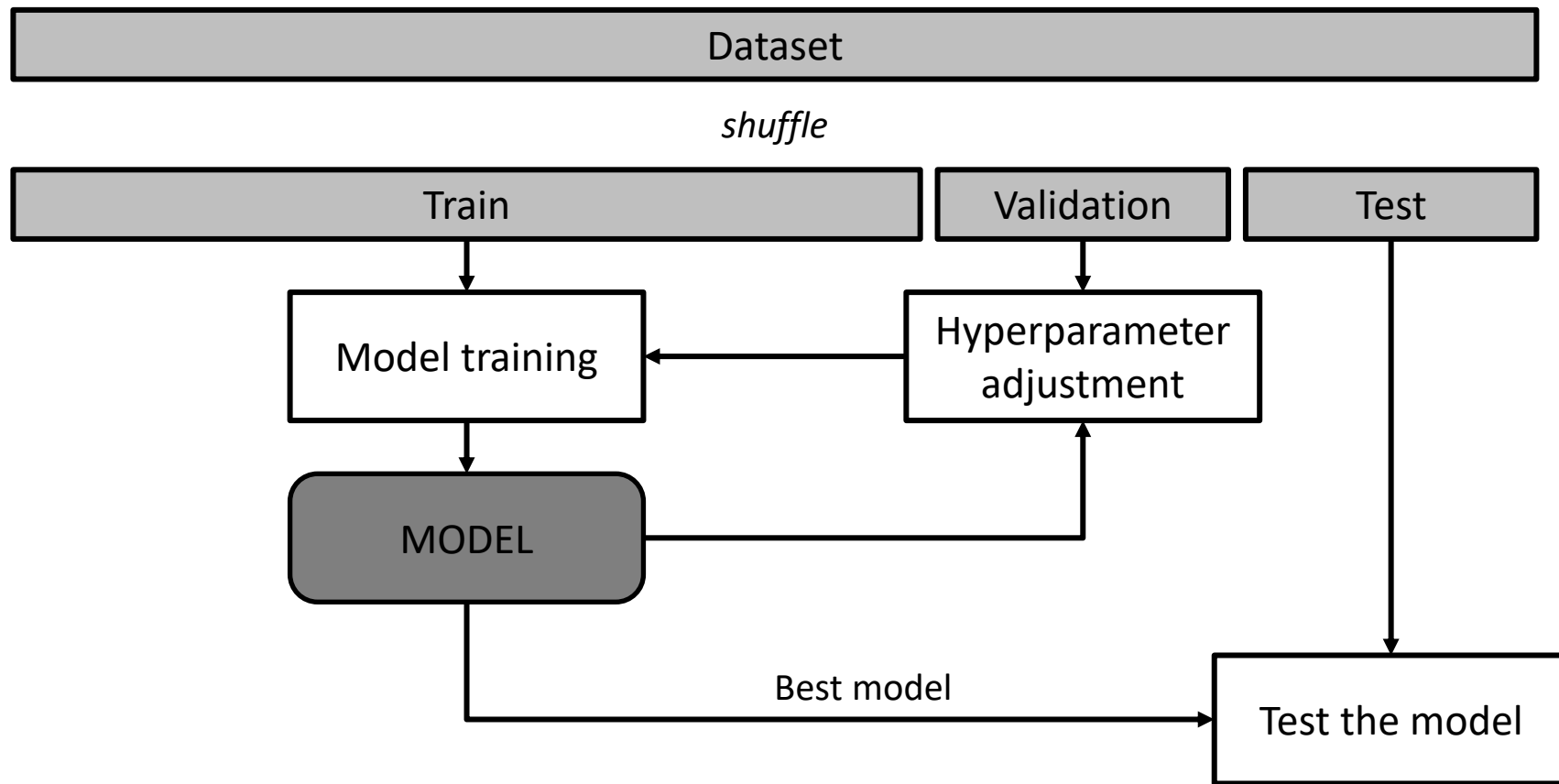








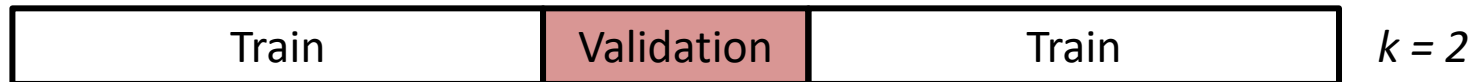
CROSS-VALIDATION



K-fold cross-validation



shuffle



CLASSIFICATION EVALUATION

Confusion matrix

- **True positive (TP):**
 - Objects of class C1 classified as C1.
- **True negative (TN):**
 - Objects of other classes (C2 and C3) classified as not being C1.
- **False positive (FP) (type I error):**
 - Objects classified as C1 but belonging to other classes (C2 or C3).
- **False negative (FN) (type II error):**
 - Objects of class C1 classified as other classes (C2 or C3).

		Classification			Sum
		Class C1	Class C2	Class C3	
Real class	Class C1	5	3	0	8
	Class C2	2	3	1	6
	Class C3	0	2	11	13
	Soma	7	8	12	

		Classification	
		Class C1	Others
Real class	Class C1	5 TP	3 FN
	Others	2 FP	17 TN

Accuracy, precision, recall, and F1-score

- Accuracy:

- $Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$

- Precision:

- $Precision = \frac{TP}{TP+FP}$

- Recall:

- $Recall = \frac{TP}{TP+FN}$

- F1-score:

- $F1 - score = \frac{2 \times TP}{2 \times TP + FP + FN}$

- Support:

- $Support = TP + FN$

- GONZALEZ, R.C.; WOODS, R.E.; **Processamento Digital de Imagens**. 3ª edição. Editora Pearson, 2009.
- COSTA, L. DA F.; CESAR-JR., R. M. **Shape analysis and classification: theory and practice**. CRC Press, 2000. Chapter 8.
- Yann LeCun', Alfredo Canziani. **Yann LeCun's Deep Learning Course at CDS - SPRING 2021**
 - <https://cds.nyu.edu/deep-learning/>

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THE END