Intro to Machine Learning (CS436/CS580L)

Lecture 2: Model Representation & Cost Function

Xi Peng, Fall 2018

Thanks to Tom Mitchell, Andrew Ng, Ben Taskar, Carlos Guestrin, Eric Xing, Hal Daume III, David Sontag, Jerry Zhu, and Tina Eliassi-Rad for some slides & teaching material.

This Class

- Graphical Example
  - Classification
  - Regression
  - Clustering
- Model representation
- Loss function

Median

Types of Machine Learning

- Supervised Learning (SL)
- Unsupervised Learning (UL)
- Reinforcement Learning (RL)

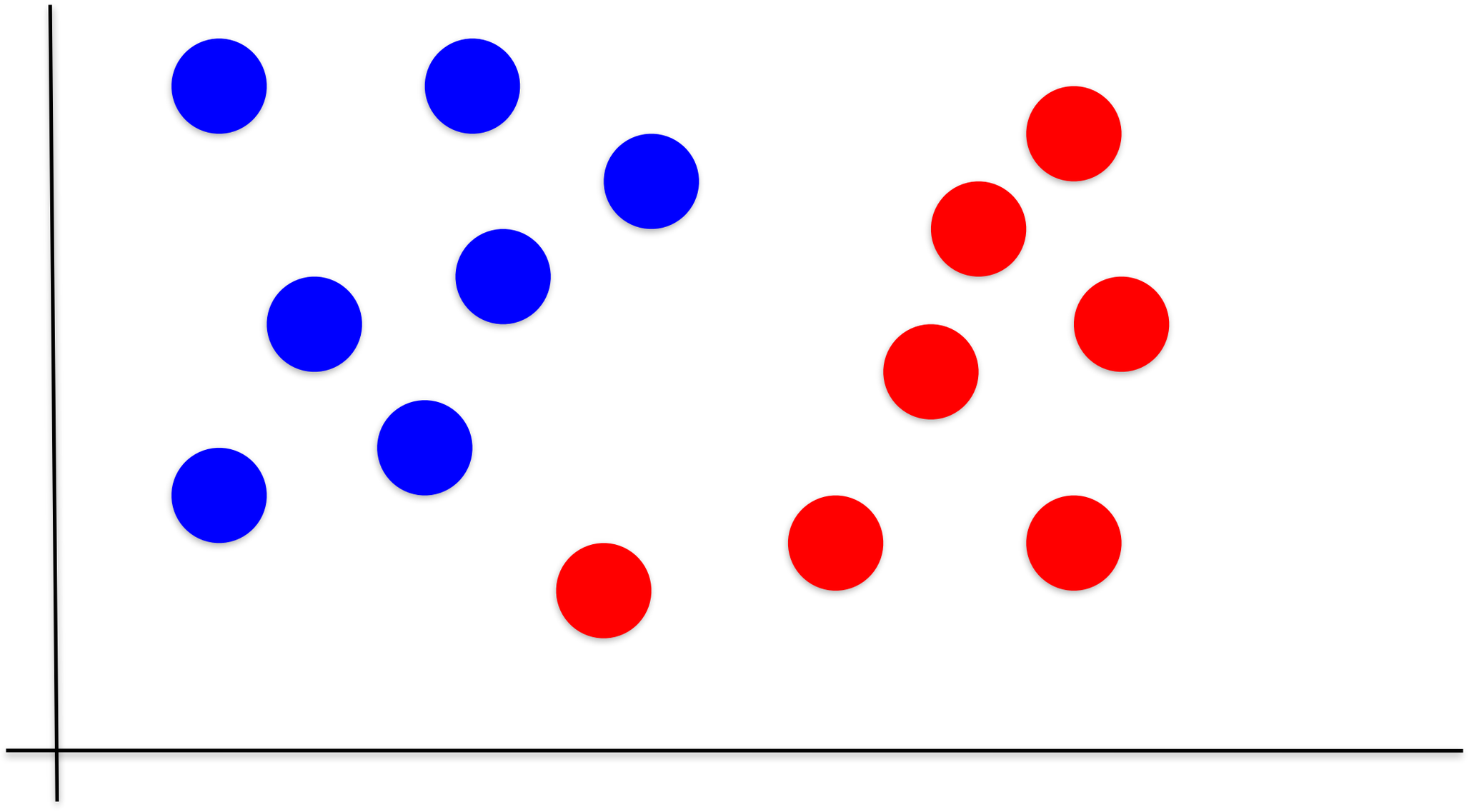
Types of Machine Learning

Supervised Learning

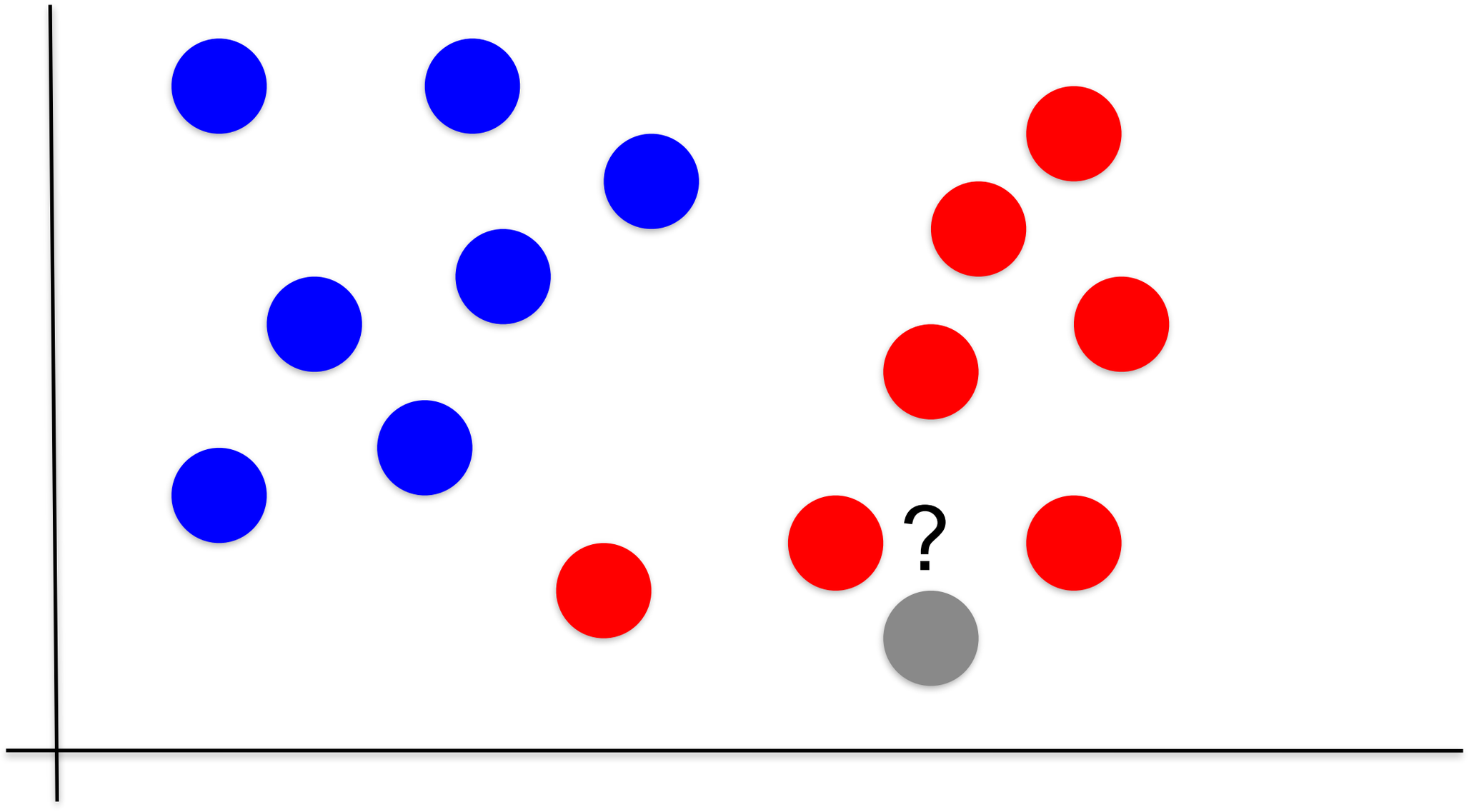
- Observe *n* training examples $D=\{x_i, y_i\}$
- Learn a function, *h*, mapping any input *x to output y*: $h(x) \approx y$

- Classification: predict a small number of discrete-valued outputs
- Regression: predict a continuous-valued output
- Ranking
- …

Graphical Example of Classification



Graphical Example of Classification



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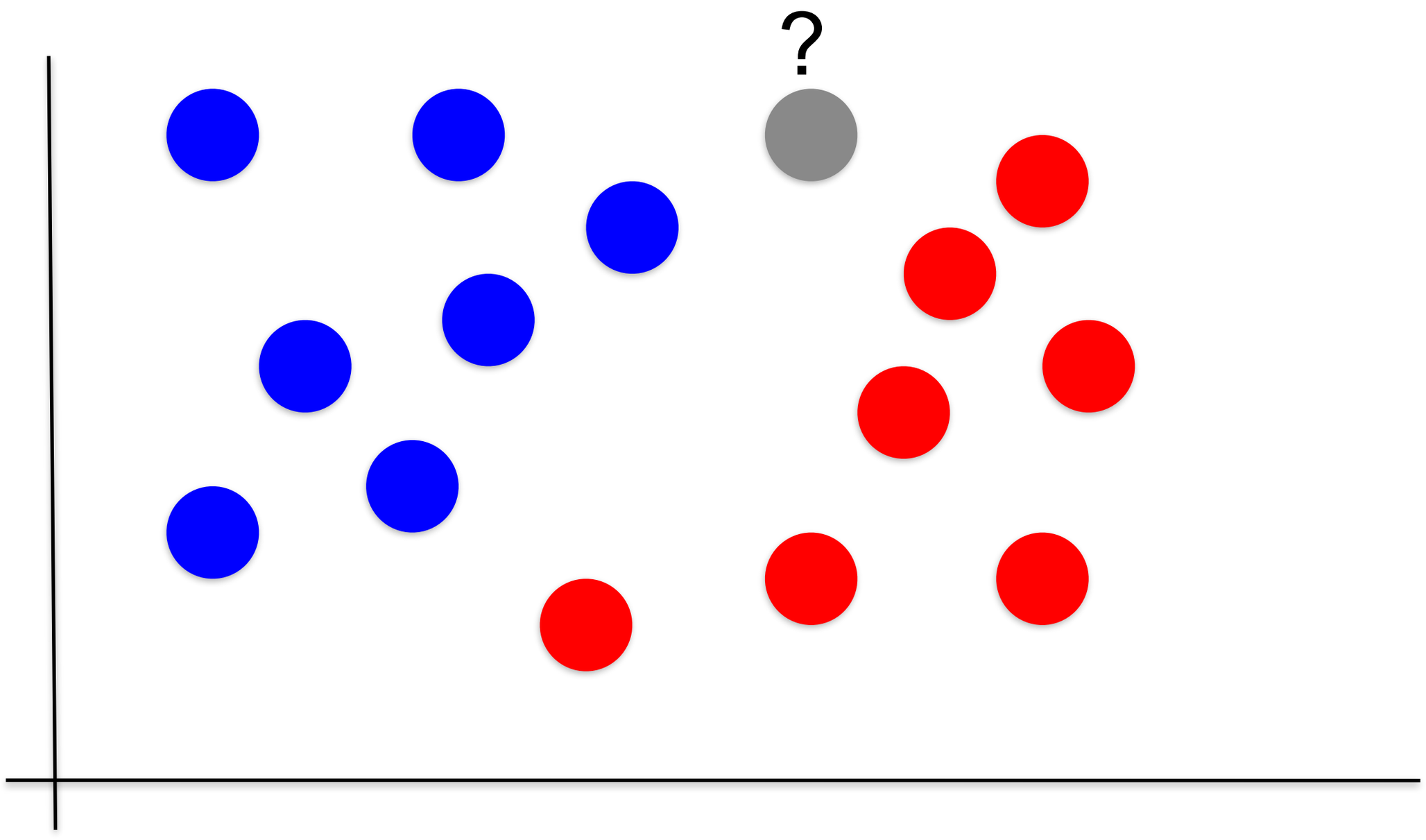

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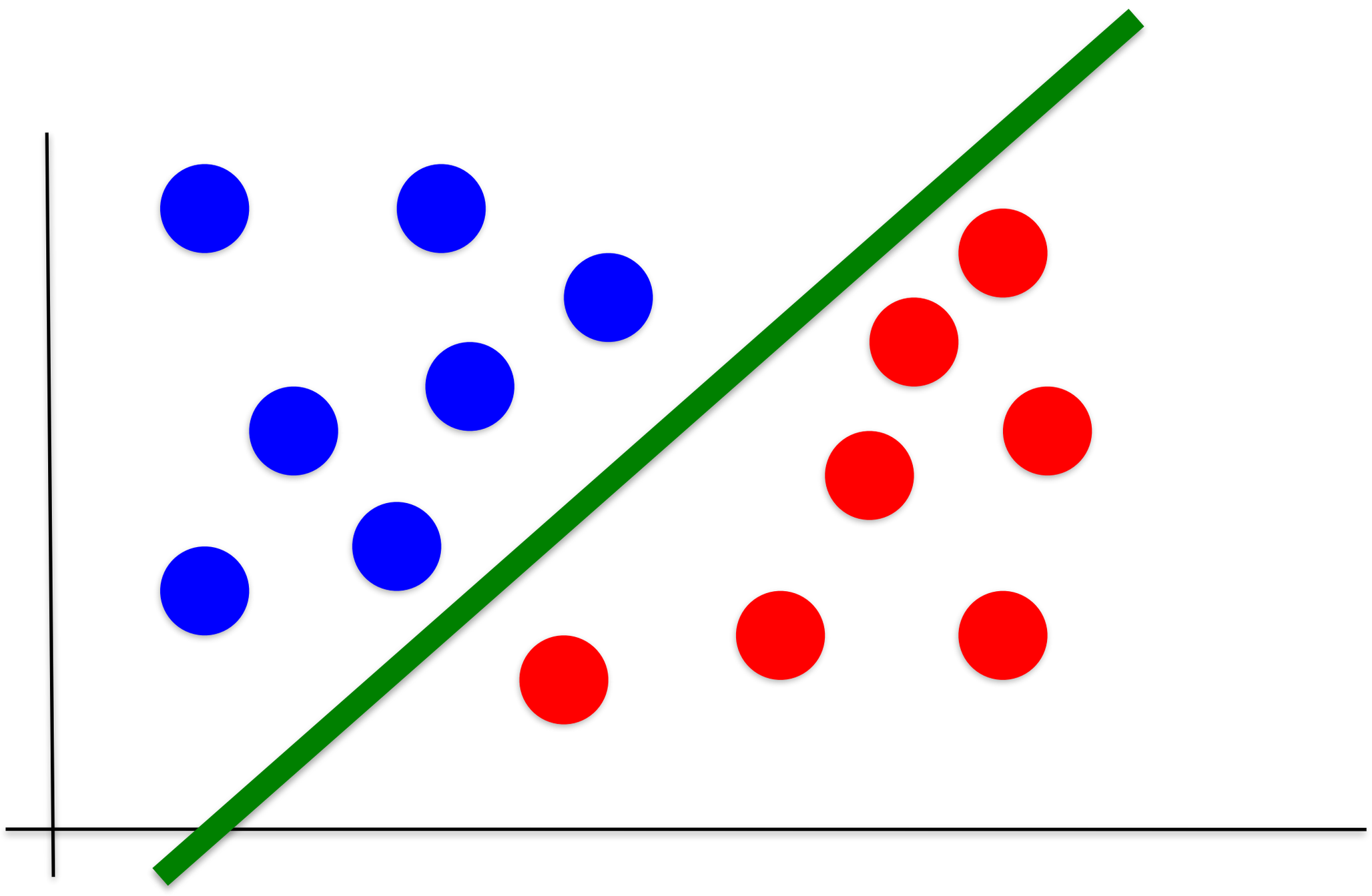

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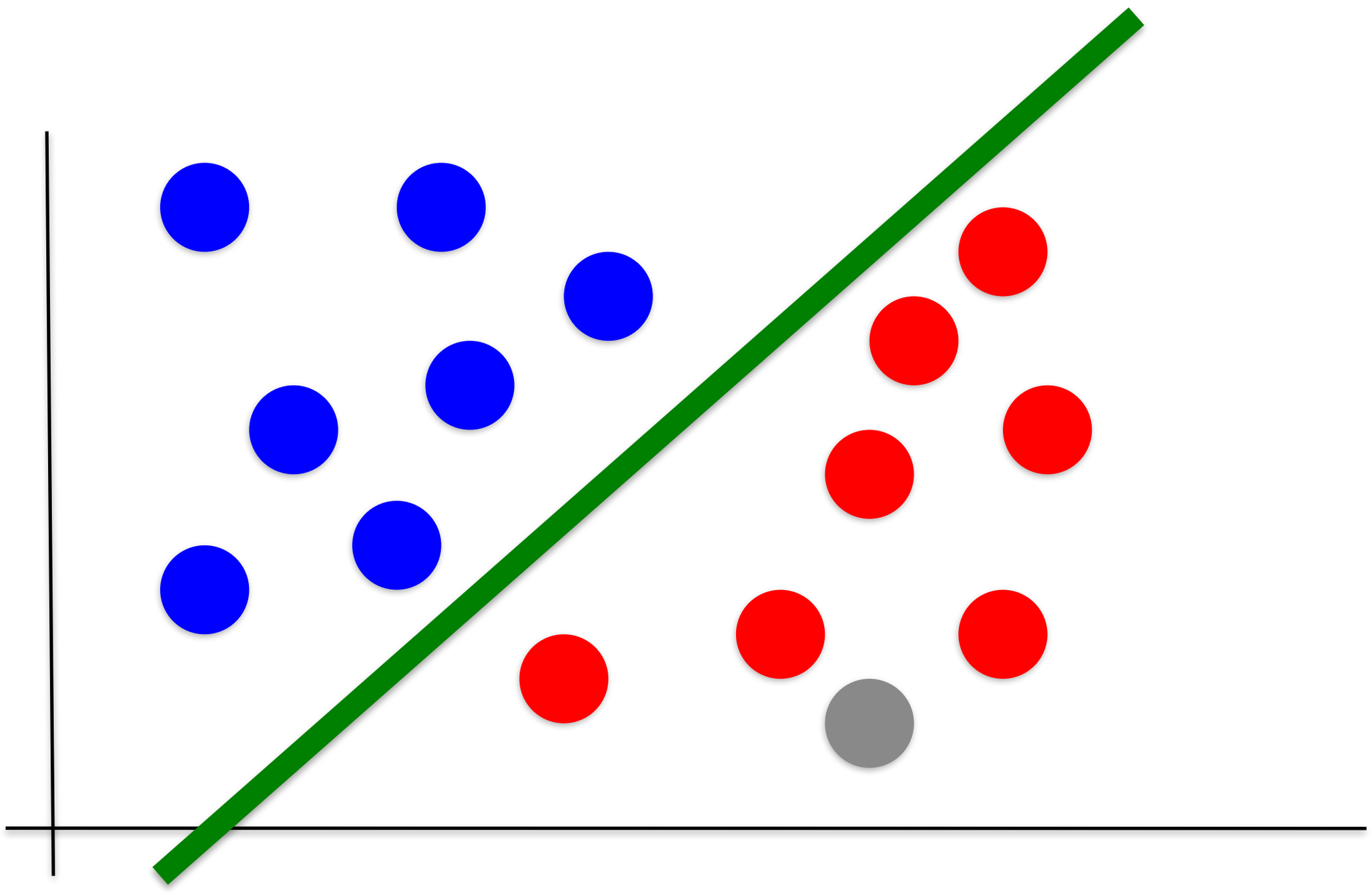

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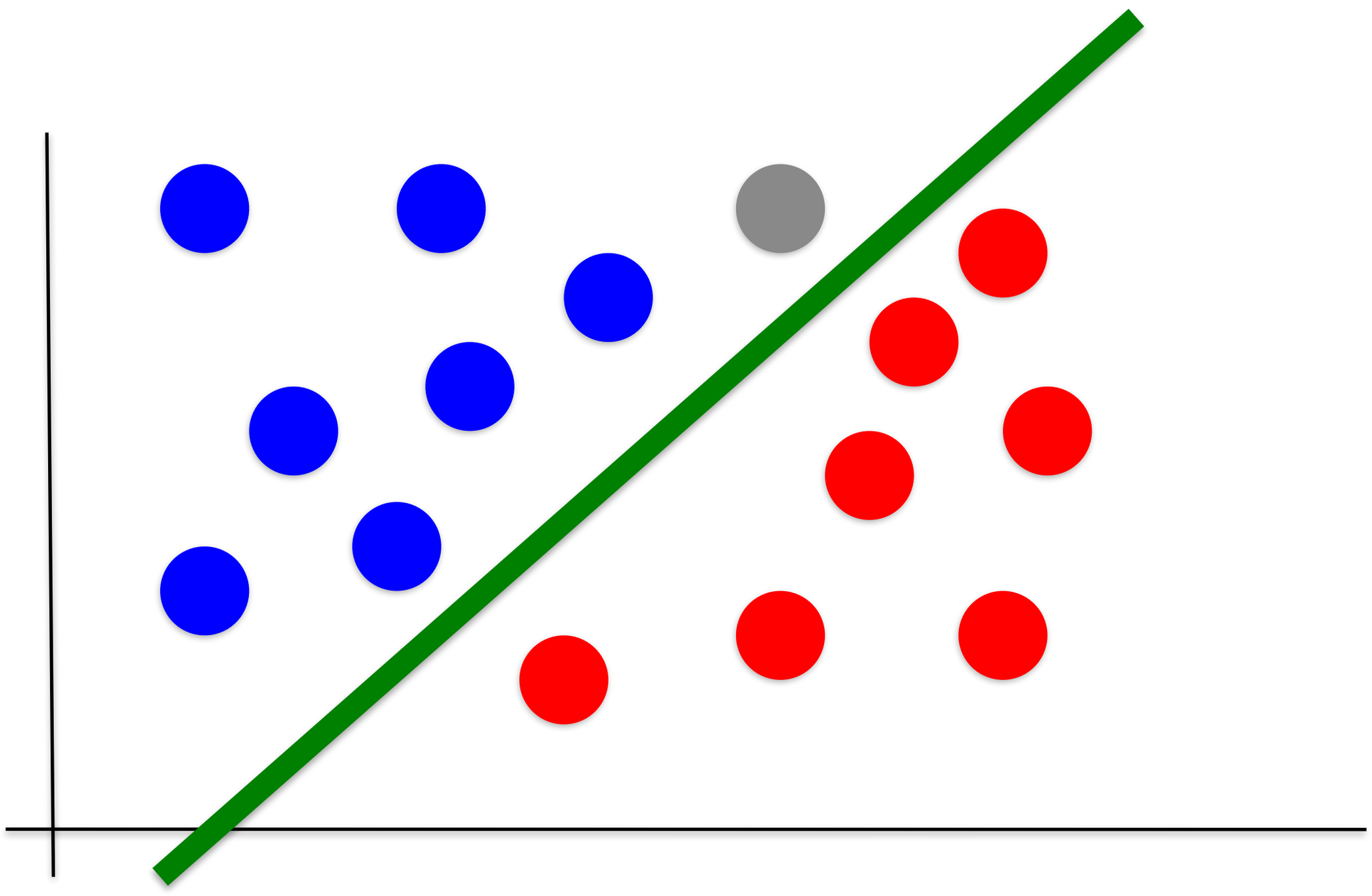
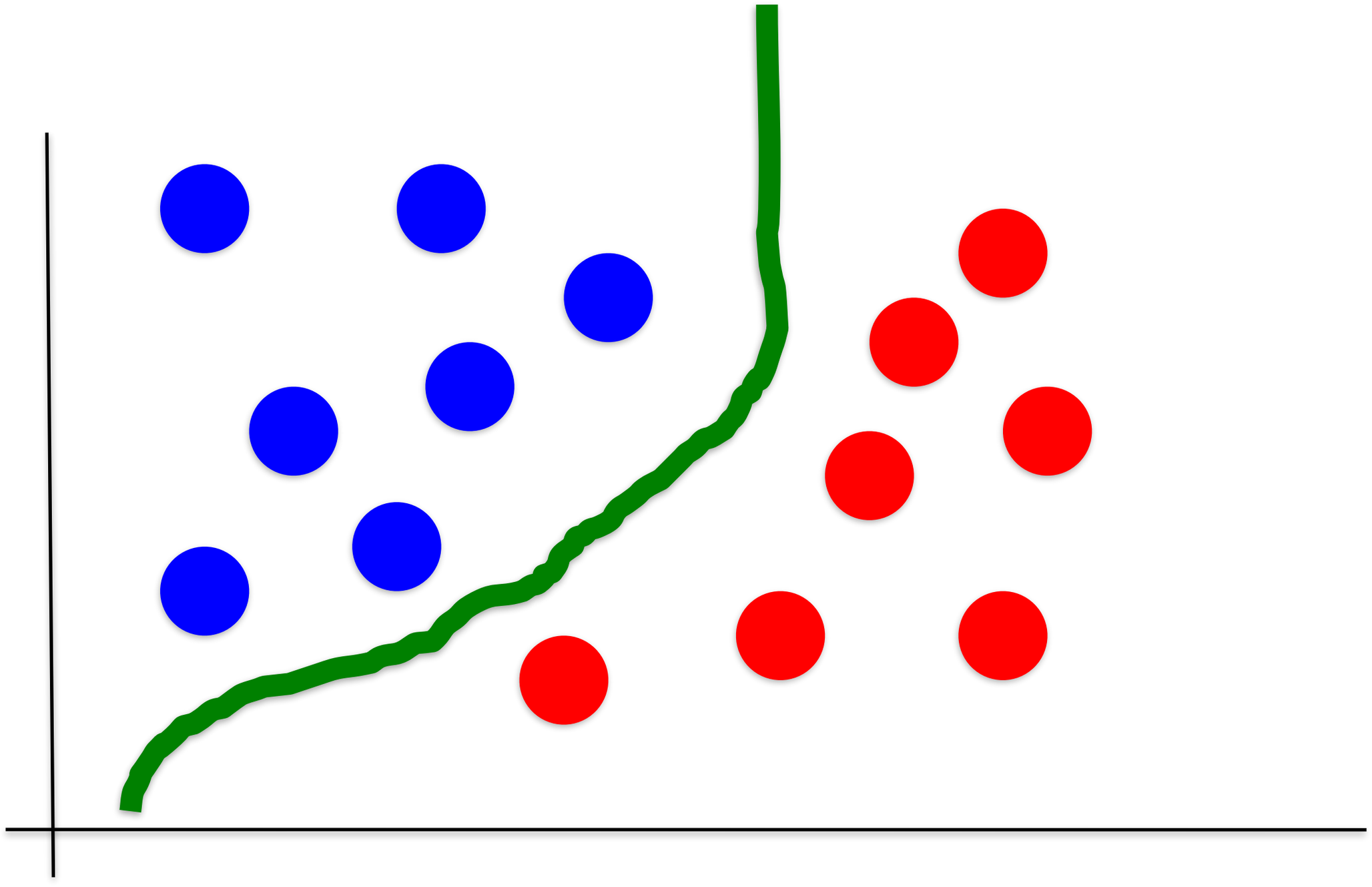
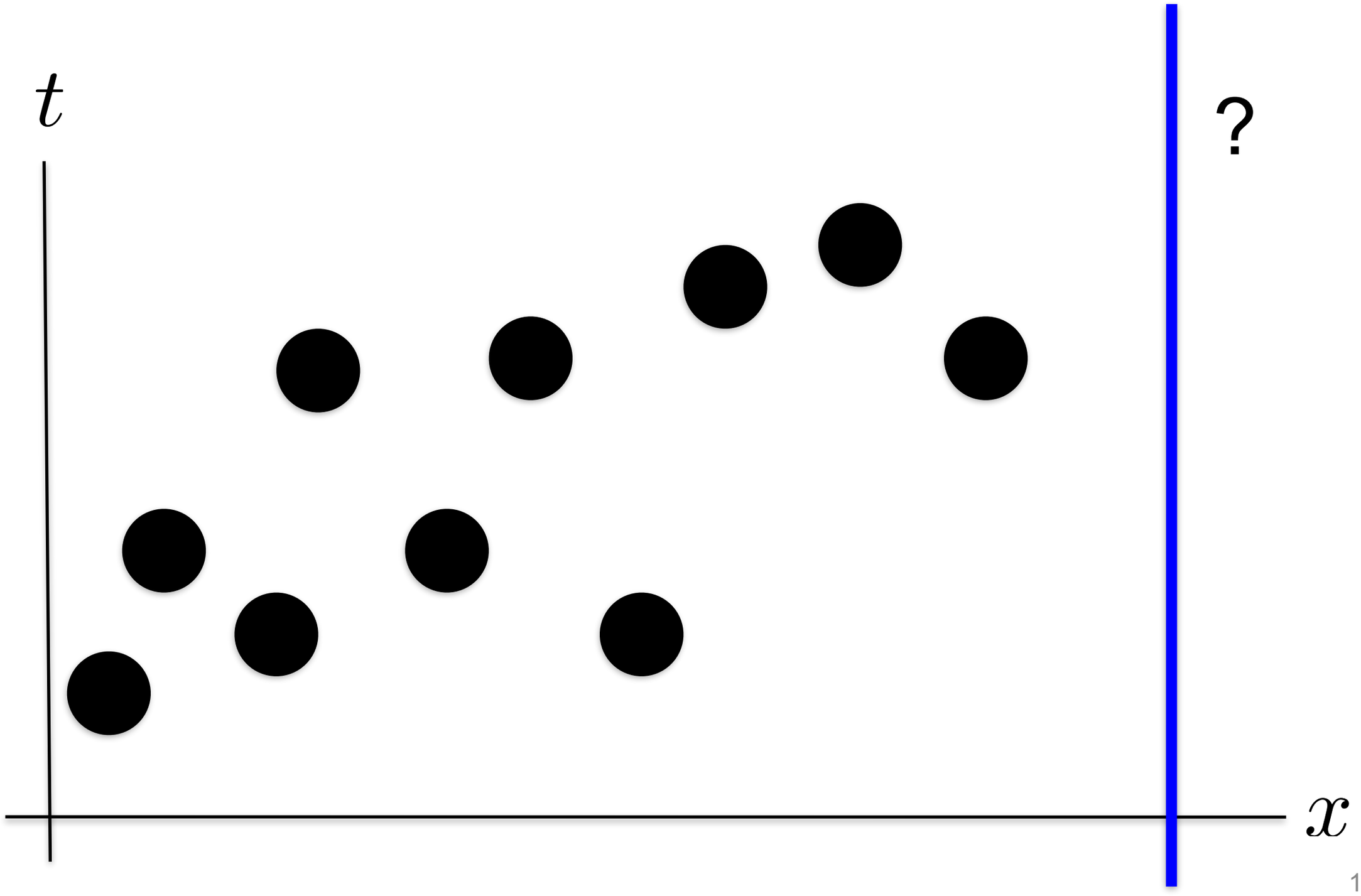


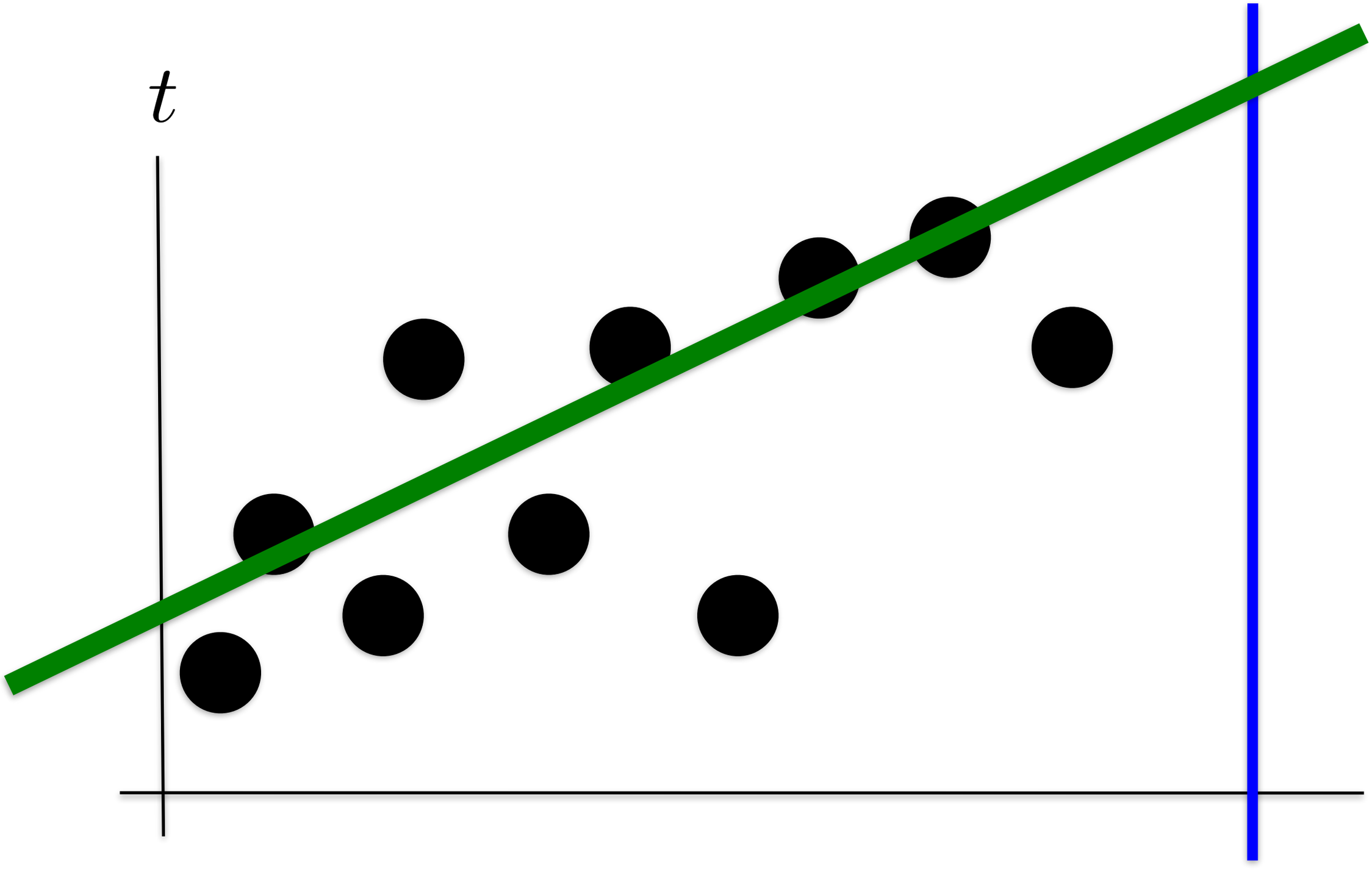
Decision Boundaries



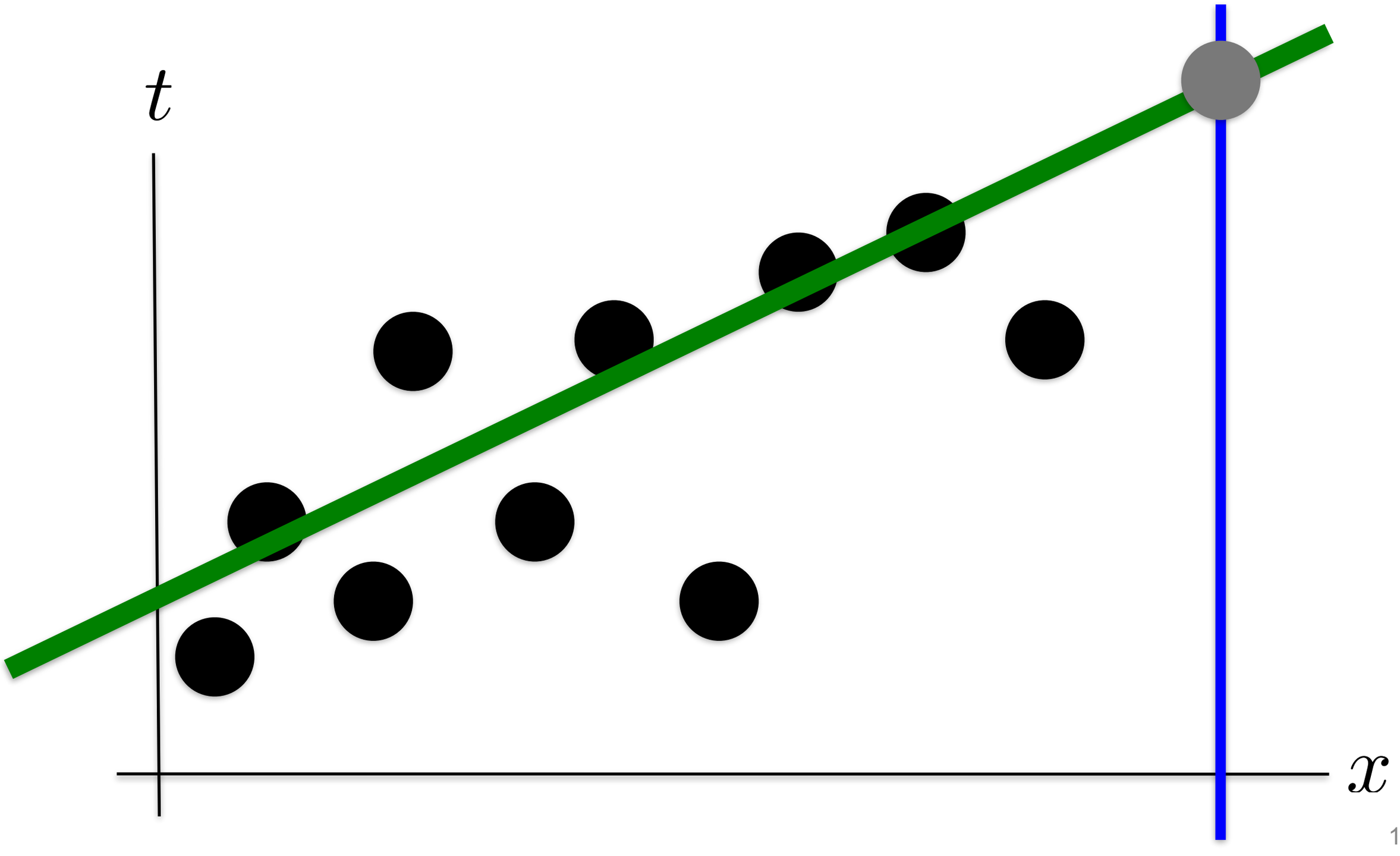
Graphical Example of Regression



Graphical Example of Regression



Graphical Example of Regression



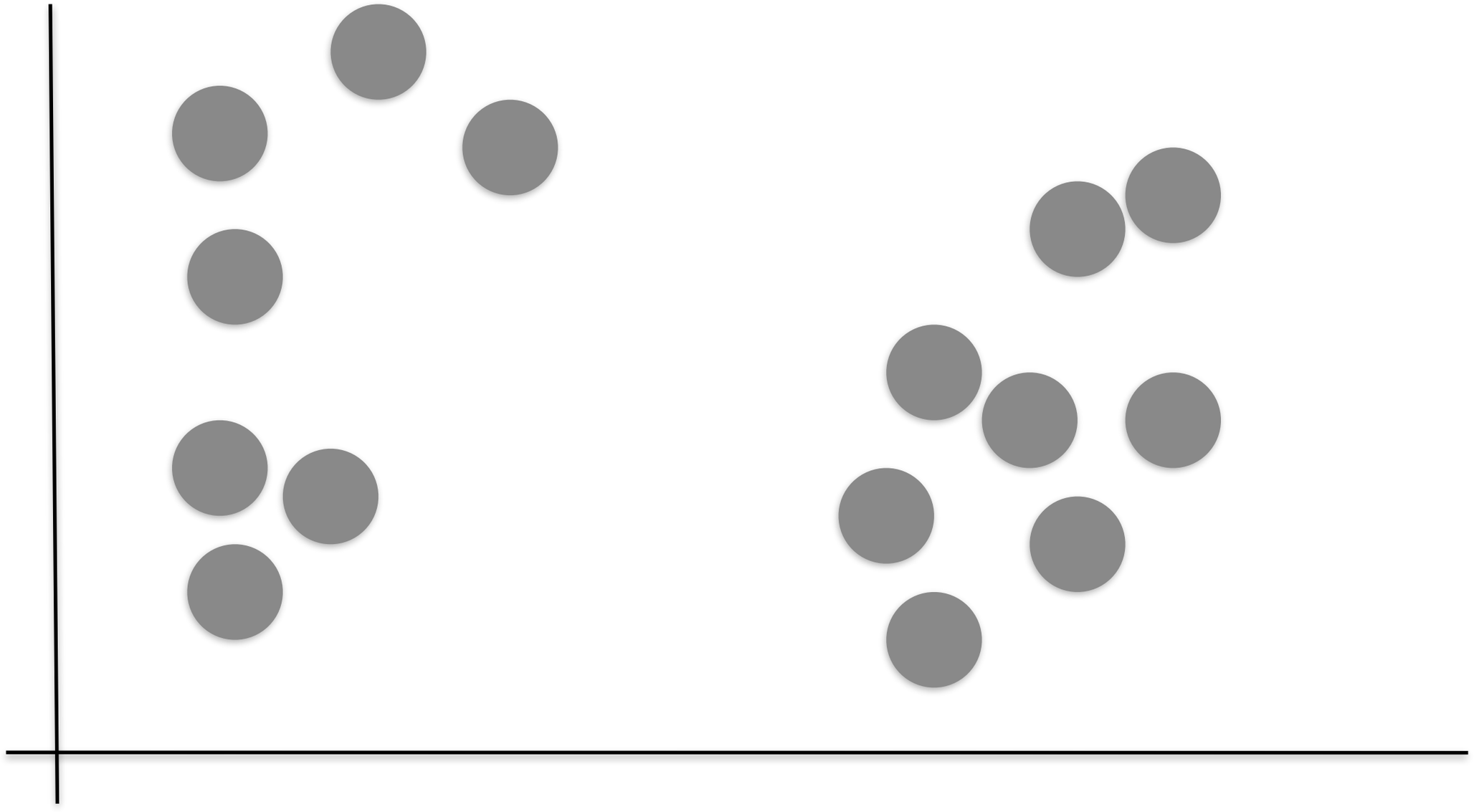
Types of Machine Learning
Unsupervised Learning

- Observe *n* examples $D = \{x_i\}$
- Clustering: Find a well-separated partition of example $D=\{D_1, D_2, \ldots, D_k\}$
- Dimensionality reduction: Find a low-distortion, low-dimensional projection $y = P\,x$, where the number of dimensions of *y* is less than (sometimes much less than) the number of dimensions of *x*
- The goal is to replace the high-complexity description of with a lower-complexity one

Clustering

- Clustering is an **unsupervised** learning task.
  - There is no target value to shoot for.
- Identify groups of “similar” data points, that are “dissimilar” from others.
- **Partition** the data into groups (clusters) that satisfy these constraints
  1. Points in the same cluster should be **similar.**
  2. Points in different clusters should be **dissimilar.**

Graphical Example of Clustering



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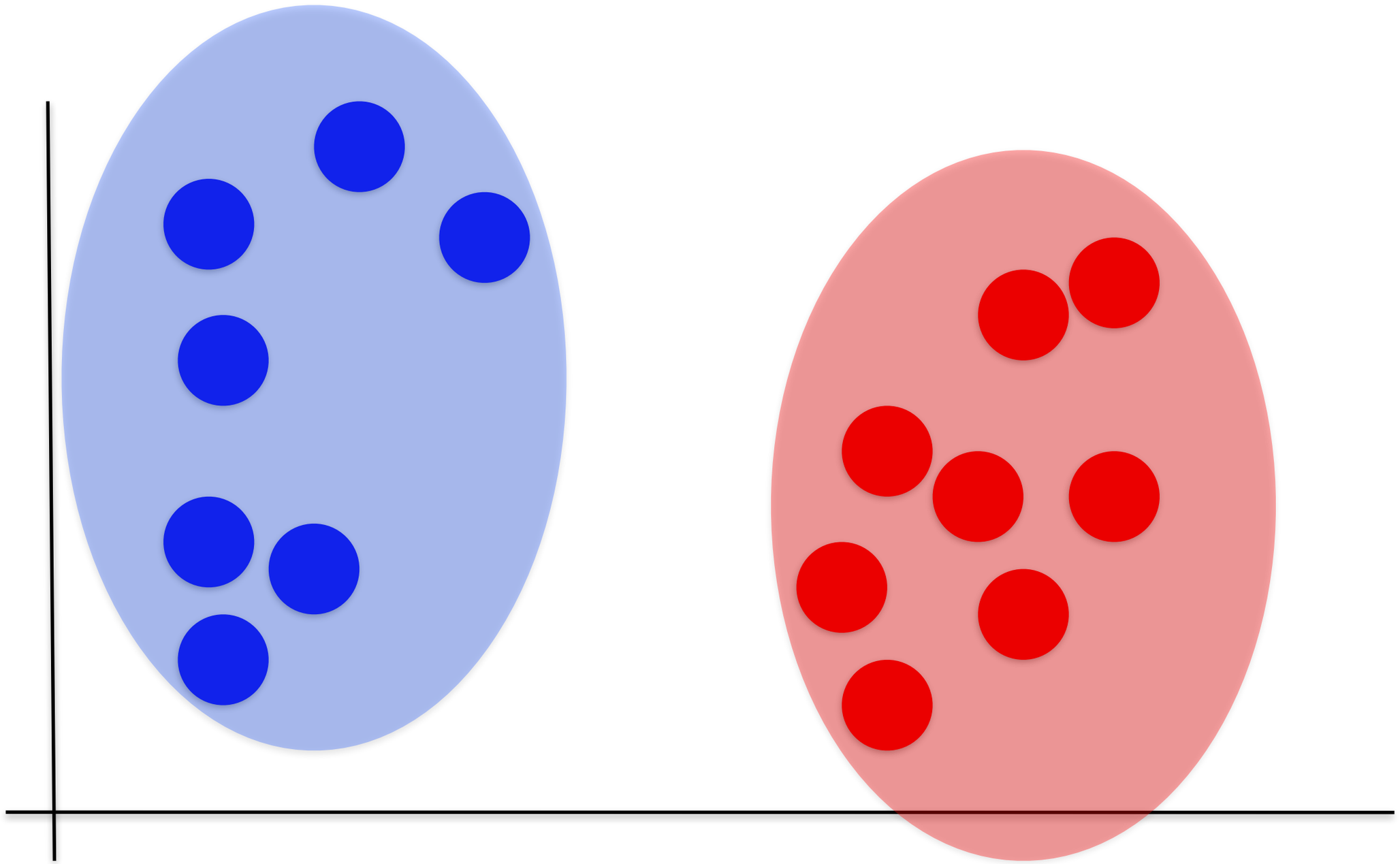
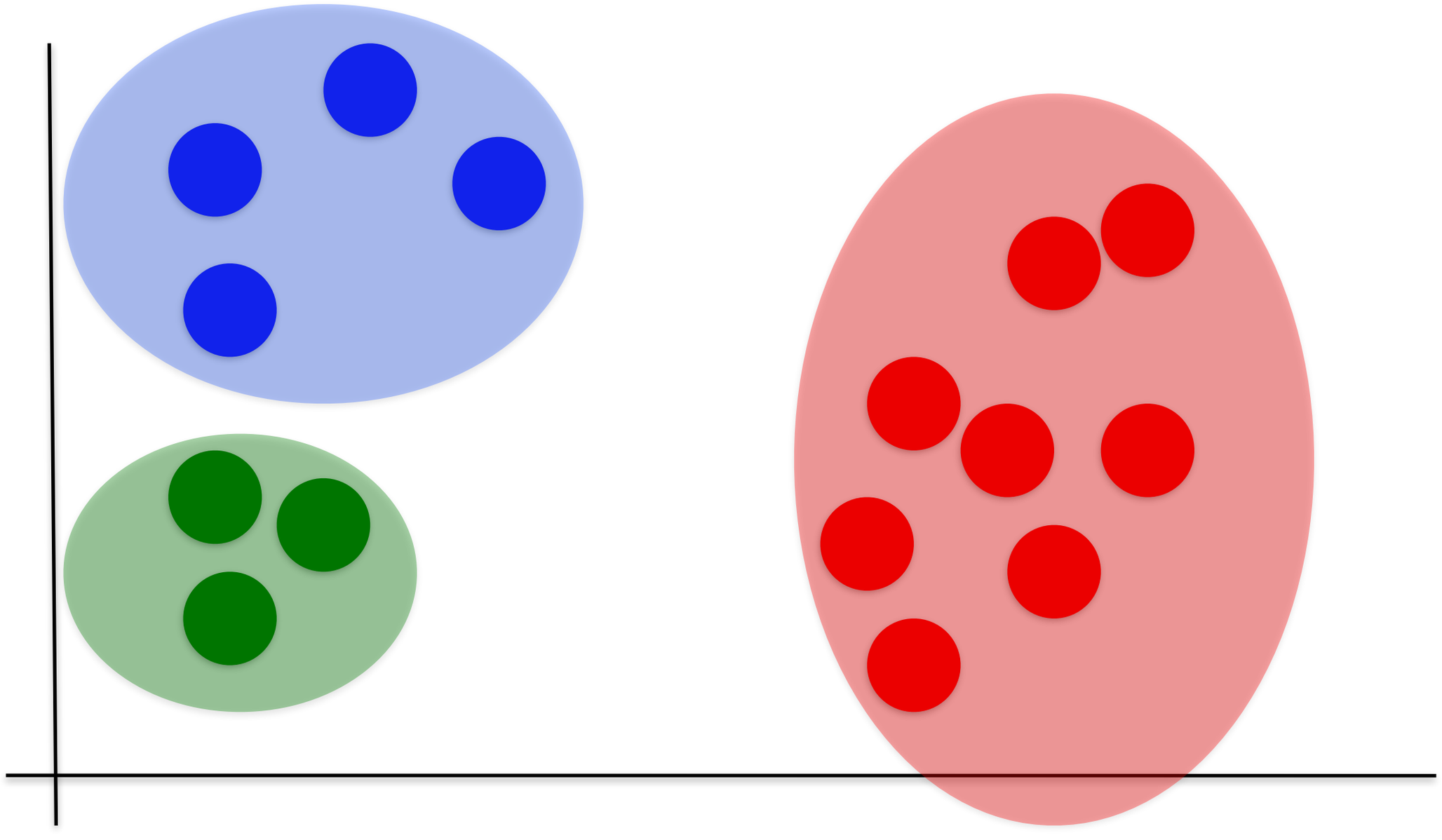
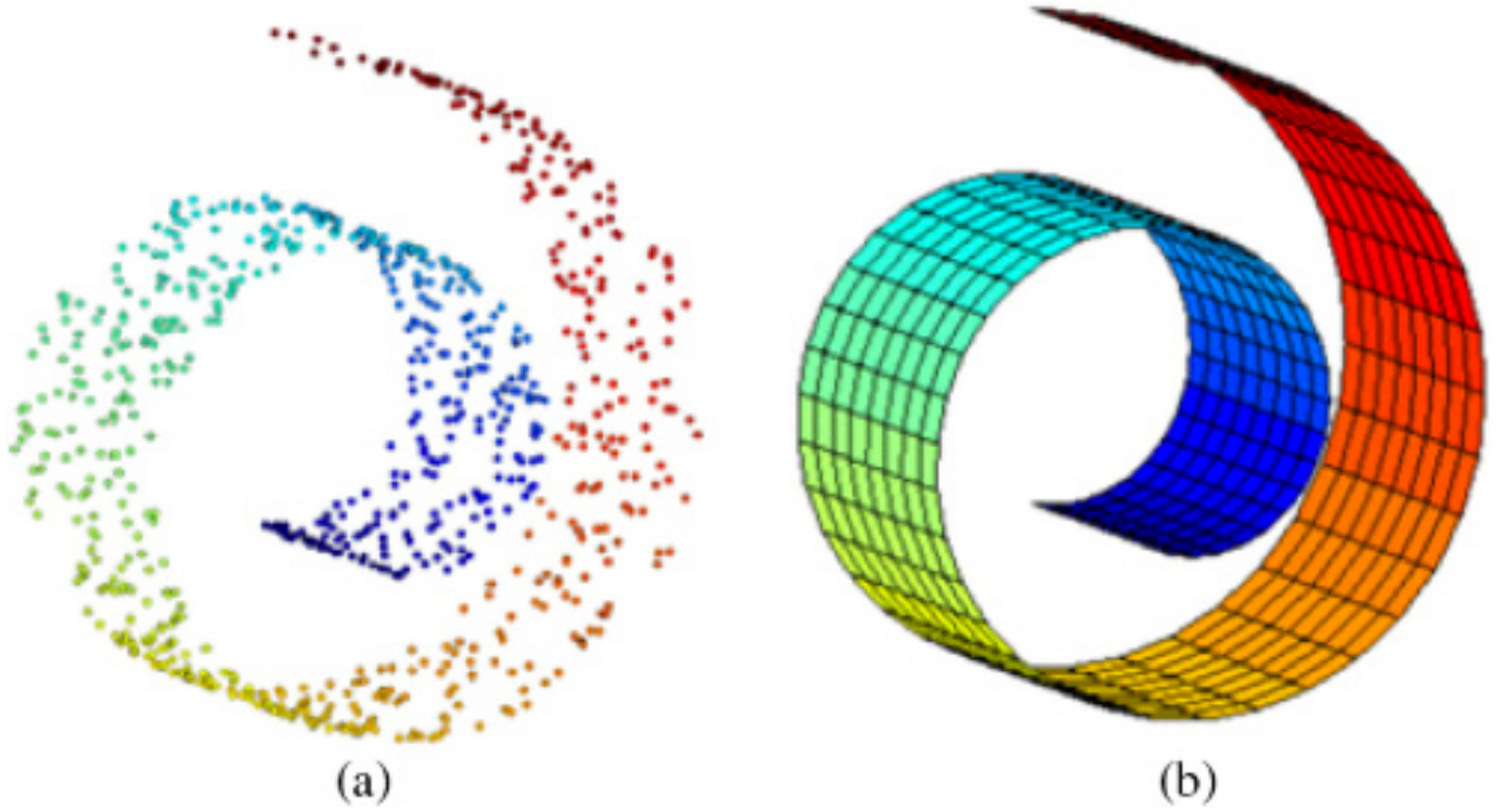


Graphical Example of Clustering

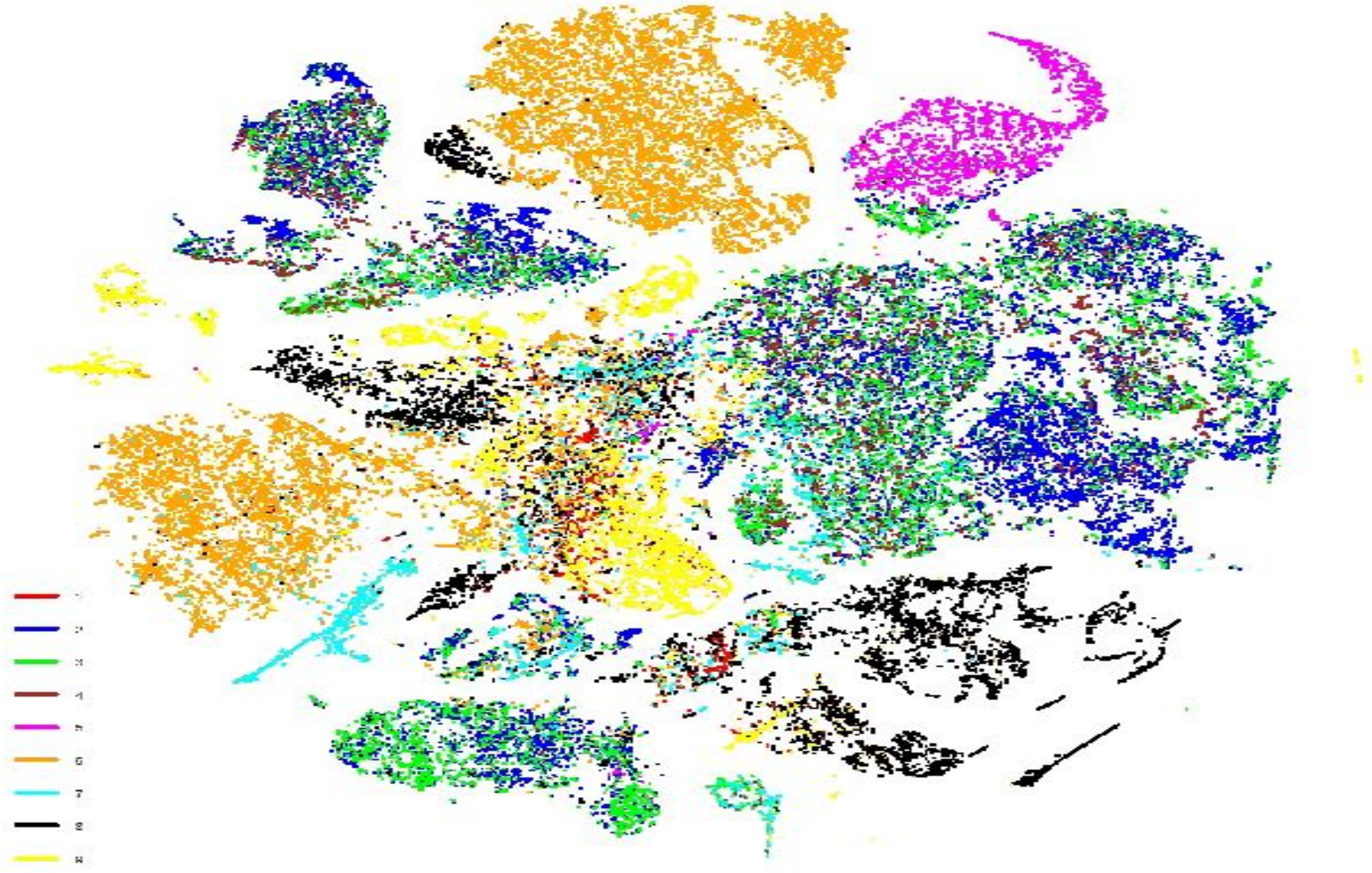


Dimension Reduction

- High dimension → low dimension
  - Dimension: number of features
- Principle:
  - Preserve some quantity of the original data
- Goal:
  - People can “see” the data in eyes
  - Some model can actually work on them



Data Manifold



https://www.kaggle.com/c/otto-group-product-classification-challenge/forums/t/13122/visualization

Kaggle competition, otto group product, 93 features, 200K products (data), 10 categoreis

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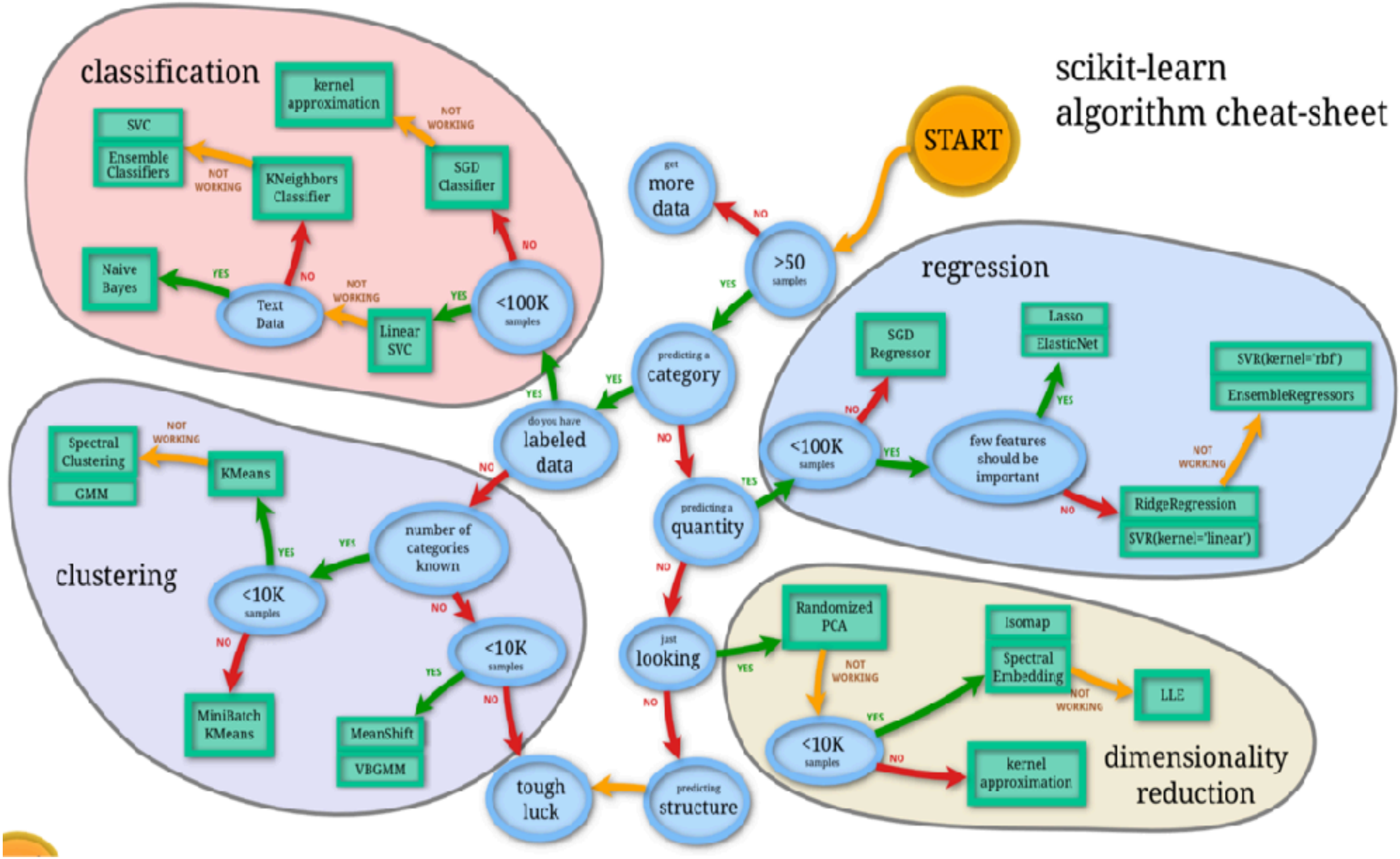


Python scikit learn
http://scikit-learn.org/stable/tutorial/machine_learning_map/

Model Representation

Task: predict the house price based on the size of house.

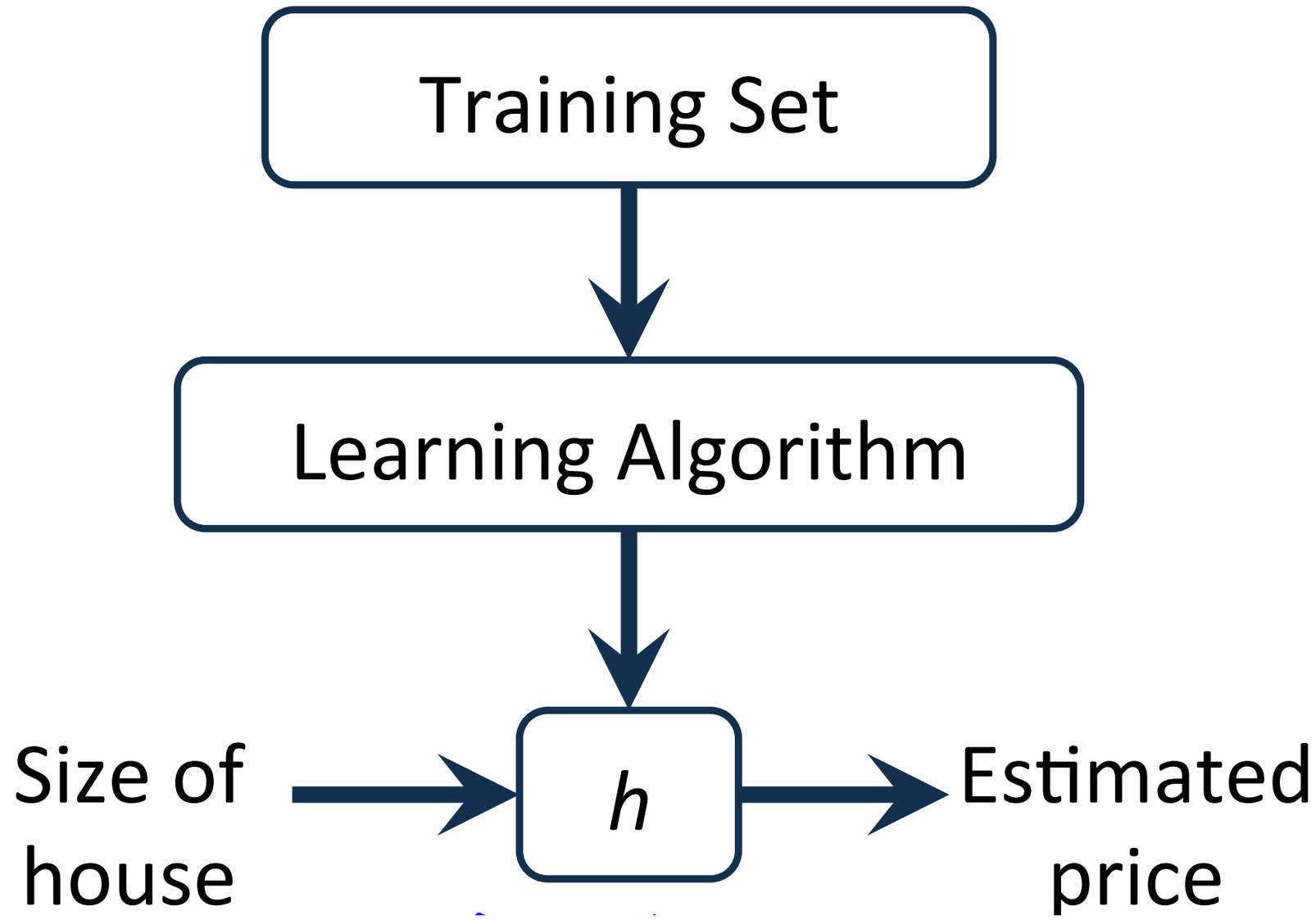
Training Set

Size in feet² (x)	Price ($) in 1000's (y)
2104	460
1416	232
1534	315
852	178
…	…

x → **y**

- Learn a function, *h*, mapping any input *x to output y*: $h(x) \approx y$

Model Representation



Model Representation

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Model Representation

Training Set

Size in feet^2 (x)	Price ($) in 1000's (y)
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Hypothesis: $h_\theta(x) = \theta_0 + \theta_1 x$

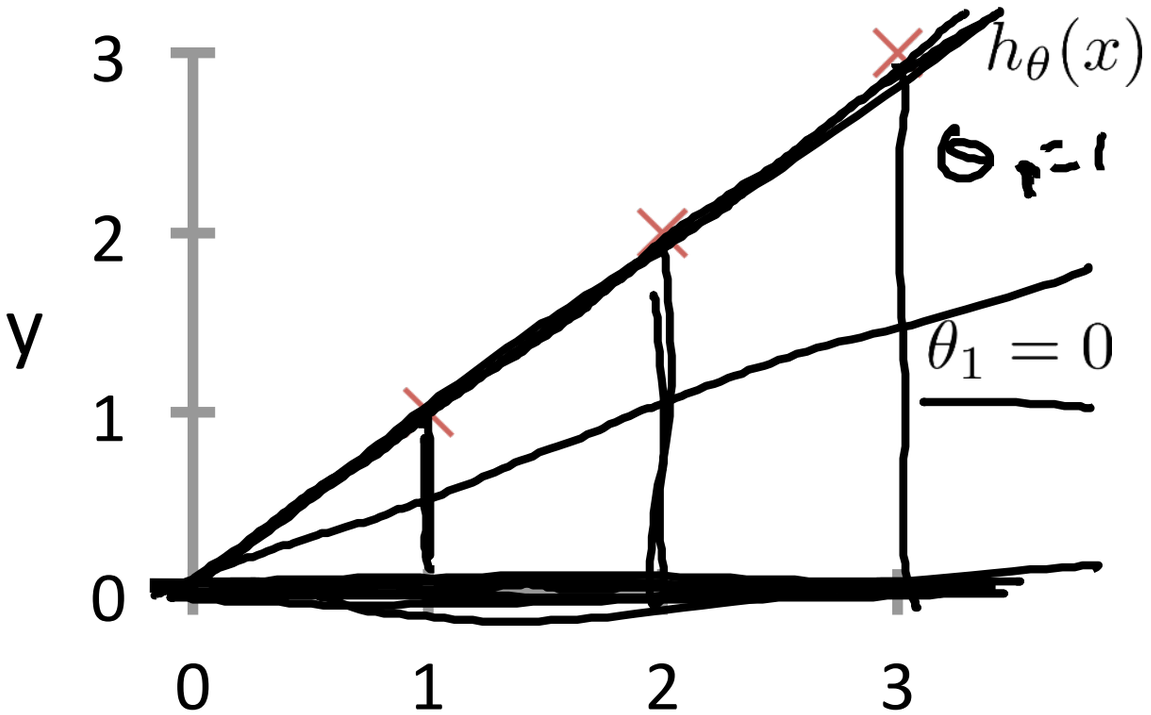
Parameters: θ_0, θ_1

Cost Function: $J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$

Goal: $\underset{\theta_0, \theta_1}{\text{minimize}}\ J(\theta_0, \theta_1)$

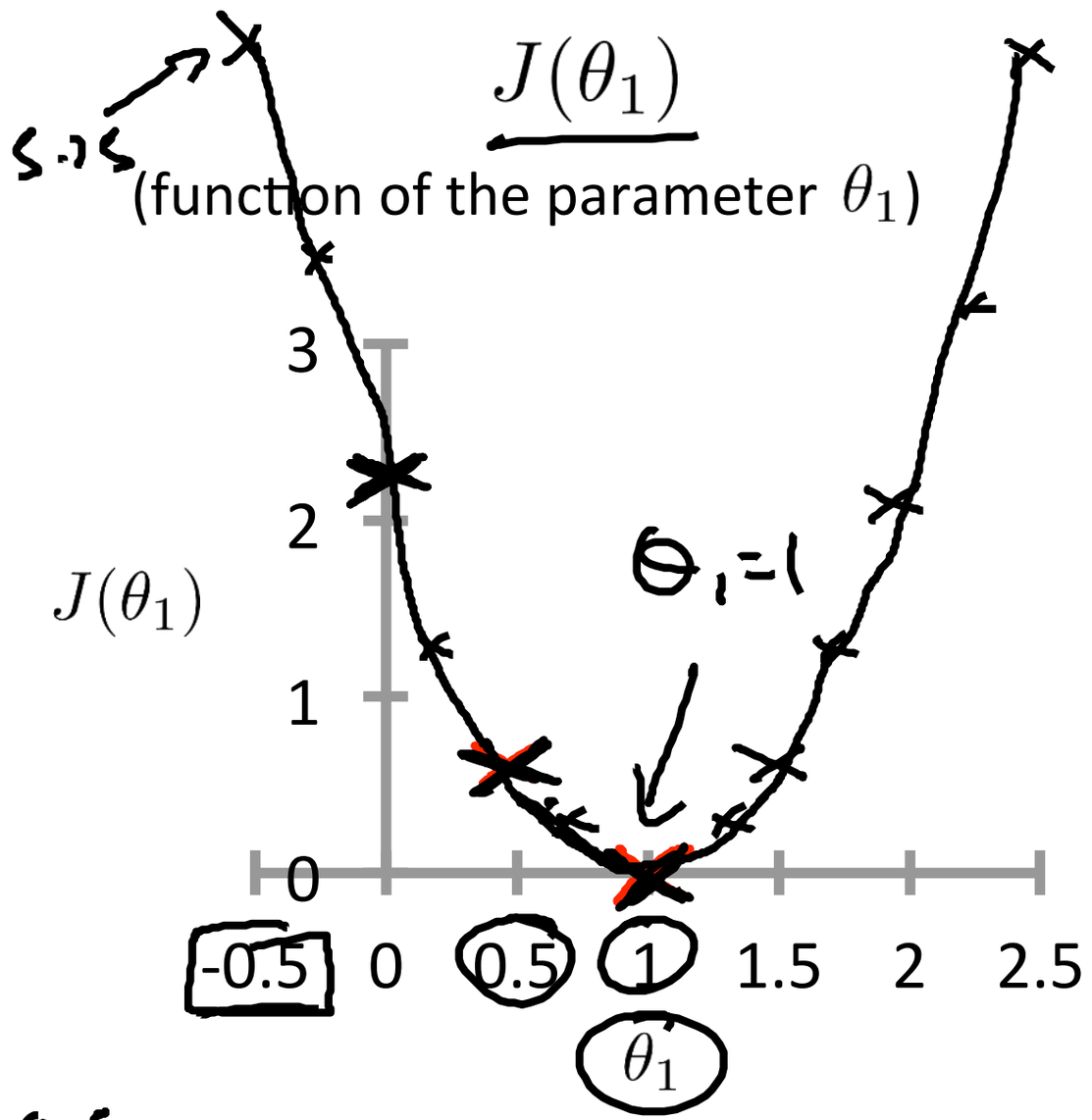
$h_\theta(x)$

(for fixed θ_1, this is a function of x)



$J(\theta_1)$

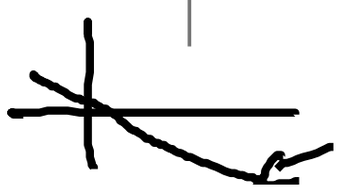
(function of the parameter θ_1)



$J(0) = \frac{1}{2m}(1^2 + 2^2 + 3^2)$

$= \frac{1}{6} \cdot 14 \approx 2.3$

$h(x) = -0.5 \times$

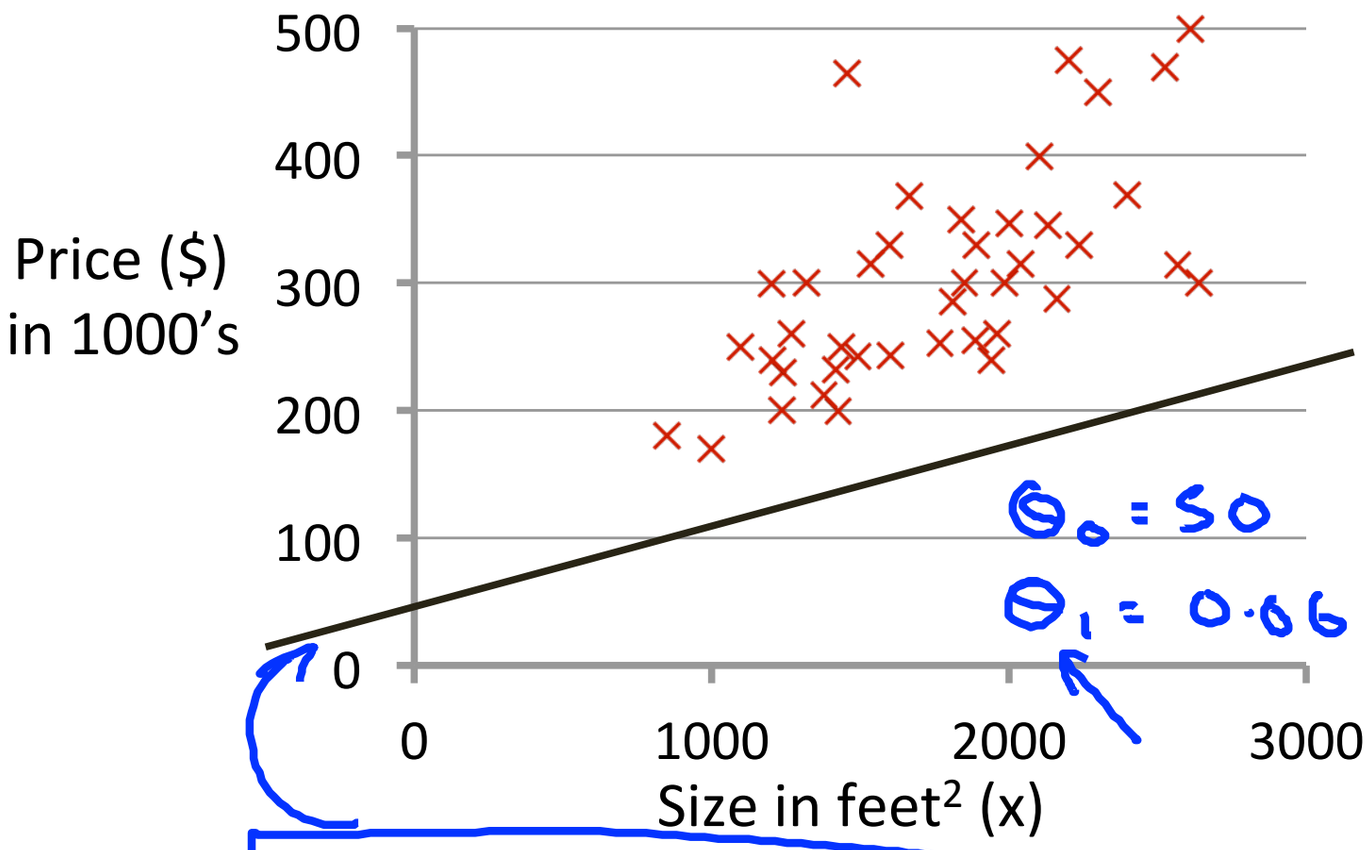


Minimize $J(\theta_1)$

θ_1

$h_\theta(x)$

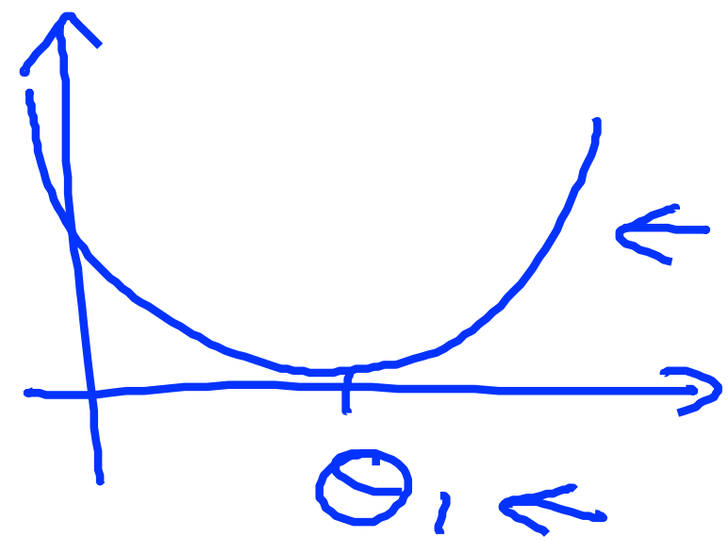
(for fixed θ_0, θ_1, this is a function of x)



$$h_\theta(x) = 50 + 0.06x$$

$J(\theta_0, \theta_1)$

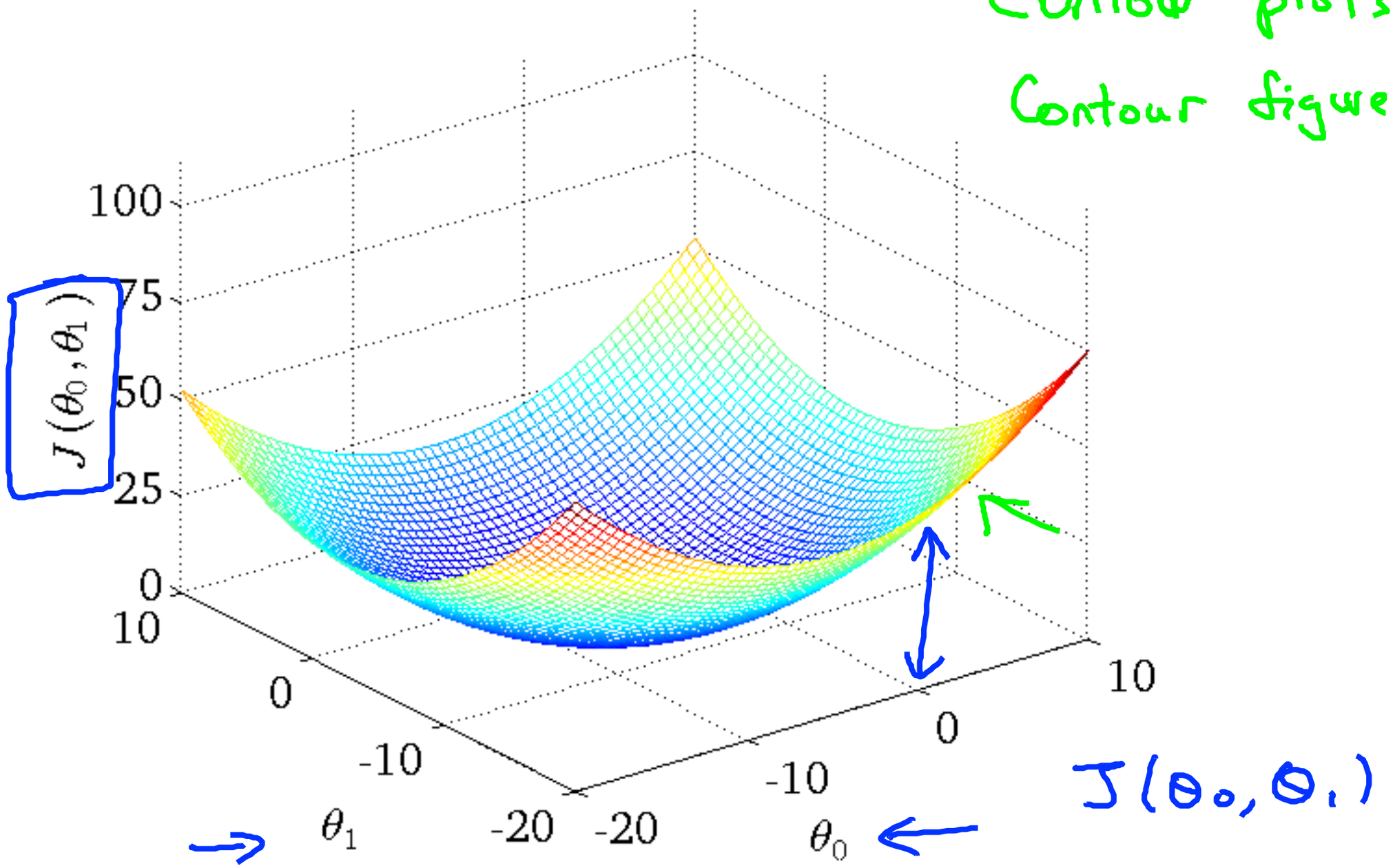
(function of the parameters θ_0, θ_1)



θ_0, θ_1

Contour plots

Contour figures -



$J(\theta_0, \theta_1)$

This Class

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- Model representation
- Loss function

Median

Next Class

- Linear Regression
- Maximum Likelihood Estimation (MLE)
- Gradient Decent
- Overfitting & Underfitting

Hard

To Do

- Read “Bishop”: Ch 2 & Ch 3.
- Read “Statistics” and “Linear Algebra” resources.
- Class project.