AI Seminar Series

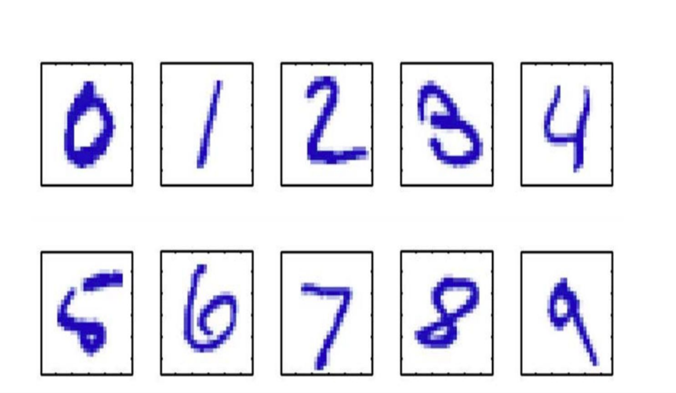
Week 1

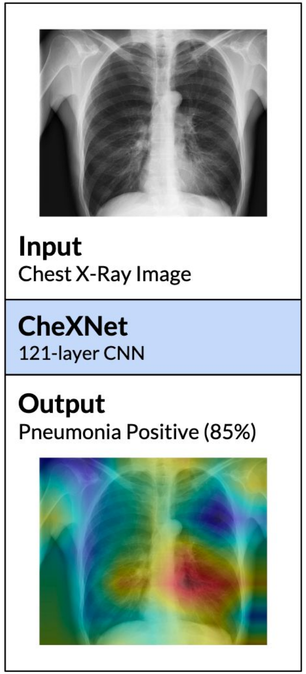
Outline

- Introduction
- Taxonomy of machine learning
- Regression
- Clustering
- Reinforcement Learning
- Python & Github Repository
- Schedule

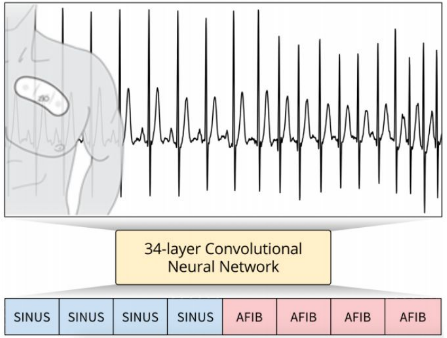
Introduction- Applications of ML

Handwriting Recognition





Medical Disease Recognition



Arrhythmia?

Figure sources: Rajpurkar et al., arXiv:1711.05225’17
Rajpurkar et al., arXiv:1707.01836,'17

Credits:
http://www.robots.ox.ac.uk/~az/lectures/ml/lect1.pdf
https://mlhc19mit.github.io/slides/lecture1.pdf

Introduction- Applications of ML

Spam Filtering in Email

Image Credit:
http://blog.etonic.net/index.php?entry=entry110316-081129

Personalization Services....

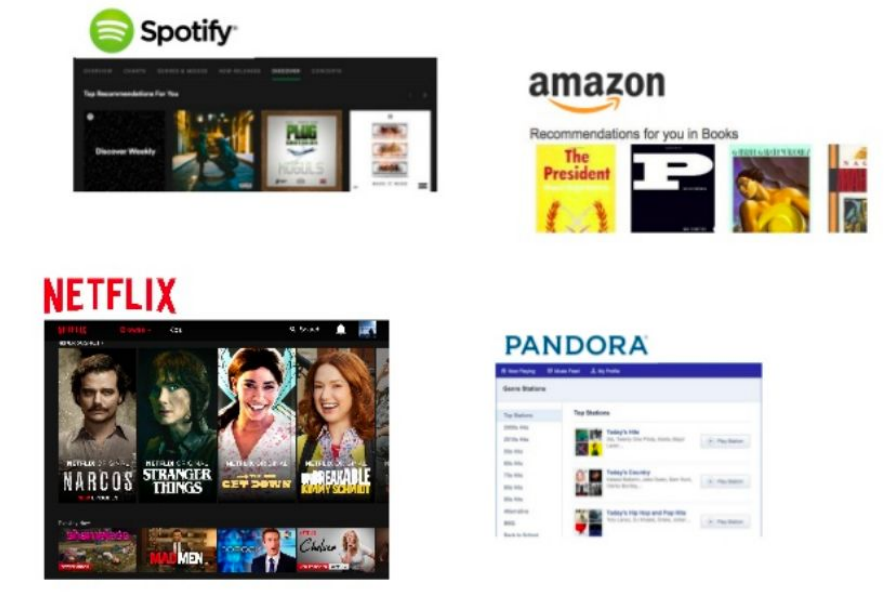


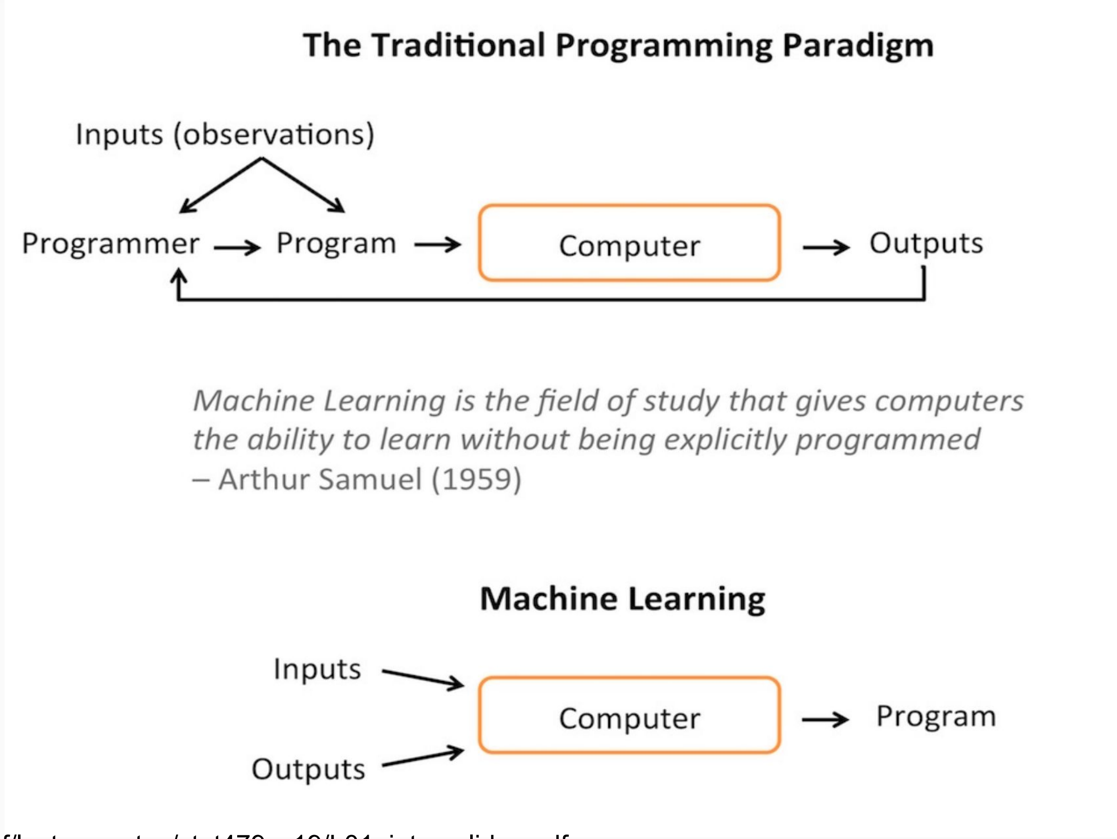
Image Credit:
https://netflixtechblog.com/netflix-at-recsys-2016-recap-e32d50d22ecb

Definition of Machine Learning

Arthur Samuel (1959): ***Machine Learning is the field of study that gives the computer the ability to learn without being explicitly programmed.***

Credit: wikipedia

Introduction



The Traditional Programming Paradigm

Inputs (observations)

Programmer → Program → Computer → Outputs

Machine Learning is the field of study that gives computers the ability to learn without being explicitly programmed
– Arthur Samuel (1959)

Machine Learning

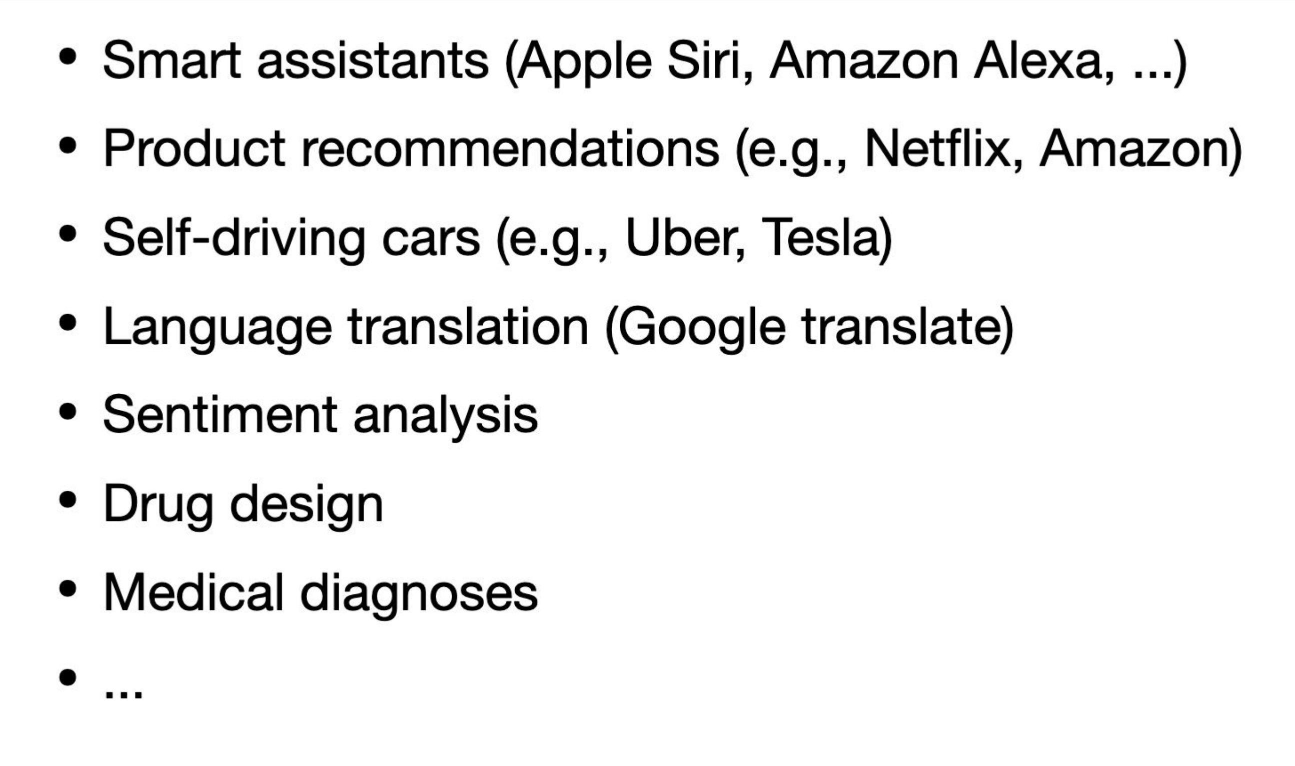
Inputs

Outputs

Computer → Program

Credits:
https://sebastianraschka.com/pdf/lecture-notes/stat479ss19/L01_intro_slides.pdf

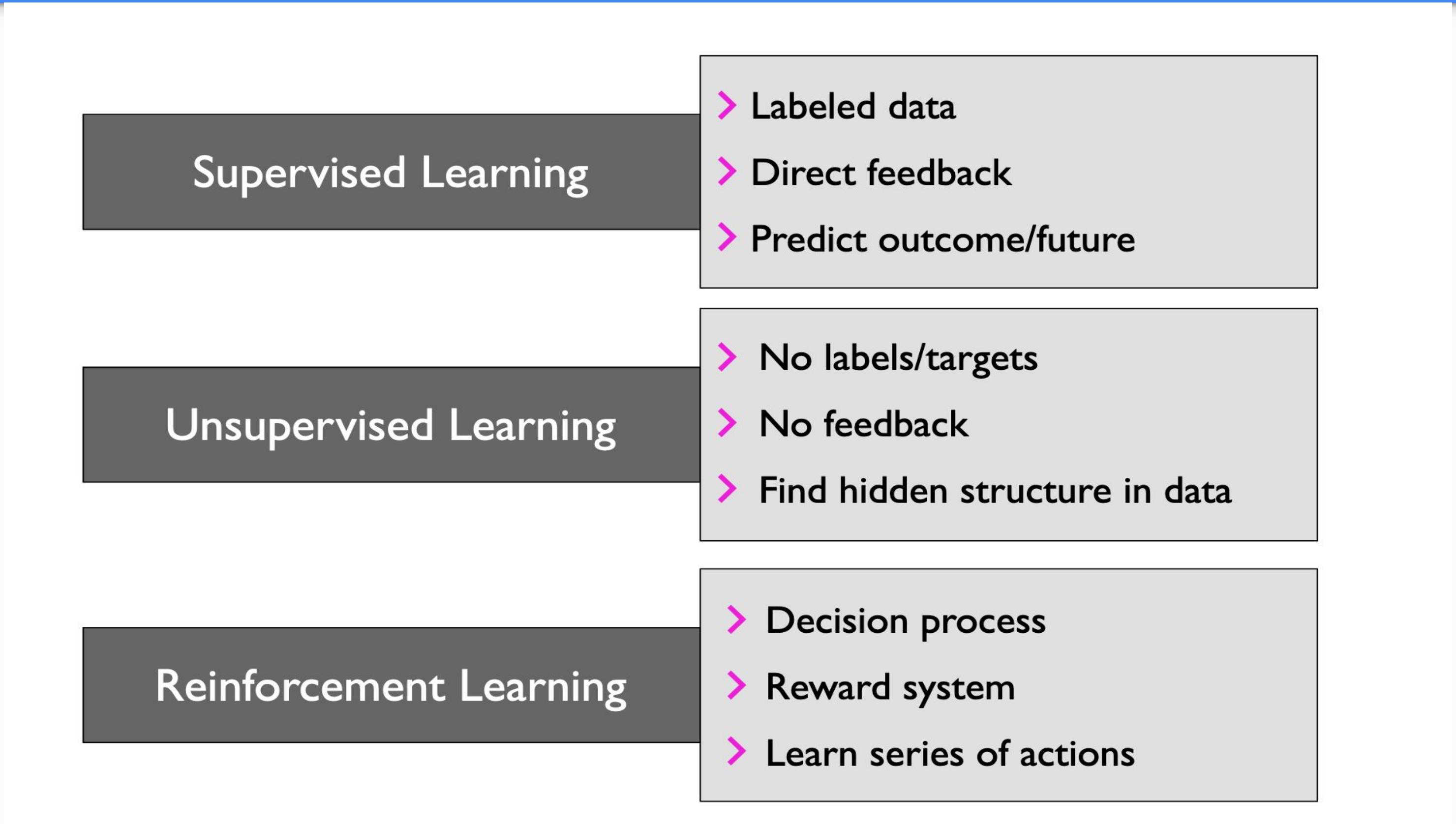
Introduction



- Smart assistants (Apple Siri, Amazon Alexa, ...)
- Product recommendations (e.g., Netflix, Amazon)
- Self-driving cars (e.g., Uber, Tesla)
- Language translation (Google translate)
- Sentiment analysis
- Drug design
- Medical diagnoses
- ...

Credits:
https://sebastianraschka.com/pdf/lecture-notes/stat479ss19/L01_intro_slides.pdf

Taxonomy of ML



Supervised Learning

- Labeled data
- Direct feedback
- Predict outcome/future

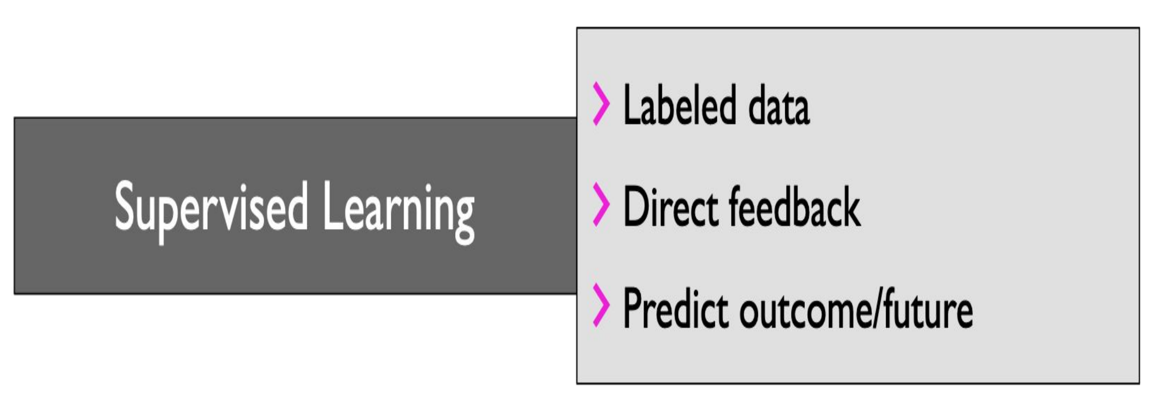
Unsupervised Learning

- No labels/targets
- No feedback
- Find hidden structure in data

Reinforcement Learning

- Decision process
- Reward system
- Learn series of actions

Credits:
https://sebastianraschka.com/pdf/lecture-notes/stat479ss19/L01_intro_slides.pdf



Supervised Learning

- Labeled data
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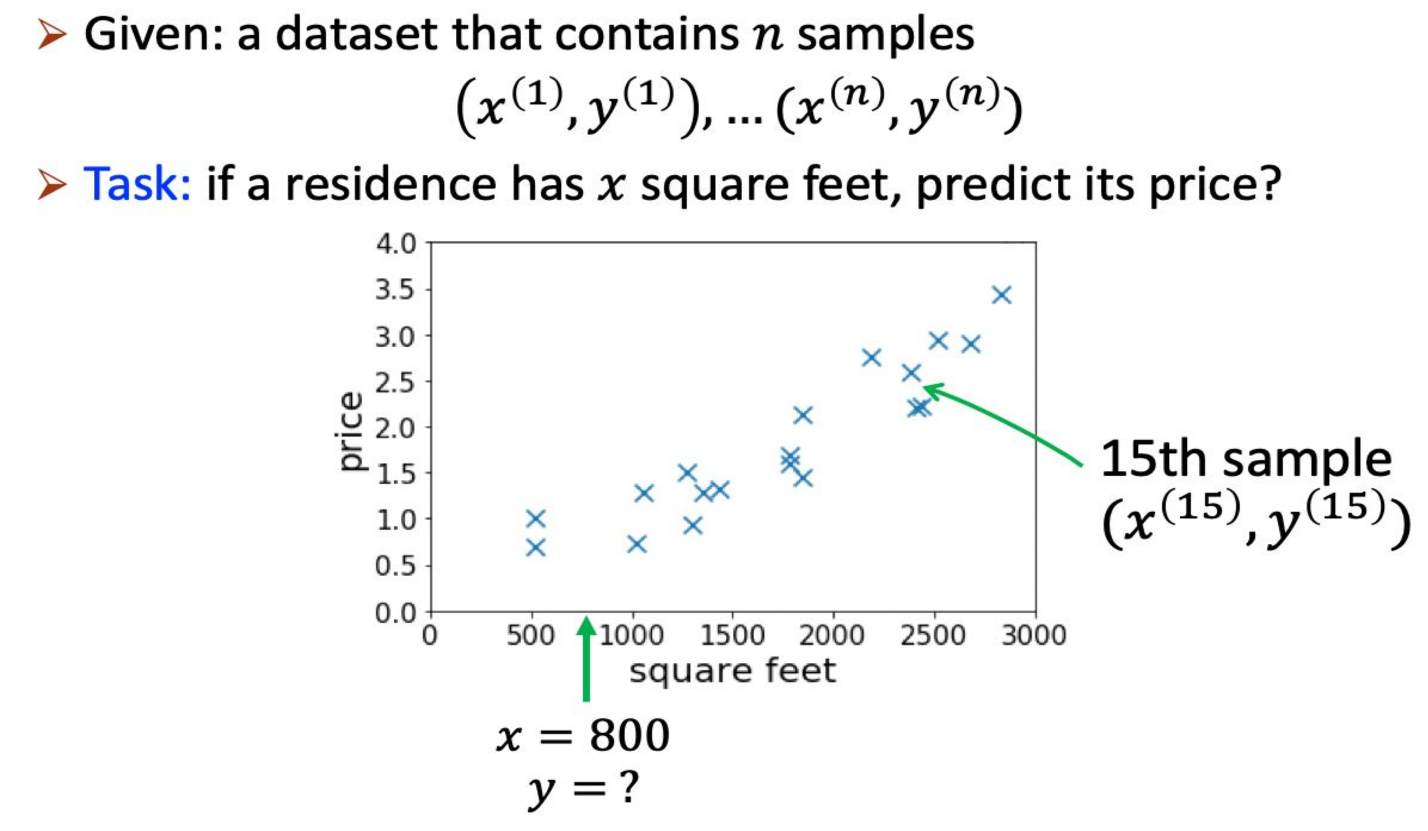
Credits:
https://sebastianraschka.com/pdf/lecture-notes/stat479ss19/L01_intro_slides.pdf

House Price Prediction



- Given: a dataset that contains n samples

$$(x^{(1)}, y^{(1)}), \dots (x^{(n)}, y^{(n)})$$

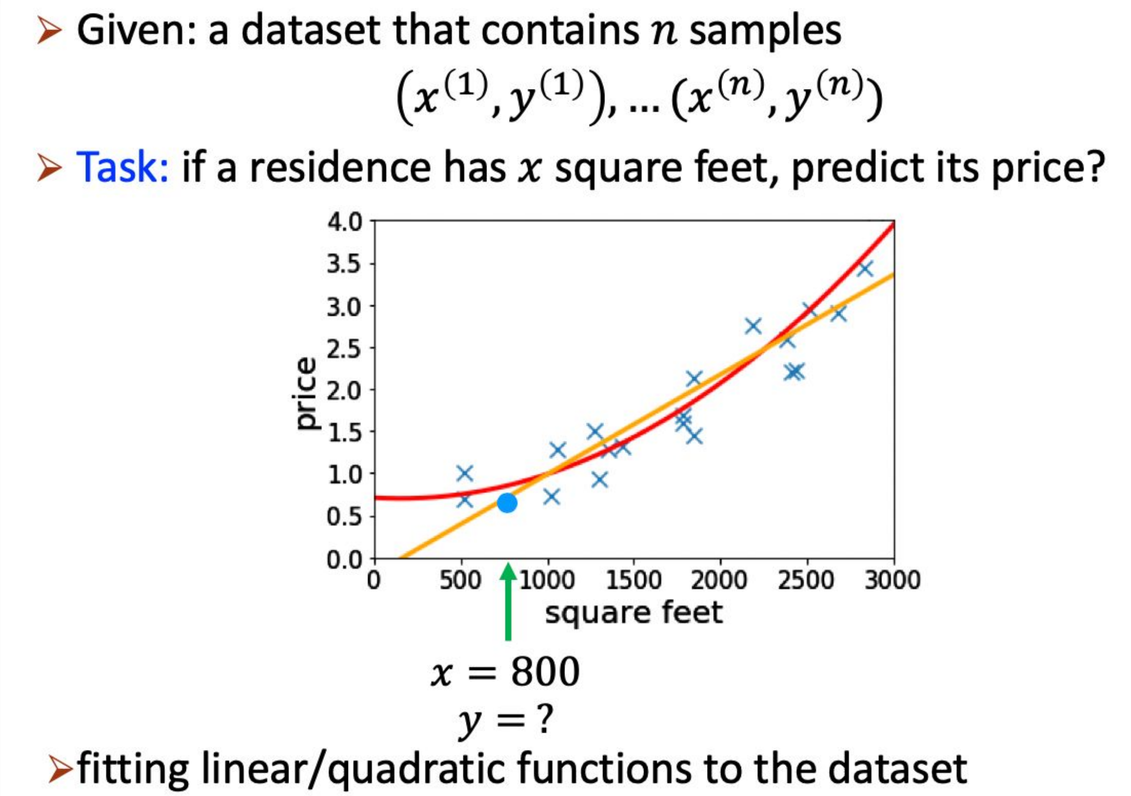
- Task: if a residence has x square feet, predict its price?

15th sample $(x^{(15)}, y^{(15)})$

$x = 800$
$y = ?$

Credits:
http://cs229.stanford.edu/notes2020spring/lecture1_slide.pdf

House Price Prediction



- Given: a dataset that contains n samples

$$(x^{(1)}, y^{(1)}), \dots (x^{(n)}, y^{(n)})$$

- Task: if a residence has x square feet, predict its price?

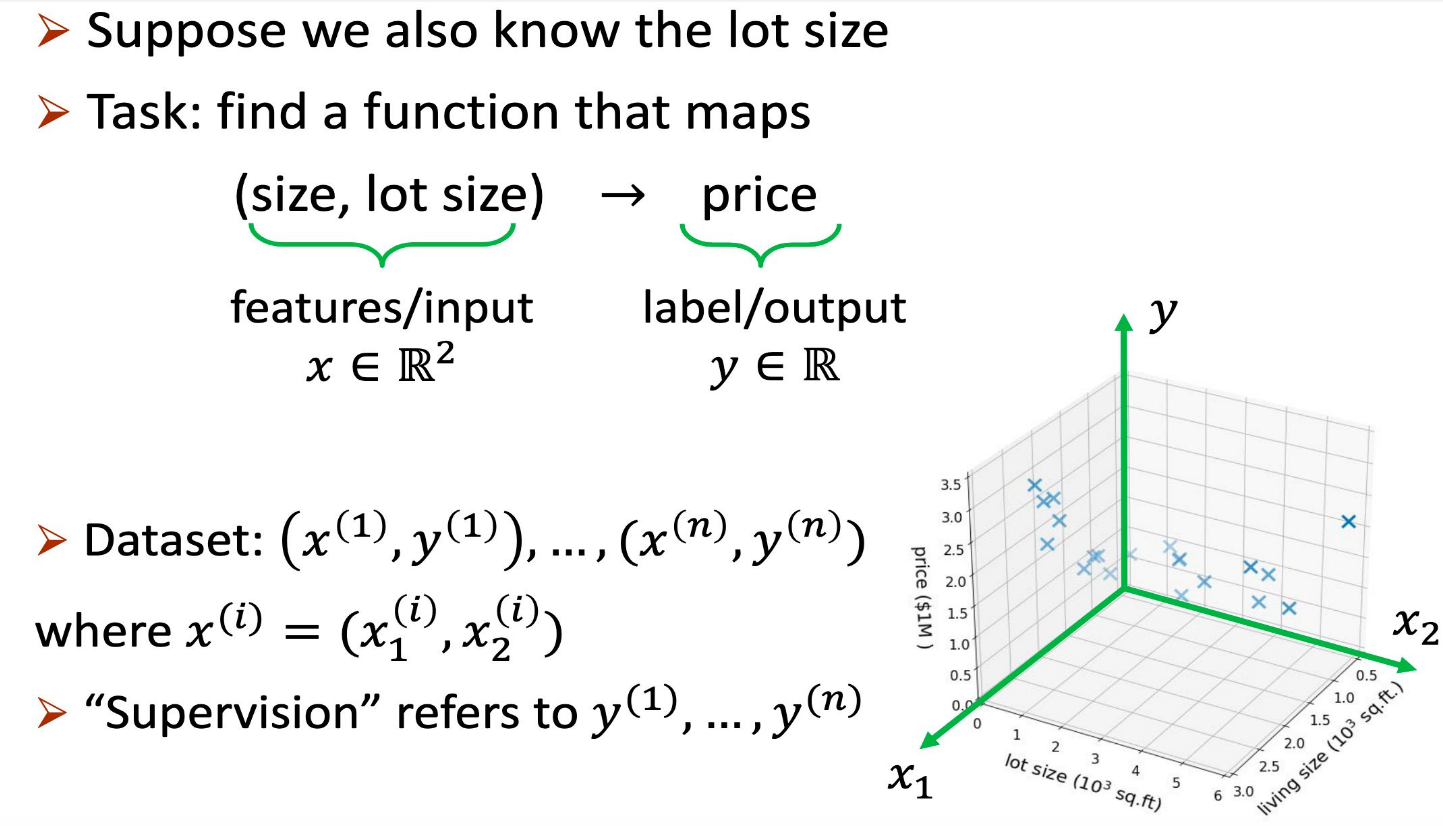
$x = 800$

$y = ?$

- fitting linear/quadratic functions to the dataset

Credits:
http://cs229.stanford.edu/notes2020spring/lecture1_slide.pdf

More Data...



- Suppose we also know the lot size
- Task: find a function that maps

$$\underbrace{\text{(size, lot size)}}_{\text{features/input}} \rightarrow \underbrace{\text{price}}_{\text{label/output}}$$

$$x \in \mathbb{R}^2 \qquad y \in \mathbb{R}$$

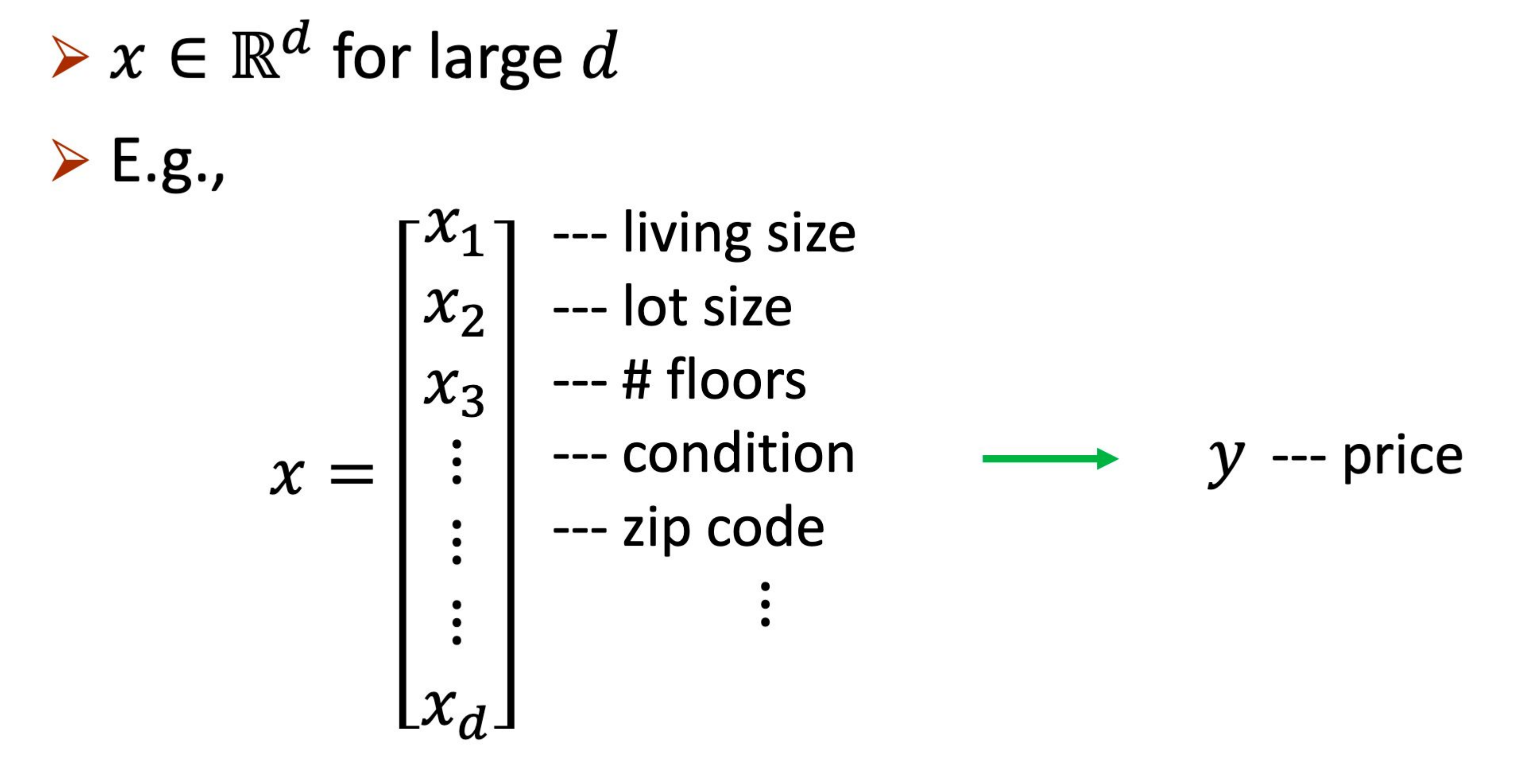
- Dataset: $(x^{(1)}, y^{(1)}), \ldots, (x^{(n)}, y^{(n)})$

where $x^{(i)} = (x_1^{(i)}, x_2^{(i)})$

- “Supervision” refers to $y^{(1)}, \ldots, y^{(n)}$

Credits:
http://cs229.stanford.edu/notes2020spring/lecture1_slide.pdf

High number of input feature

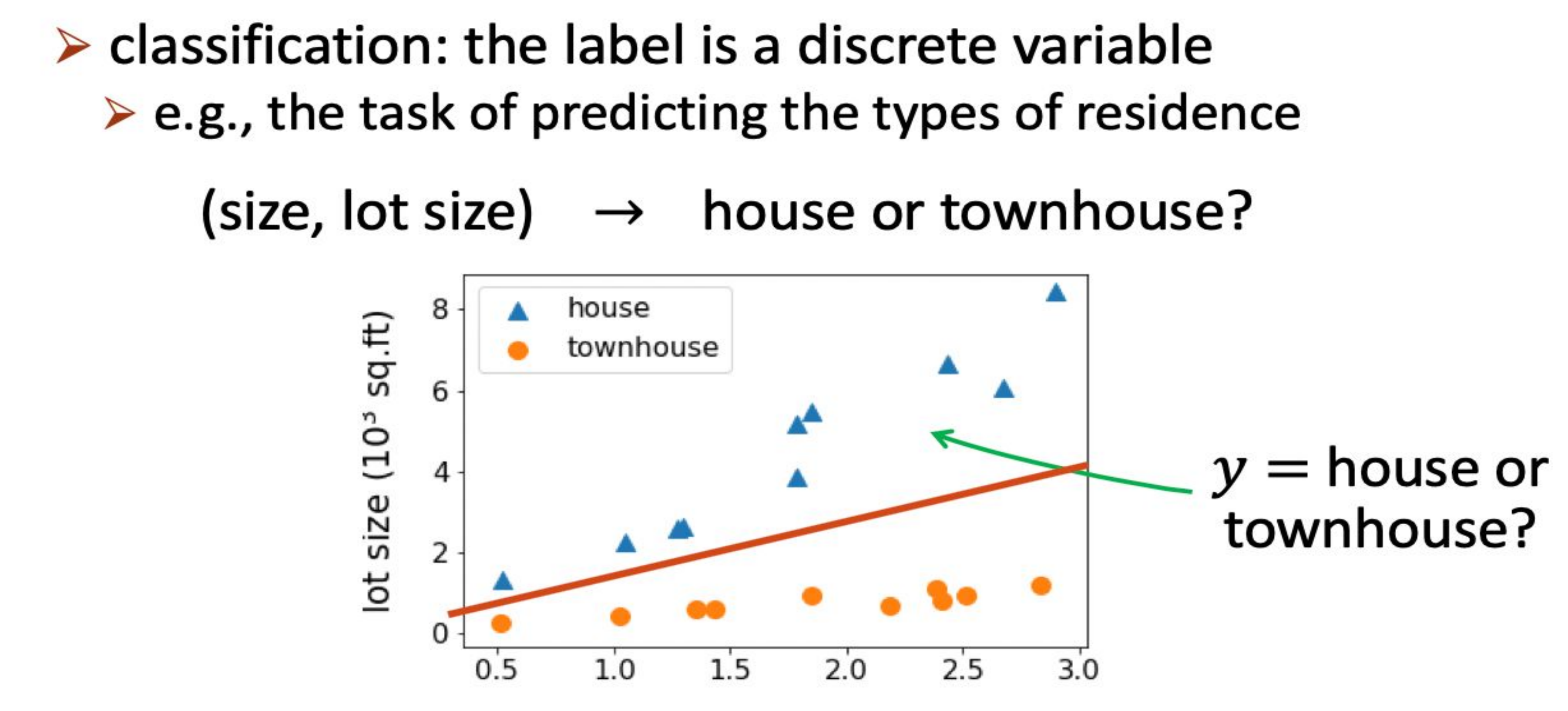


- $x \in \mathbb{R}^d$ for large d
- E.g.,

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \vdots \\ \vdots \\ \vdots \\ x_d \end{bmatrix} \begin{array}{l} \text{--- living size} \\ \text{--- lot size} \\ \text{--- \# floors} \\ \text{--- condition} \\ \text{--- zip code} \\ \qquad\quad \vdots \\ \\ \end{array} \longrightarrow \quad y \text{ --- price}$$

Credits:
http://cs229.stanford.edu/notes2020spring/lecture1_slide.pdf

Classification



- classification: the label is a discrete variable
  - e.g., the task of predicting the types of residence

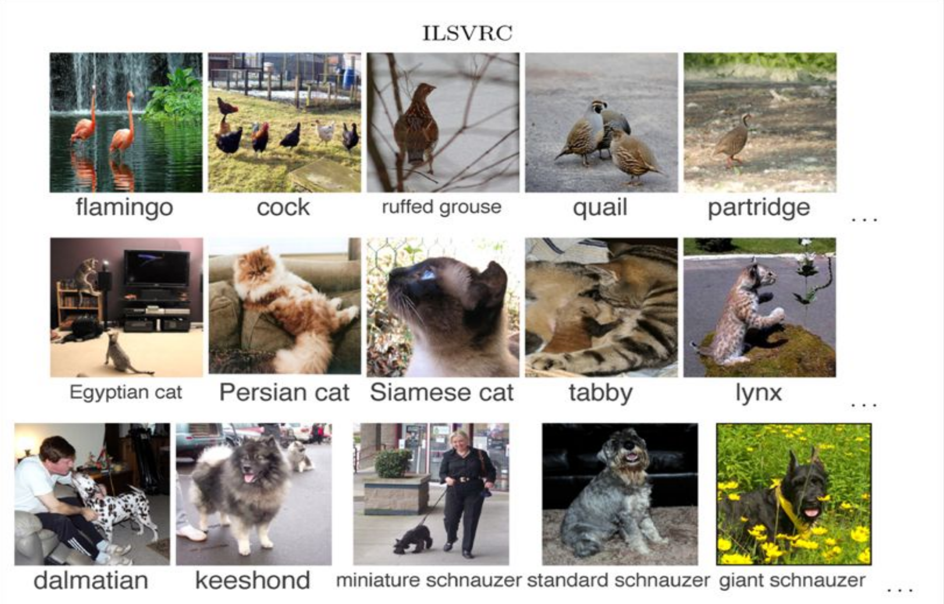
(size, lot size) → house or townhouse?

y = house or townhouse?

Credits:
http://cs229.stanford.edu/notes2020spring/lecture1_slide.pdf

Classification

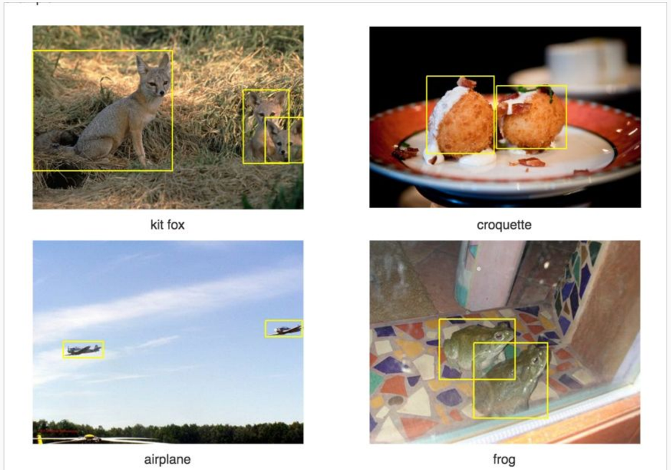
- Image Classification
  - x = raw pixels of the image, y = the main object



Credits:
http://cs229.stanford.edu/notes2020spring/lecture1_slide.pdf

Classification

- Object localization and detection
  - x = raw pixels of the image, y = the bounding boxes



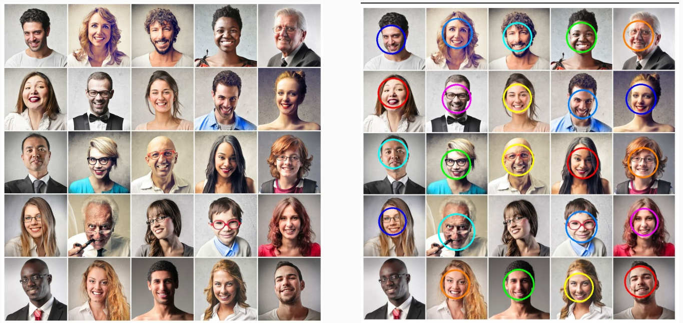
kit fox

croquette

airplane

frog

- Facial detection: libraries like OpenCV let you do the detection below with a handful of lines of code
  - But note the two false negatives



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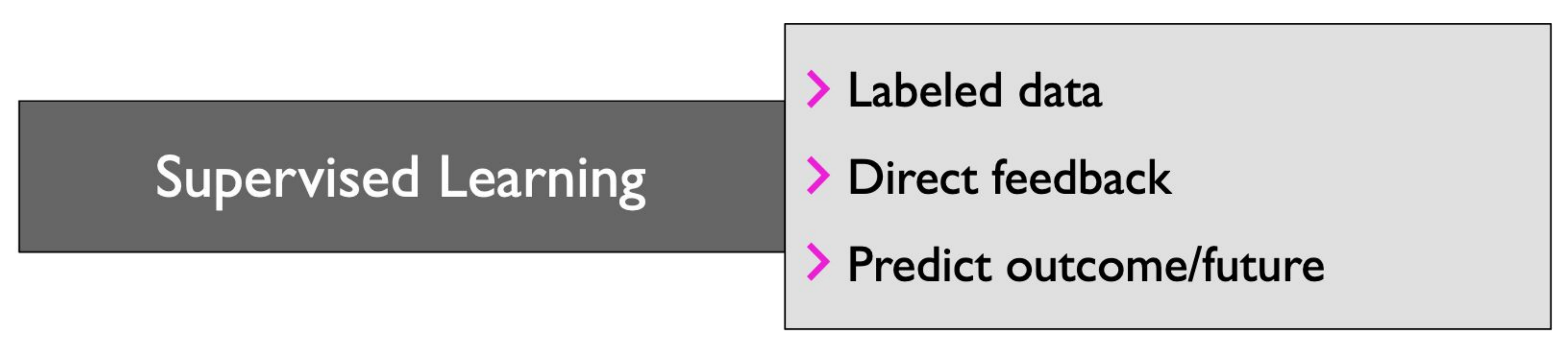

Supervised Learning

- Labeled data
- Direct feedback
- Predict outcome/future

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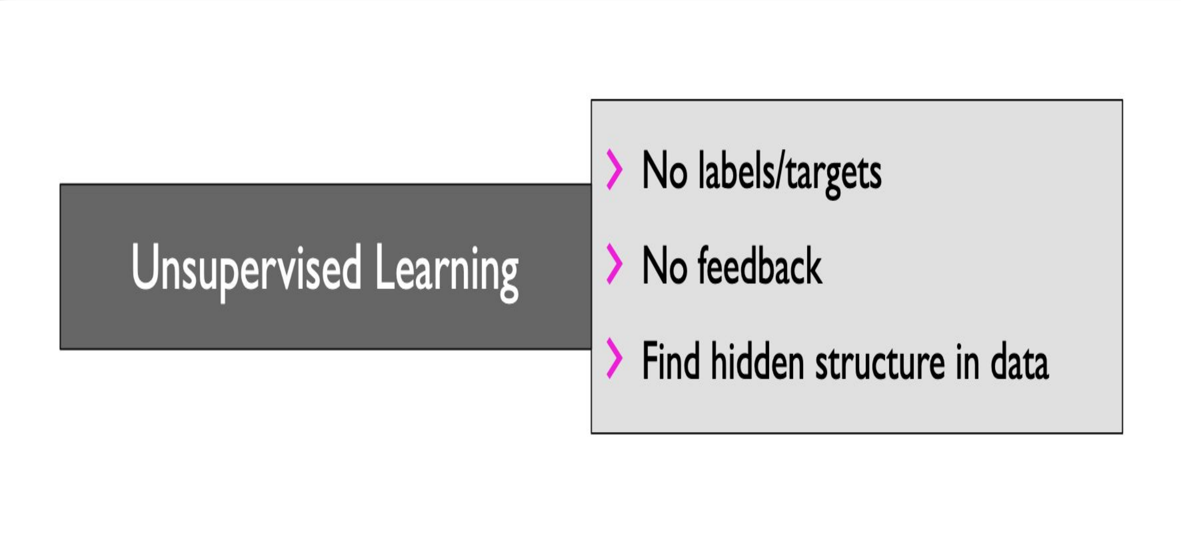


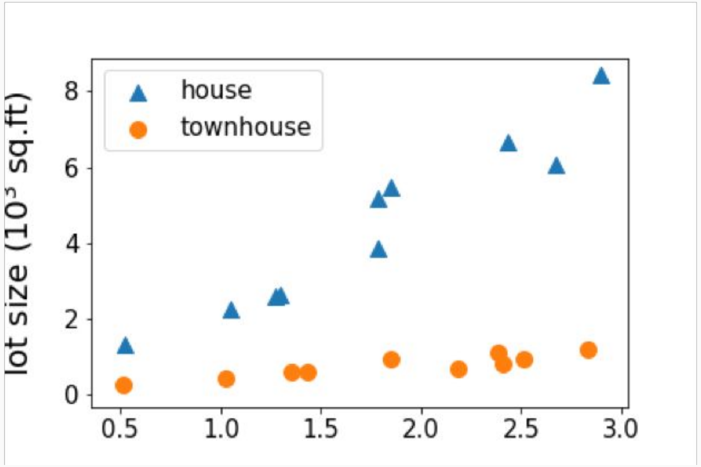
Unsupervised Learning

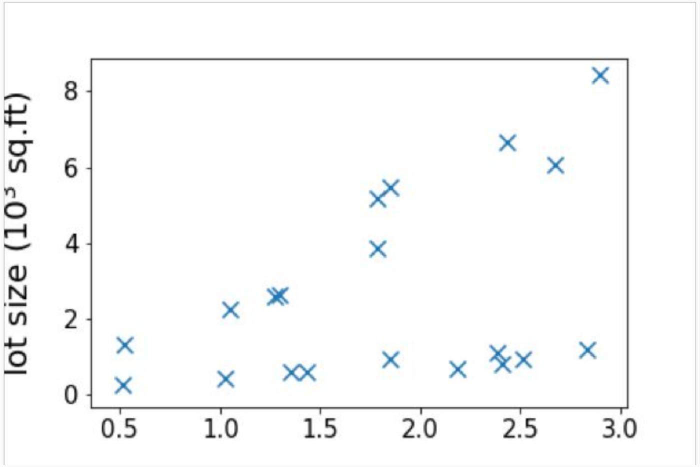
- No labels/targets
- No feedback
- Find hidden structure in data

Credits:
https://sebastianraschka.com/pdf/lecture-notes/stat479ss19/L01_intro_slides.pdf

Unsupervised Learning

- Dataset contains no labels: $x^{(1)}, \dots x^{(n)}$
- Goal (vaguely-posed): to find interesting structures in the data





Credits:
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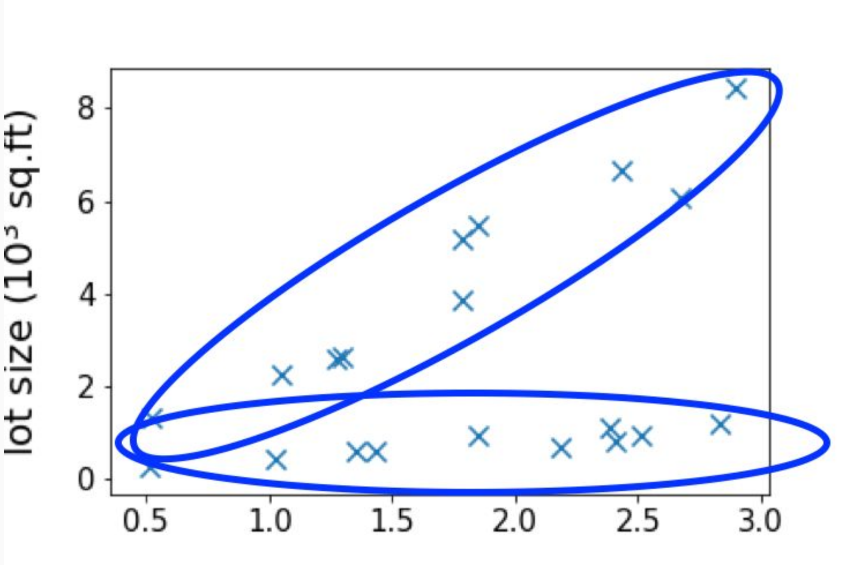
Clustering



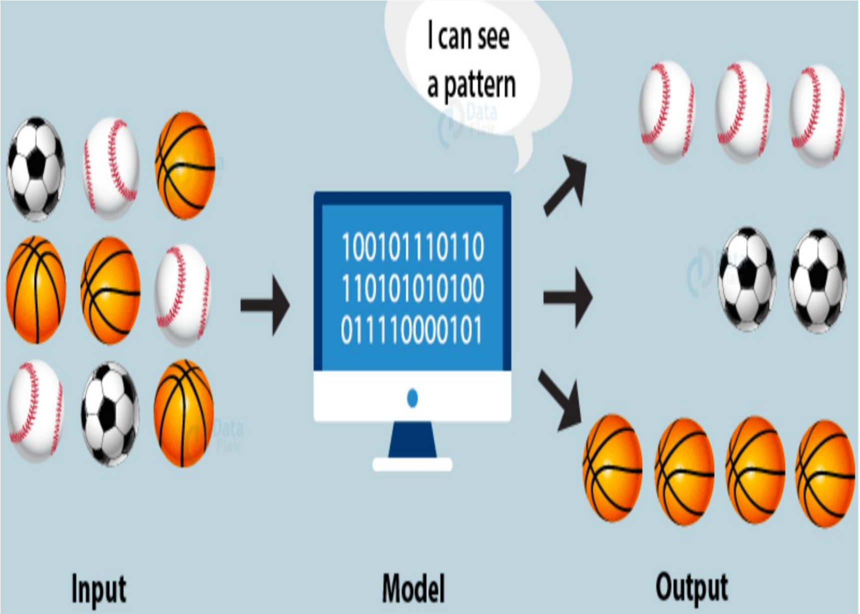
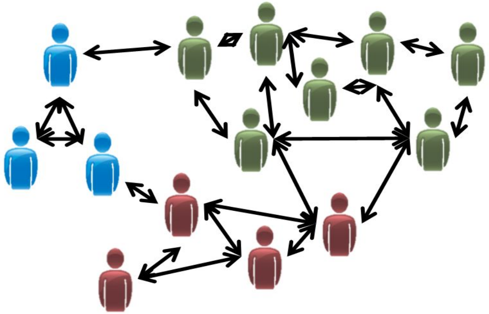


Image Source:
https://data-flair.training/blogs/clustering-in-machine-learning/

Credits:
http://cs229.stanford.edu/notes2020spring/lecture1_slide.pdf

Clustering Use-cases

Organize computing clusters



Social network analysis

Market segmentation

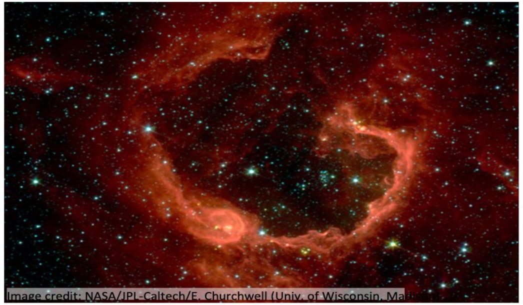
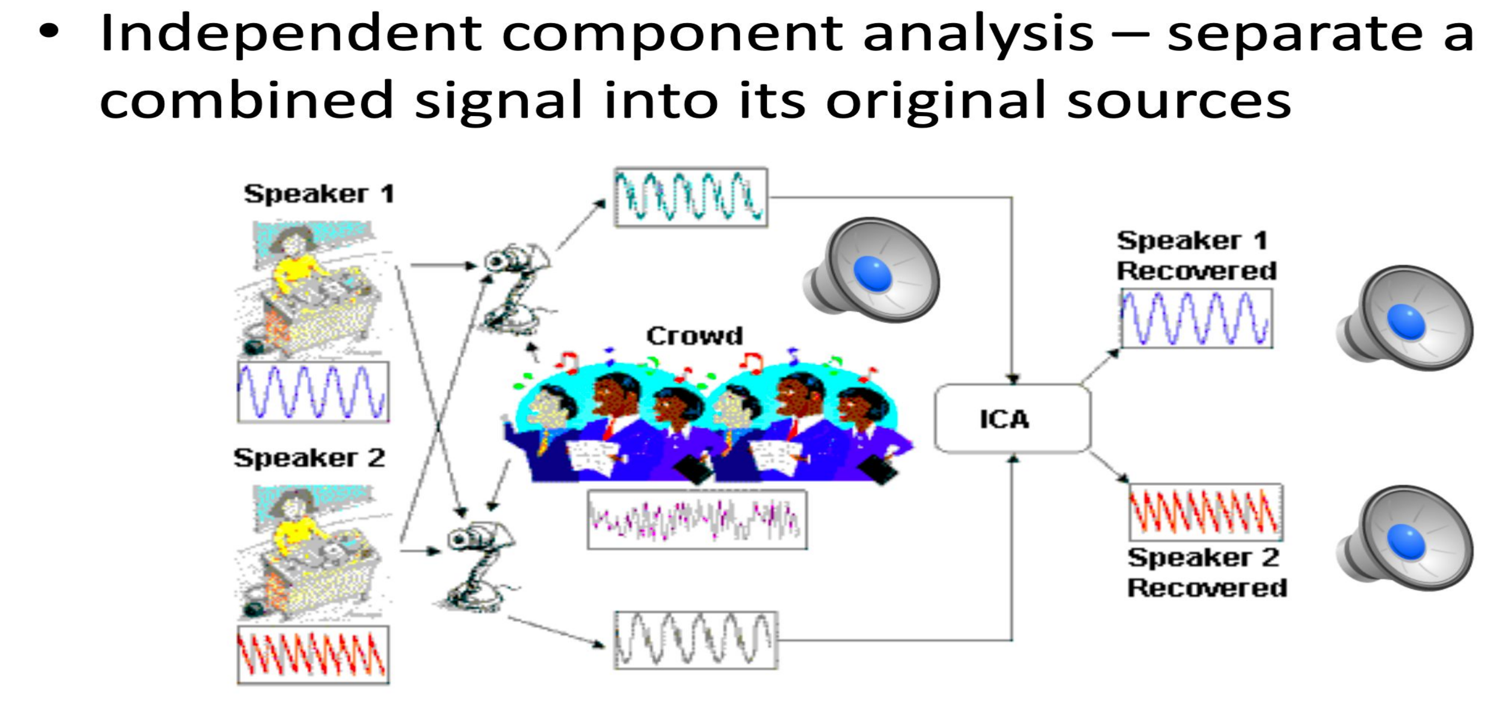


Image credit: NASA/JPL-Caltech/E. Churchwell (Univ. of Wisconsin, Madison)

Astronomical data analysis

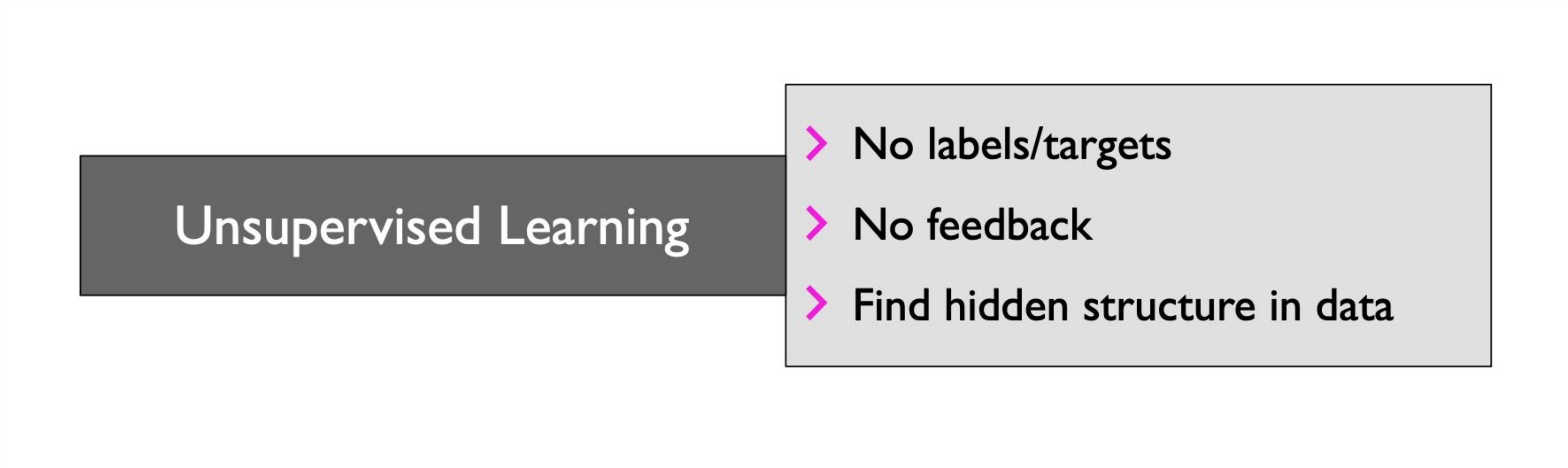
Credits:
https://www.seas.upenn.edu/~cis519/fall2017/lectures/01_introduction.pdf

Clustering - Usecase



- Independent component analysis – separate a combined signal into its original sources

Credits:
https://www.seas.upenn.edu/~cis519/fall2017/lectures/01_introduction.pdf



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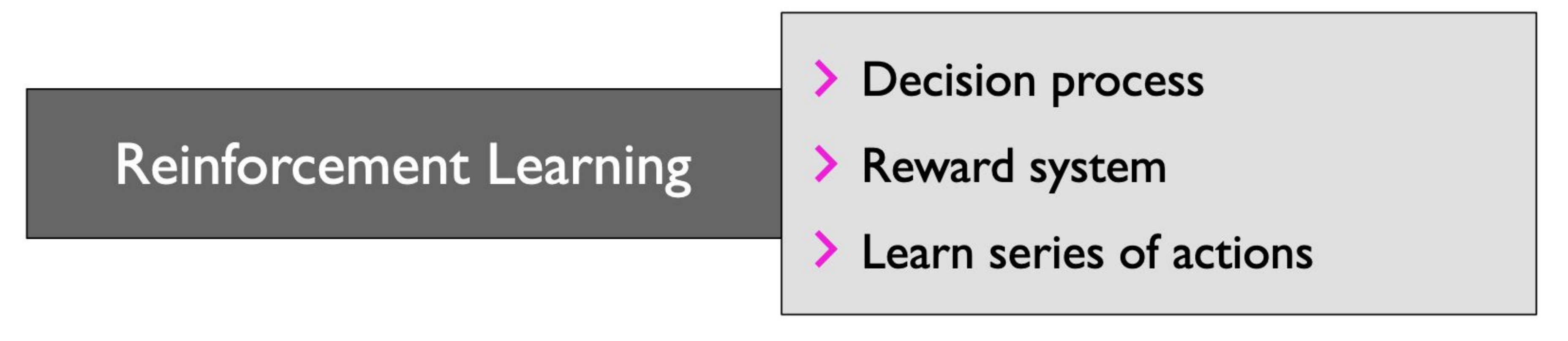

Reinforcement Learning

- Decision process
- Reward system
- Learn series of actions

Credits:
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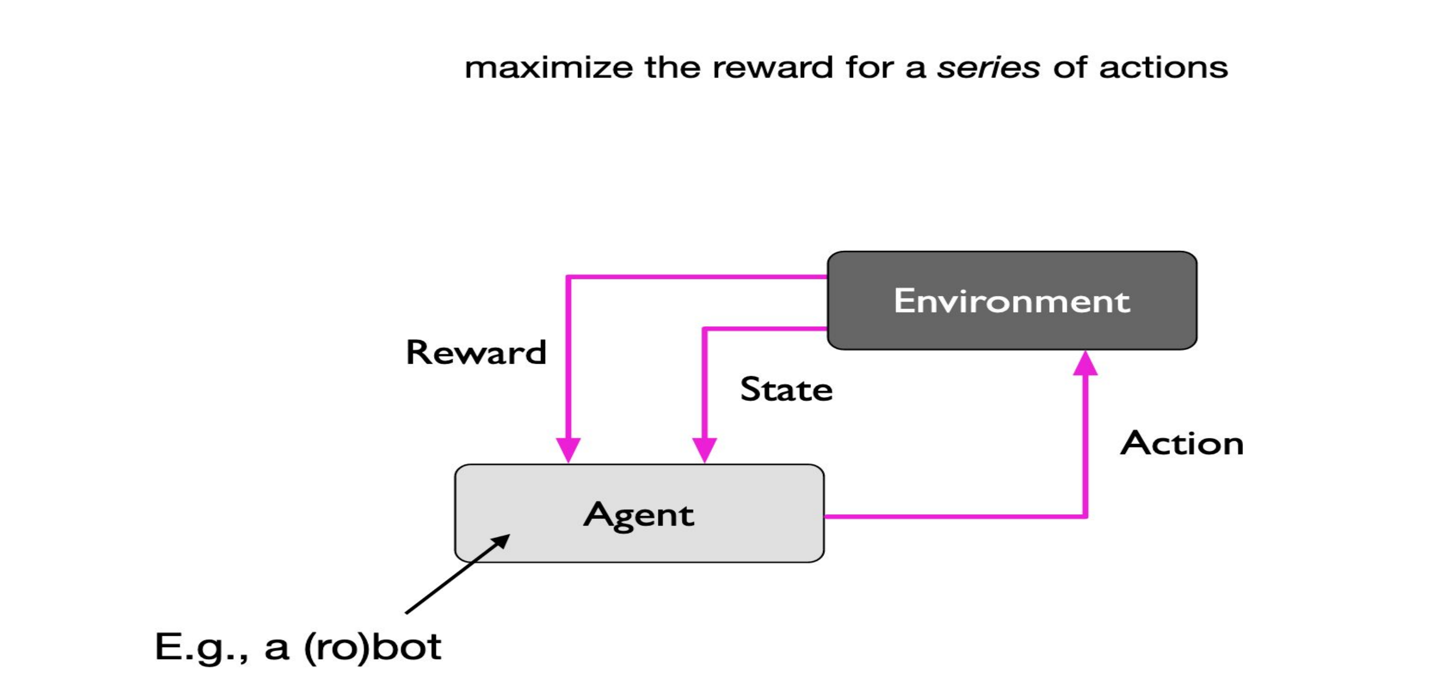
Reinforcement Learning

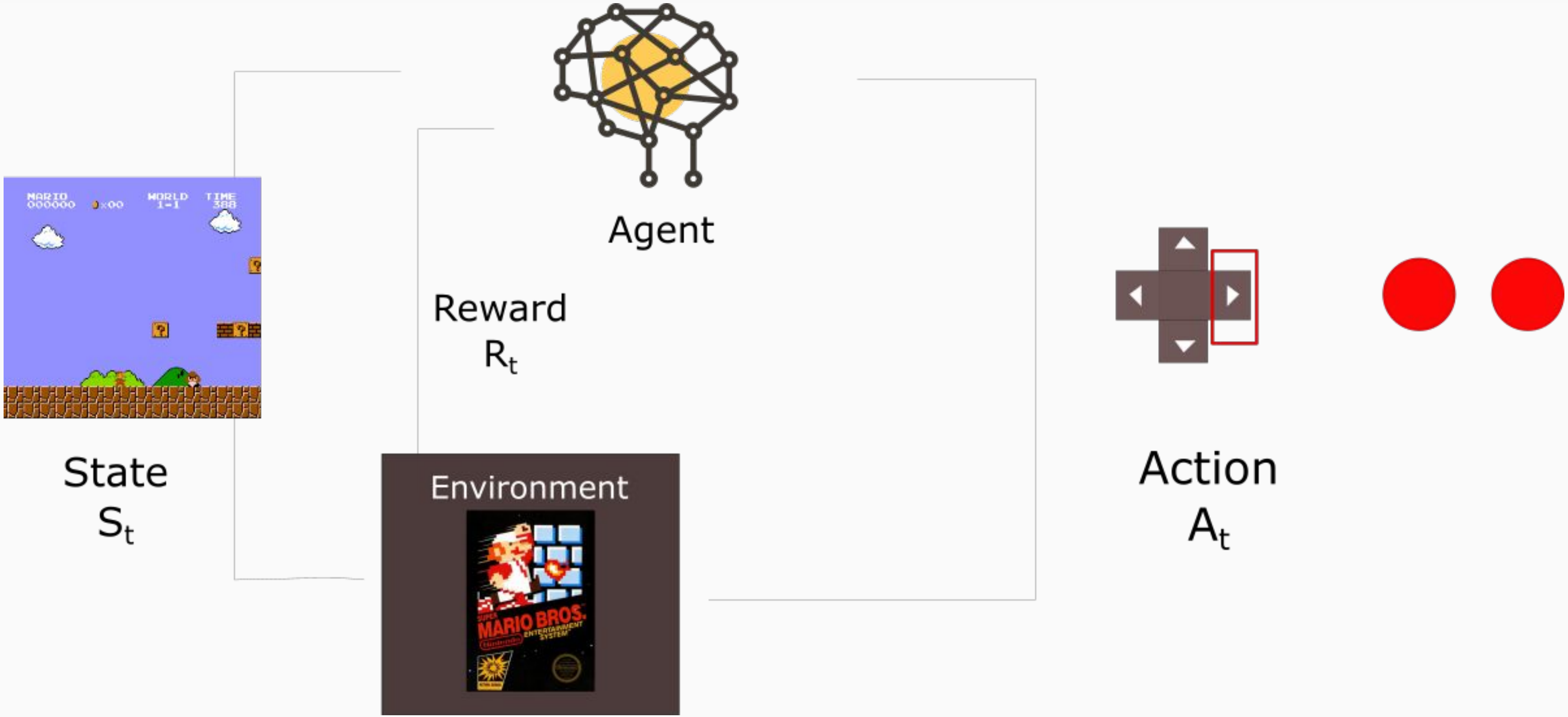


maximize the reward for a *series* of actions

E.g., a (ro)bot

Credits:
https://sebastianraschka.com/pdf/lecture-notes/stat479ss19/L01_intro_slides.pdf

Reinforcement Learning



Agent

Reward

R_t

State

S_t

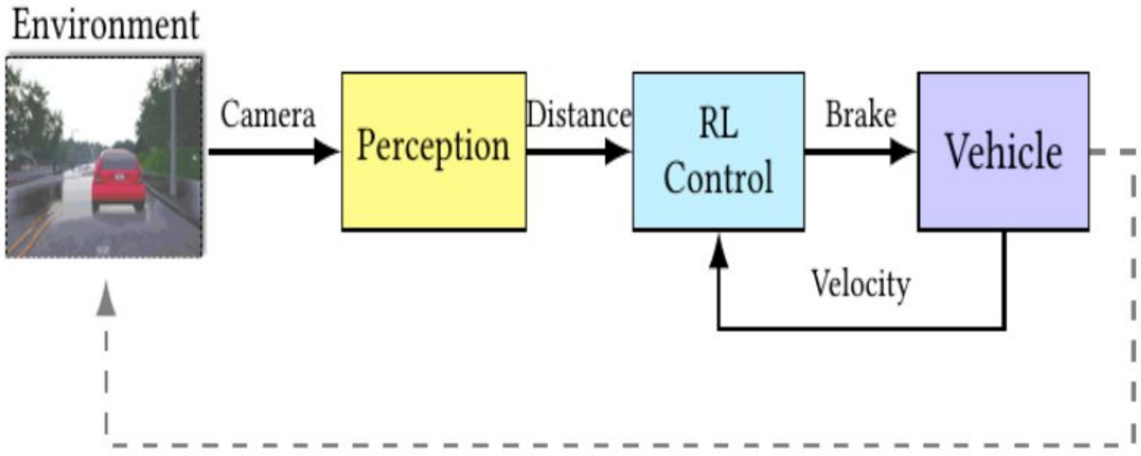
Environment

Action

A_t

Credits:
https://cai.tools.sap/blog/the-future-with-reinforcement-learning-part-1/

Reinforcement Learning



Advaced Emergency Braking System with Reinforcement Controller

Credits:
https://github.com/verivital/nnv

Reinforcement Learning

DeepMind

AlphaGo

Learning to Walk via Deep Reinforcement Learning

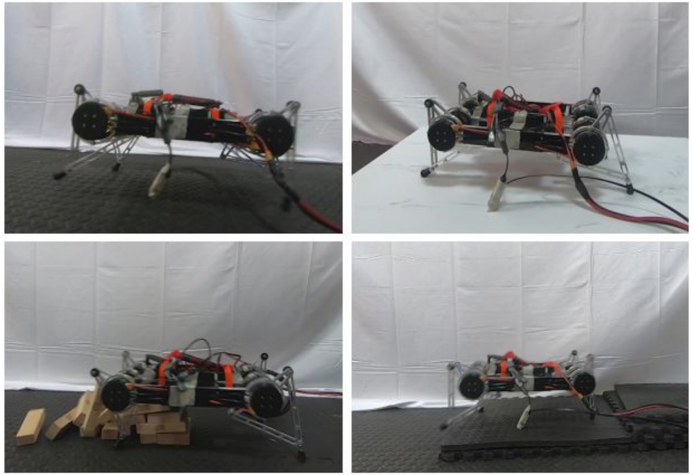
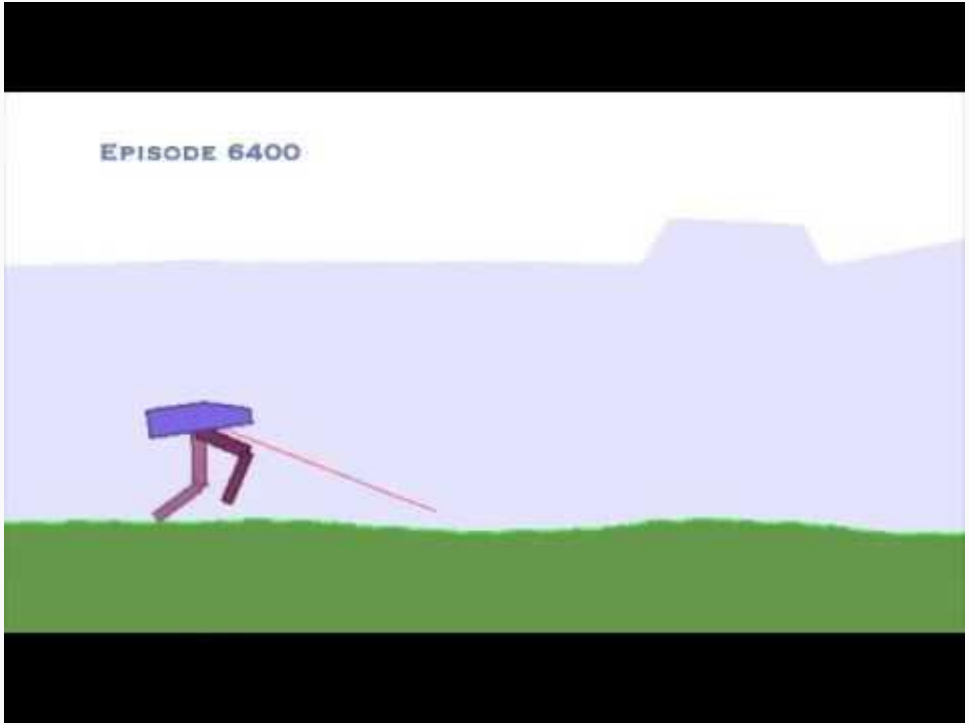


Fig. 1: Illustration of a walking gait learned in the real world. The policy is trained only on a flat terrain, but the learned gait is robust and can handle obstacles that were not seen during training.

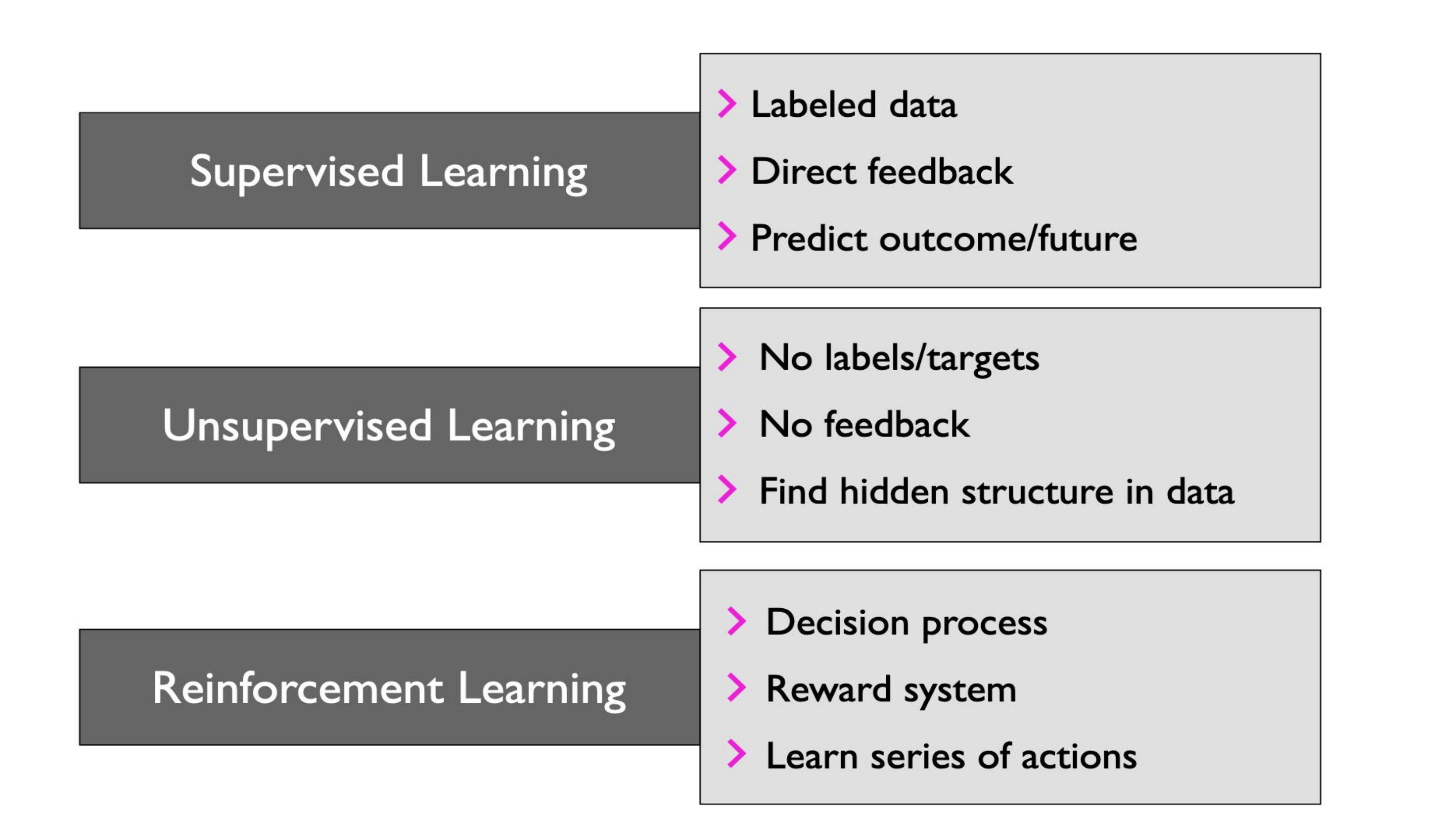
Credits:
“Learning to Walk via Deep Reinforcement Learning”

Demo Of RL -- Robot Walking



Credit: https://www.youtube.com/watch?v=TEFXp2Ro-10

Taxonomy of ML



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Seminar Relevant Info

Github: https://github.com/balasub/ai-seminar/

- Please feel free to fork and send feedback via pull requests!

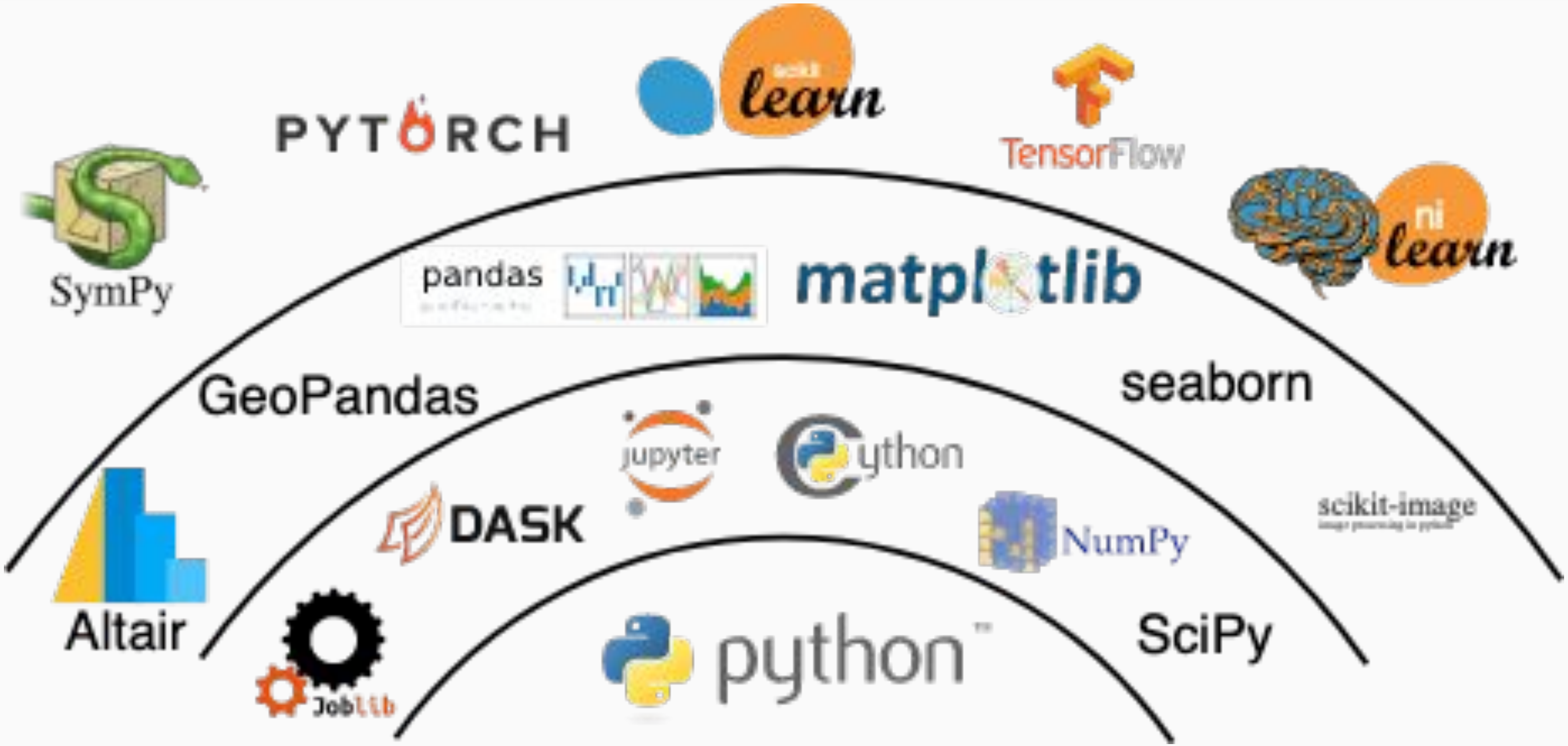
Programming Language:

- Python

Runtime IDE:

- Jupyter Notebook on Google Colab

Programming ML in Python



Credits:
http://josephsalmon.eu/HLMA310.html

Jupyter Notebook on Colab

Questions..