



INTRODUCTION TO MACHINE LEARNING

# **Machine Learning: What's The Challenge?**


# Goals of the course

- Identify a machine learning problem
- Use basic machine learning techniques
- Think about your data/results

# What is Machine Learning?

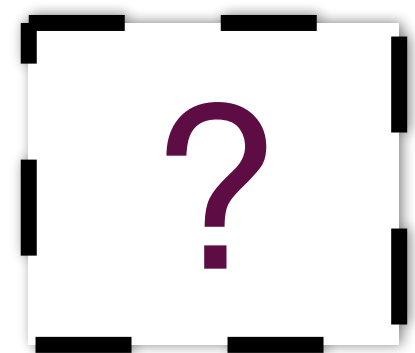
- Construct/use algorithms that learn from data
- More information → Higher **performance**
- Previous solutions → Experience

# Example

- Label squares: size and edge  color
- Earlier observations (labeled by humans):



- Task for computer = label unseen square:



- Result: right or wrong!

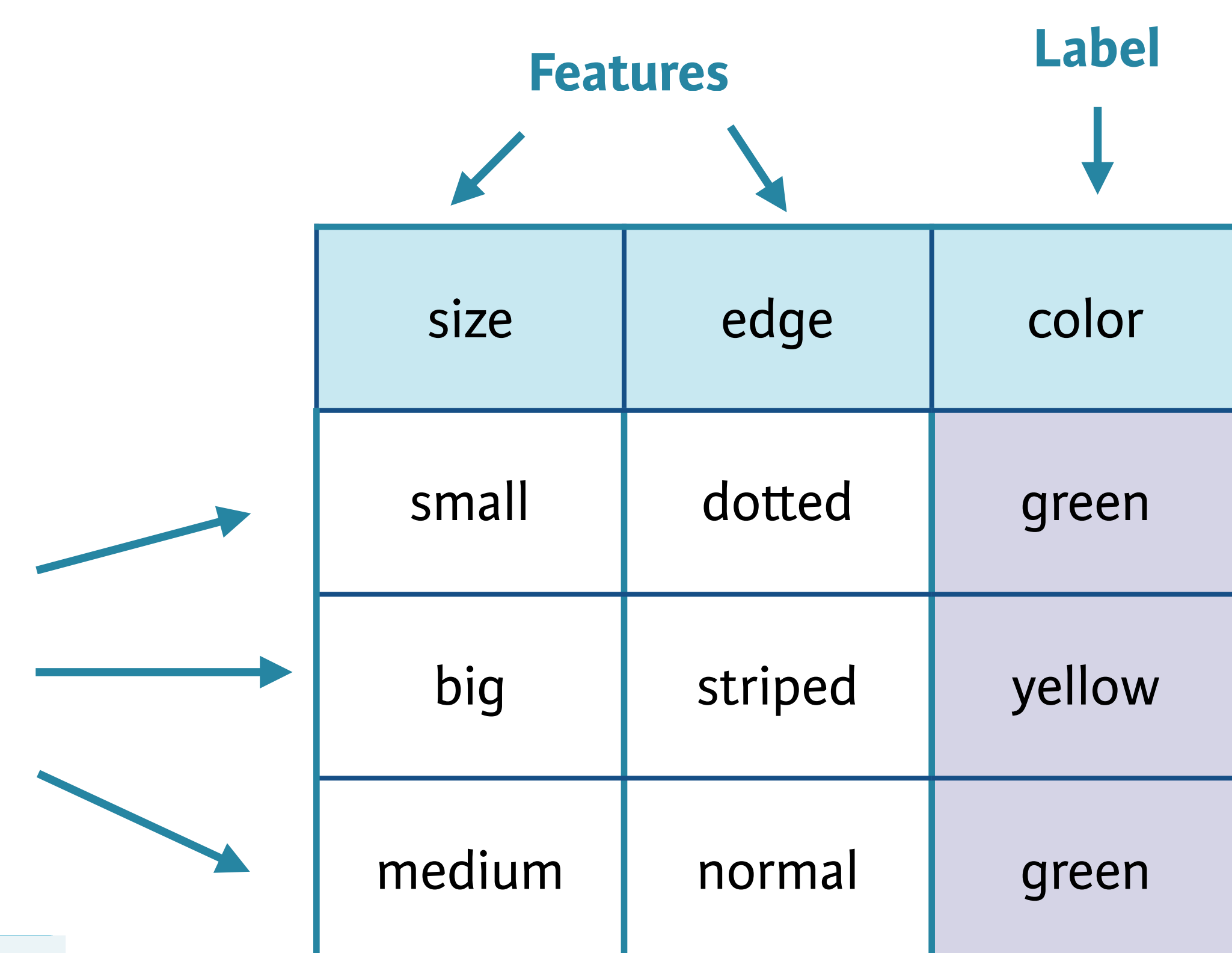
# Input Knowledge

In example: pre-labeled squares

In R - use `data.frame()`

```
> squares <- data.frame(  
  size = c("small", "big", "medium"),  
  edge = c("dotted", "striped", "normal"),  
  color = c("green", "yellow", "green"))
```

Observations



Features		Label
size	edge	color
small	dotted	green
big	striped	yellow
medium	normal	green

# Data Frame Functions

> `dim(squares)`      ←      **#Observations, #Features**

> `str(squares)`      ←      **Structured Overview**

> `summary(squares)`      ←      **Distribution Measures**

# Formulation



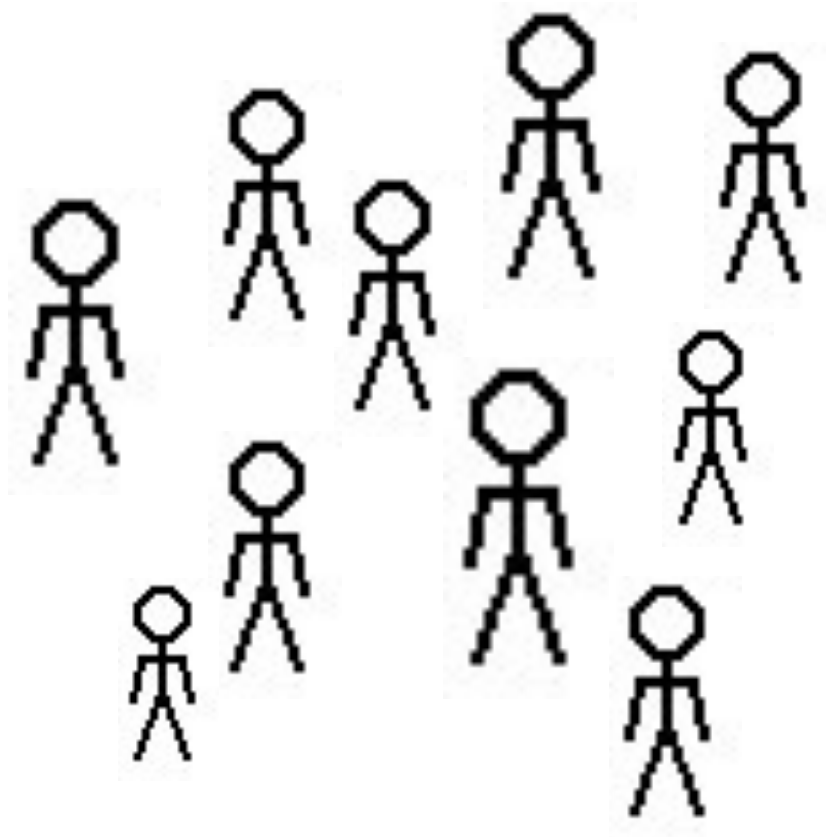
# ML: What It Is Not

- Determining most occurring color
  - Calculating average size
- } NOT Machine Learning

**Goal:** Building models for prediction!



# Regression



INPUT: Weight  
OUTPUT: Height

Regression



Estimated  
function:

$\hat{f}$



Weight

$\hat{f}$



Height

# More Applications!

- Shopping basket analysis
- Movie recommendation systems
- **Decision making for self-driving cars**
- and many more!



## INTRODUCTION TO MACHINE LEARNING

# Let's practice!



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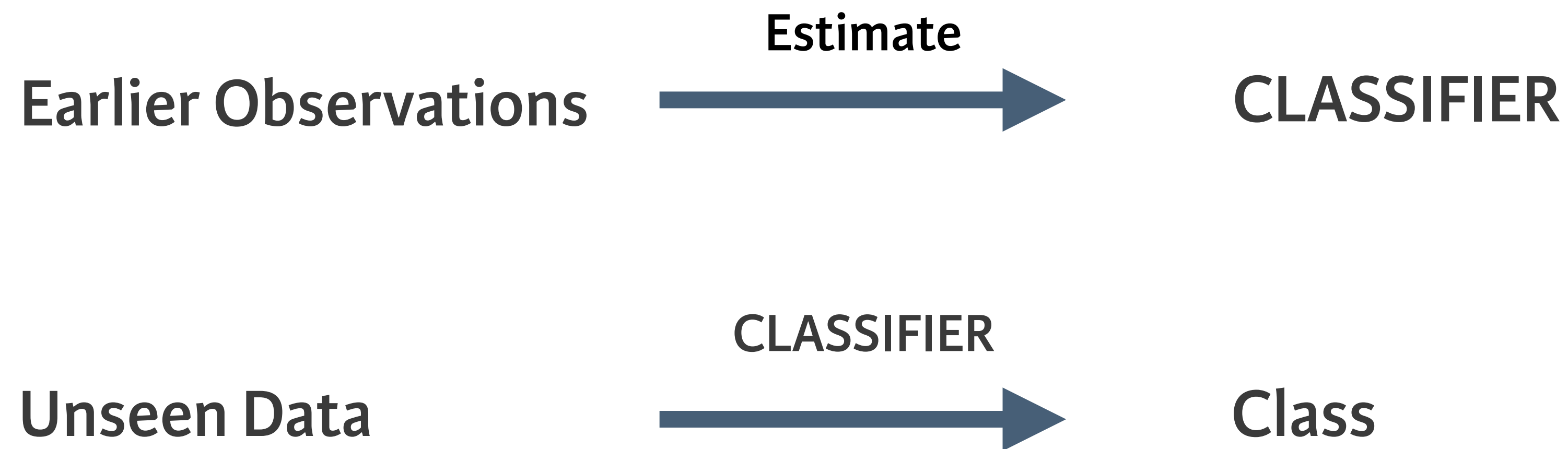
**Classification**  
**Regression**  
**Clustering**

# Common ML Problems

- Classification
- Regression
- Clustering

# Classification Problem

Goal: predict category of new observation



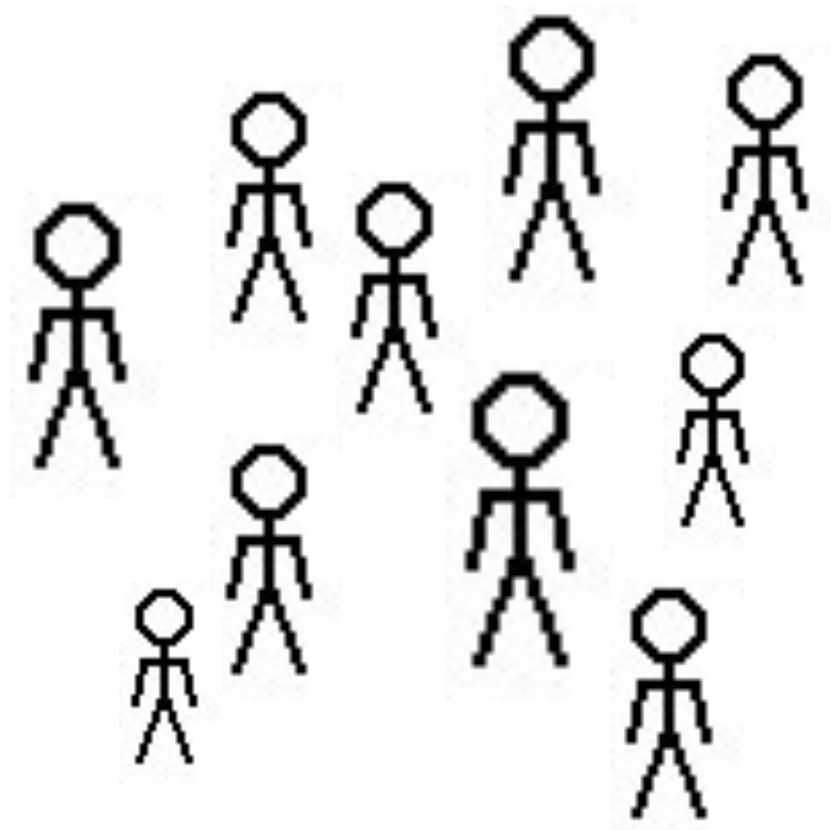
# Classification Applications

- Medical Diagnosis      Sick and Not Sick
- Animal Recognition      Dog, Cat and Horse

## Important:

- Qualitative Output
- Predefined Classes

# Regression



- Relationship: Height - Weight?
- Linear?
- Predict: Weight  $\longrightarrow$  Height



# Regression Model

Fitting a linear function

$$\text{Height} \approx \beta_0 + \beta_1 \times \text{Weight}$$

- Predictor: Weight
- Response: Height
- Coefficients:  $\beta_0, \beta_1$

Estimate on previous input-output



```
> lm(response ~ predictor)
```

# Regression Applications

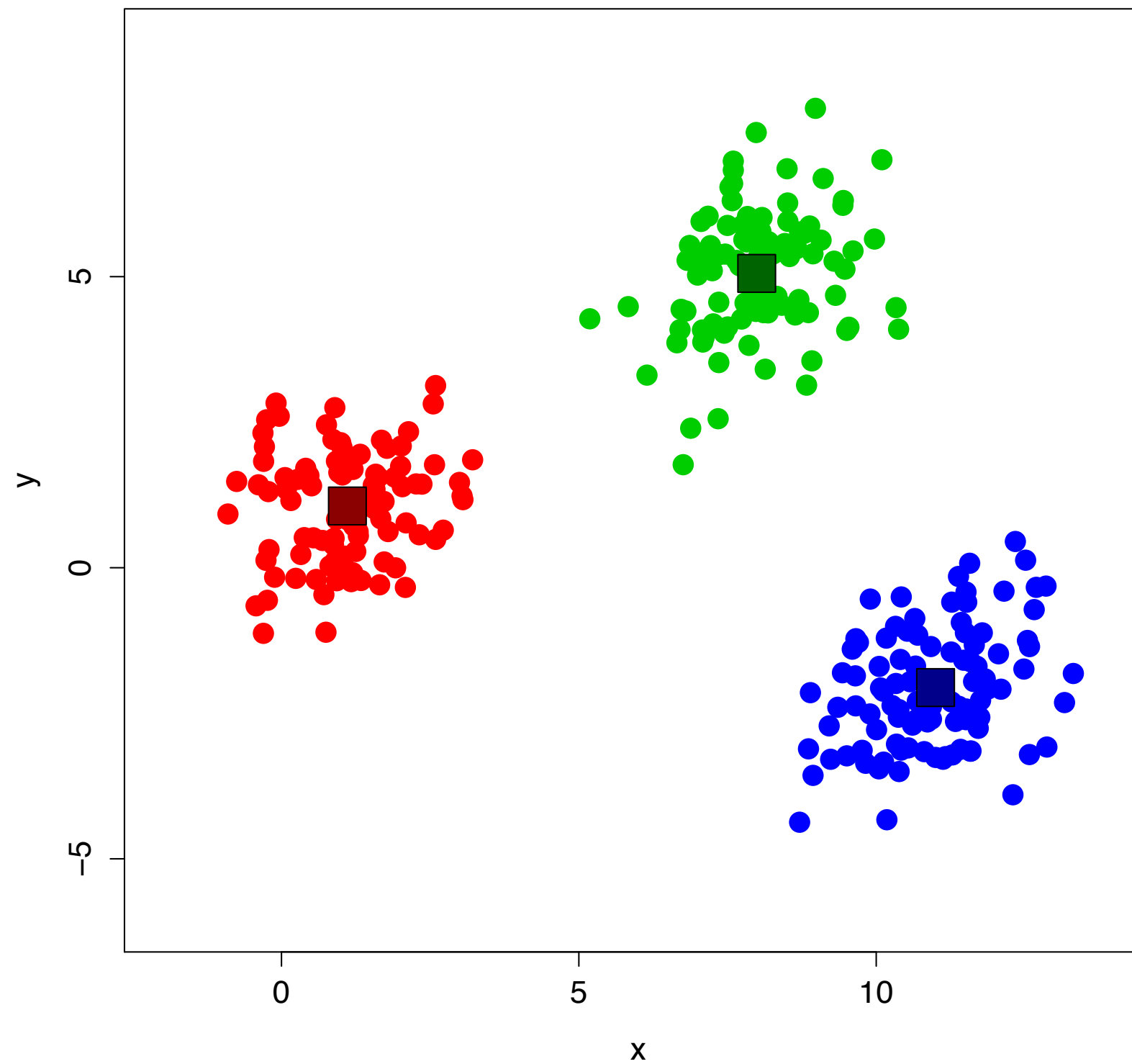
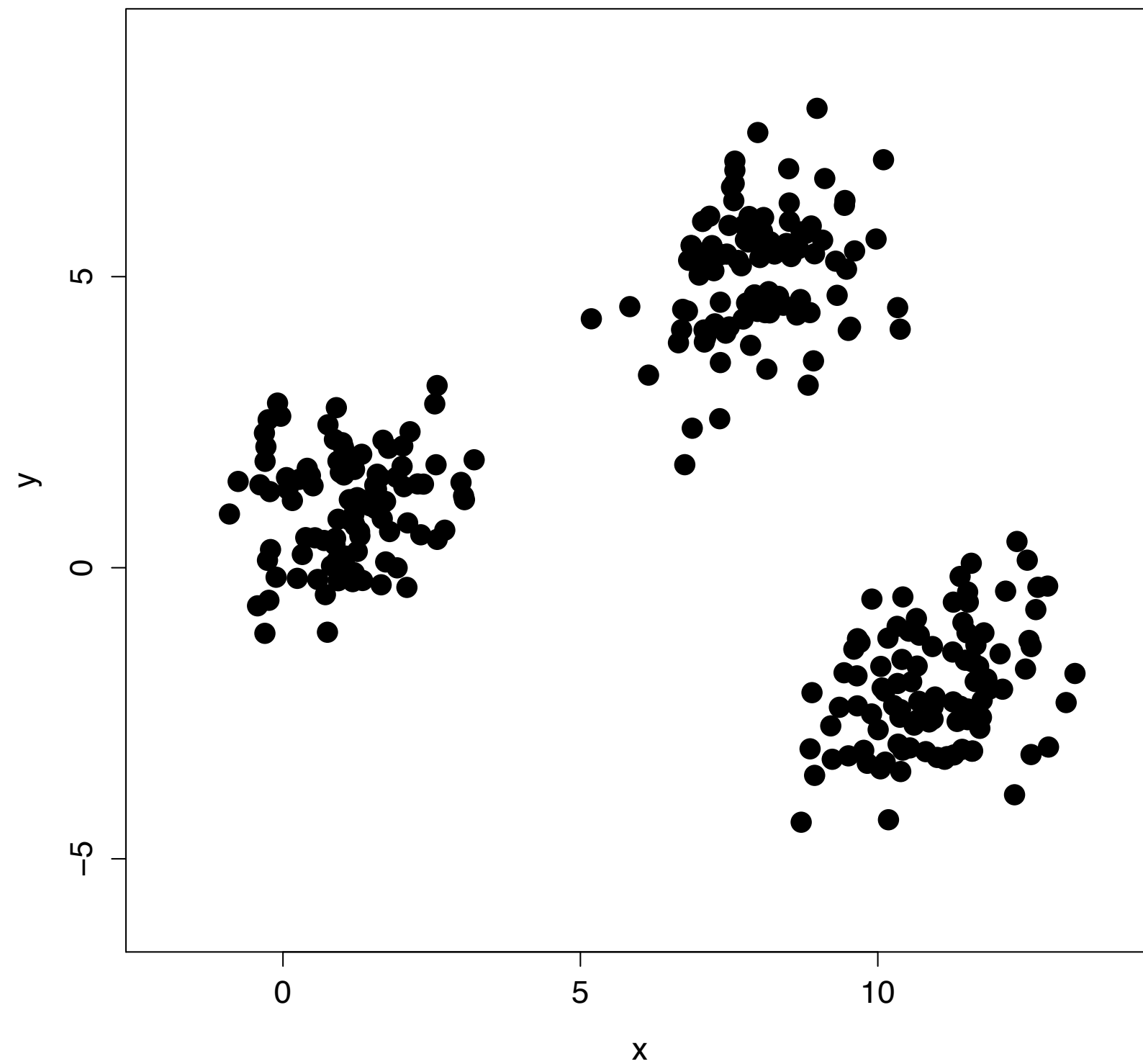
- Payments → Credit Scores
- Time → Subscriptions
- Grades → Landing a Job
- Quantitative Output
- Previous input-output observations

# Clustering

- Clustering: grouping objects in clusters
  - *Similar* within cluster
  - *Dissimilar* between clusters
- Example: Grouping similar animal photos
  - No labels
  - No right or wrong
  - Plenty possible clusterings

# k-Means

Cluster data in  $k$  clusters!





INTRODUCTION TO MACHINE LEARNING


# Let's Practice



INTRODUCTION TO MACHINE LEARNING

# **Supervised vs. Unsupervised**

# Machine Learning Tasks

- Classification
  - Regression
  - Clustering
- 
- quite similar

# Supervised Learning

Find: function  $\hat{f}$  which can be used to assign a class or value to unseen observations.

Given: a set of labeled observations



Supervised Learning



# Unsupervised Learning

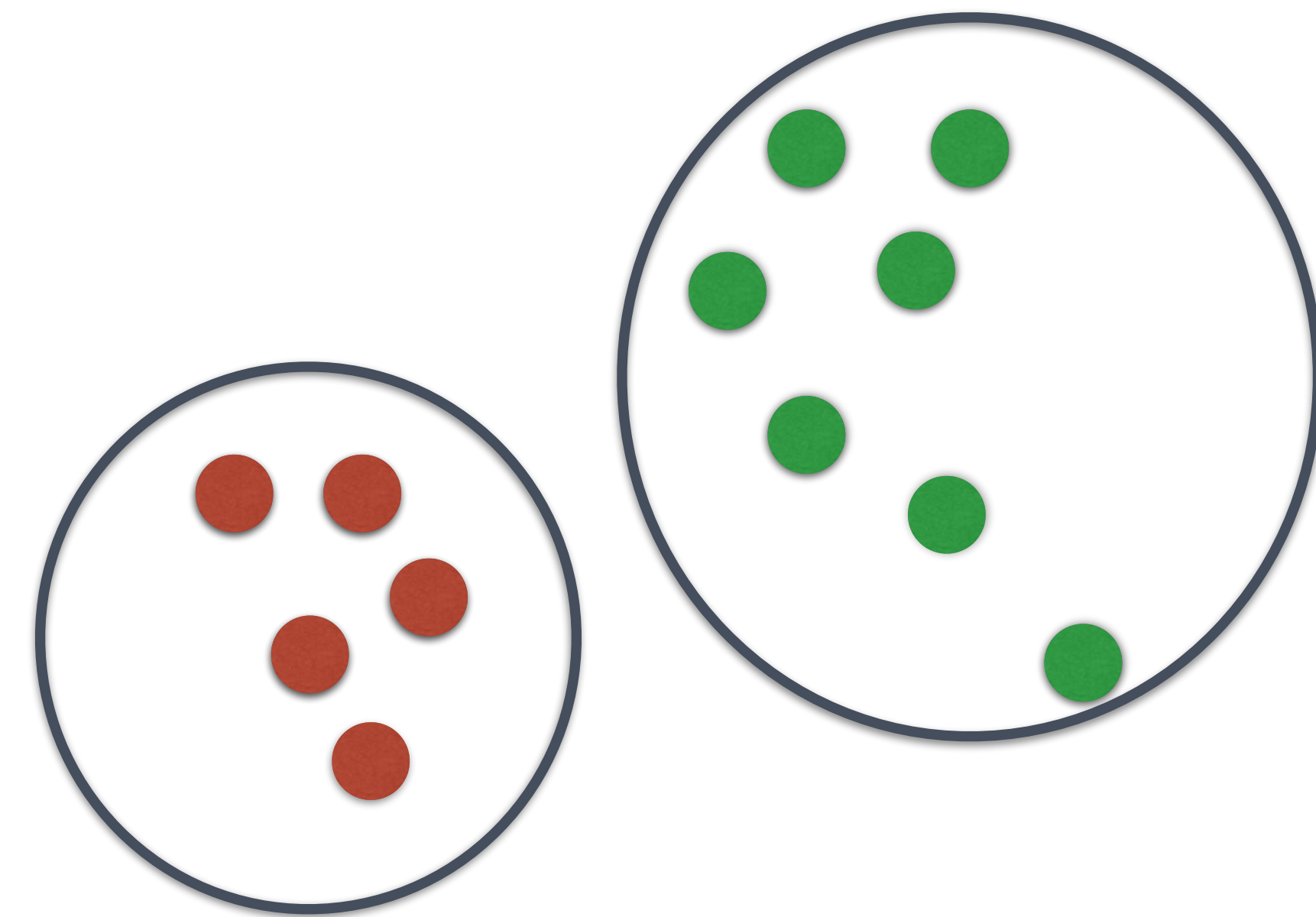
- Labeling can be tedious, often done by humans
- Some techniques don't require labeled data
- Unsupervised Learning
  - Clustering: find groups observation that are similar
  - Does not require labeled observations

# Performance of the model

- Supervised Learning
  - Compare real labels with predicted labels
  - Predictions should be similar to real labels
- Unsupervised Learning
  - No real labels to compare
  - Techniques will be explained in this course

# Semi-Supervised Learning

- A lot of unlabeled observations
- A few labeled
- Group similar observations using clustering
- Use clustering information and classes of labeled observations to assign a class to unlabelled observations
- More labeled observations for supervised learning





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# Let's practice!