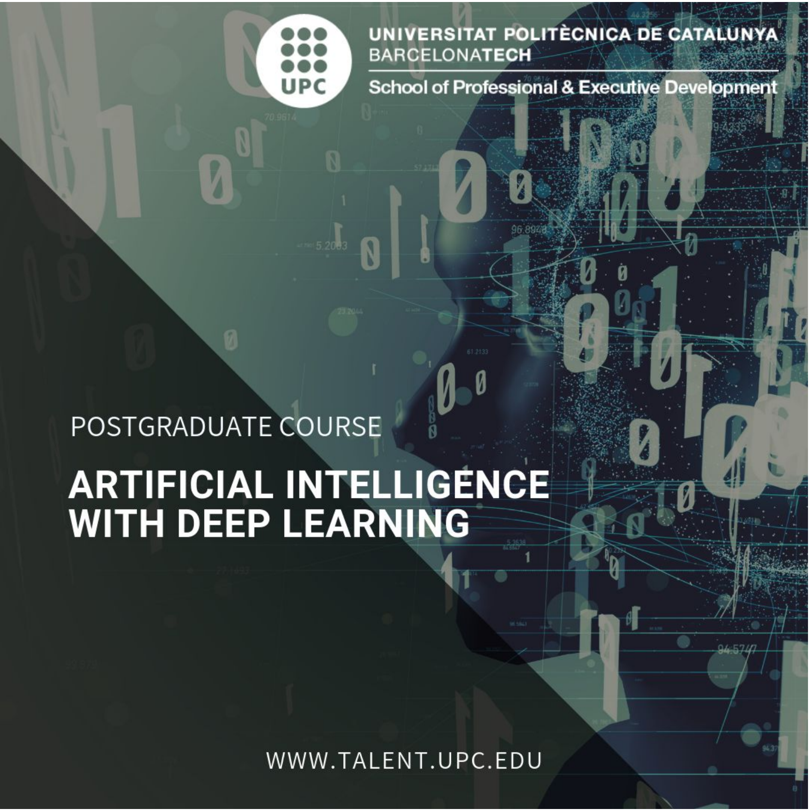
#DLUPC



Day 1 Lecture 2

Machine Learning

Xavier Giro-i-Nieto
xavier.giro@upc.edu

Associate Professor
Universitat Politècnica de Catalunya
Technical University of Catalonia

Acknowledgements

Kevin McGuinness
kevin.mcguinness@dcu.ie

Research Fellow
Insight Centre for Data Analytics
Dublin City University

Machine Learning

	...with a teacher	...without a teacher
Active agent...	Reinforcement learning (with extrinsic reward)	Intrinsic motivation / Exploration.
Passive agent...	Supervised learning	Unsupervised learning

Slide inspired by Alex Graves (Deepmind) at
"Unsupervised Learning Tutorial" @ NeurIPS 2018.

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Types of machine learning

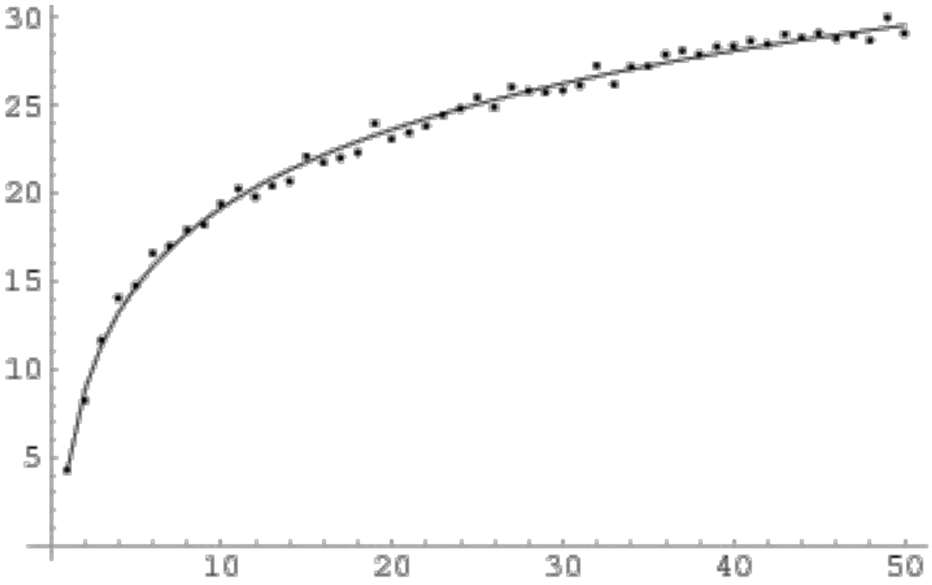
Yann Lecun's Black Forest cake

- **"Pure" Reinforcement Learning (cherry)**
  - The machine predicts a scalar reward given once in a while.
  - **A few bits for some samples**
- **Supervised Learning (icing)**
  - The machine predicts a category or a few numbers for each input
  - Predicting human-supplied data
  - **10→10,000 bits per sample**
- **Unsupervised/Predictive Learning (cake)**
  - The machine predicts any part of its input for any observed part.
  - Predicts future frames in videos
  - **Millions of bits per sample**

- (Yes, I know, this picture is slightly offensive to RL folks. But I'll make it up)

Supervised learning

Fit a function: $\mathbf{y} = f(\mathbf{x}), \quad \mathbf{x} \in \mathbb{R}^m$



Supervised learning

Fit a function: $\mathbf{y} = f(\mathbf{x}), \quad \mathbf{x} \in \mathbb{R}^m$

Given paired training examples $\{(\mathbf{x}_i, \mathbf{y}_i)\}$

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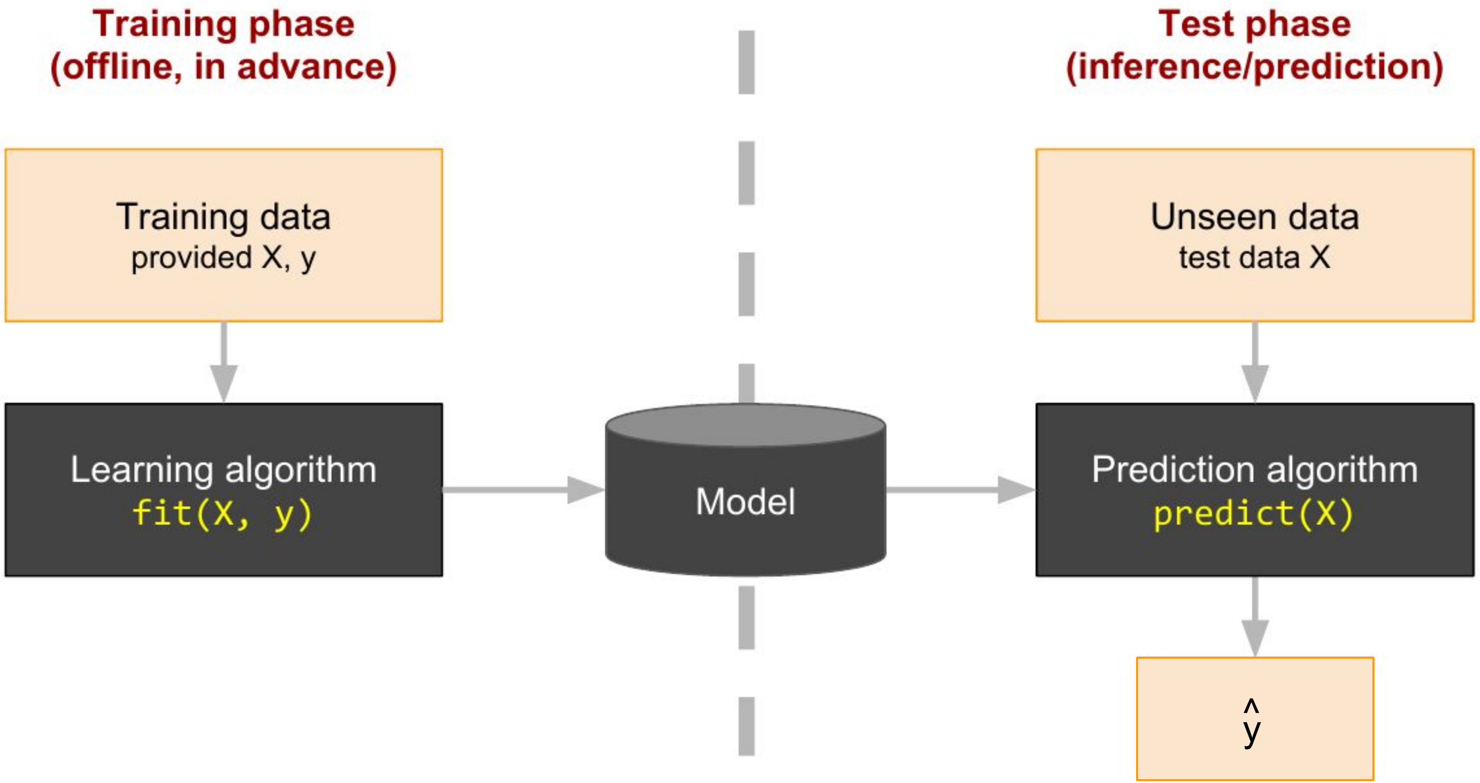
Key point: **generalize well to unseen examples**

Black box abstraction of supervised learning



Regression vs Classification

Depending on the type of target $\mathbf{y}$ we get:

- **<u>Regression</u>:** $\mathbf{y} \in \mathbb{R}^N$ is continuous (e.g. temperatures $\mathbf{y}$ = {19º, 23º, 22º})
- **<u>Classification</u>:** $\mathbf{y}$ is discrete (e.g. $\mathbf{y}$ = {“dog”,”cat”,”ostrich”}).

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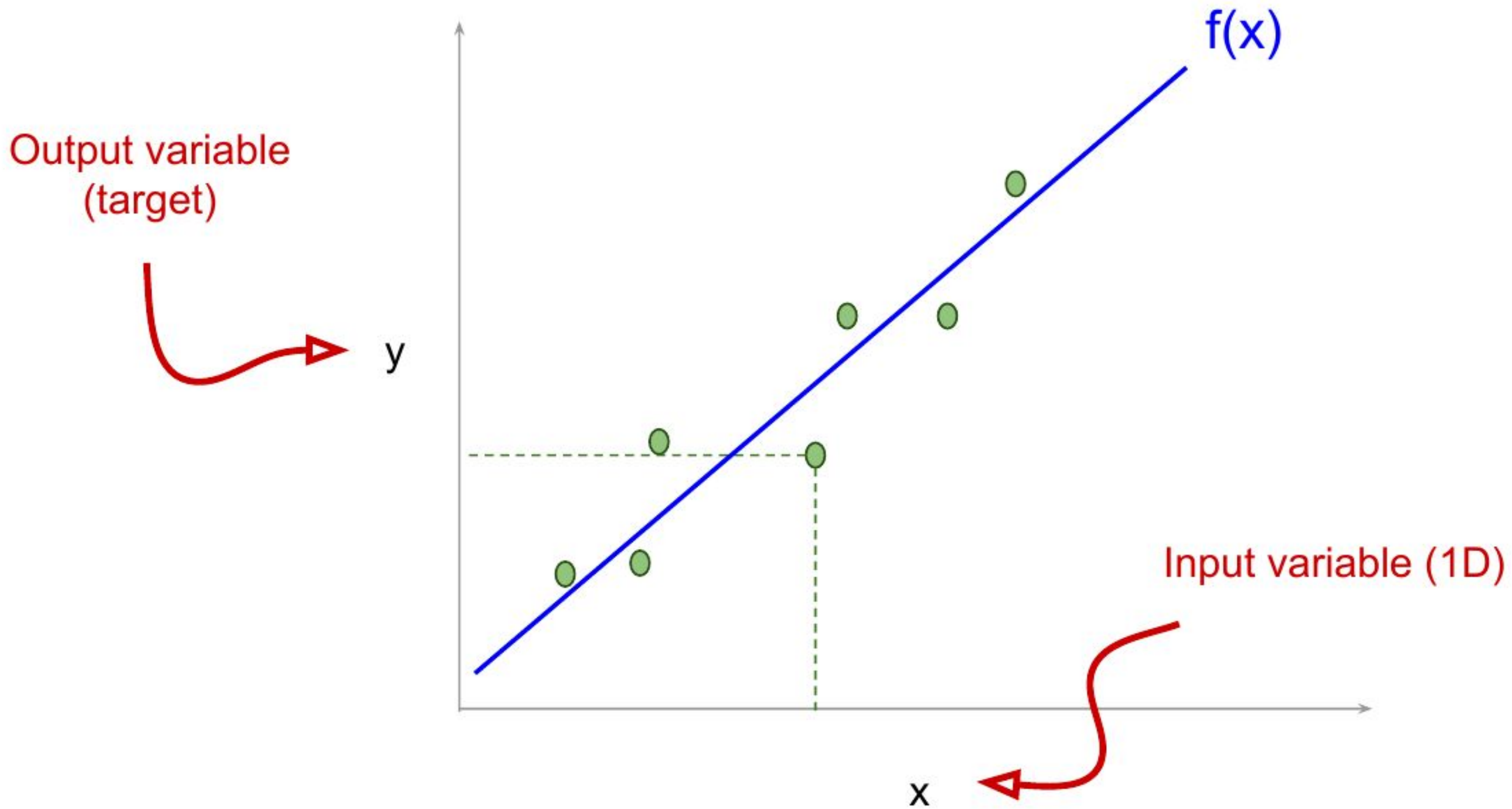
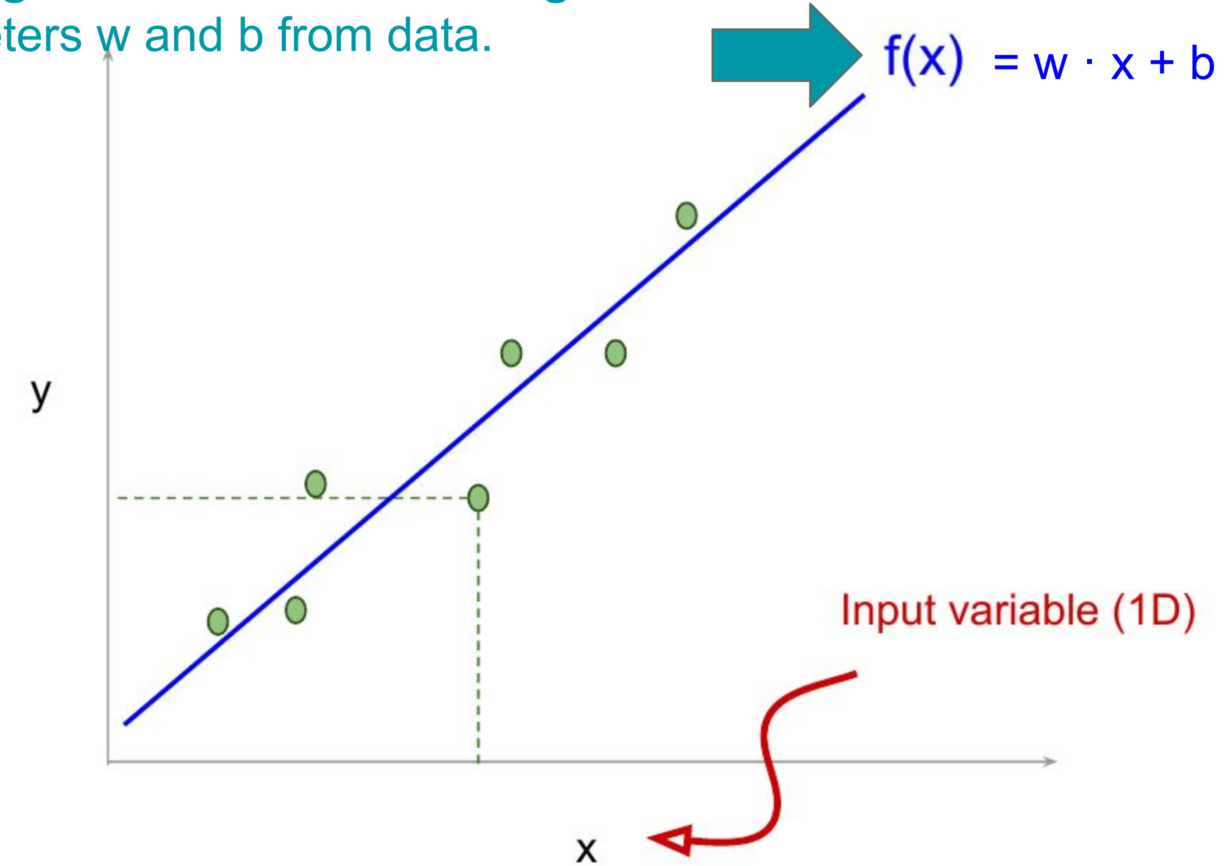
Linear Regression (eg. 1D input - 1D ouput)



Linear Regression (eg. 1D input - 1D ouput)

Training a model means **learning** parameters w and b from data.



Linear Regression (M-D input)

Input data can also be M-dimensional with vector **x**:

$$\boxed{y = \mathbf{w}^T \cdot \mathbf{x} + b} = \mathit{w1} \cdot x1 + \mathit{w2} \cdot x2 + \mathit{w3} \cdot x3 + \ldots + \mathit{wM} \cdot xM + b$$

e.g. we want to predict the **price of a house (y)** based on:

x1 = square-meters (sqm)

x2,3 = location (lat, lon)

x4 = year of construction (yoc)

y = price = $\mathit{w1} \cdot$(sqm) + $\mathit{w2} \cdot$(lat) + $\mathit{w3} \cdot$(lon) + $\mathit{w4} \cdot$(yoc) + b

Regression vs Classification

How many parameters must be estimated for a linear regressor ?

A. One: the line slope (w).
B. One: the bias (b).
C. Two: the line slope (w) and bias (b).
D. As many as the dimensionality of the input data x, plus a bias (b).

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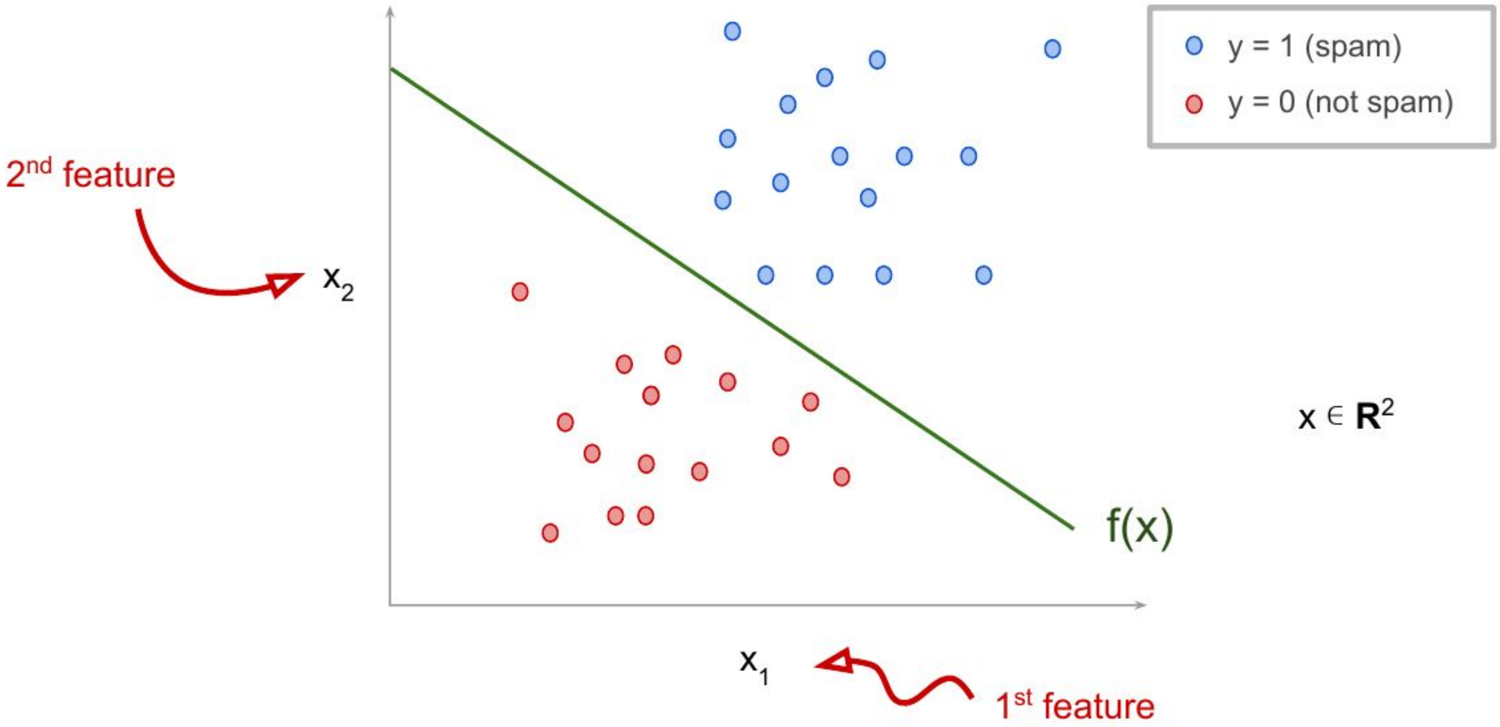
Binary Classification (eg. 2D input, 1D ouput)



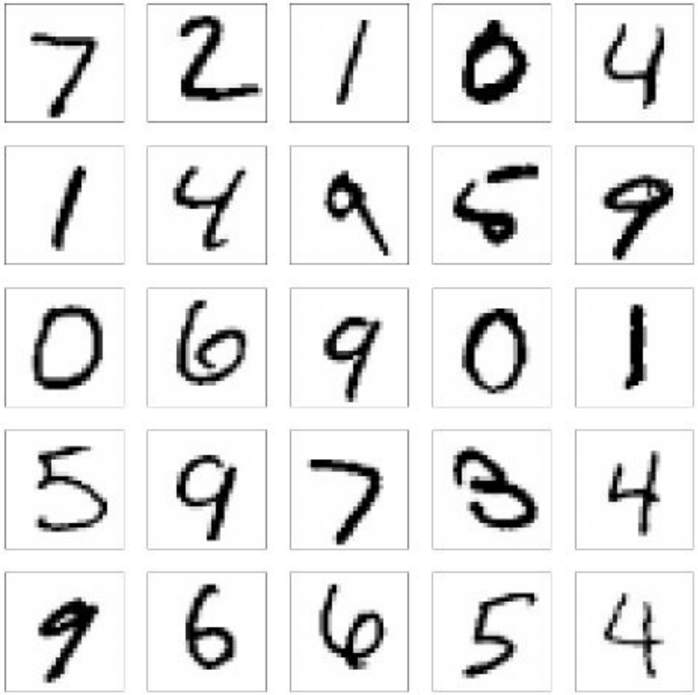
$x \in \mathbf{R}^2$

Multi-class Classification

Produce a classifier to map from pixels to the digit.

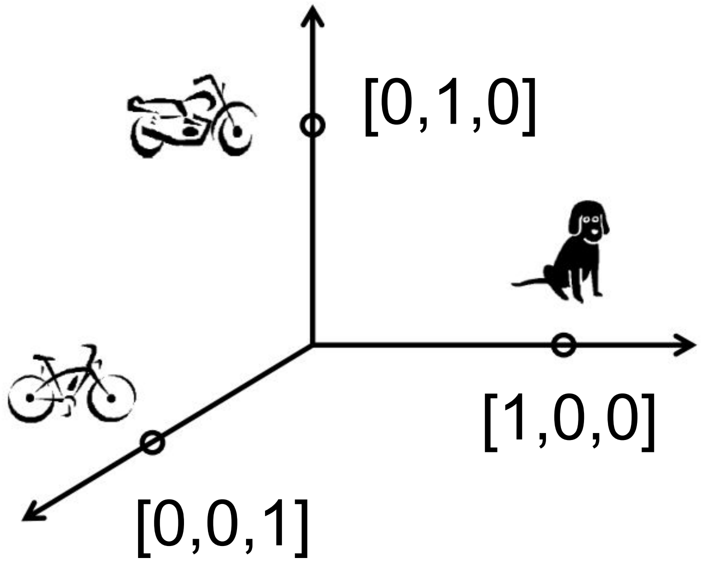
- If images are grayscale and 28×28 pixels in size, then $\mathbf{x}_i \in \mathbb{R}^{784}$
- $y_i \in \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$

Example of a **multi-class classification** task.



Multi-class Classification

- **<u>Classification</u>:** $\mathbf{y}$ is discrete (e.g. $\mathbf{y}$ = {"dog","cat","ostrich"}.
  - Classes are often coded as **one-hot vector** (each class corresponds to a different dimension of the output space)



One-hot representations

Perronin, F., CVPR Tutorial on LSVR @ CVPR'14, Output embedding for LSVR

Multi-class Classification

What is the dimensionality of a one-hot representation of the MNIST classes ?

A. 1
B. 28
C. 10
D. 784

Multi-class Classification

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A. 1

B. 28

C. 10

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Regression vs Classification

Should you treat these three problems as classification or as regression problems?

Problem	Regression ?	Classification ?
Predicting whether stock price of a company will increase tomorrow		
Predict the number of copies a music album will be sold next month		
Predicting the gender of a person by his/her handwriting style		

Regression vs Classification

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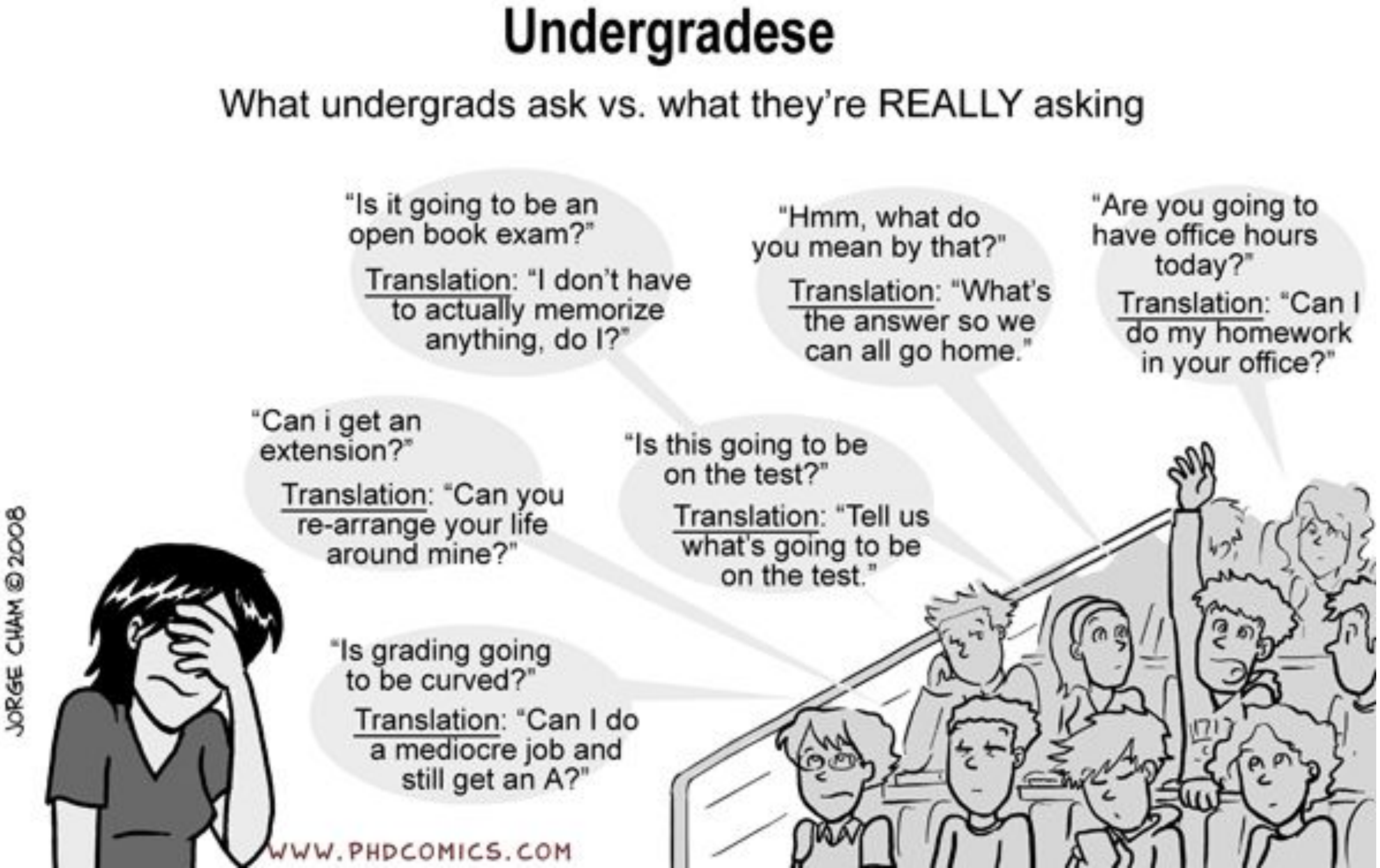
Predicting whether stock price of a company will increase tomorrow		✔
Predict the number of copies a music album will be sold next month	✔	
Predicting the gender of a person by his/her handwriting style		✔

Q&A


Undergradese
What undergrads ask vs. what they're REALLY asking
"Is it going to be an open book exam?" Translation: "I don't have to actually memorize anything, do I?"
"Hmm, what do you mean by that?" Translation: "What's the answer so we can all go home."
"Are you going to have office hours today?" Translation: "Can I do my homework in your office?"
"Can i get an extension?" Translation: "Can you re-arrange your life around mine?"
"Is this going to be on the test?" Translation: "Tell us what's going to be on the test."
"Is grading going to be curved?" Translation: "Can I do a mediocre job and still get an A?"
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