Day 1 Lecture 2

Machine Learning Basics

Acknowledgements: To my colleagues of this seminar and previous ones, specially Xavier Giró, Kevin Mc Guiness

https://telecombcn-dl.github.io/idl-2021/

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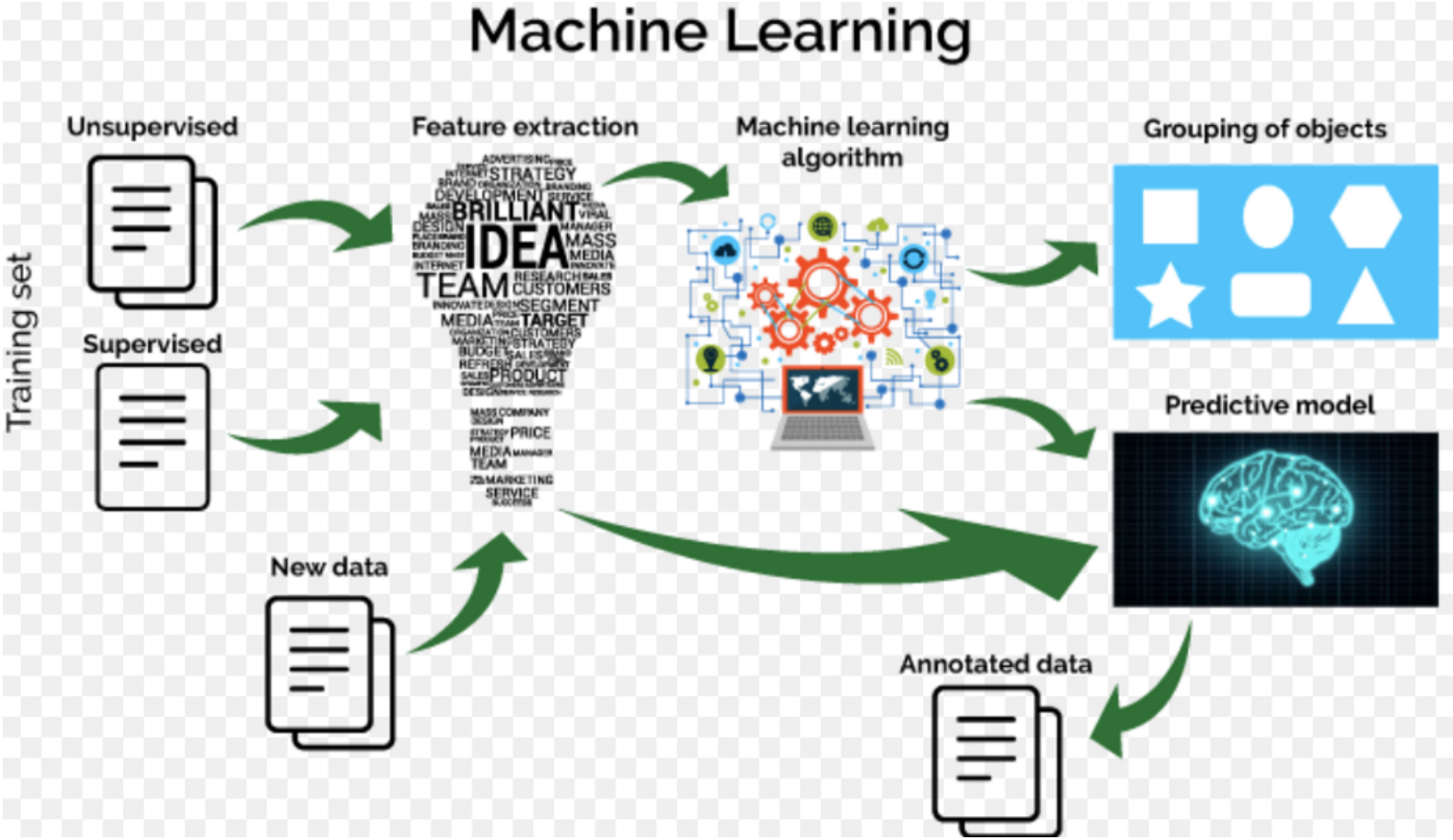
Outline

1. Machine Learning
2. Supervised Learning
3. Regression and Classification

Machine Learning

Machine Learning (ML)

*is all about **algorithms** that can tell you something about a set of **data** without you having to write any custom code specific to the problem; ie., instead of writing code, you feed data to the generic algorithm and it **builds its own logic** based on the data.*



https://medium.com/@jorgesleonel/supervised-learning-c16823b00c13

Machine Learning

jolt

Machine Learning Approaches

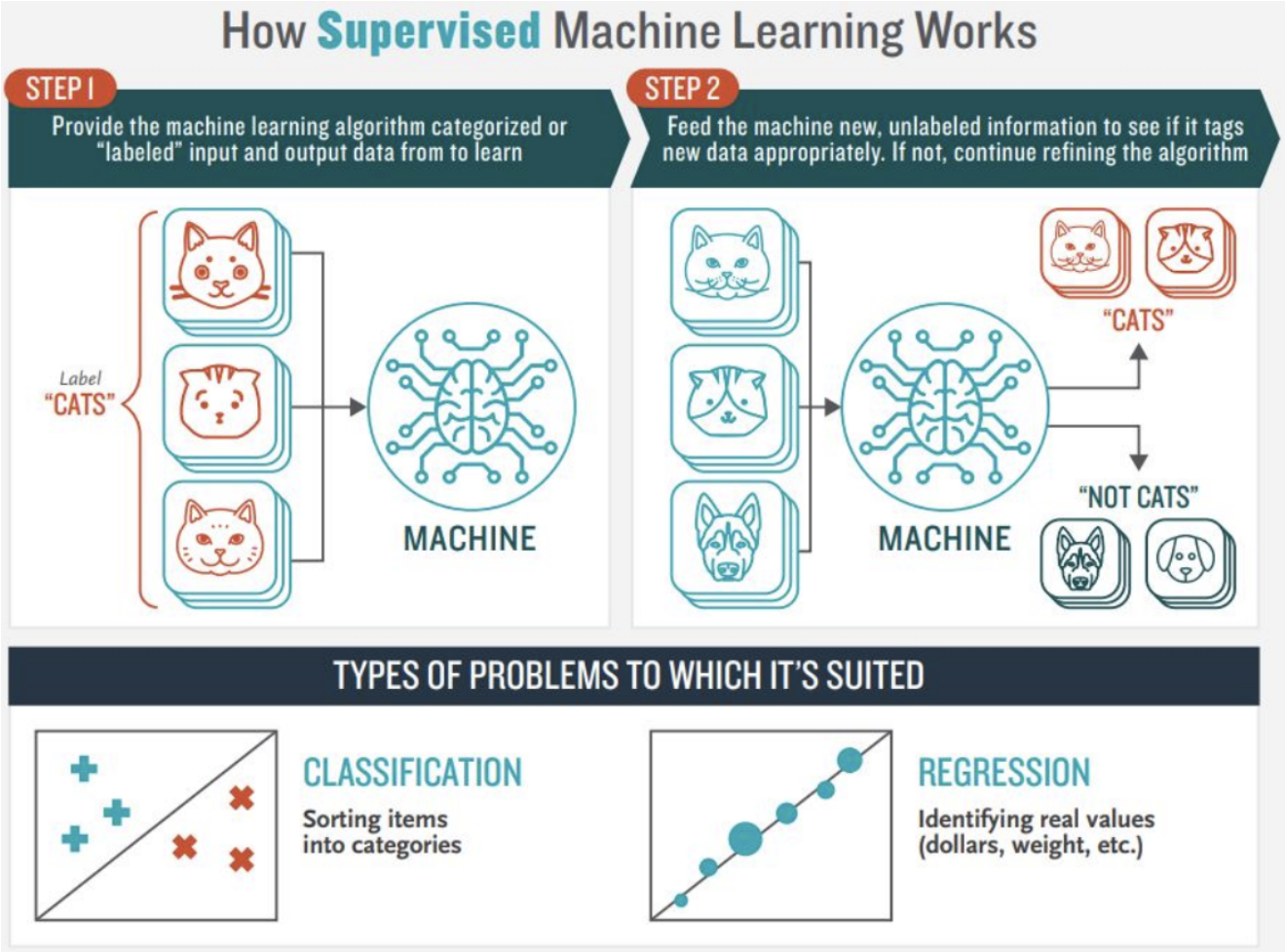
	...with a teacher	...without a teacher
Active agent...	Reinforcement learning (with extrinsic reward)	Intrinsic motivation / Exploration.
Passive agent...	Supervised learning (labels)	Unsupervised learning

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

Machine Learning

Machine Learning Approaches

Supervised learning



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Machine Learning

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Passive agent...	Supervised learning (labels)	Unsupervised learning

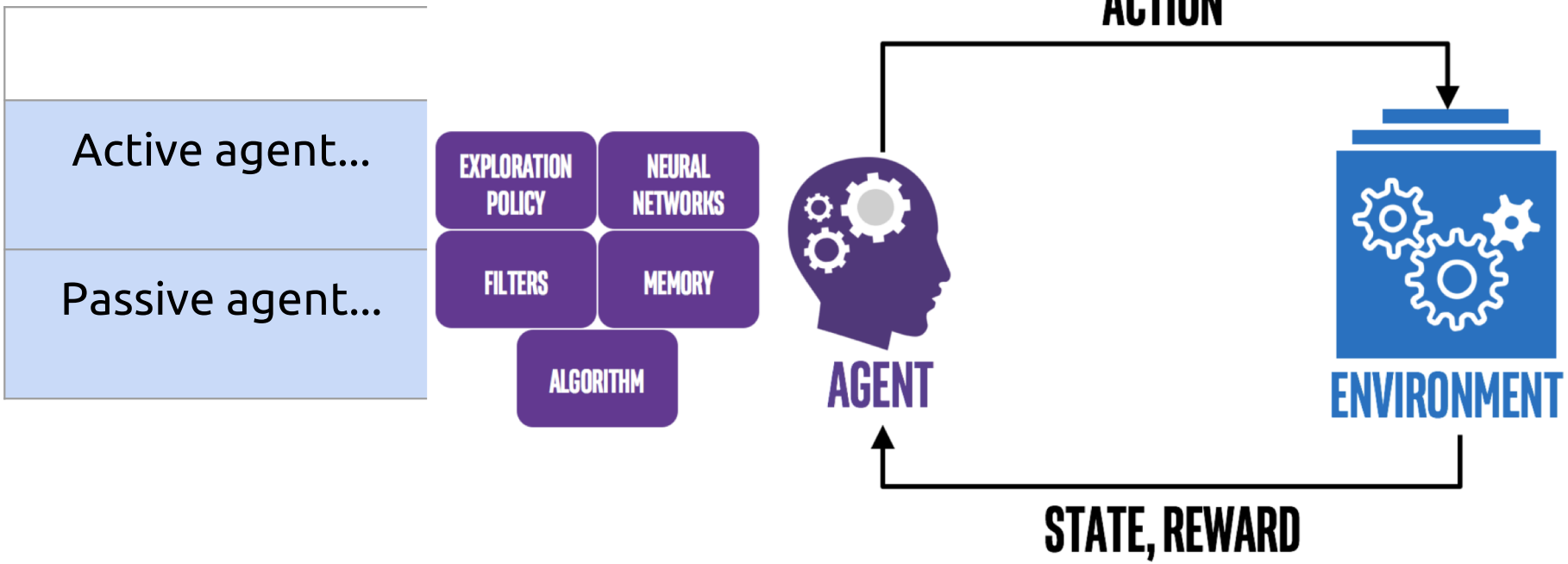
- No label or target class
- Find out properties of the structure of the data
- Clustering (k-means, PCA, etc.)

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

Machine Learning

Machine Learning Approaches

Reinforcement Learning is a subfield of machine learning that teaches an agent how to choose an action from its action space, within a particular environment, in order to maximize rewards over time.



Reinforcement Learning, Part 1: A Brief Introduction (medium.com)

https://nervanasystems.github.io/coach

Machine Learning

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	...with a teacher	...without a teacher
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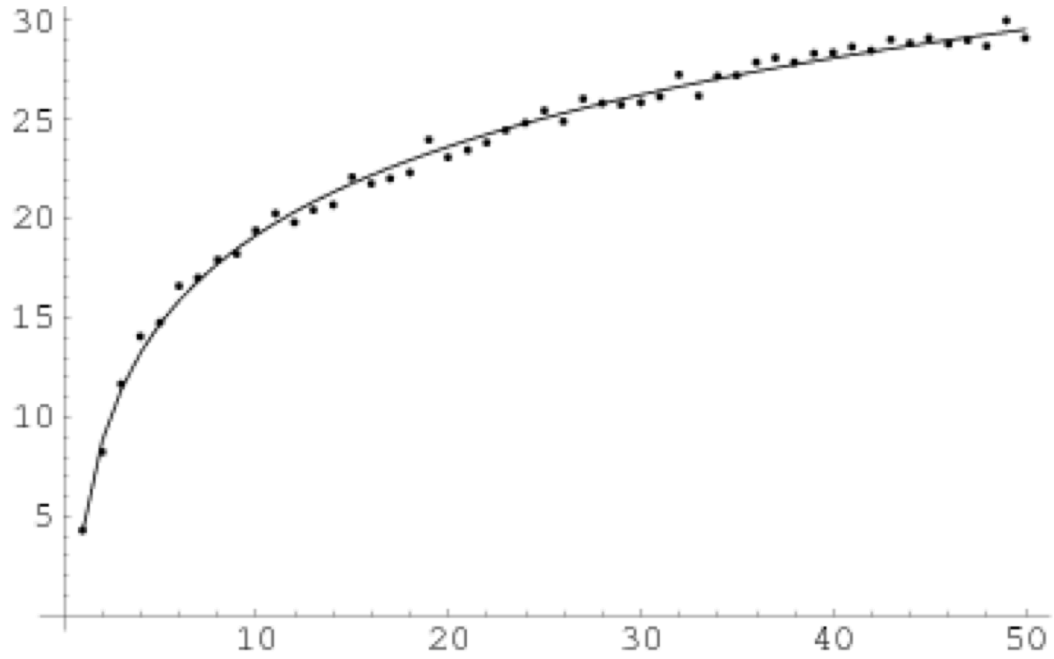
Supervised learning

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



Supervised learning

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

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

x_i

y_i

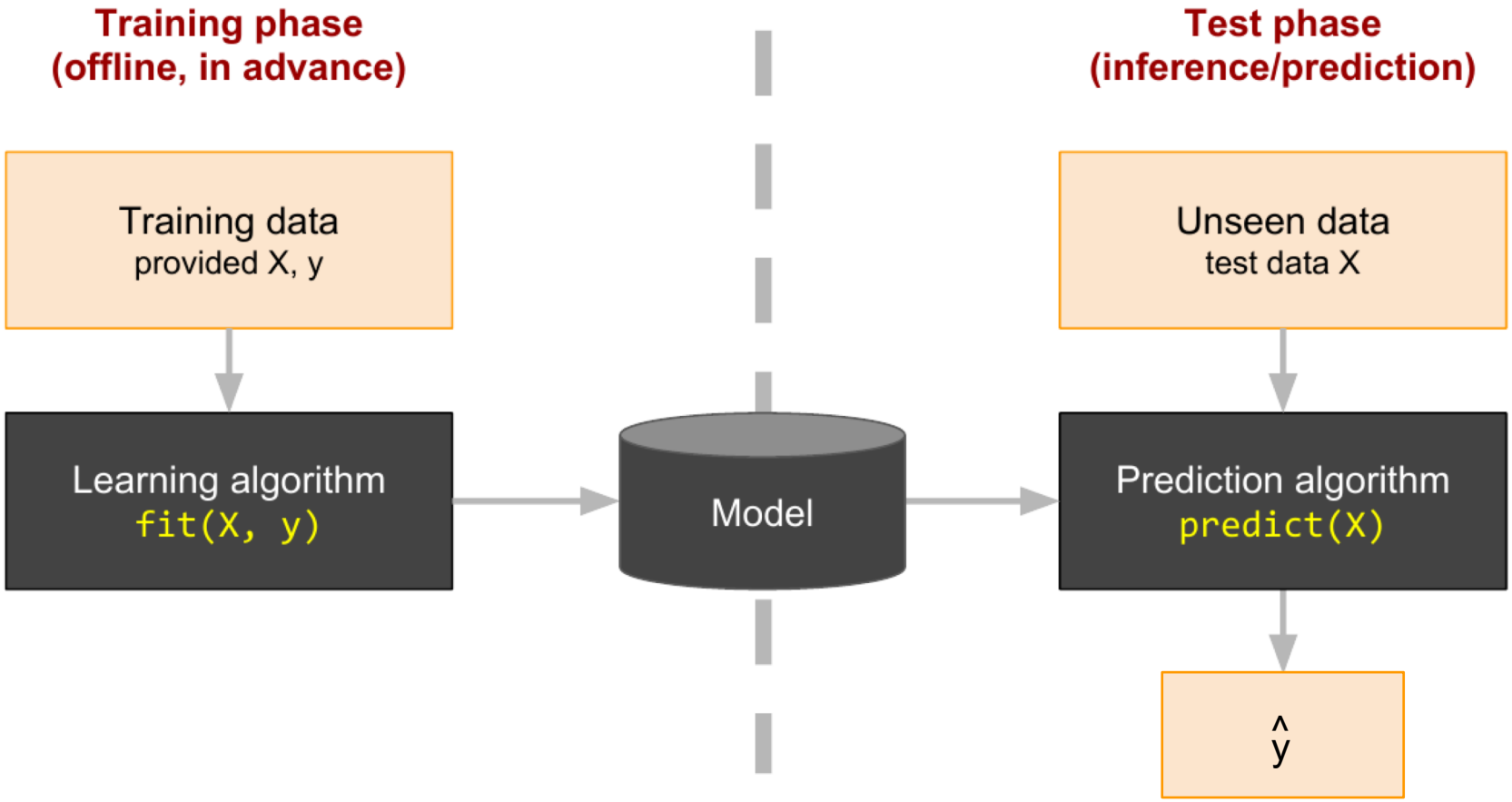
Supervised learning

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

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

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:

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

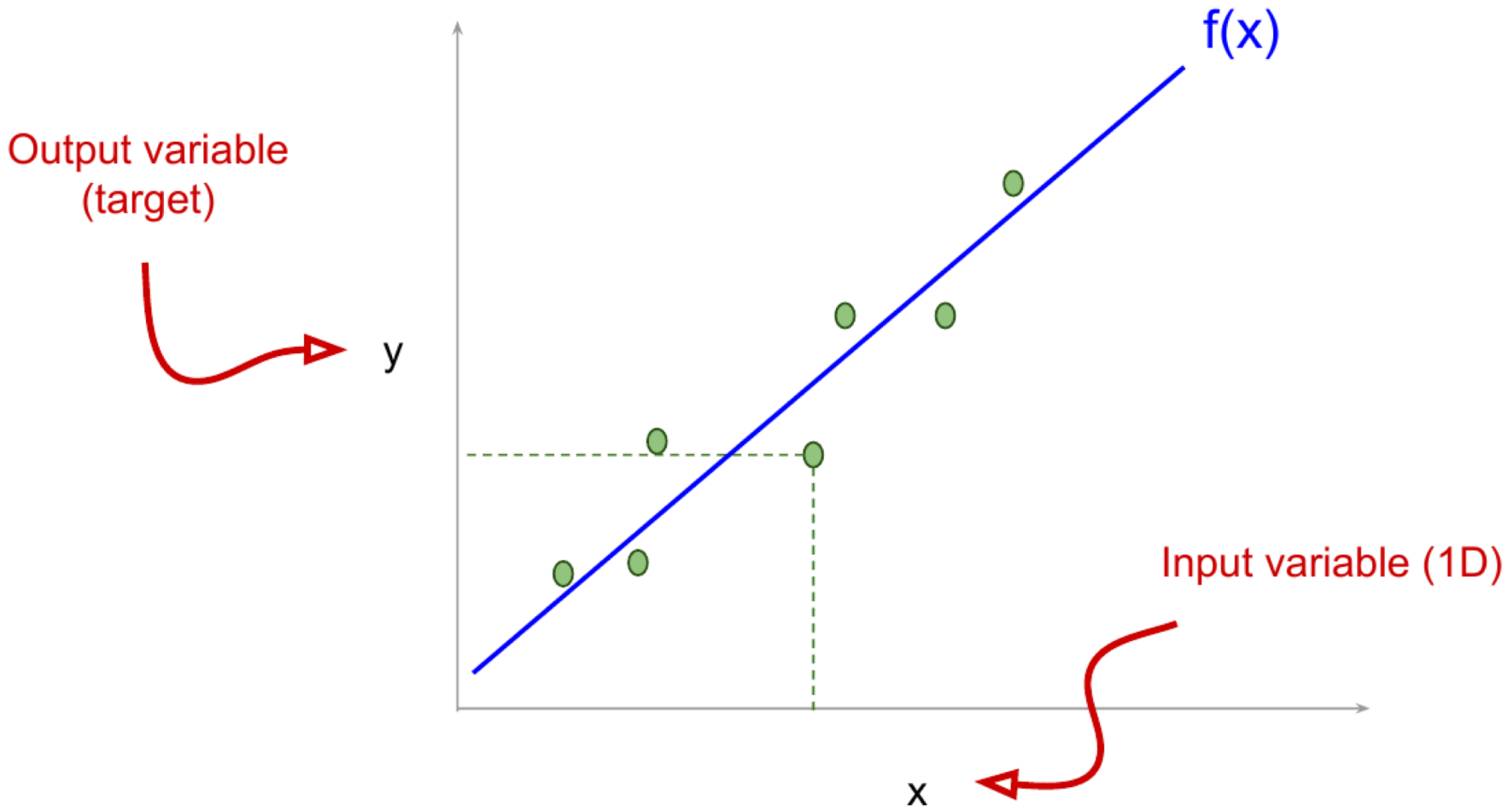
Regression vs Classification

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

- **Regression:** $\mathbf{y} \in \mathbb{R}^N$ is continuous (e.g. temperatures $\mathbf{y} = \{19°, 23.2°, 22.8°\}$)

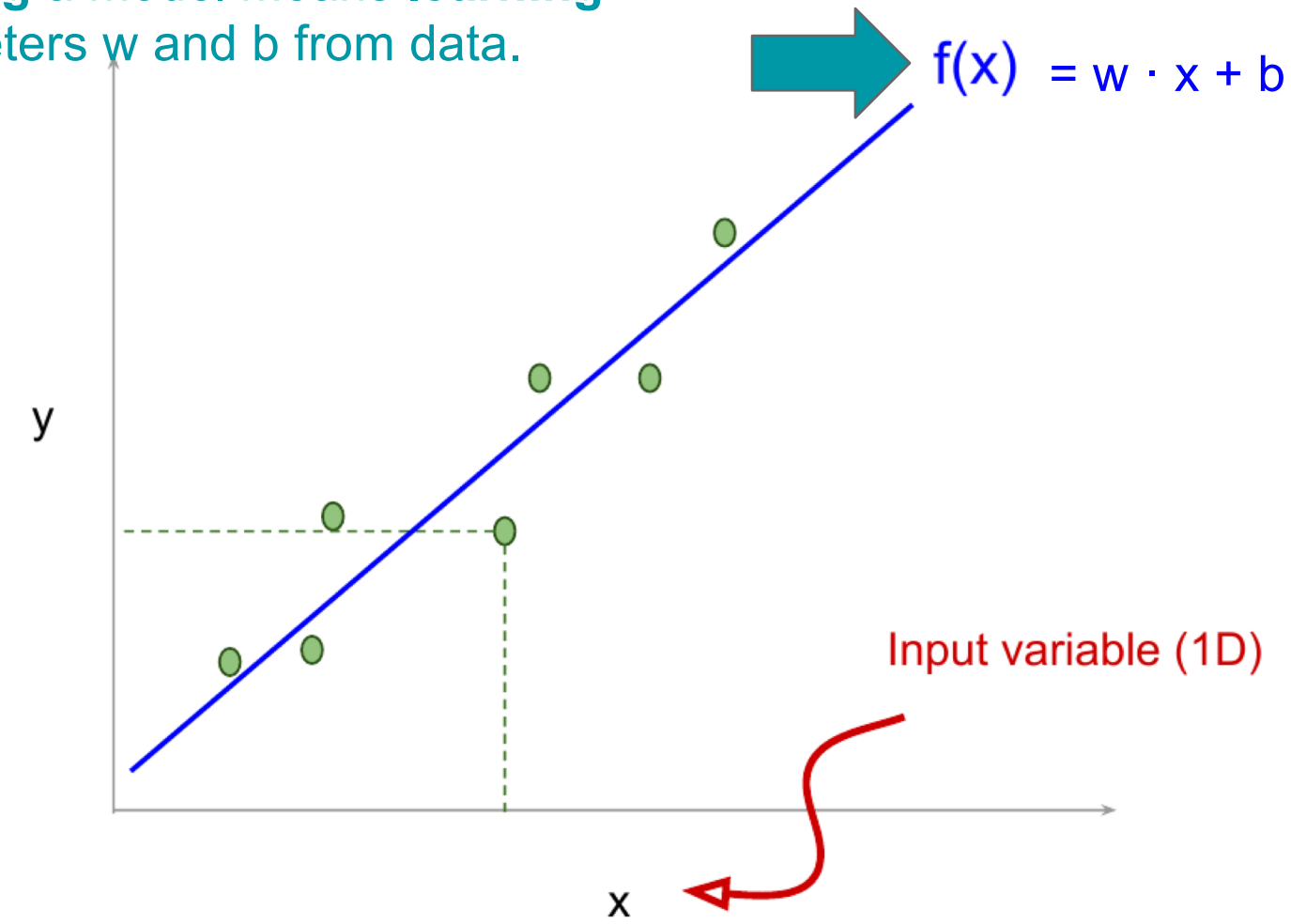
- **Classification:** $\mathbf{y}$ is discrete (e.g. $\mathbf{y} = \{$“dog”, “cat”, “ostrich”$\}$).

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**:

$$y = \mathbf{w}^T \cdot \mathbf{x} + b = w_1 \cdot x_1 + w_2 \cdot x_2 + w_3 \cdot x_3 + \ldots + w_M \cdot x_M + b$$

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

x_1 = square-meters (sqm)

$x_{2,3}$ = location (lat, lon)

y = price = $w_1 \cdot$(sqm) + $w_2 \cdot$(lat) + $w_3 \cdot$(lon)+ b

Regression vs Classification

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

- **Regression:** $\mathbf{y} \in \mathbb{R}^N$ is continuous (e.g. temperatures $\mathbf{y} = \{19°, 23°, 22°\}$)
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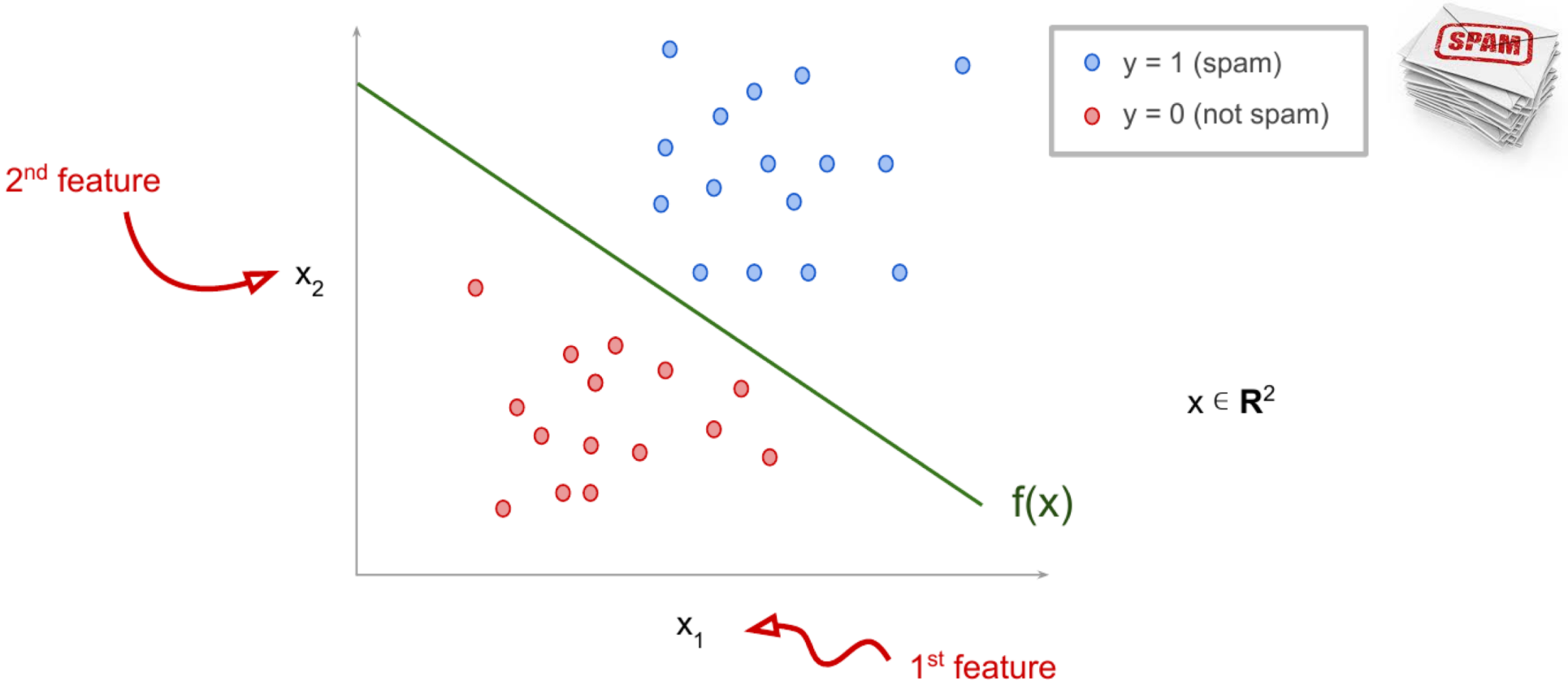
Binary Classification (eg. 2D input, 1D ouput)



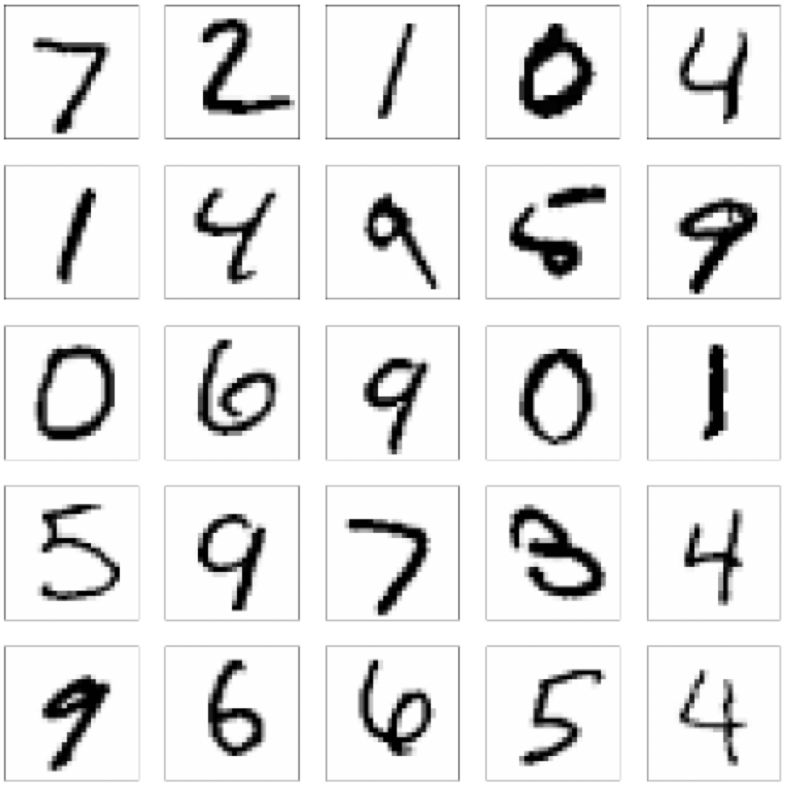
Multi-class Classification

Produce a classifier to map from pixels to the digit.

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

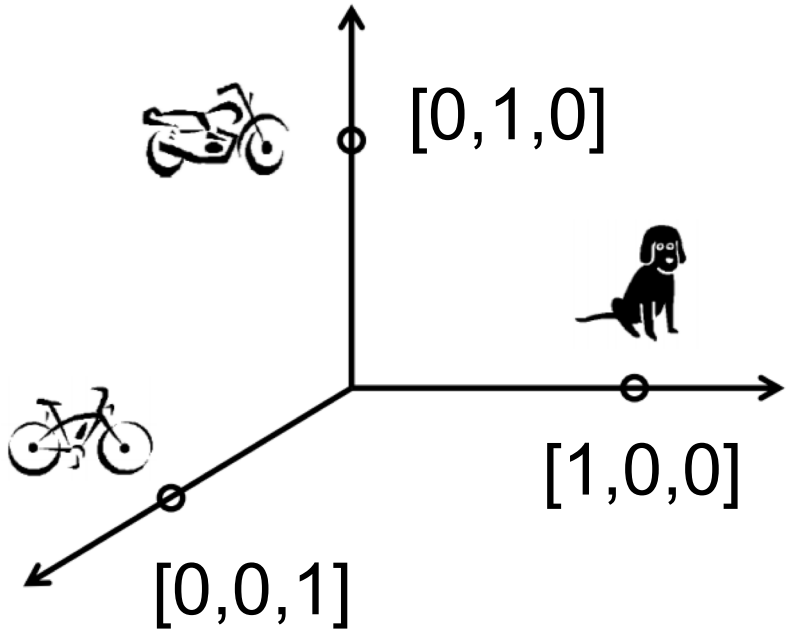
Example of a **multi-class classification** task.

MNIST DataBase



Multi-class Classification

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

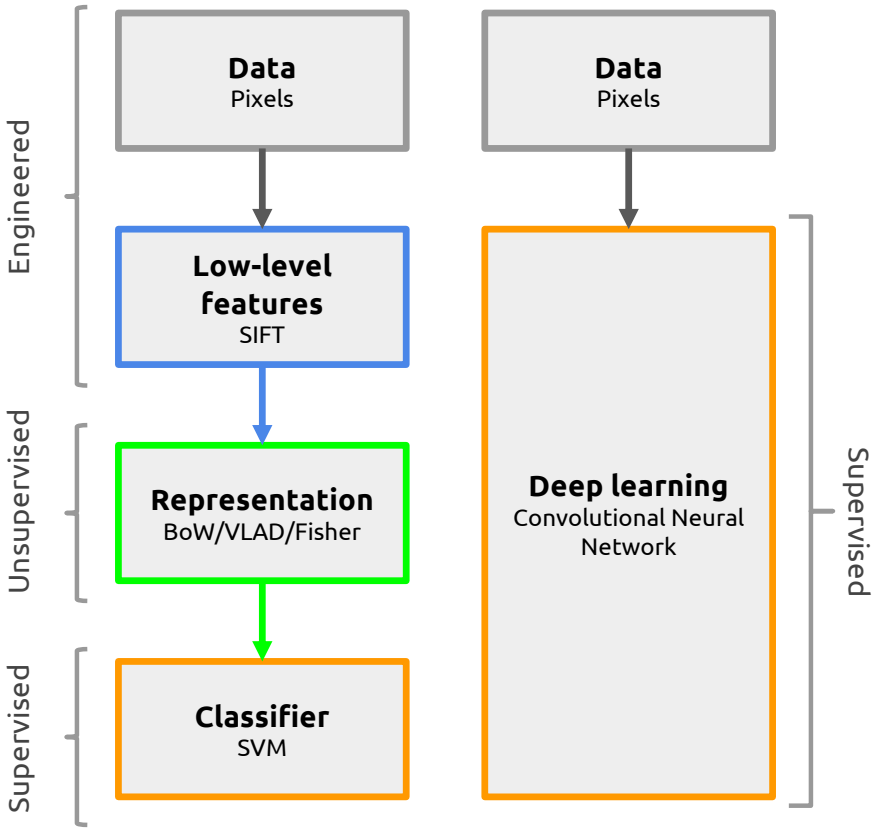


One-hot representations

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

End-to-end Learning

- Old style machine learning:
  - Engineer features (by some unspecified method)
  - Create a representation (descriptor)
  - Train shallow classifier on representation
- Example:
  - SIFT features (engineered)
  - BoW representation (engineered + unsupervised learning)
  - SVM classifier (convex optimization)
- **Deep learning**
  - Learn layers of features, representation, and classifier in one go based on the data alone
  - Primary methodology: deep neural networks (non-convex)



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

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

A. 1

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C. 10

D. 784

Regression vs Classification

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

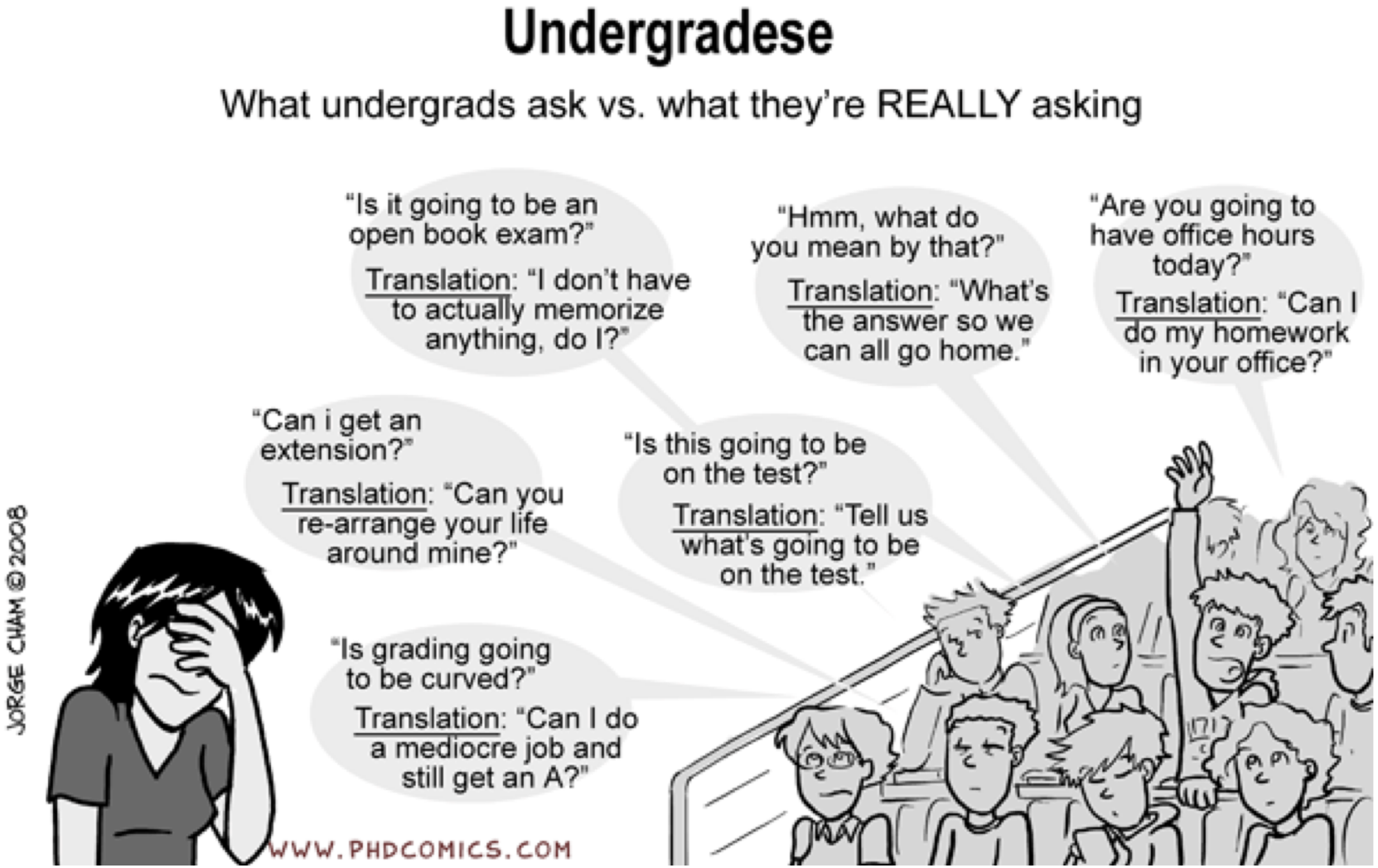
Problem	**Regression ?**	**Classification ?**
Predicting whether stock price of a company will increase tomorrow		
Predict the number of copies a music album will be sold next month		
Predicting the gender of a person by his/her handwriting style		

Regression vs Classification

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		✓

Questions ?


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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