



Machine Learning Complete Course



MACHINE LEARNING COMPLETE COURSE

LECTURER: ENG. ABOLFAZL MOHAMMADIJOO

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Course Content

- **Chapter 1: Introduction**
- **Chapter 2: Linear Regression with One Variable**
- **Chapter 3: Linear Algebra Review**
- **Chapter 4: Linear Regression with Multiple Variables**
- **Chapter 5: Octave Tutorial**
- **Chapter 6: Logistic Regression**
- **Chapter 7: Regularization**
- **Chapter 8: Neural Networks Representation**



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Course Content

- **Chapter 9: Neural Networks Learning**
- **Chapter 10: Advice for Applying Machine Learning**
- **Chapter 11: Machine Learning System Design**
- **Chapter 12: Support Vector Machines**
- **Chapter 13: Clustering**
- **Chapter 14: Dimensionality Reduction**
- **Chapter 15: Anomaly Detection**
- **Chapter 16: Recommender Systems**



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Course Content



- **Chapter 17: Large Scale Machine Learning**
- **Chapter 18: Application Example Photo OCR**
- **Chapter 19: Conclusion**



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Chapter 1: Introduction

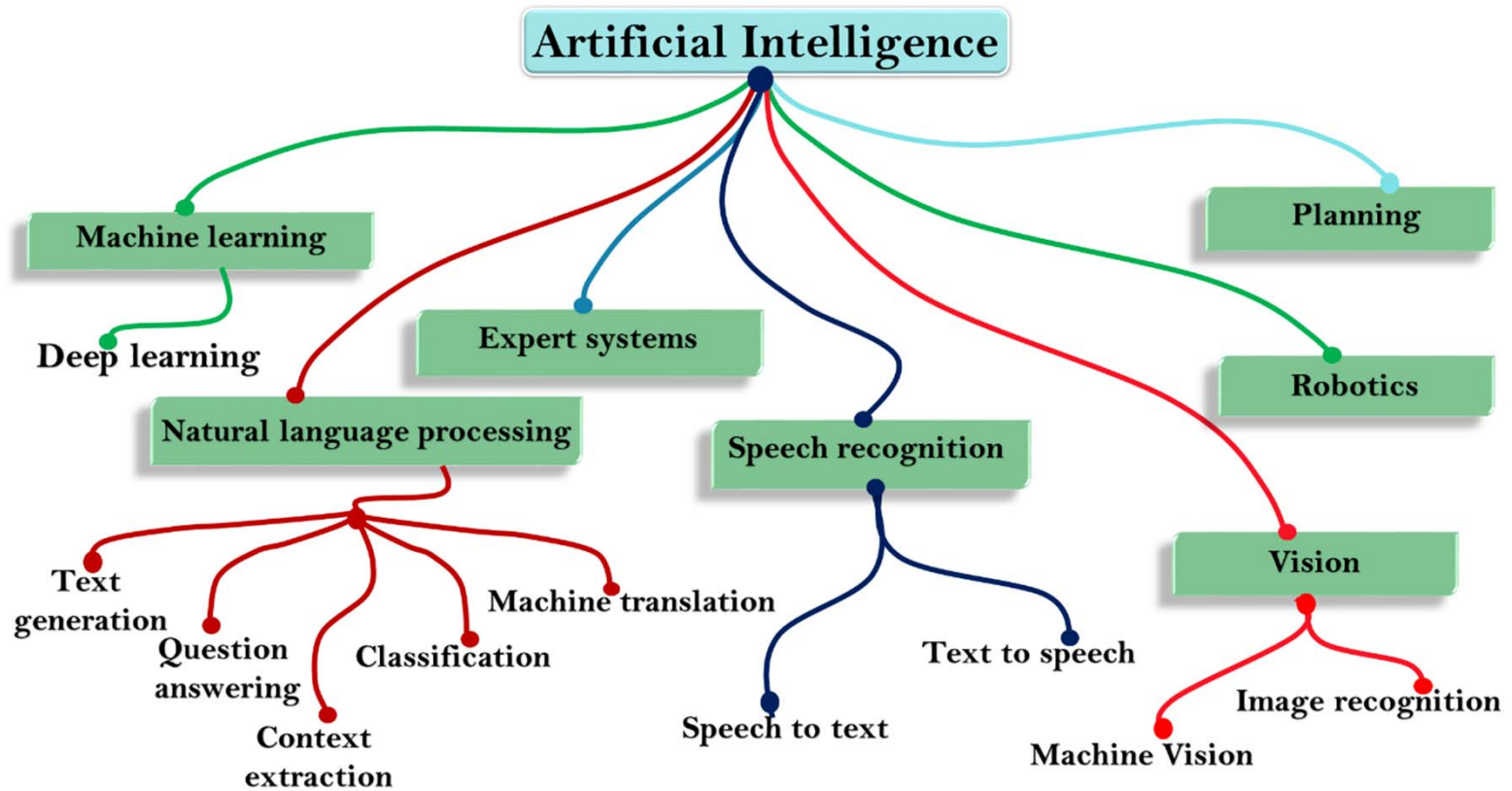
Welcome

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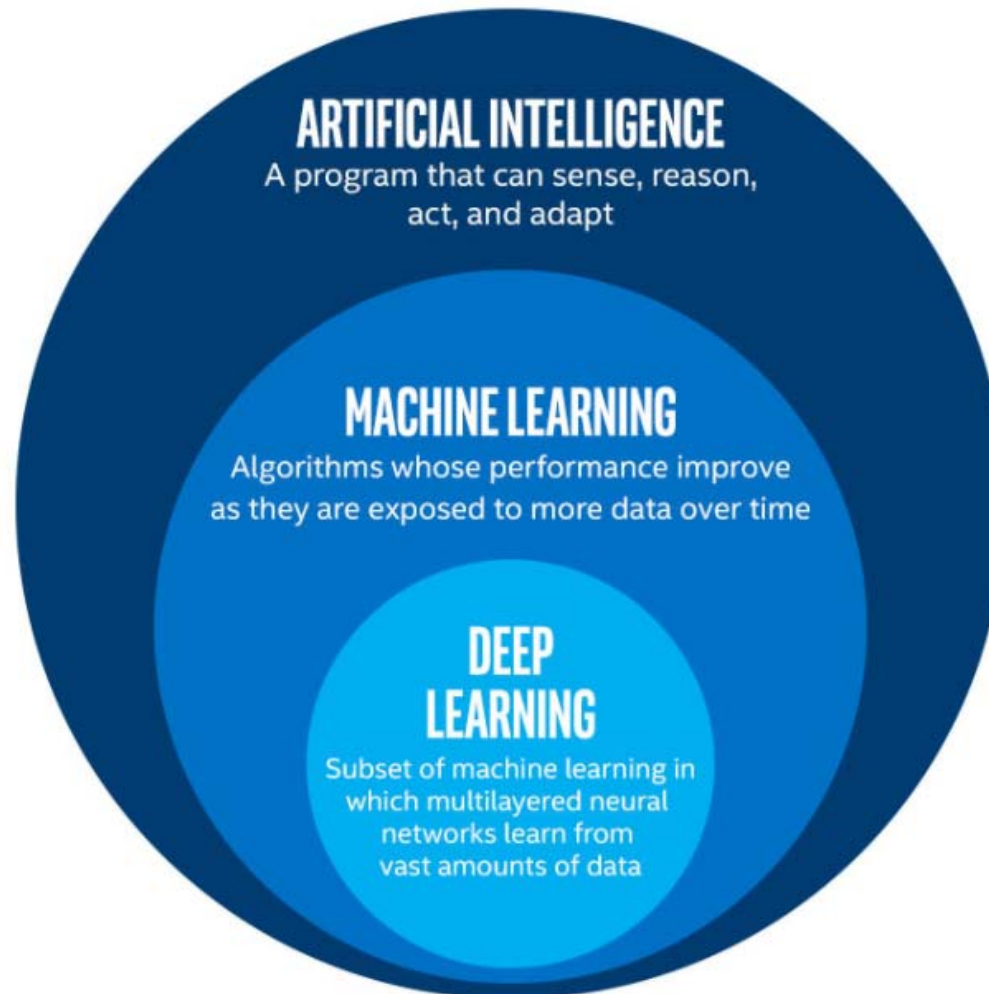




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Question:
How a **Machine** can
learn?!!
(conceptual answer)



Question:
How a **Human** can
learn?!!
(conceptual answer)



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Machine Learning Daily Examples:

- Google Search Engine (to rank pages)
- Finding Spam emails and etc
- Photo Tagging



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Machine Learning

- Grew out of work in AI
- New capability for computers

Examples:

- Database mining

Large datasets from growth of automation/web.

E.g., Web click data, medical records, biology, engineering



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- Applications can't program by hand.
E.g., Autonomous helicopter, handwriting recognition, most of Natural Language Processing (NLP), Computer Vision.
- Self-customizing programs
E.g., Amazon, Netflix product recommendations
- Understanding human learning (brain, real AI).



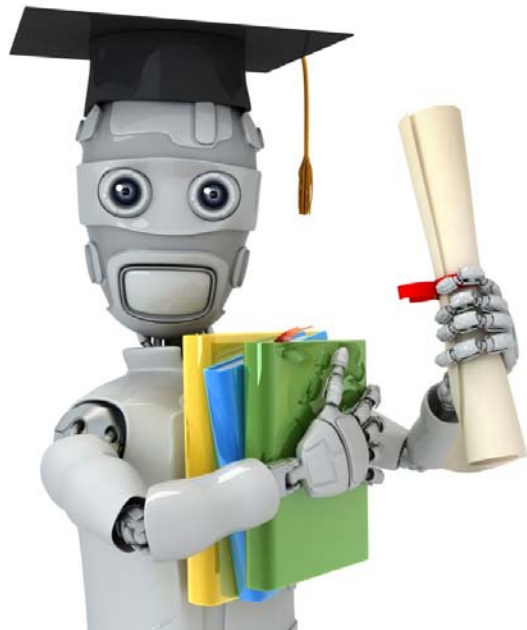
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Introduction

What is machine learning

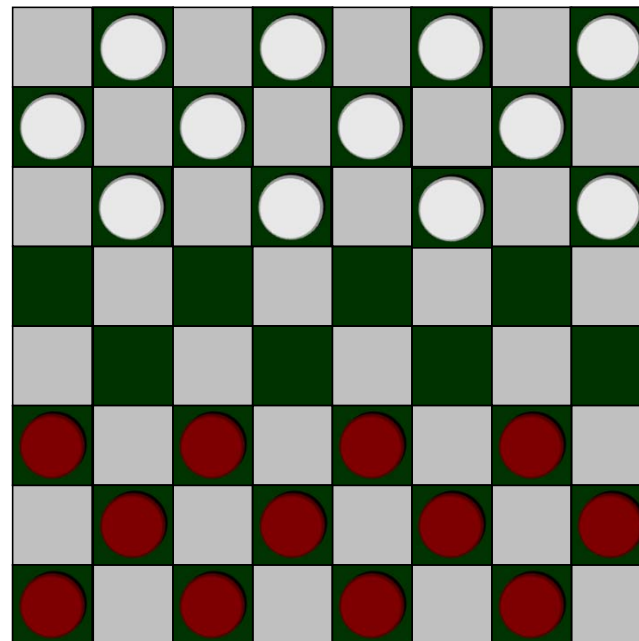
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Machine Learning definition

- Arthur Samuel (1959). Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.





Machine Learning definition

- Tom Mitchell (1998) Well-posed Learning Problem:
A computer program is said to *learn* from experience E with respect to some task T and some performance measure P , if its performance on T , as measured by P , improves with experience E .



“A computer program is said to *learn* from experience E with respect to some task T and some performance measure P , if its performance on T , as measured by P , improves with experience E .”

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

- ❖ Classifying emails as spam or not spam. $T \leftarrow$
- ❖ Watching you label emails as spam or not spam. $E \leftarrow$
- ❖ The number (or fraction) of emails correctly classified as spam/not spam. $E \leftarrow$
- ❖ None of the above—this is not a machine learning problem. $P \leftarrow$

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A screenshot of a Gmail inbox in a browser window. The browser tab is titled 'Tintedbox.com Mail - Test'. The address bar shows the URL 'https://mail.google.com/mail/?shva=1#inbox/131d0094416e006e'. The Gmail interface includes the 'Gmail by Google' logo, search bars for 'Search Mail' and 'Search the Web', and navigation links for 'Mail', 'Calendar', 'Documents', 'Sites', and 'Groups'. The left sidebar shows the 'Inbox' selected, with other folders like 'Starred', 'Important', 'Sent Mail', 'Drafts', 'Follow up', 'Misc', 'Priority', and '4 more'. The main content area displays a 'Test message' from 'Andrew Y. Ng' dated 'Aug 15 (6 days ago)'. Below the sender's name is a reply from 'Tarun Vir' with a 'show details' link and a 'Reply' button. The body of the email is a large black redaction box. At the bottom of the window, there is a 'Chat' section.



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Machine learning algorithms:

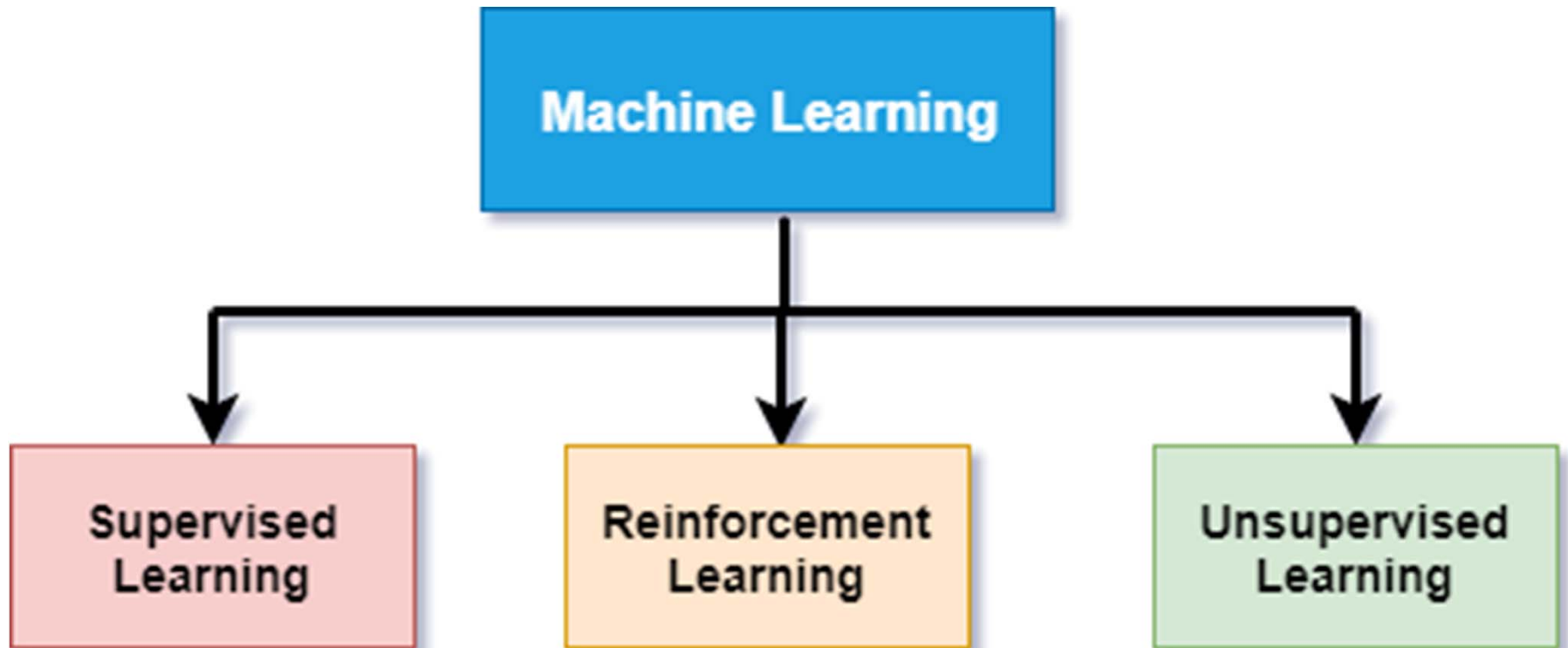
- Supervised learning
- Unsupervised learning

Others: Reinforcement learning, recommender systems.

Also talk about: Practical advice for applying learning algorithms.



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Introduction

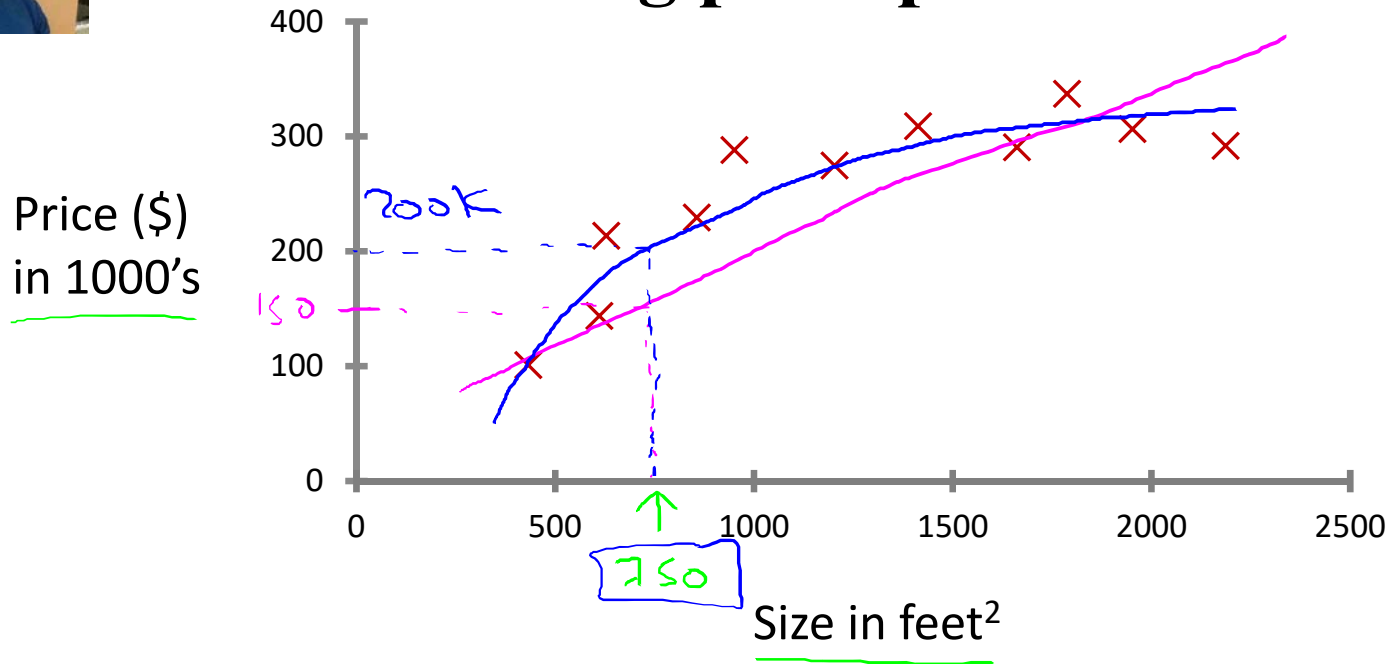
Supervised Learning

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Housing price prediction:



Supervised Learning

"right answers" given

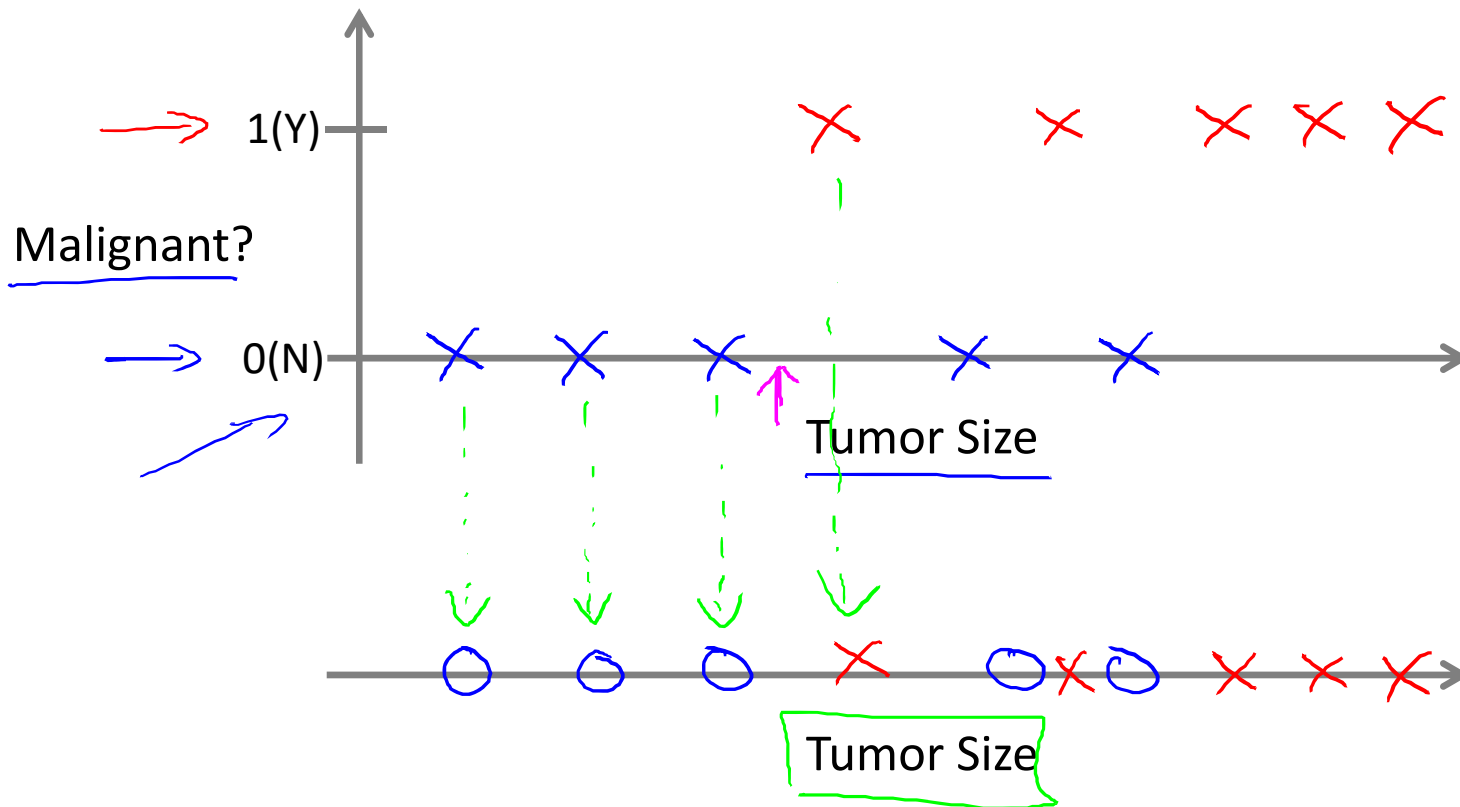
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Regression: Predict continuous

valued output (price)

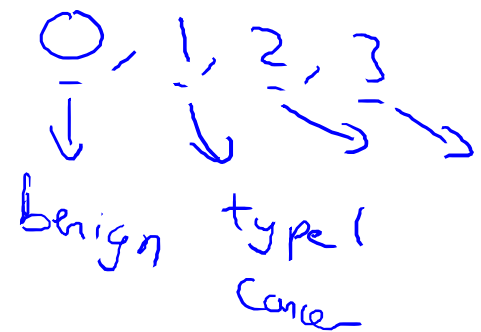


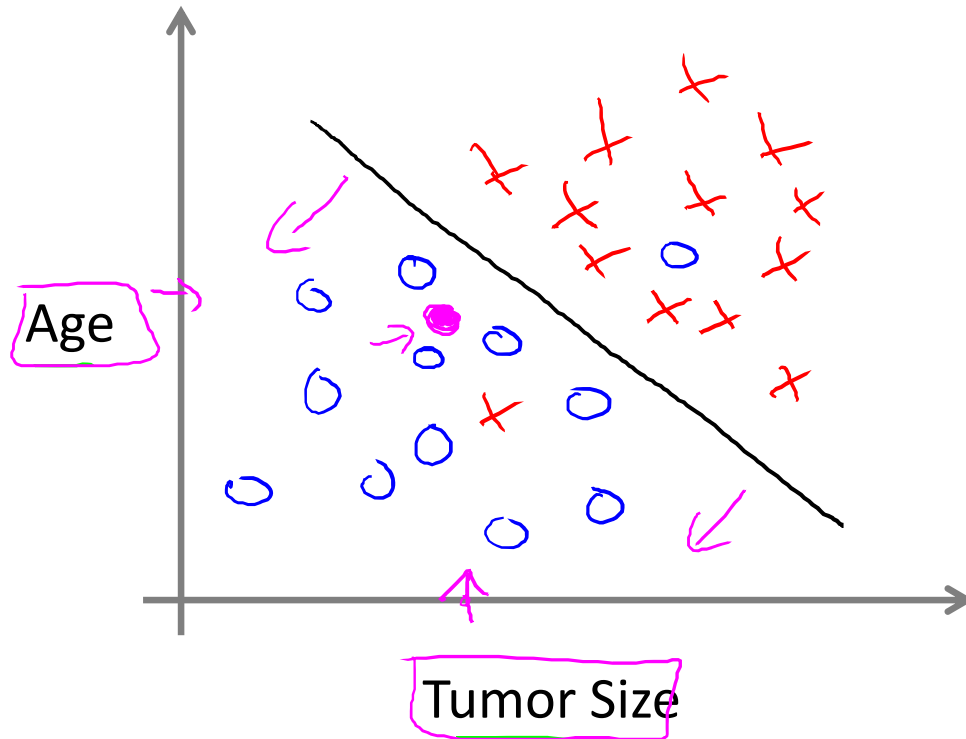
Breast cancer (malignant, benign)



Classification

Discrete valued output (0 or 1)





- Clump Thickness
- Uniformity of Cell Size
- Uniformity of Cell Shape

...

As the factors grow up, we cannot explain the model by a mathematical expression!!!



- ✓ Imagine How a physics formula discovered?!! (for example $F=ma$)
- ✓ And also imagine how a complex physics formula discovered?!! (Like Navier–Stokes equations of Fluid Mechanics)

Navier–Stokes momentum equation in non-inertial frame

$$\rho \frac{D\mathbf{u}}{Dt} = -\nabla \bar{p} + \mu \nabla^2 \mathbf{u} + \frac{1}{3} \mu \nabla (\nabla \cdot \mathbf{u}) + \rho \mathbf{g} - \rho \left(2\boldsymbol{\Omega} \times \mathbf{u} + \boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{x}) + \frac{d\mathbf{U}}{dt} + \frac{d\boldsymbol{\Omega}}{dt} \times \mathbf{x} \right).$$

It is almost impossible to derive a explicit mathematical model for a “machine learning model”, and that’s exactly why we need machine learning.



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You're running a company, and you want to develop learning algorithms to address each of two problems.

1000's

→ Problem 1: You have a large inventory of identical items. You want to predict how many of these items will sell over the next 3 months.

→ Problem 2: You'd like software to examine individual customer accounts, and for each account decide if it has been hacked/compromised.

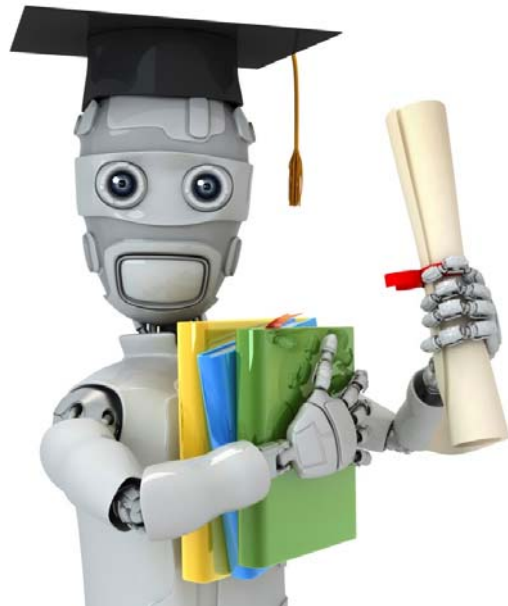
→ 0 - not hacked
→ 1 - hacked

Should you treat these as classification or as regression problems?

- Treat both as classification problems.
- Treat problem 1 as a classification problem, problem 2 as a regression problem.
- ▪ Treat problem 1 as a regression problem, problem 2 as a classification problem.
- Treat both as regression problems.



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Machine Learning

Introduction

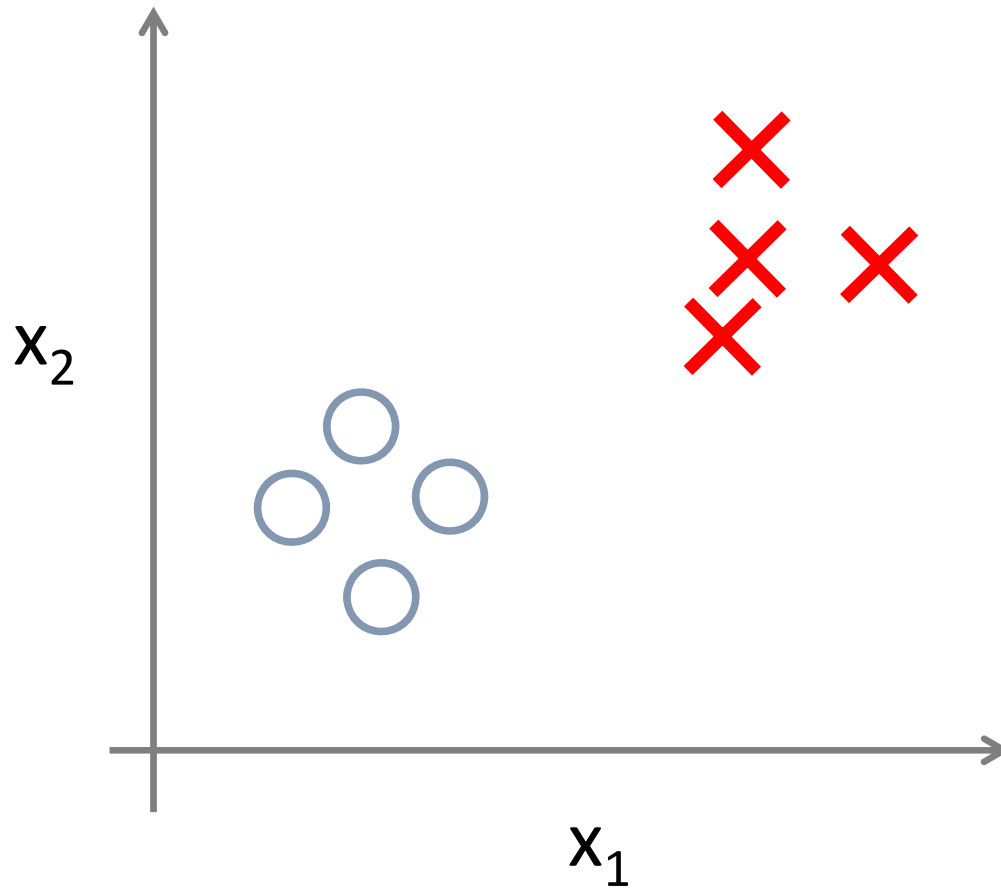
Unsupervised Learning

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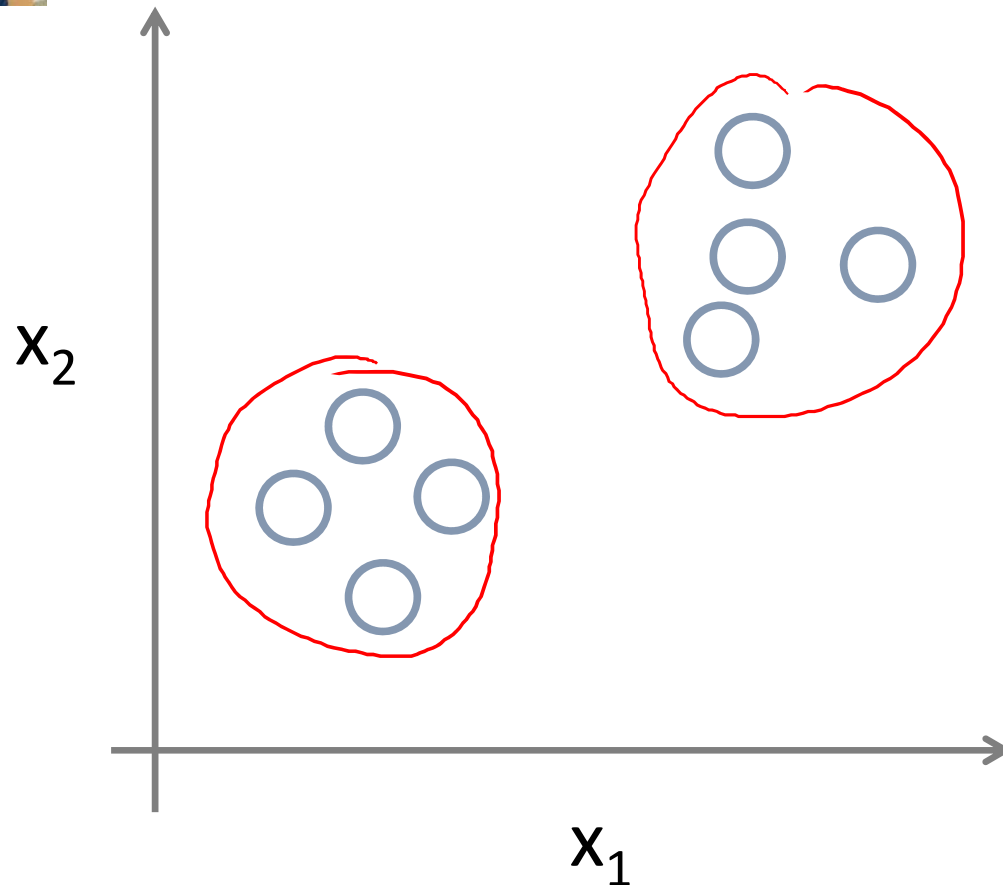
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Supervised Learning





Unsupervised Learning



Clustering Problem:

- For example, if a new data came in (after the model trained), we expect the model tell us, the new data belongs to which cluster?
- Or even tell us new data belongs partially to which cluster?! For example 40% to first cluster and 60% to second cluster.



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Clustering Example

Like google news, Instagram, Youtube or any other search engine:

When you look for something, it suggests you the things that classified in same cluster.

The screenshot shows the Google News interface. A red arrow points to the search bar. A red box highlights a cluster of news articles related to the BP oil well disaster, including headlines like "BP Oil Well, Site of National Catastrophe, Dies at One" and "US Stocks Climb After Recession Called Over, Homebuilders Gain".

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A screenshot of the Google News website. The search bar contains the text "BP Oil Well". The search results are displayed in a grid format. The top story is titled "White House official denies Tea Party-focused ad campaign". Below it, another story is titled "BP Oil Well, Site of National Catastrophe, Dies at One". This story is highlighted with a red box. Other stories include "Recession officially ended in June 2009", "Hurricane Igor lashes Bermuda", and "US Stocks Climb After Recession Called Over, Homebuilders Gain".

A screenshot of The Wall Street Journal website. The article title is "BP Kills Macondo, But Its Legacy Lives On". The author is James Hiron. The article text begins with "BP confirmed late Sunday that the Macondo well that leaked almost five million barrels of oil into the Gulf of Mexico has been permanently sealed, but the well will continue to affect BP and the wider oil industry for many years." There is a large image of an oil rig on fire. The article is part of "THE SOURCE" section.

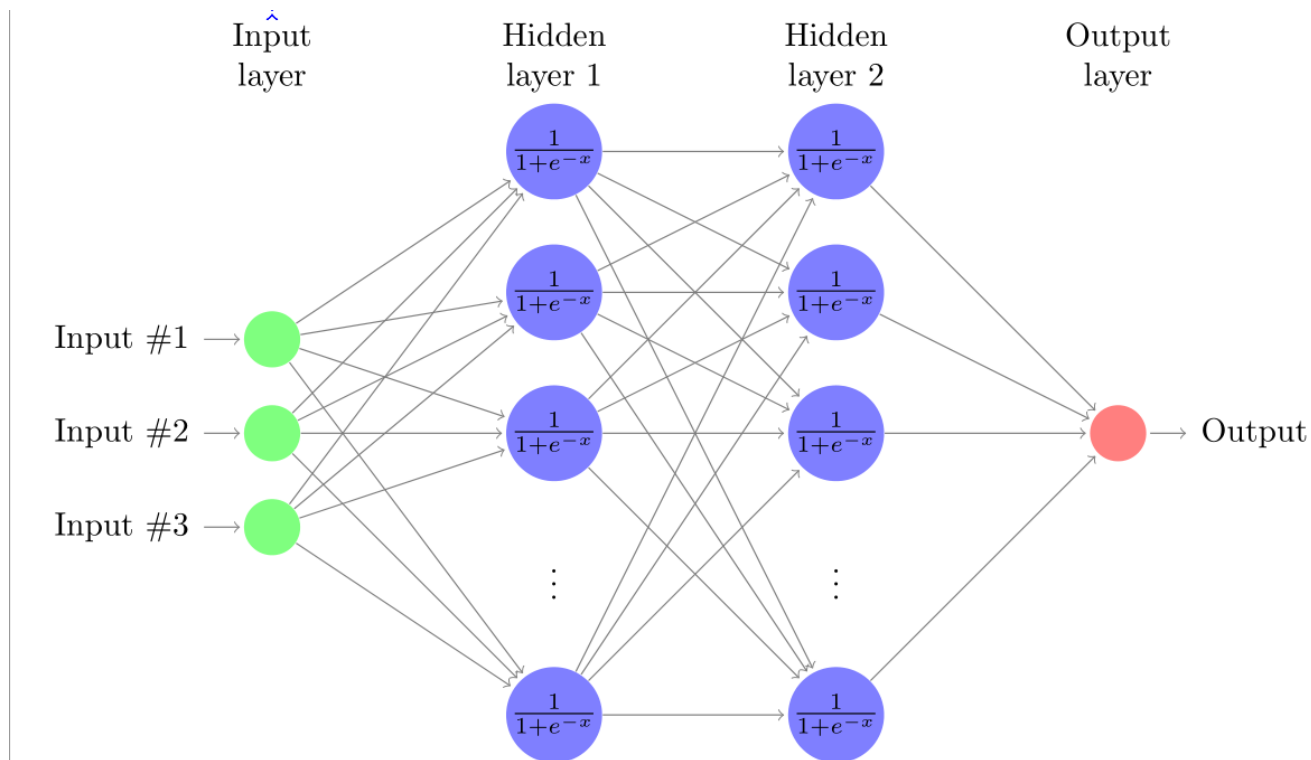
A screenshot of the CNN website. The article title is "Allen: Well is dead, but much Gulf Coast work remains". The author is "By the CNN Wire Staff". The article text begins with "The BP oil well, site of the Deepwater Horizon explosion that led to the worst oil spill in US history, died today at one year old." There is a video player showing an oil rig on fire. The article is dated September 20, 2010.

A screenshot of the Guardian website. The article title is "BP oil spill cost hits nearly \$10bn". The author is Julia Kollwe. The article text begins with "BP has set up a \$20bn compensation fund after the Deepwater Horizon disaster, which has so far paid out 19,000 claims totalling more than \$240m." There is a large image of an oil rig on fire. The article is dated Monday 20 September 2010.

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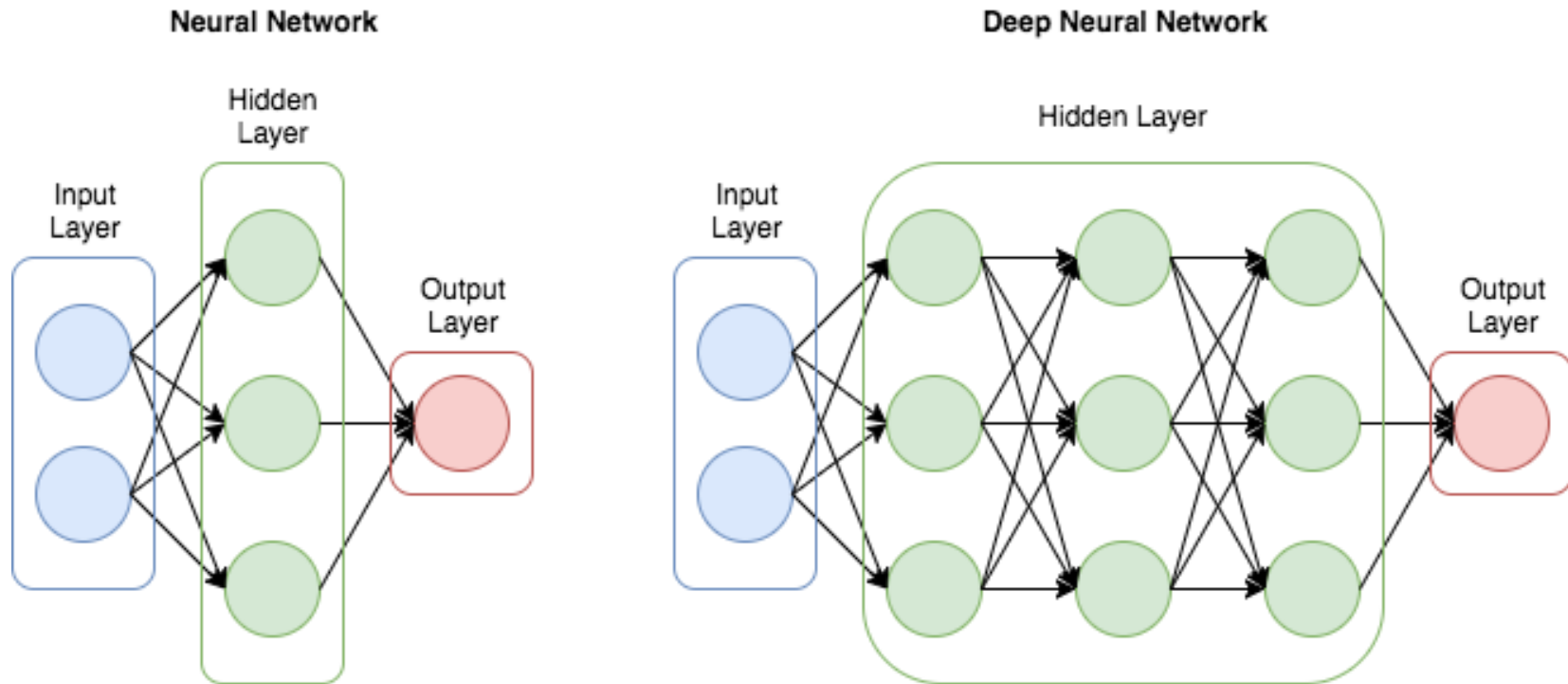
How Neural Network, works?



There is no explicit mathematical model in hidden layers and the weight of neurons will update in each training process.

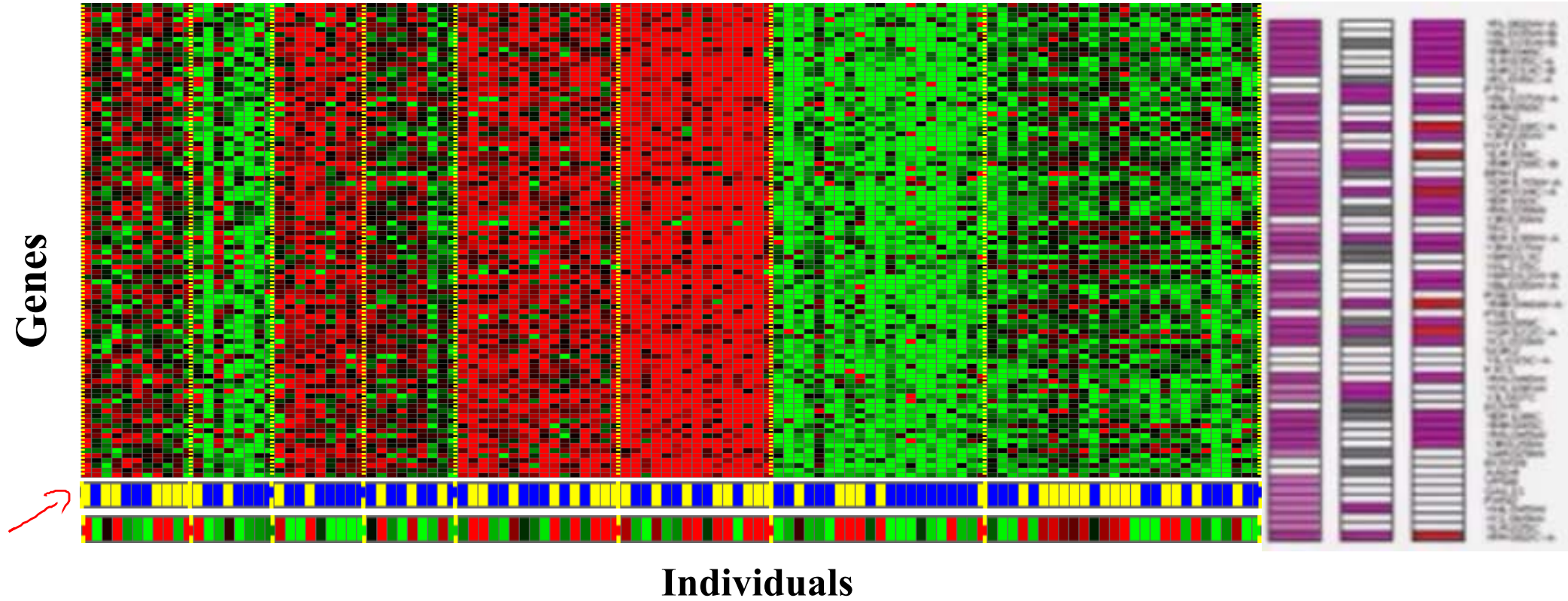


How Neural Network, works?



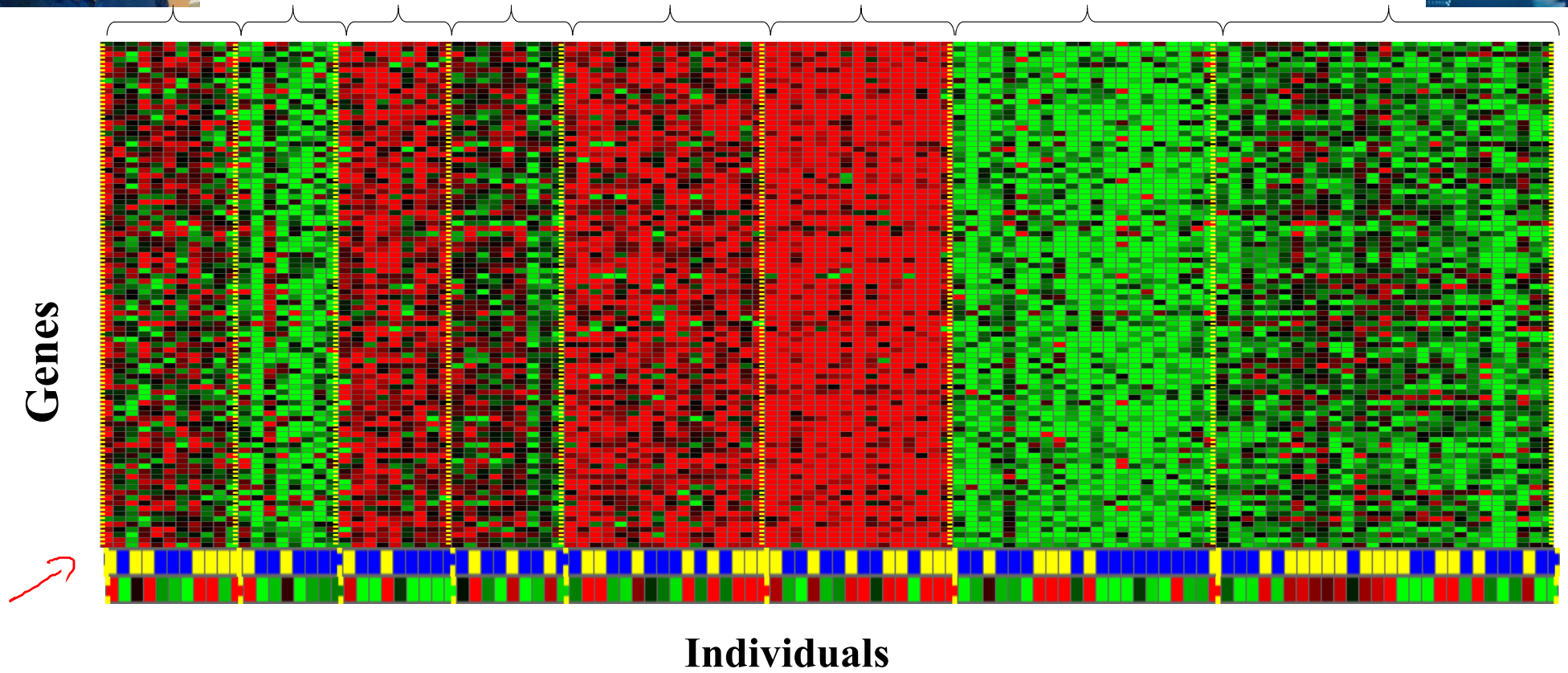


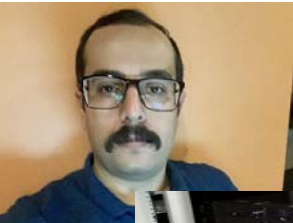
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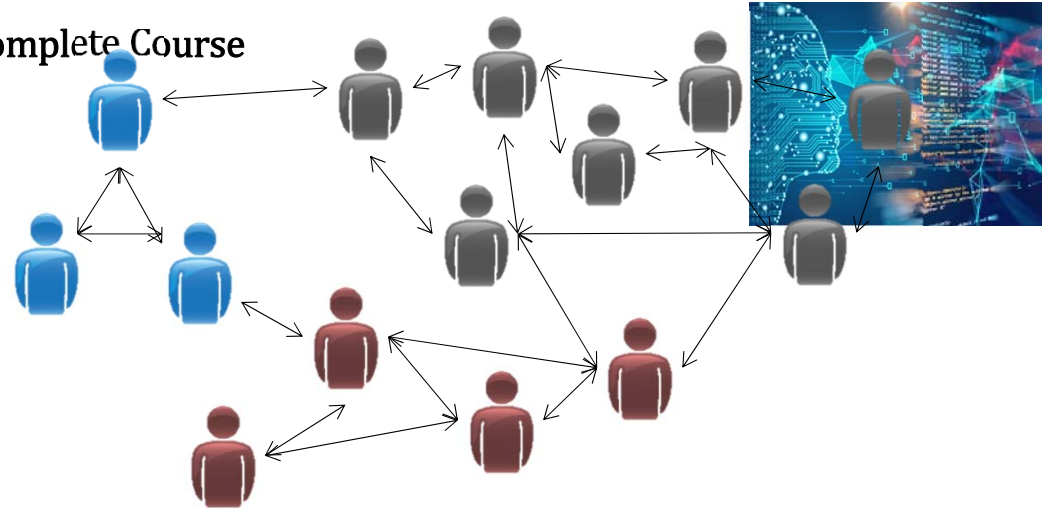




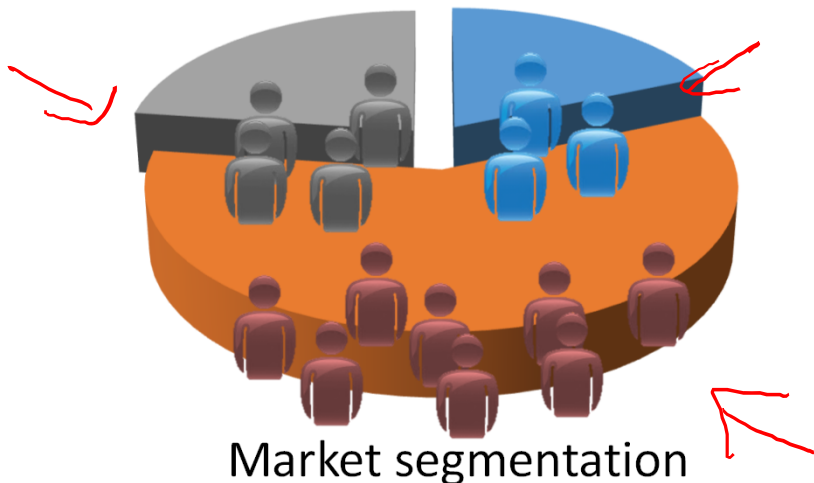
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Organize computing clusters



Social network analysis



Market segmentation

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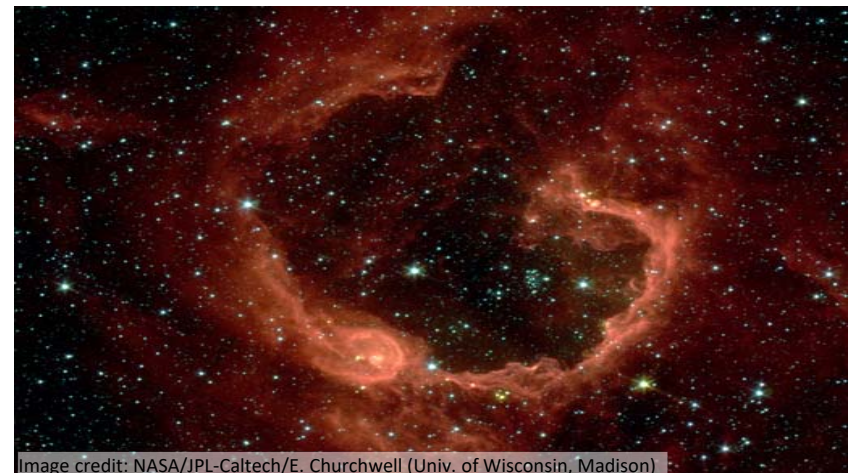
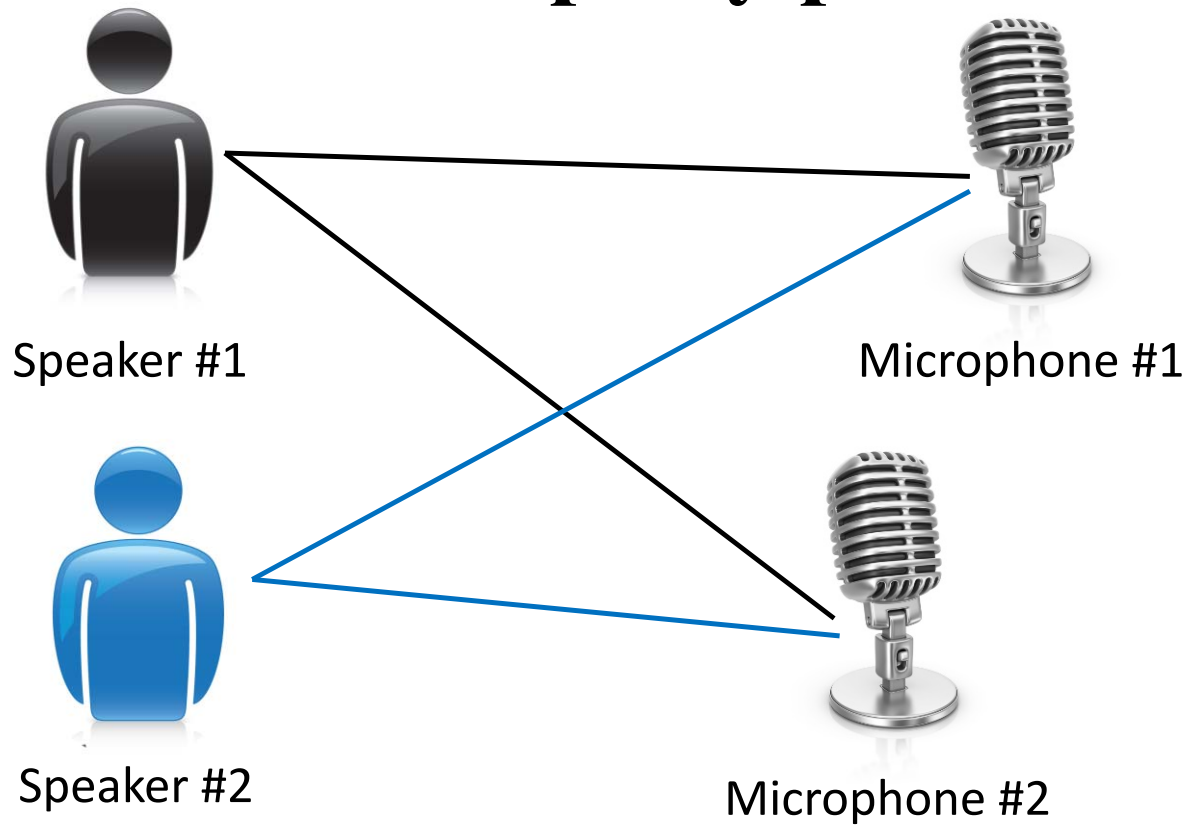


Image credit: NASA/JPL-Caltech/E. Churchwell (Univ. of Wisconsin, Madison)

Astronomical data analysis



Cocktail party problem





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Microphone #1: 🔊

Output #1: 🔊

Microphone #2: 🔊

Output #2: 🔊

Microphone #1: 🔊

Output #1: 🔊

Microphone #2: 🔊

Output #2: 🔊



Cocktail party problem algorithm

$$[W,s,v] = \text{svd}(\text{ repmat}(\text{sum}(x.*x,1),\text{size}(x,1),1).*x)*x');$$

[Source: Sam Roweis, Yair Weiss & Eero Simoncelli]



Of the following examples, which would you address using an unsupervised learning algorithm? (Check all that apply.)

Given email labeled as spam/not spam, learn a spam filter.

Given a set of news articles found on the web, group them into set of articles about the same story.

Given a database of customer data, automatically discover market segments and group customers into different market segments.

Given a dataset of patients diagnosed as either having diabetes or not, learn to classify new patients as having diabetes or not.

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**THANK YOU FOR
YOUR ATTENTION!**

You can keep in touch with me for any other possible helps or workshops, via:

Emails: a.mohamadijoo@gmail.com & info@abolfazlm.com

Mobile No: 09124908372