GENERAL ASSEMBLY

DATA SCIENCE
MACHINE LEARNING / KNN

I. WHAT IS MACHINE LEARNING?
II. SUPERVISED LEARNING
III. UNSUPERVISED LEARNING
IV. SUMMARY
V. CLASSIFICATION WITH K-NEAREST NEIGHBORS

I. WHAT IS MACHINE LEARNING?

"A field of study that gives computers the ability to learn without being explicitly programmed." (1959)

Arthur Samuel, AI pioneer
Source: Stanford

Machine Learning is a class of algorithms which are data-driven. Unlike classical algorithms, it is the data that defines a “good” answer.

Example:

A **Non-**Machine Learning algorithm might “define” a face as having a roundish structure, two eyes, hair, nose, etc. The algorithm then looks for these “hard-coded” features in test cases.

A Machine Learning algorithm might only be given several pictures of faces and non-faces that are labeled as such. From the examples (called training set) it would “figure out” it’s own definition of a face.

Training set

Face

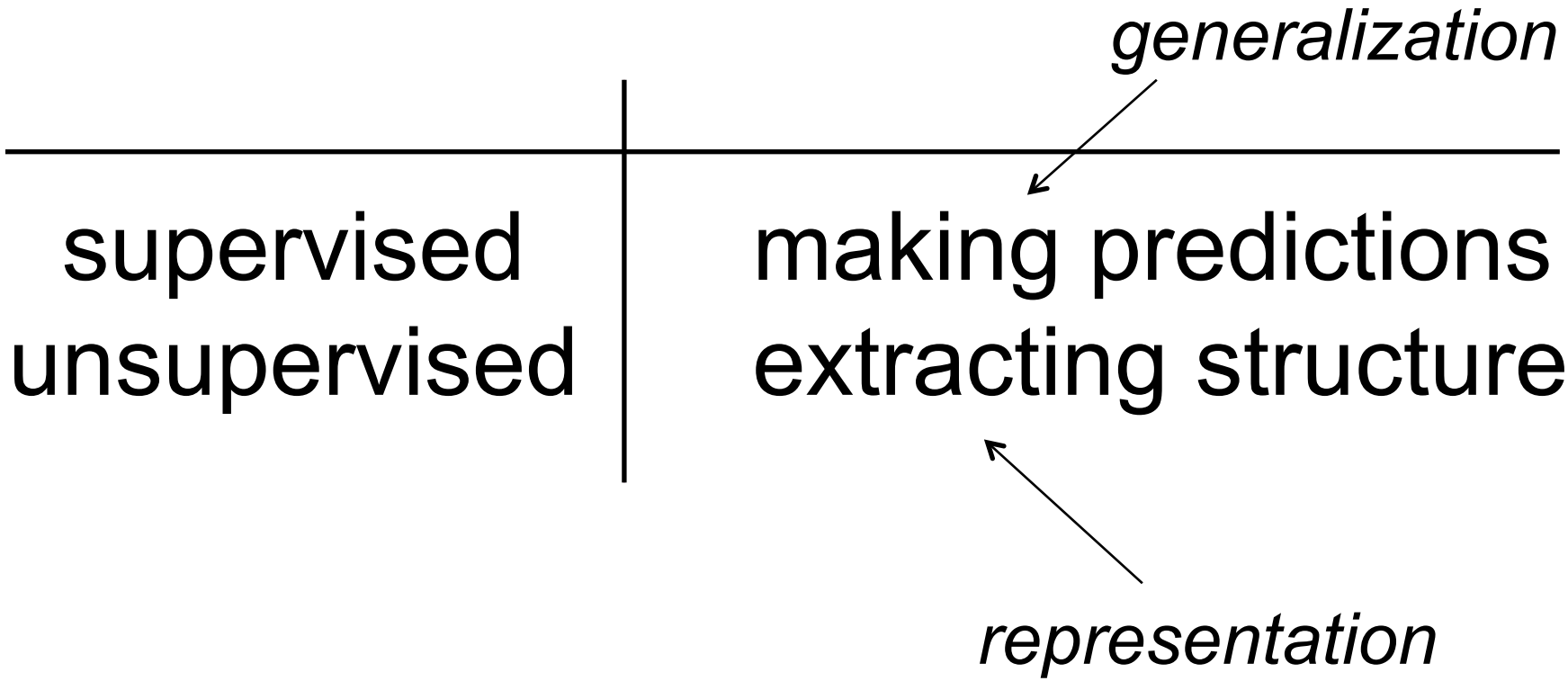
Not Face

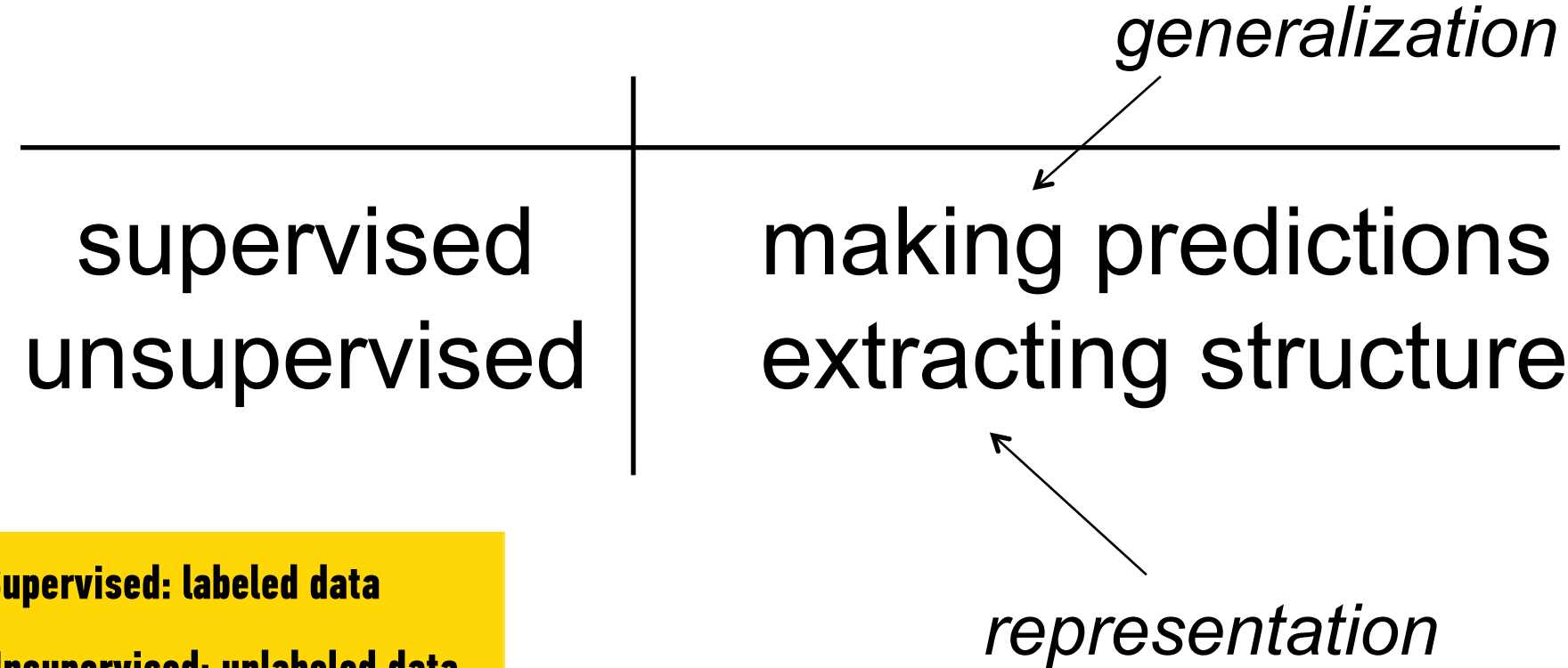
Face

Test

Face?

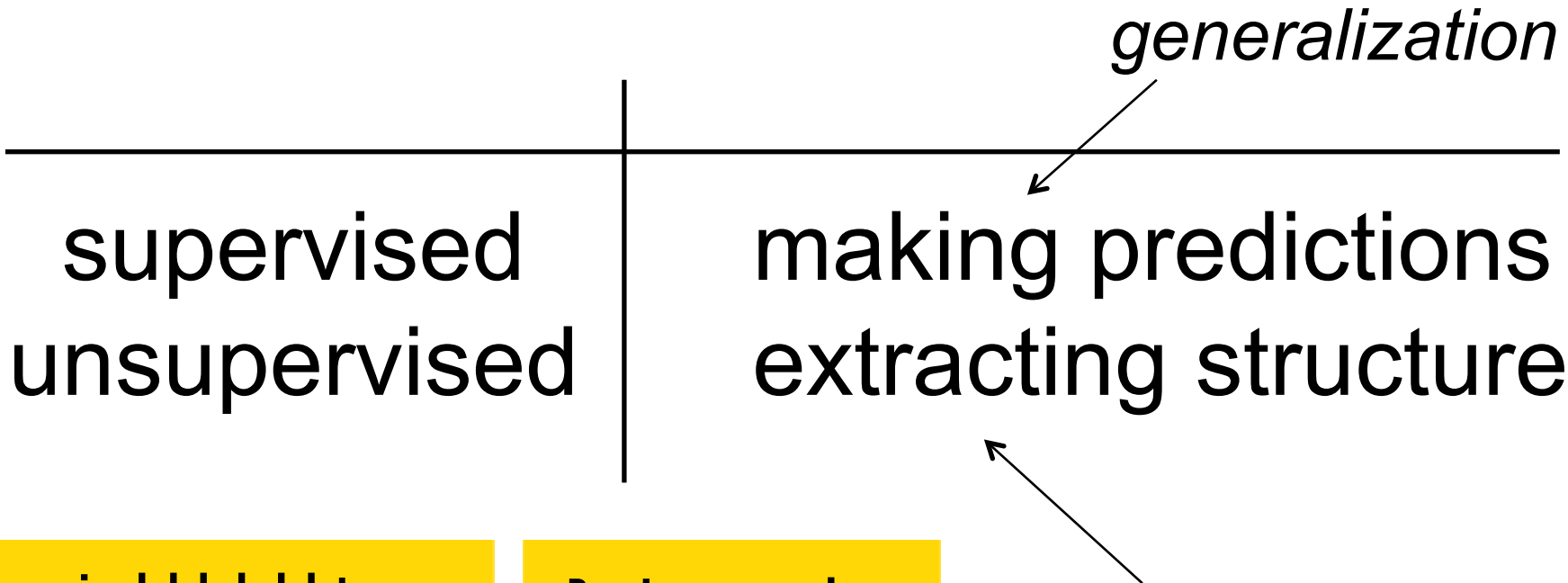
The core of machine learning deals with *representation* and *generalization*…


generalization
supervised
unsupervised
making predictions
extracting structure
representation



Supervised: labeled data

Unsupervised: unlabeled data



Supervised: labeled data

Unsupervised: unlabeled data

Previous example was supervised!

II. SUPERVISED LEARNING

- Vector(list) of "Predictors" X
  - Also known as features, independent variables, inputs, regressors, covariates, attributes
- "Response" y
  - Also known as outcome, label, target, dependent variable
- If y is continuous: **Regression**
  - e.g., price, blood pressure
- If y is categorical (values in a finite, unordered set): **Classification**
  - e.g., spam/ham, digit 0-9, cancer class of tissue sample
- Data is composed of "observations" (predictors and the associated response)
  - Also known as samples, examples, instances, records

EXAMPLE #1: PREDICTING NEONATAL INFECTION

Problem: Children born prematurely are at high risk of developing infections, many of which are not detected until after the baby is sick

Goal: Detect subtle patterns in the data that predicts infection before it occurs

Data: 16 vital signs such as heart rate, respiration rate, blood pressure, etc…

Impact: Model is able to predict the onset of infection 24 hours before the traditional symptoms of infection appear

predictors

Sample response: Did the child develop an infection? True/False

150 observations *(n = 150)*

Fisher's *Iris* Data

Sepal length	Sepal width	Petal length	Petal width	Species
5.1	3.5	1.4	0.2	*I. setosa*
4.9	3.0	1.4	0.2	*I. setosa*
4.7	3.2	1.3	0.2	*I. setosa*
4.6	3.1	1.5	0.2	*I. setosa*
5.0	3.6	1.4	0.2	*I. setosa*
5.4	3.9	1.7	0.4	*I. setosa*
4.6	3.4	1.4	0.3	*I. setosa*
5.0	3.4	1.5	0.2	*I. setosa*

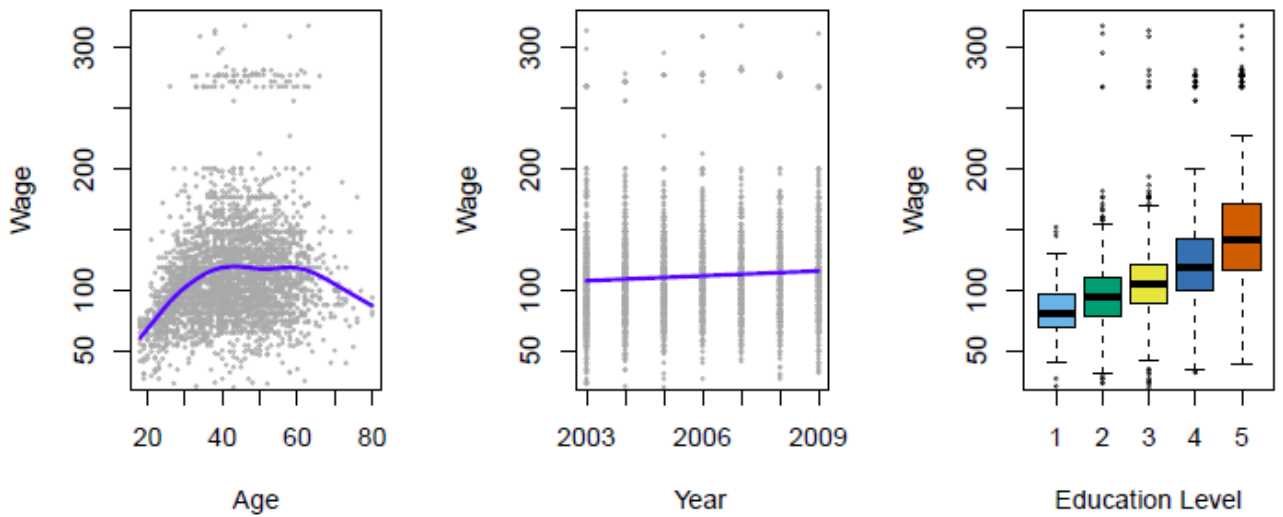
response

4 predictors (p = 4)

- Supervised Learning uses known/labeled "**training** cases" in order to:
  - Accurately predict unseen **test** cases
  - Understand which predictors affect the response, and how
  - Assess the quality of our predictions

REGRESSION EXAMPLE

- Establish the relationship between salary and demographic variables in population survey data

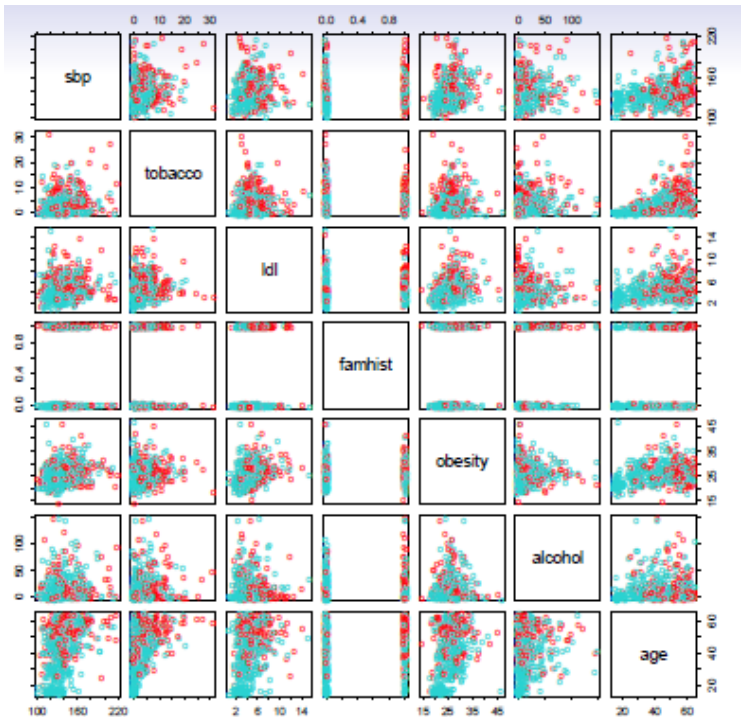


Income survey data for males from the central Atlantic region of the USA in 2009

Source: https://class.stanford.edu/c4x/HumanitiesScience/StatLearning/asset/introduction.pdf

CLASSIFICATION EXAMPLE

- Predict whether someone will have a heart attack on the basis of demographic, diet and clinical measurements

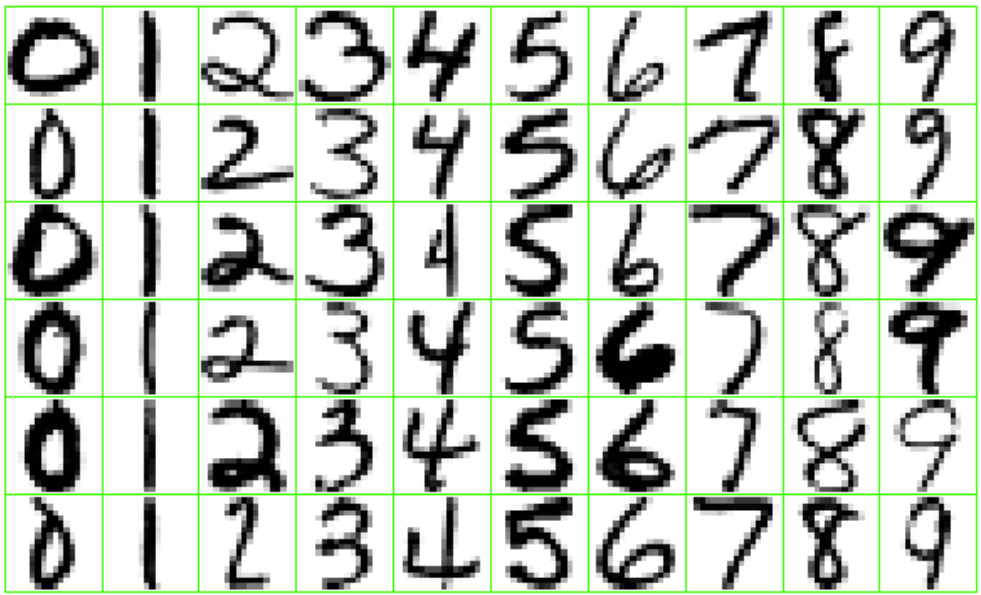


Case-control sample of men from South Africa
Red = heart disease
Blue = no heart disease

Source: https://class.stanford.edu/c4x/HumanitiesScience/StatLearning/asset/introduction.pdf

CLASSIFICATION EXAMPLE

- Identify the numbers in a handwritten zip code



Source: https://class.stanford.edu/c4x/HumanitiesScience/StatLearning/asset/introduction.pdf

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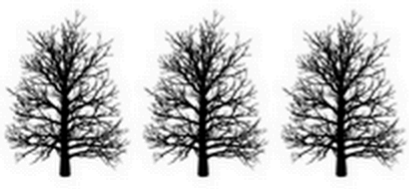


Knowledge • 1,029 teams

Forest Cover Type Prediction

Fri 16 May 2014 — Mon 11 May 2015 (3 months to go)

Dashboard

Home
- Data
- Make a submission

Information
- Description
- Evaluation

Competition Details » Get the Data » Make a submission

Use cartographic variables to classify forest categories

Random forests? Cover trees? Not so fast, computer nerds. We're talking about the

The study area includes four wilderness areas located in the Roosevelt National Forest of northern Colorado. Each observation is a 30m x 30m patch. You are asked to predict an integer classification for the forest cover type. The seven types are:

1 - Spruce/Fir
2 - Lodgepole Pine
3 - Ponderosa Pine
4 - Cottonwood/Willow
5 - Aspen
6 - Douglas-fir
7 - Krummholz

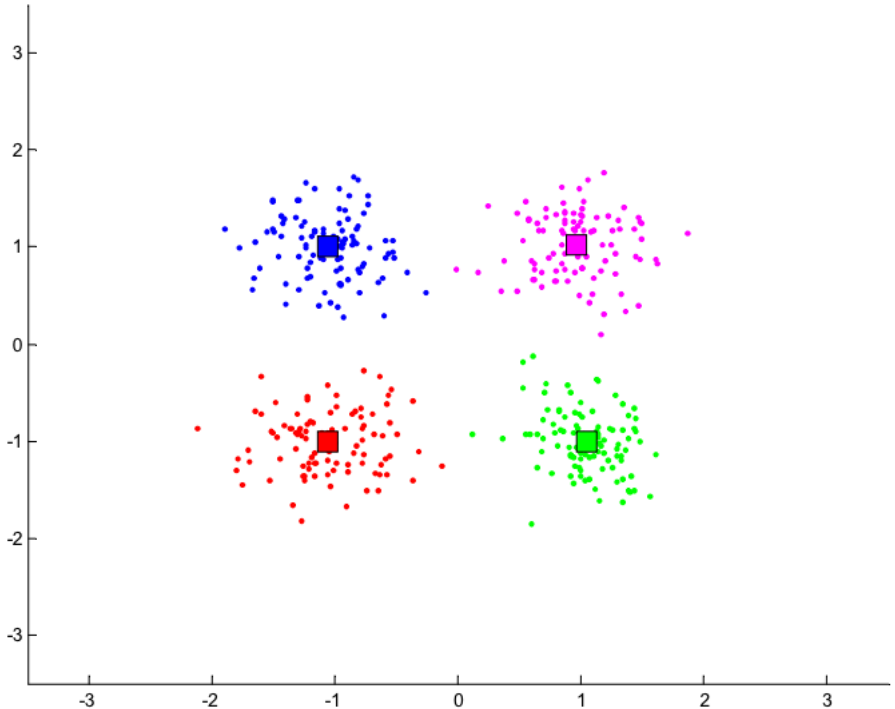
The training set (15120 observations) contains both features and the Cover_Type. The test set contains only the features. You must predict the Cover_Type for every row in the test set (565892 observations).

III. UNSUPERVISED LEARNING

- No response variable y, just a set of predictors X
- Objective is more open:
  - Find groups of observations that behave similarly
  - Find predictors that behave similarly
  - Find combinations of features that explain the variation in the data
- Difficult to evaluate how well you are doing
- Data is easier to obtain for unsupervised learning since it can be "unlabeled" (i.e., it hasn't been labeled with a response)
- Sometimes useful as a preprocessing step for supervised learning
- Common techniques: clustering, principal components analysis

	continuous	categorical
supervised	regression	classification
unsupervised	dimension reduction	clustering

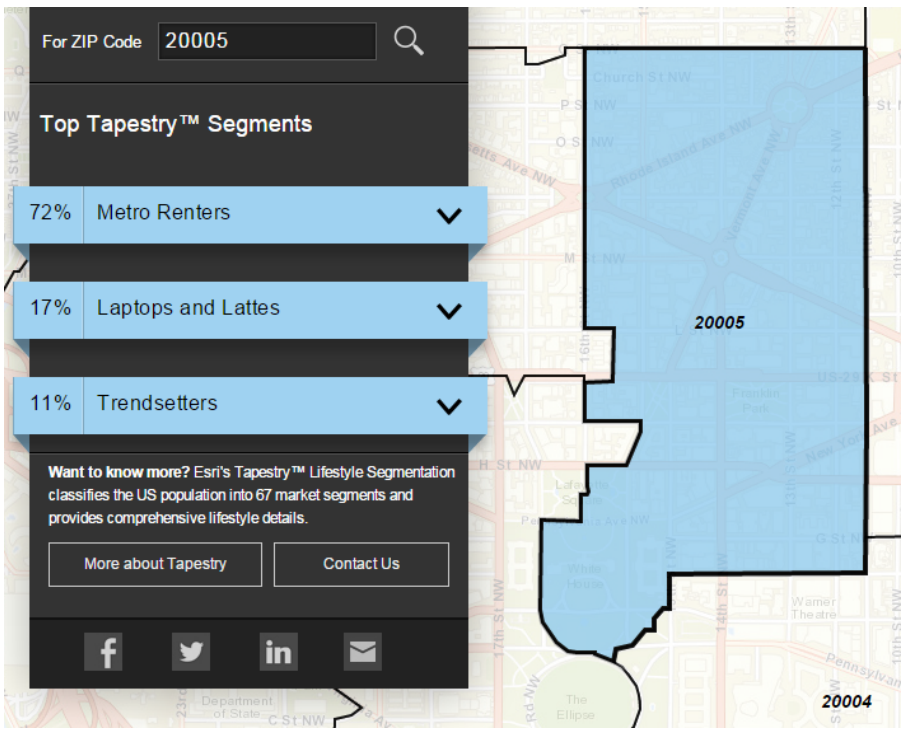
CLUSTERING EXAMPLE



Source: http://people.cs.pitt.edu/~milos/courses/cs2750-Spring03/lectures/class17.pdf

CLUSTERING EXAMPLE

- Classify US residential neighborhoods into 67 unique segments based on demographic and socioeconomic characteristics



Example of cluster: **Metro Renters:**

- Young, mobile, educated, or still in school
- Live alone or with a roommate
- Works long hours
- Buys groceries at Whole Foods and Trader Joe's
- Shops at Banana Republic, Nordstrom, and Gap
- Loves yoga, go skiing, and attend Pilates sessions.

Source: http://www.esri.com/landing-pages/tapestry/

IV. SUMMARY

	continuous	categorical
supervised	regression	classification
unsupervised	dimension reduction	clustering

V. CLASSIFICATION WITH K-NEAREST NEIGHBORS

	continuous	categorical
supervised	regression	classification
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response

4 predictors (p = 4)

Q: How does a classification problem work?
A: Data in, predicted labels out.

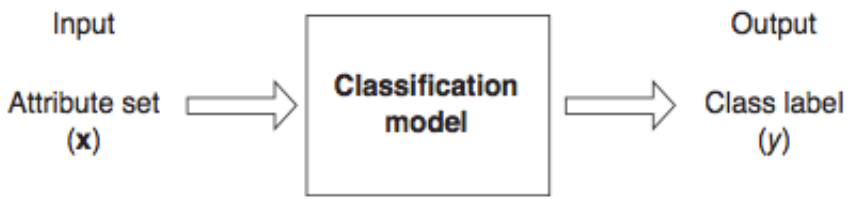


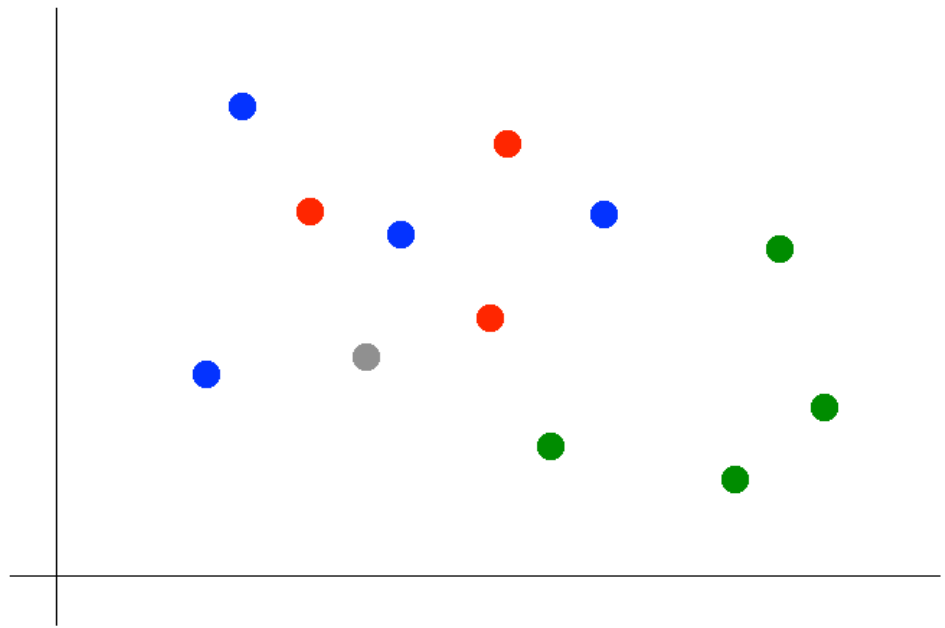
Figure 4.2. Classification as the task of mapping an input attribute set $\mathbf{x}$ into its class label y.

Source: http://www-users.cs.umn.edu/~kumar/dmbook/ch4.pdf

Suppose we want to predict the color of the gray dot.

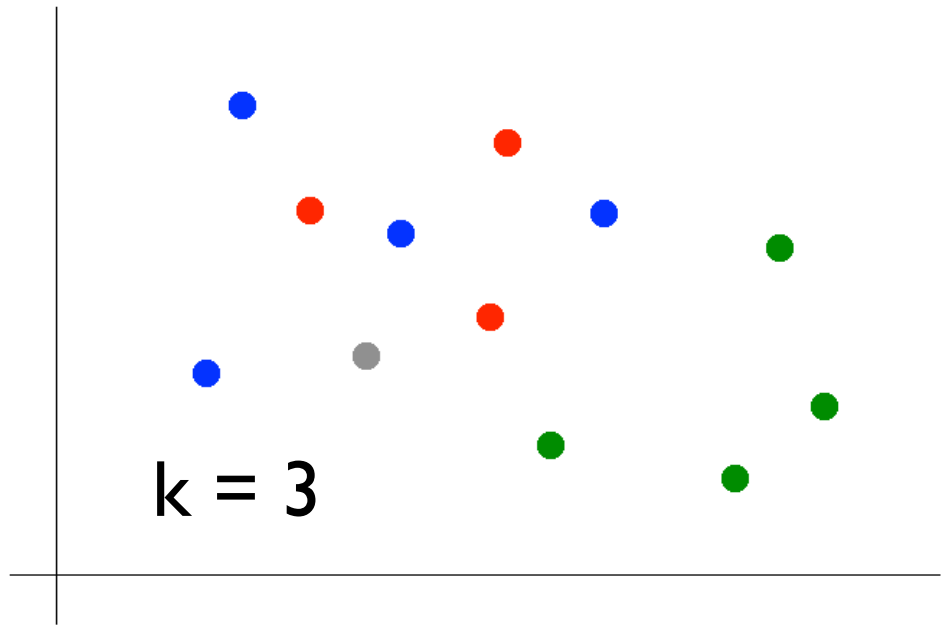
QUESTION:

What are the predictors?
What is the response?



Suppose we want to predict the color of the gray dot.

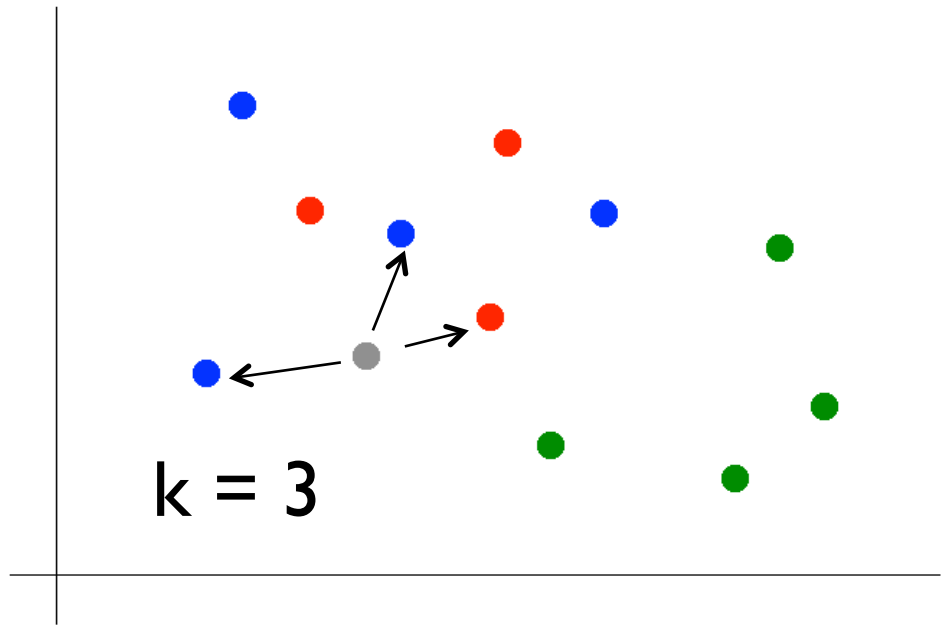
1) Pick a value for k.



Suppose we want to predict the color of the gray dot.

1) Pick a value for k.

2) Find colors of k nearest neighbors.

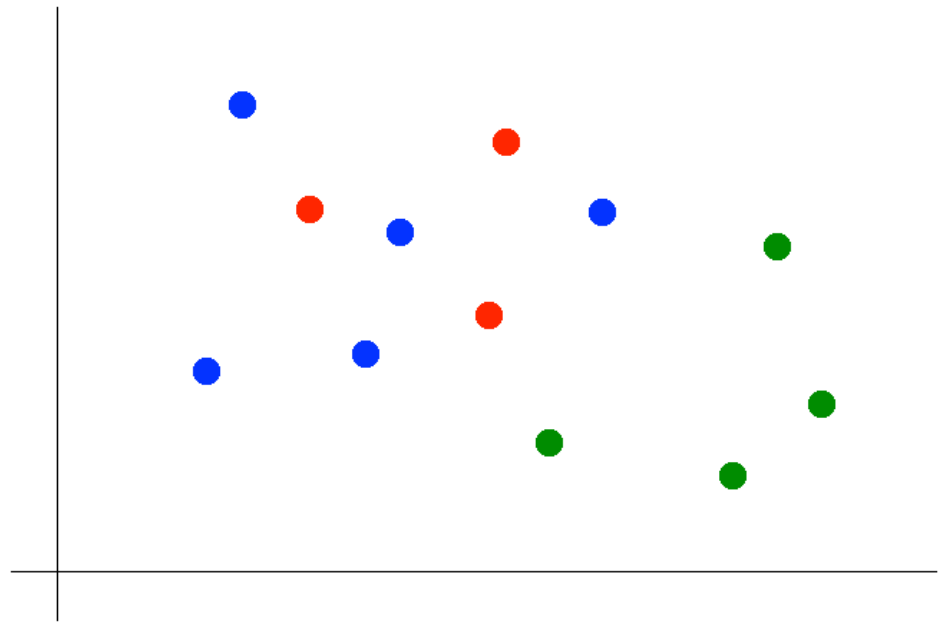


Suppose we want to predict the color of the gray dot.

1) Pick a value for k.

2) Find colors of k nearest neighbors.

3) Assign the most common color to the gray dot.



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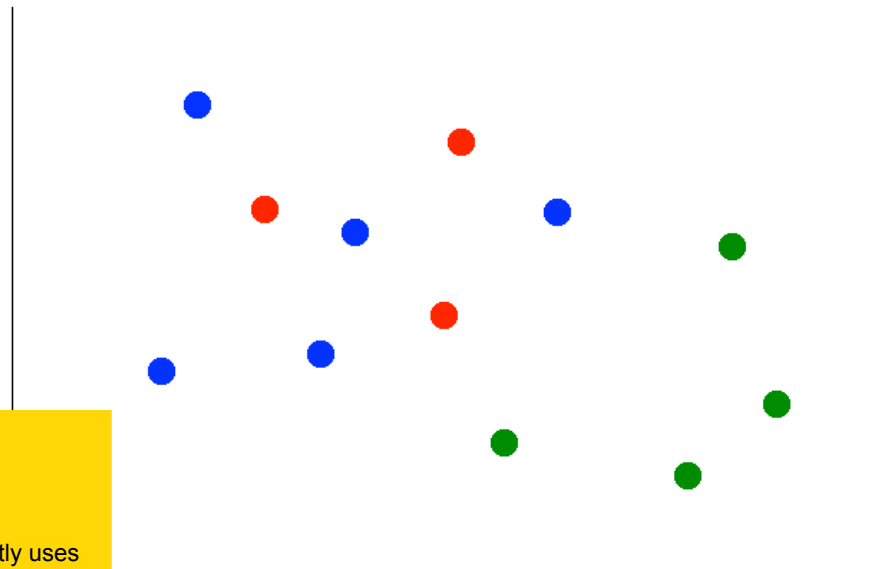

NOTE:

Our definition of "nearest" implicitly uses the *Euclidean distance function.*

Advantages of KNN:

- Simple to understand and explain
- Model training phase is fast
- Non-parametric (does not presume a "form" of the "decision boundary")

Disadvantages of KNN:

- Prediction phase can be slow when n is large
- Sensitive to irrelevant features

DATA SCIENCE