האוניברסיטה
העברית
בירושלים
THE HEBREW
UNIVERSITY
OF JERUSALEM

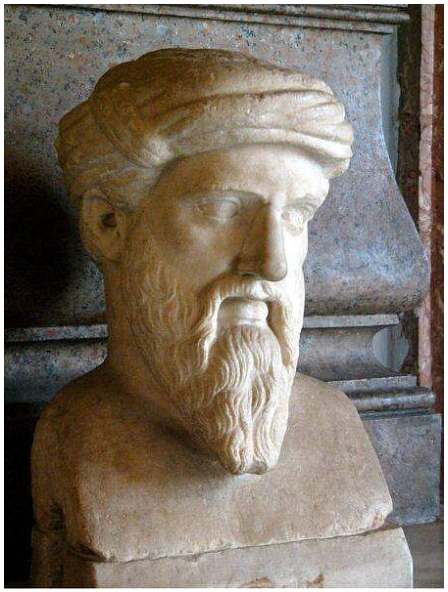
Artificial Intelligence in Medicine

Classification

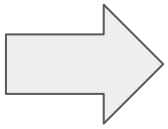
Nir Friedman and Tommy Kaplan 31/10/22

“The oldest, shortest words - 'yes' and 'no' - are those which require the most thought.”

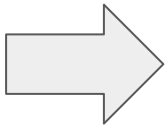
Pythagoras



Classifiers

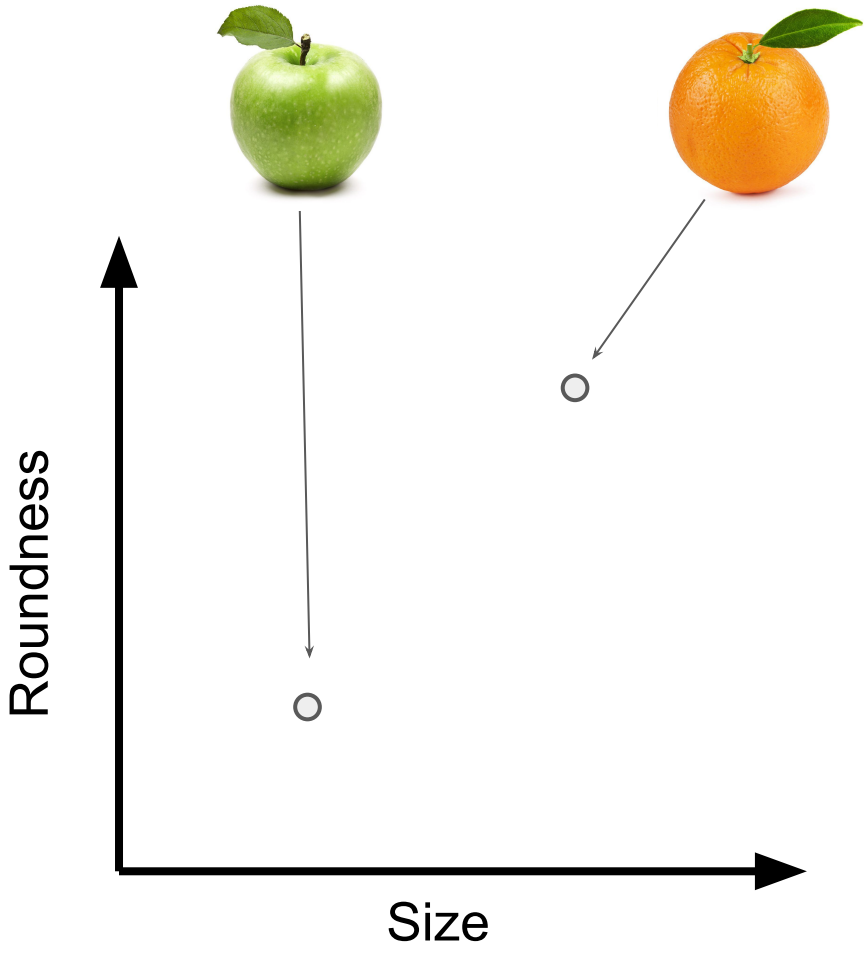


Classifier

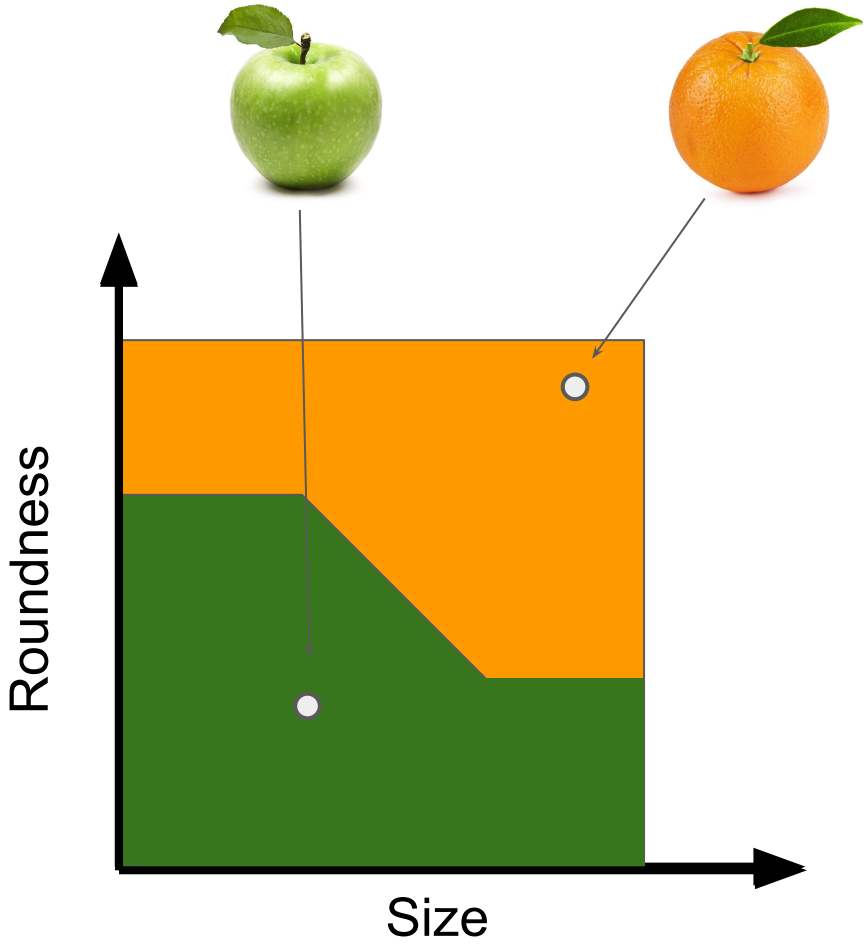


Apple
or
Orange

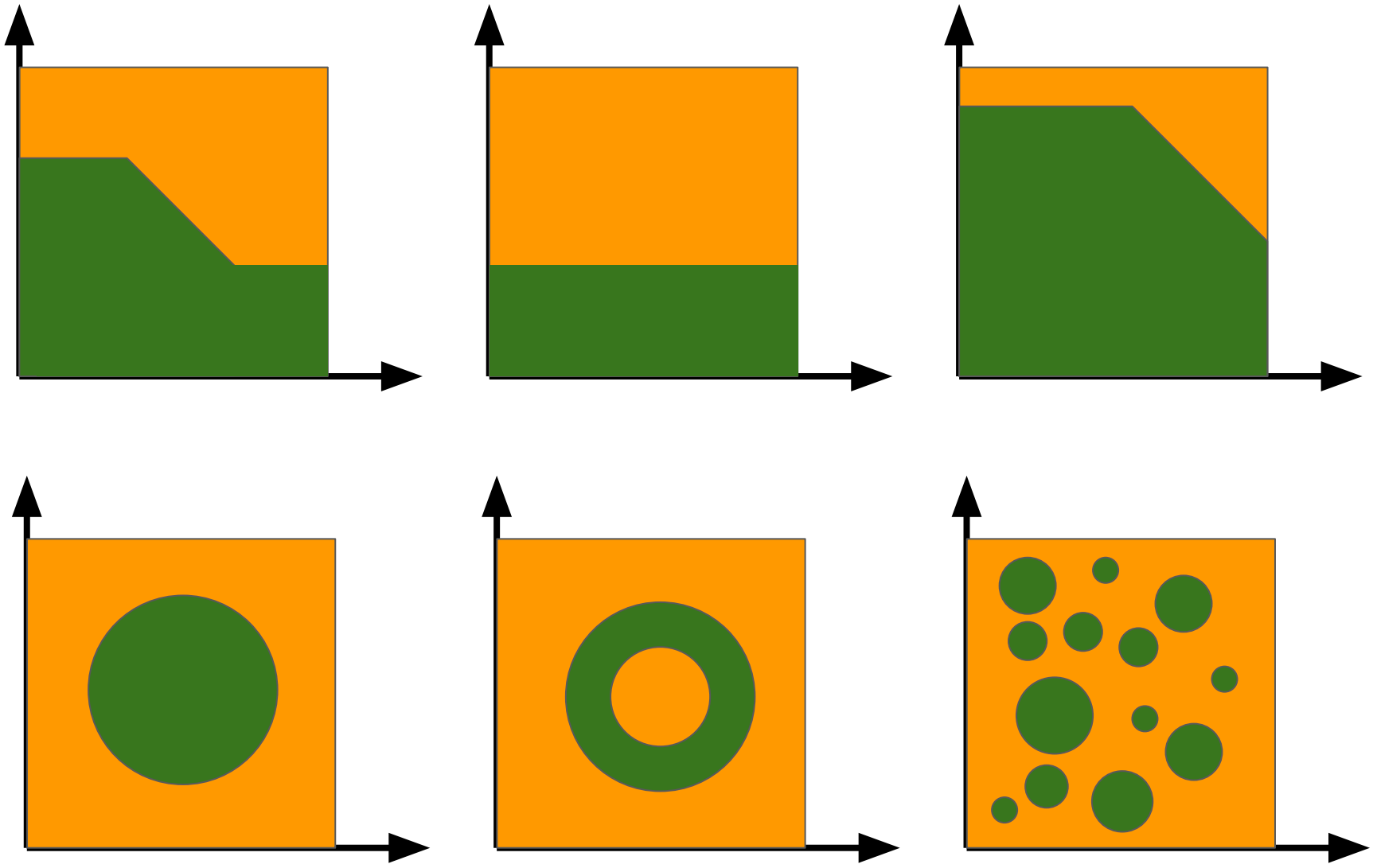
Classification Boundary



Classification Boundary



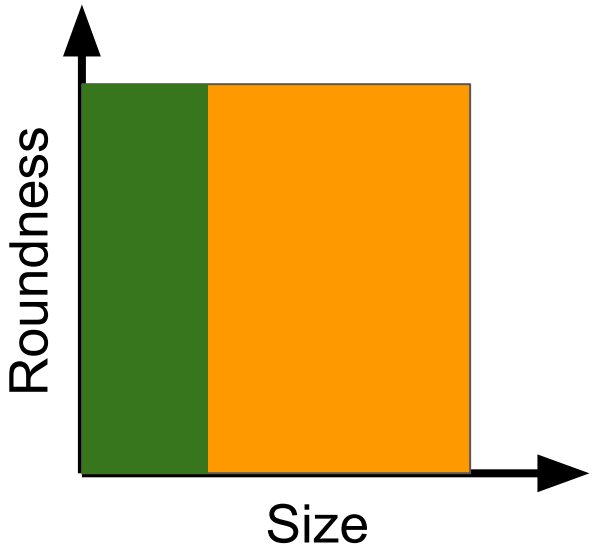
Hypotheses



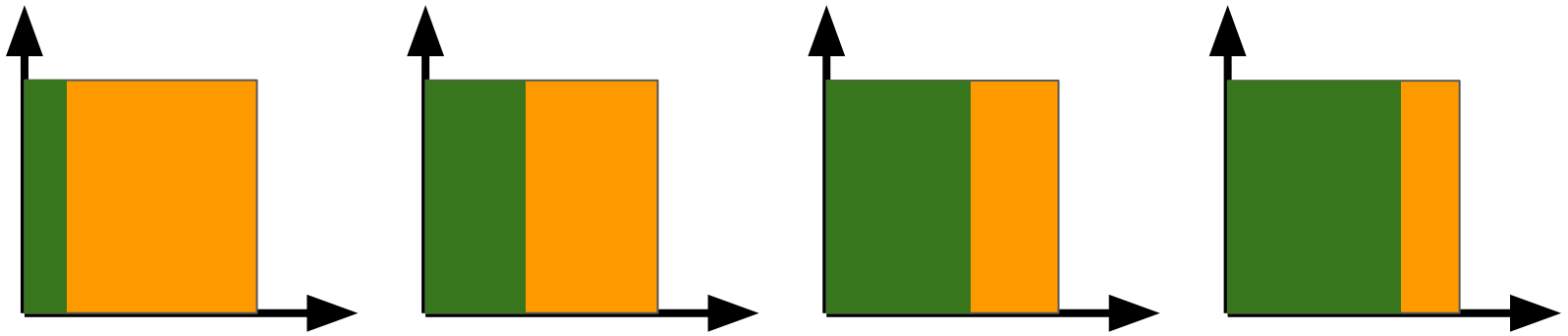
Representation

How to implement a classification?

```
if size > 100 then
   “orange”
else
   “apple”
```

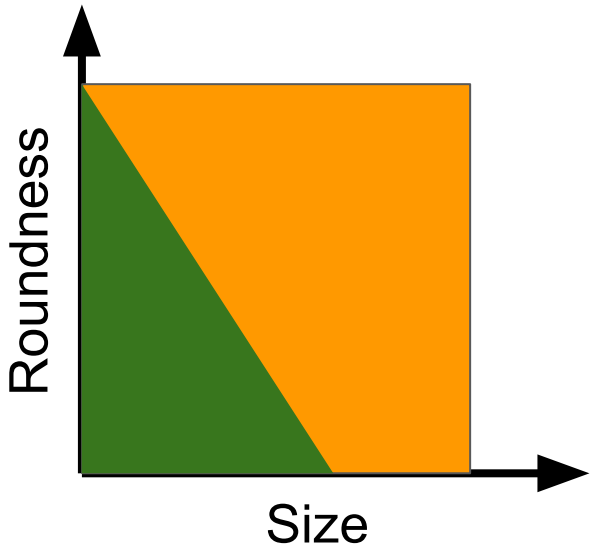


Whole range of hypotheses

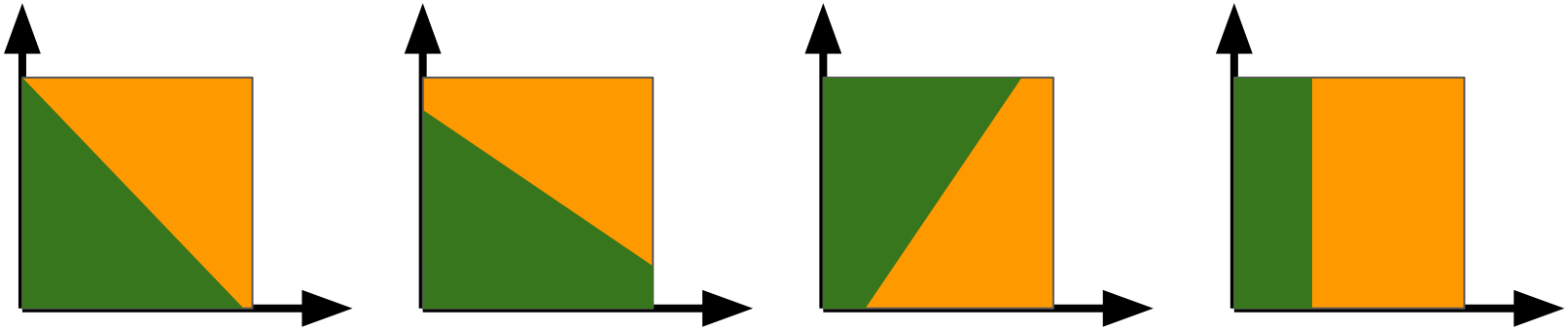


Linear classifier

```
if 2*size + 5*round > 100 then
   “orange”
else
   “apple”
```

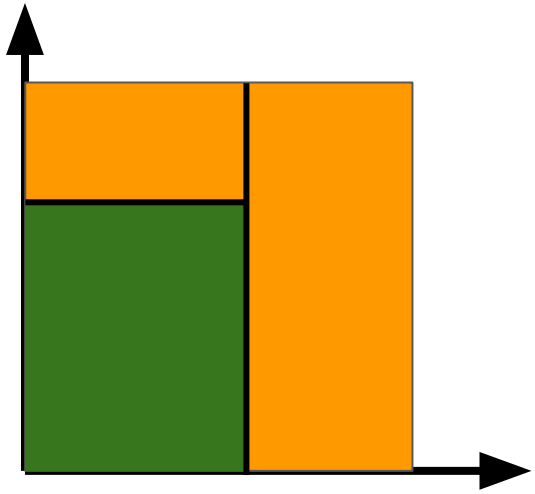


Wider range of hypotheses



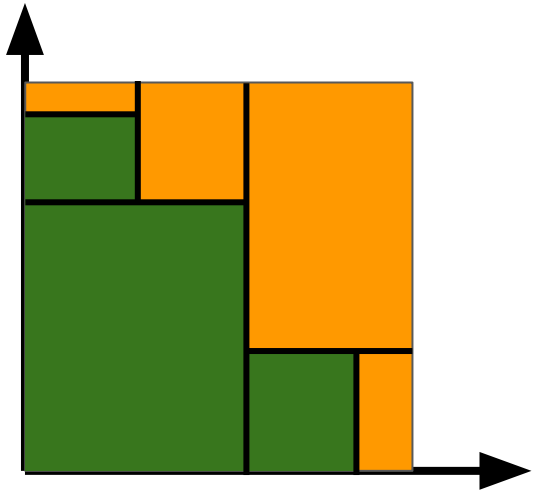
Classification Tree

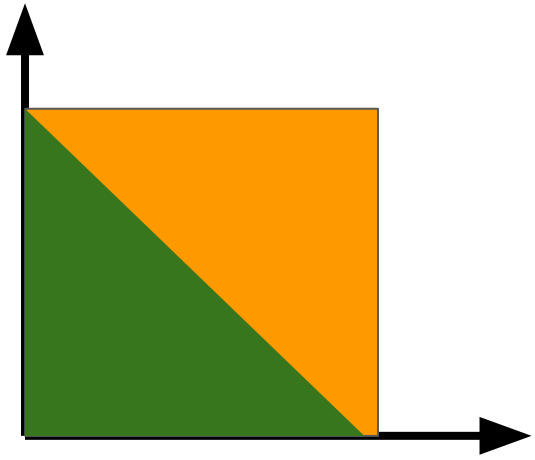
```
if size < 100 then
    if round > 200
        “orange”
    else
        “apple”
else
    “orange”
```



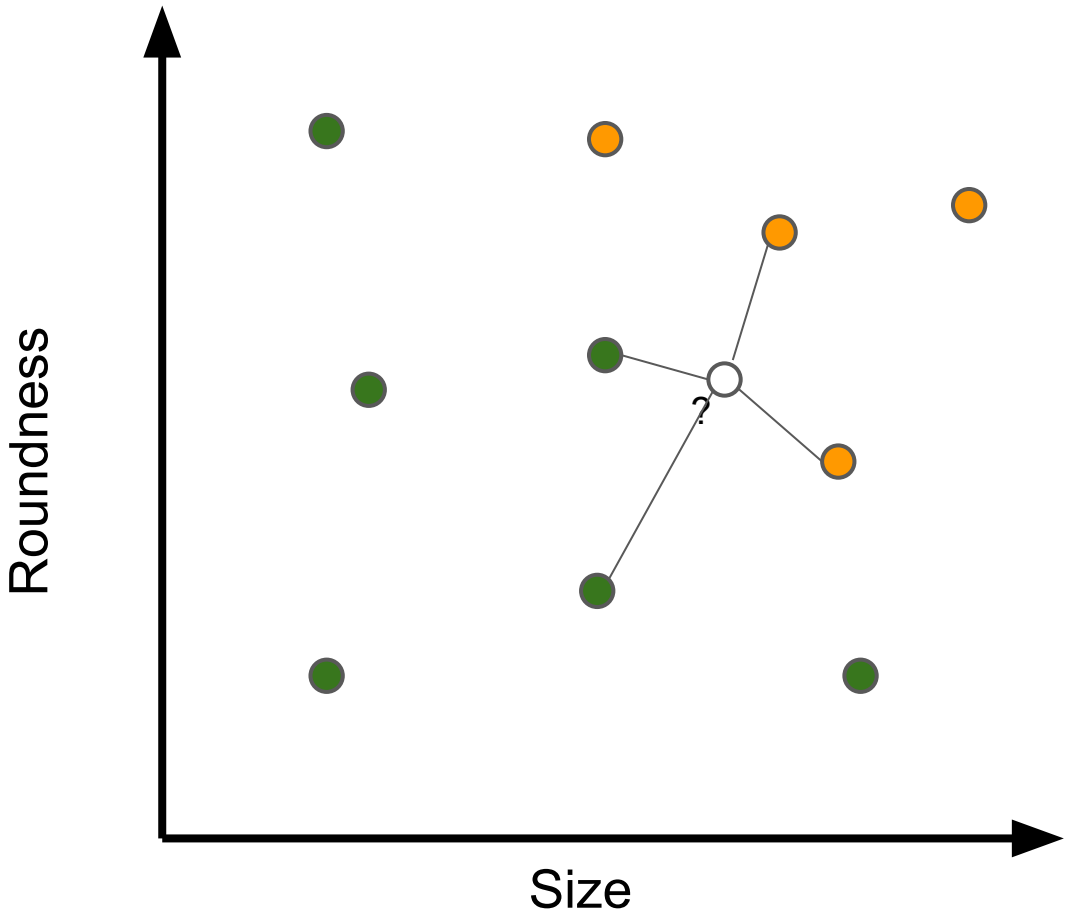
Classification Tree

```
if size < 100 then
    if round > 200
        if size <  50
            if round > 240
                "orange"
            else
                "apple"
        else
            "orange"
    else
        "apple"
else
    if round > 100
        "orange"
    else
        if size < 230
            "apple"
        else
            "orange"
```

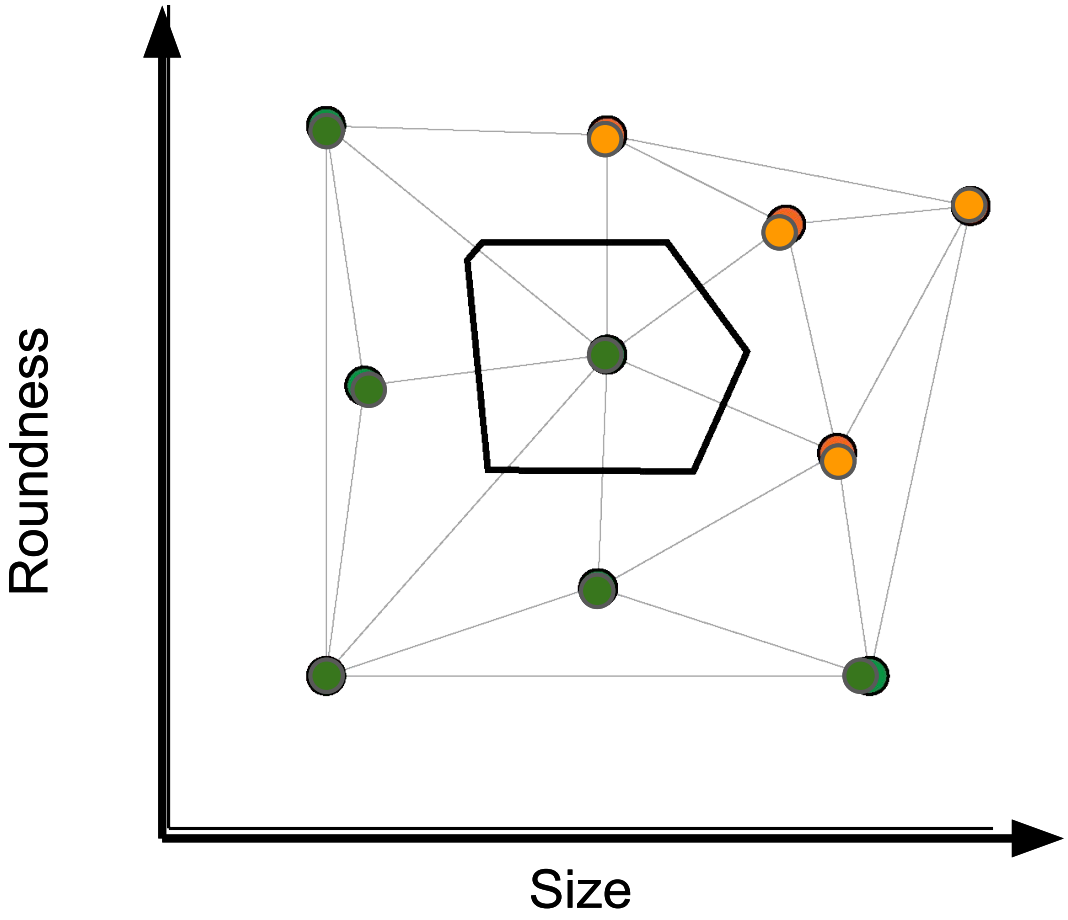




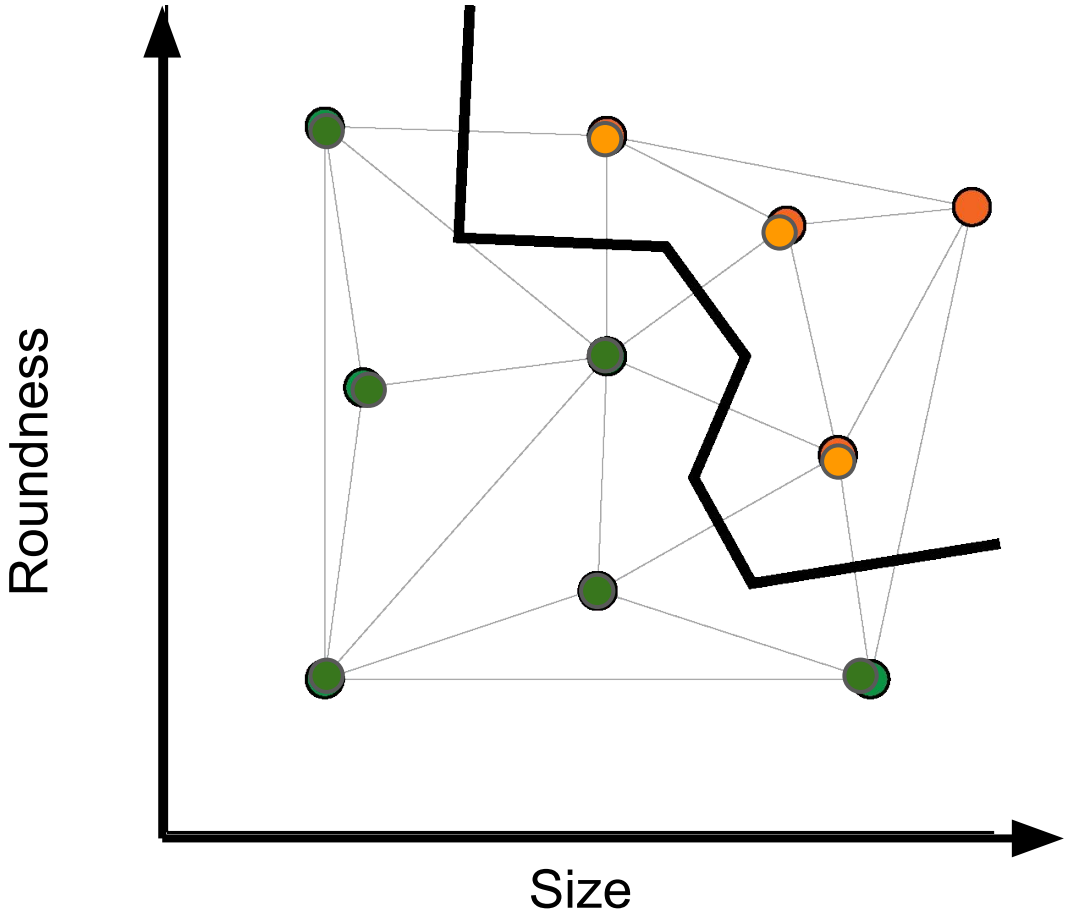
Nearest neighbor



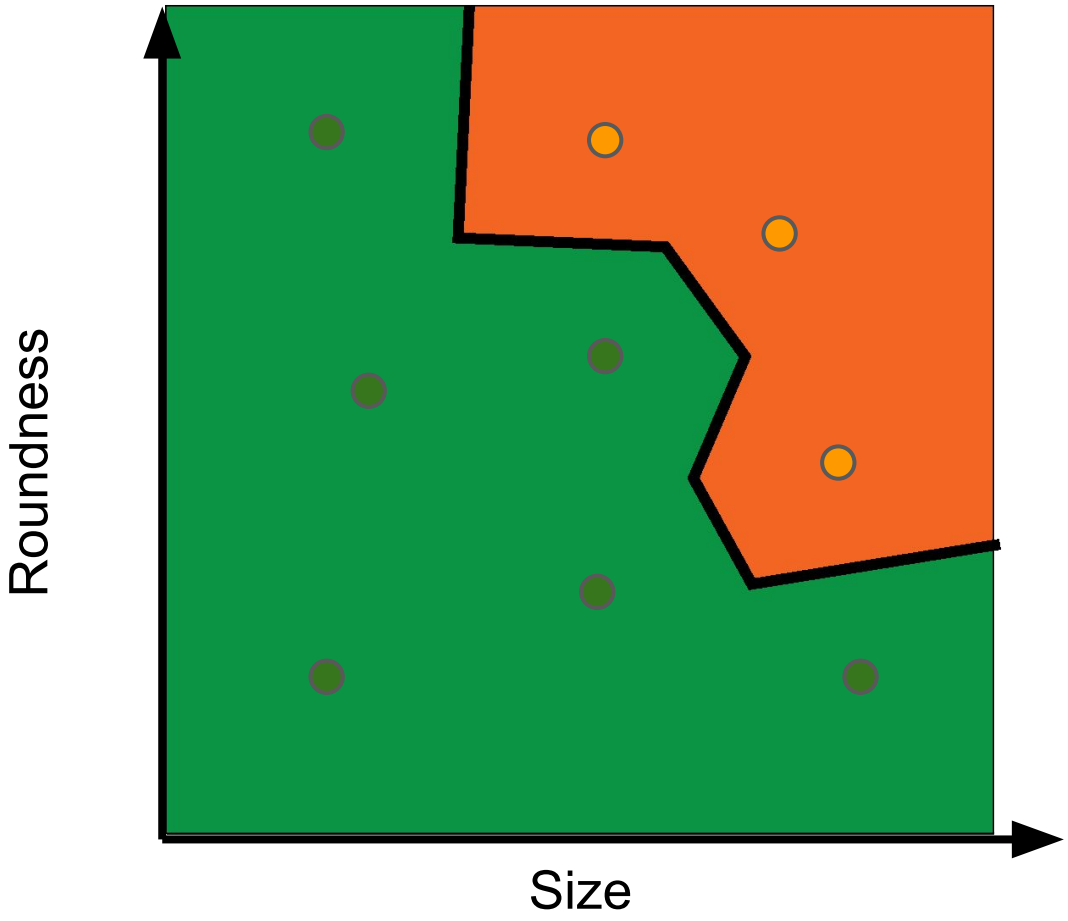
Nearest neighbor



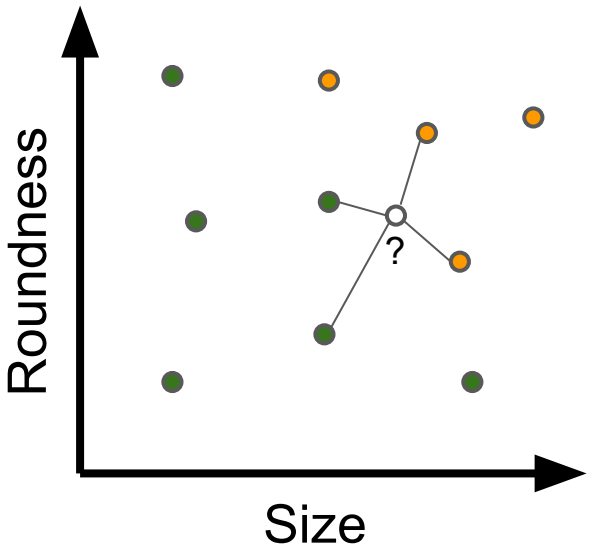
Nearest neighbor

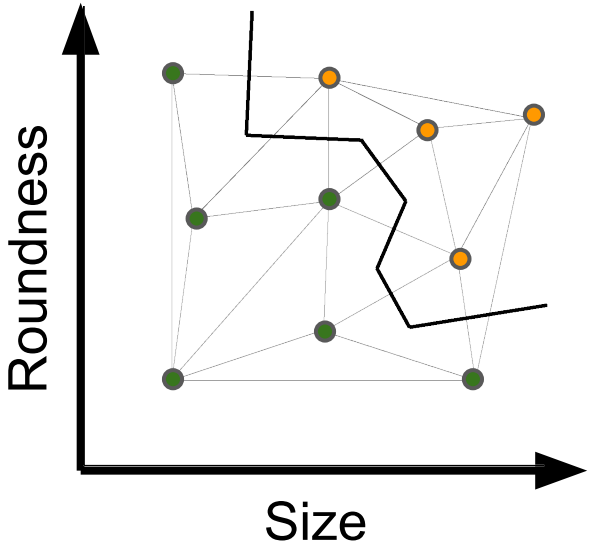


Nearest neighbor



Nearest neighbor





Non-parametric!!

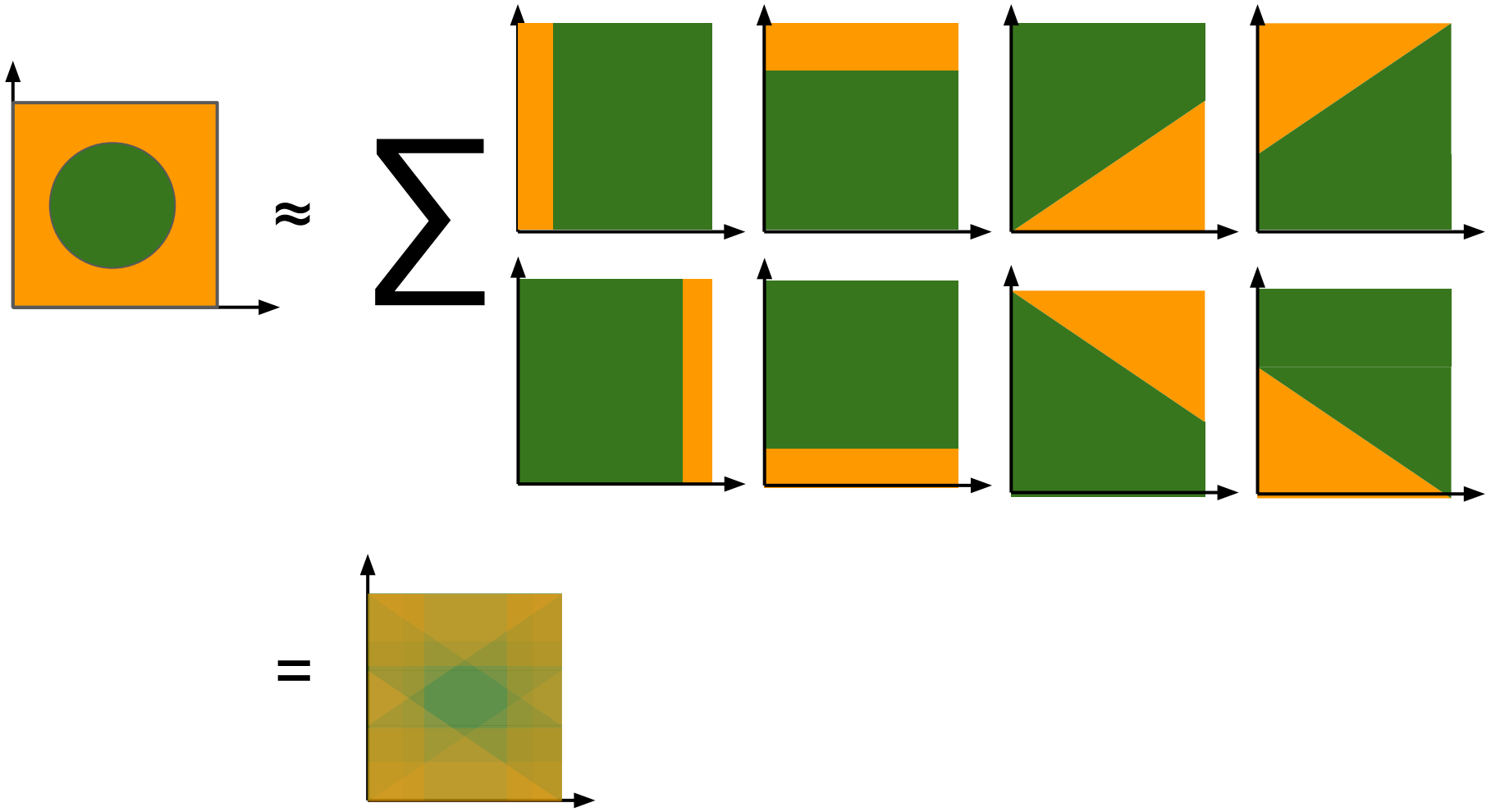
$$\forall i, C_i = C_j | j = \arg\min_k D_{i,k}$$

```
def NN_classify(i)
   j = find_nearest(i)
   return j.class
```

```
def NN_classify(i)
   j = NaN
   min_dist = Inf
   for k in samples:
      if dist(i,k)<min_dist:
         min_dist = dist(i,k)
         j = k
   return j.class
```

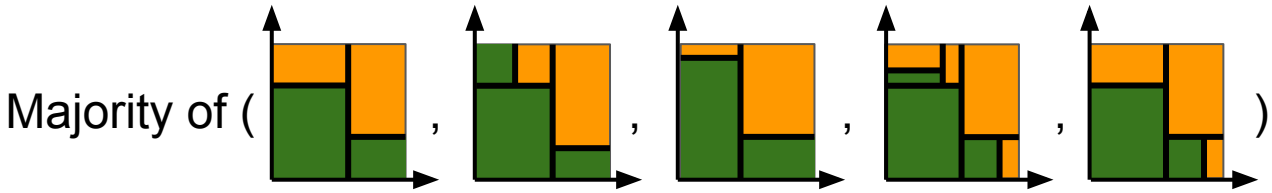
Mixture of experts

- Ensemble
- Wisdom of the crowd
- Non-linear classification landscape



Forest

Ensemble of classification trees

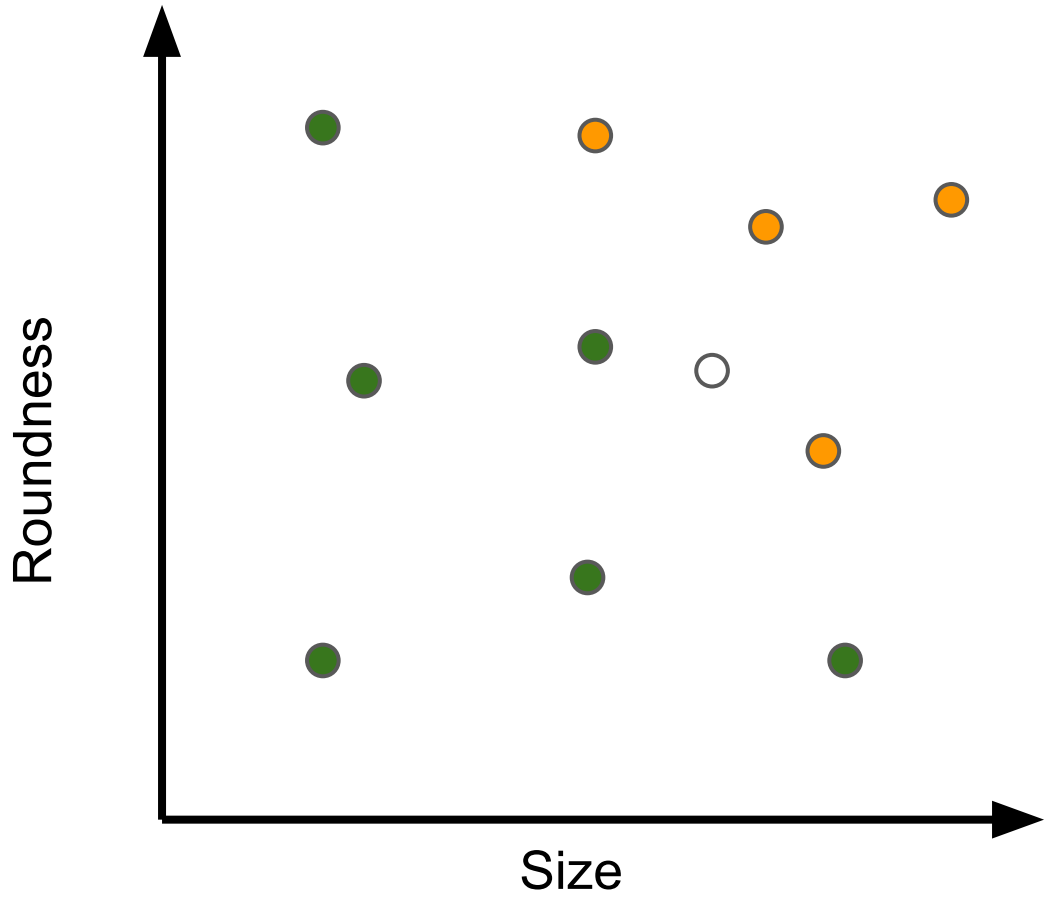


Weighted trees?

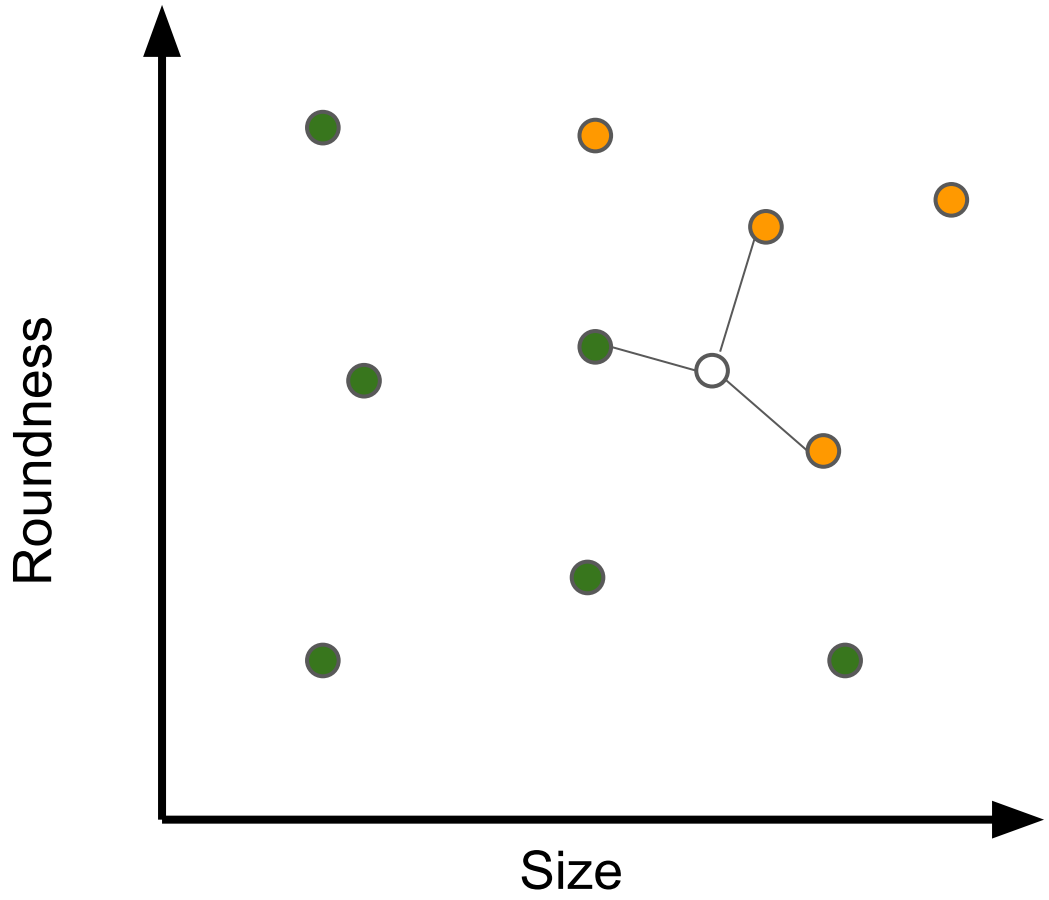
How learned?

Classifiers like: Random forest, Gradient Boosted Trees

K-nearest neighbor

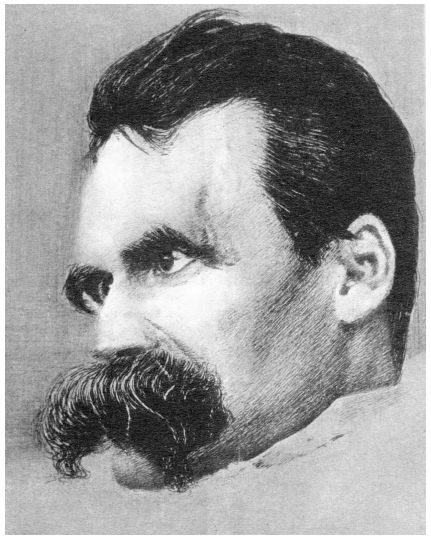


K-nearest neighbor

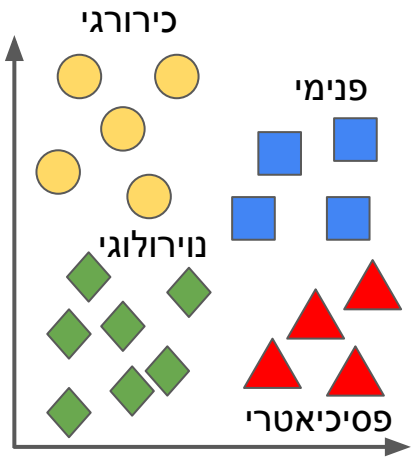


“Beyond Good and Evil…”

Nietzsche

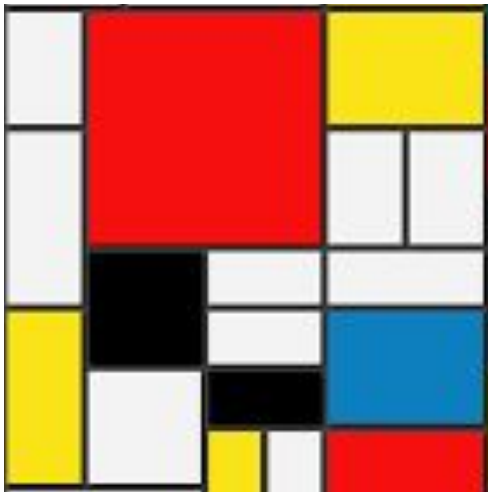


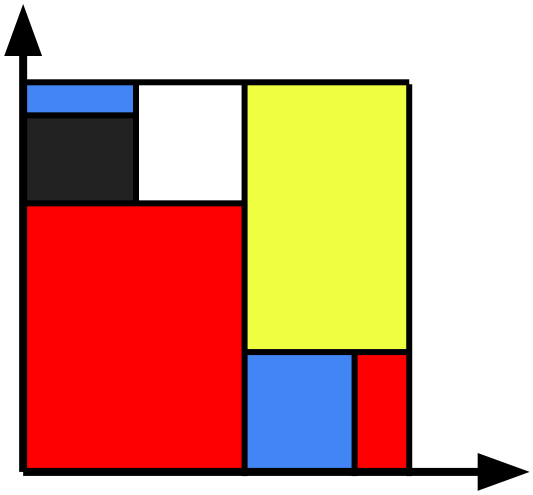
Multiclass classification



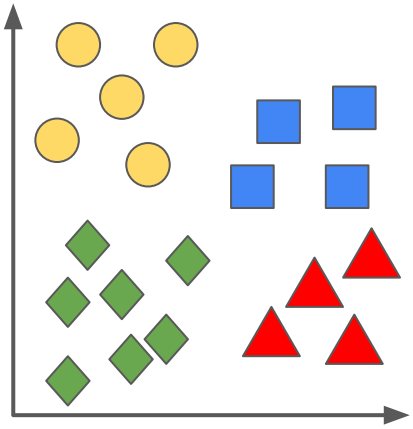
Multiclass classification tree

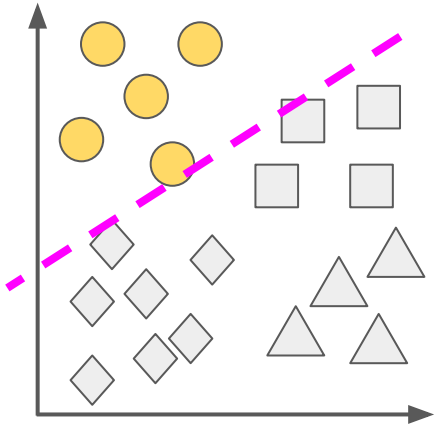
```
if size < 100 then
    if round > 200
        if size < 50
            if round > 240
                "blue"
            else
                "black"
        else
            "white"
    else
        "red"
else
    if round > 100
        "yellow"
    else
        if size < 230
            "blue"
        else
            "red"
```

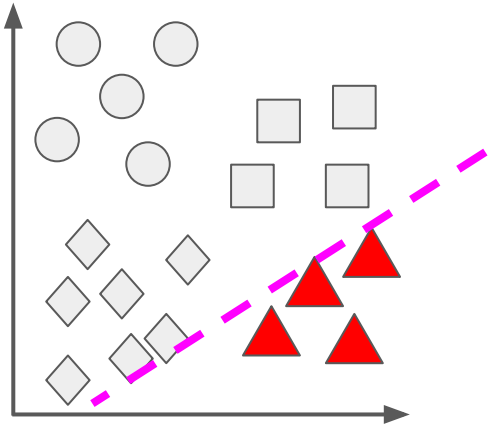


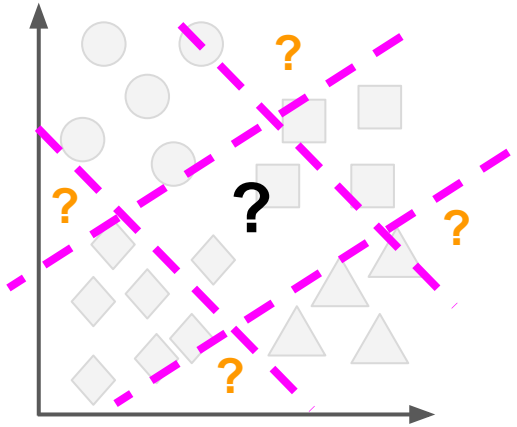


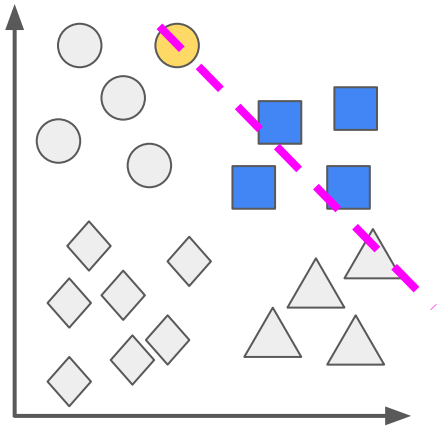
Multiclass classification using binary classifiers
One vs All

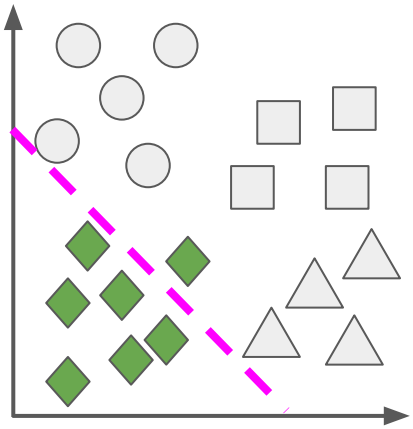




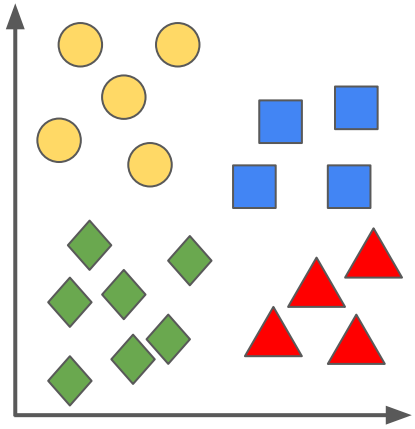


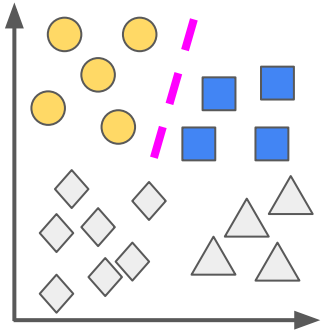


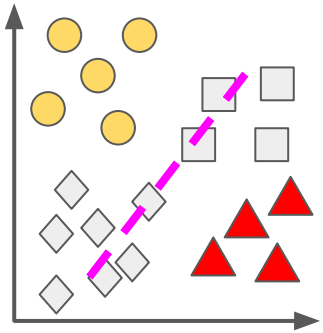


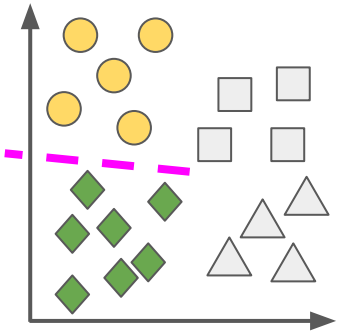


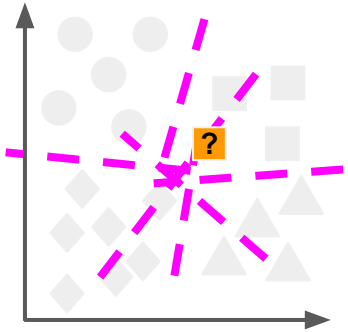
Multiclass classification using binary classifiers
One vs One

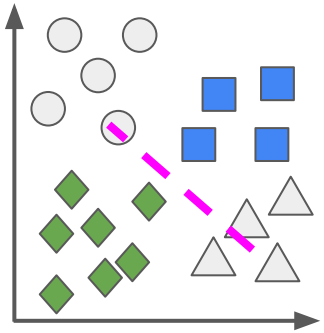


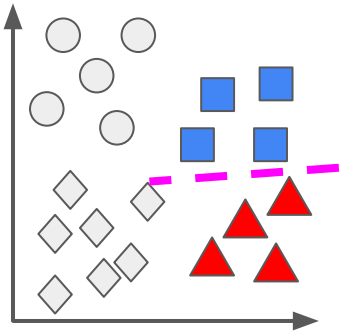


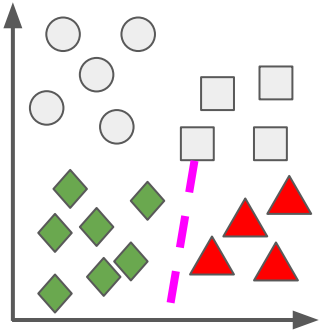


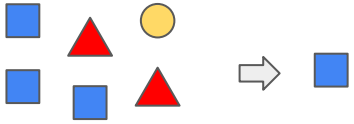












Advanced subjects

- Non-linear classification rules
- Non-linear transformations of the data (generalized linear models)
- Confidence?

Summary

- Classifier
- Different types of classifiers
- Hypothesis class
- Different complexities
- Different types of “rules”
- Capture different aspects of the data

- Ensemble models
- Binary/multiclass classification

Syllabus

1. Introduction
2. Classification
3. Learning 1
4. AI in ophthalmology (Prof. Itay Chowers)
5. Learning 2
6. Regression
7. Clustering
8. Visualization (and dimensionality reduction)
9. Deep learning in image analysis (Prof. Leo Joskowicz)
10. Missing data, statistical dependencies
11. Natural language in medicine (Dr. Gabi Stanovsky)
12. Decisions (utility)
13. Longitudinal Data / Project