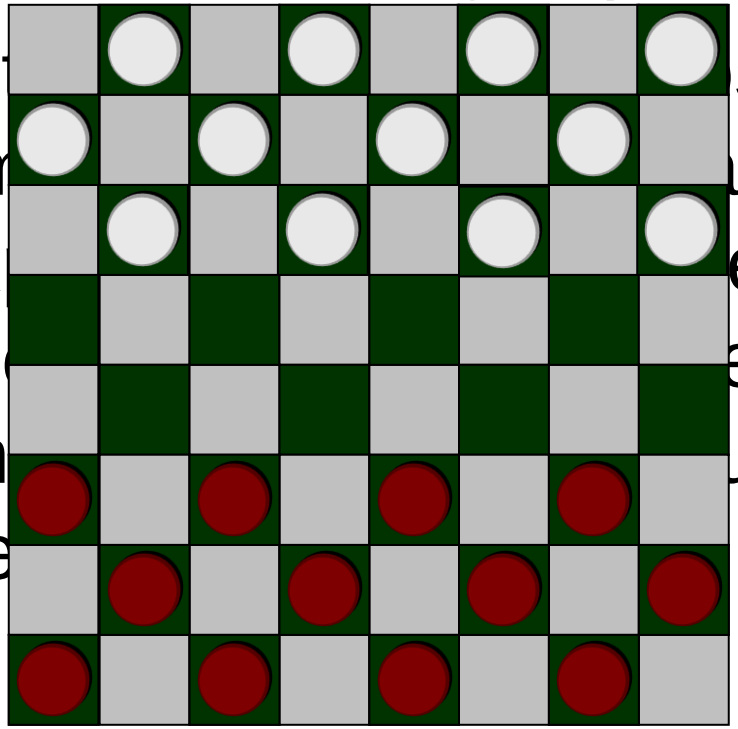
Machine Learning

Machine Learning definition

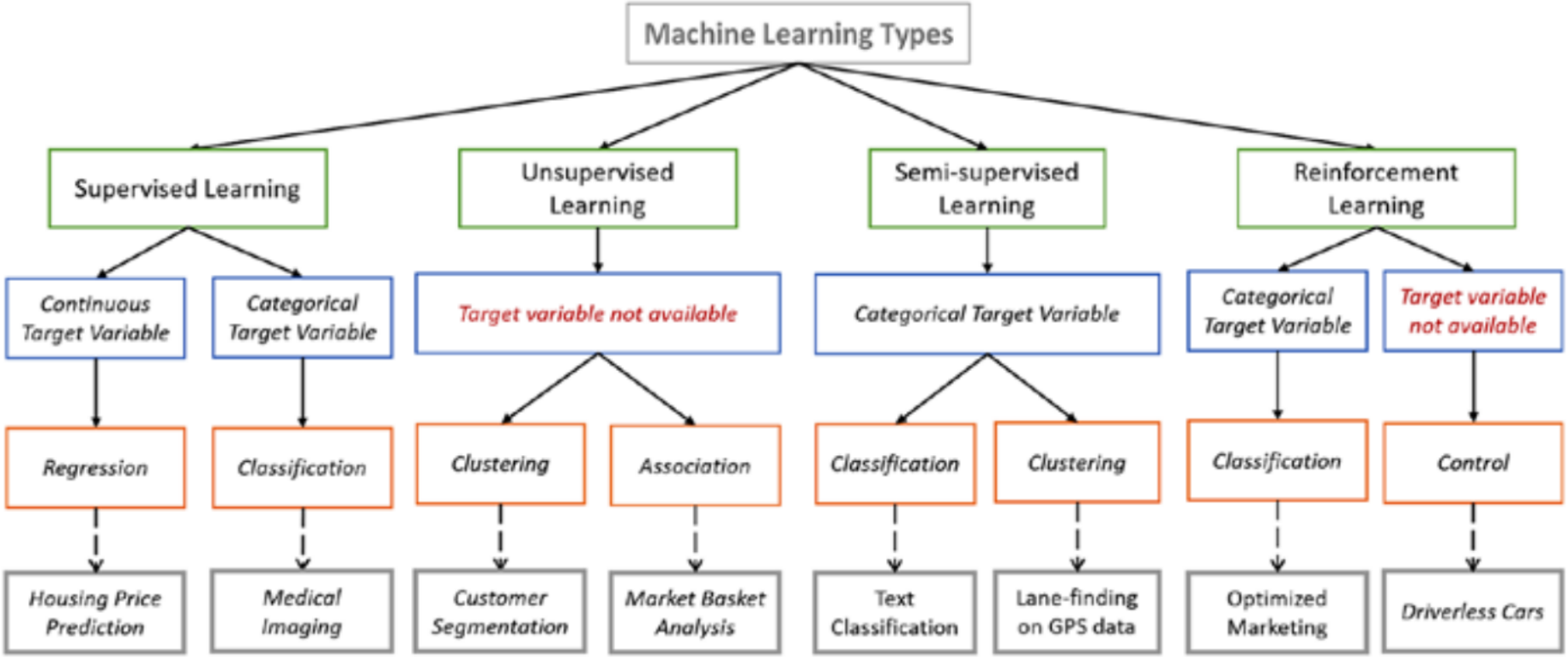
- Arthur Samuel (1959). Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.
- Tom Mi sed Learning Problem m is said to *learn* from ex ect to some task T and s easure P, if its perform ured by P, improve



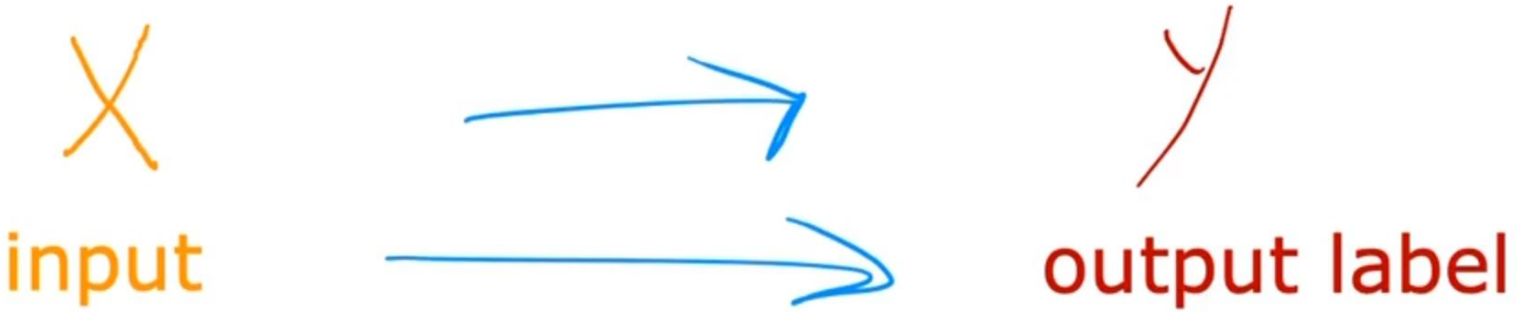
Question

If the checkers program had been allowed to play only ten games (instead of tens of thousands) against itself, a much smaller number of games, how would this have affected its performance?

- ○ Would have made it better
- ○ Would have made it worse


Machine Learning Types
Supervised Learning
Unsupervised Learning
Semi-supervised Learning
Reinforcement Learning
Continuous Target Variable
Categorical Target Variable
Target variable not available
Categorical Target Variable
Categorical Target Variable
Target variable not available
Regression
Classification
Clustering
Association
Classification
Clustering
Classification
Control
Housing Price Prediction
Medical Imaging
Customer Segmentation
Market Basket Analysis
Text Classification
Lane-finding on GPS data
Optimized Marketing
Driverless Cars

Supervised learning



Learns from being given "right answers"

Supervised learning, refers to algorithms that learn x to y or input to output mappings. The key characteristic of supervised learning is that you give your learning algorithm examples to learn from. That includes the right answers, whereby right answer, I mean, the correct label y for a given input x, and is by seeing correct pairs of input x and desired output label y that the learning algorithm eventually learns to take just the input alone without the output label and gives a reasonably accurate prediction or guess of the output.

Supervised Learning

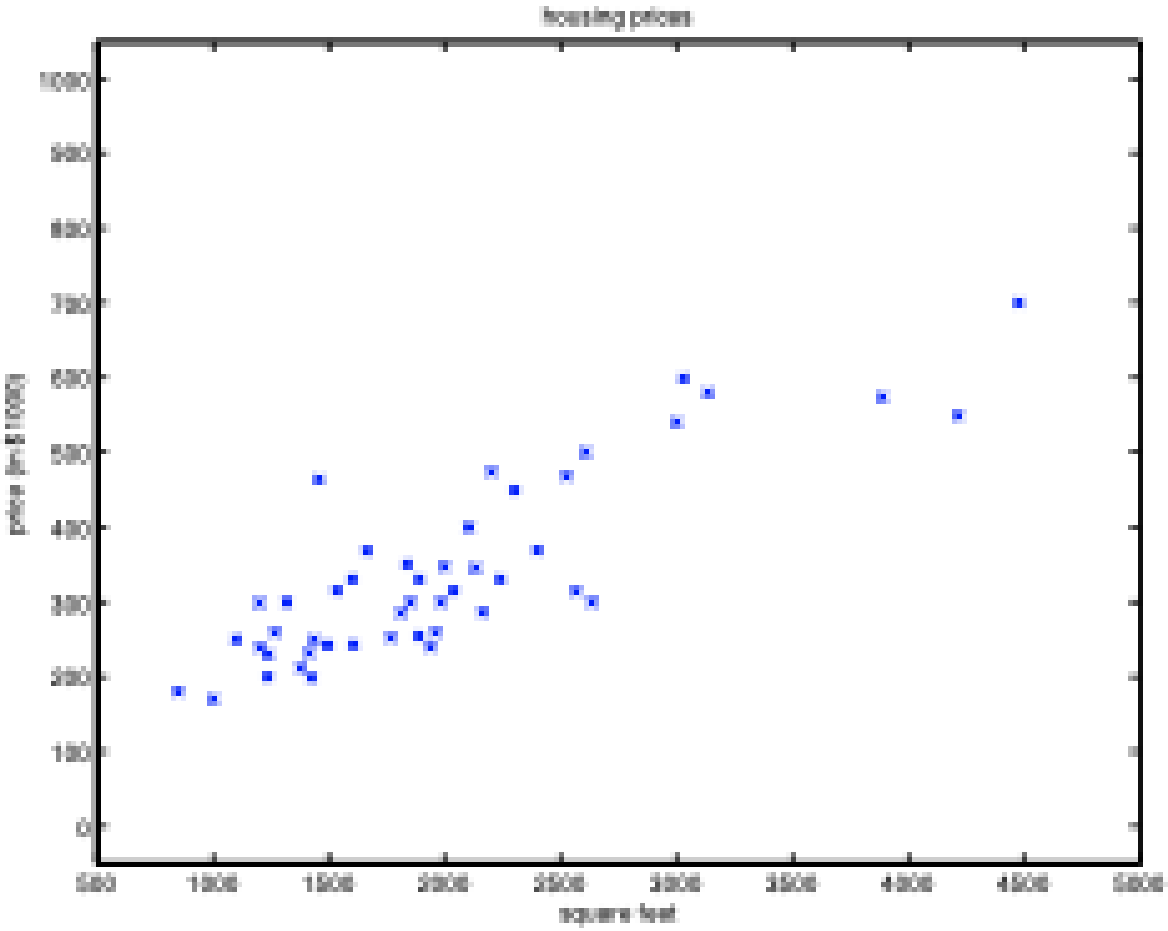
Input (X)	Output (Y)	Application
email	spam? (0/1)	spam filtering
audio	text transcripts	speech recognition
English	Spanish	machine translation
ad, user info	click? (0/1)	online advertising
image, radar info	position of other cars	self-driving car
image of phone	defect? (0/1)	visual inspection

Supervised Learning

Let's start by talking about a few examples of supervised learning problems. Suppose we have a dataset giving the living areas and prices of 47 houses from Portland, Oregon:

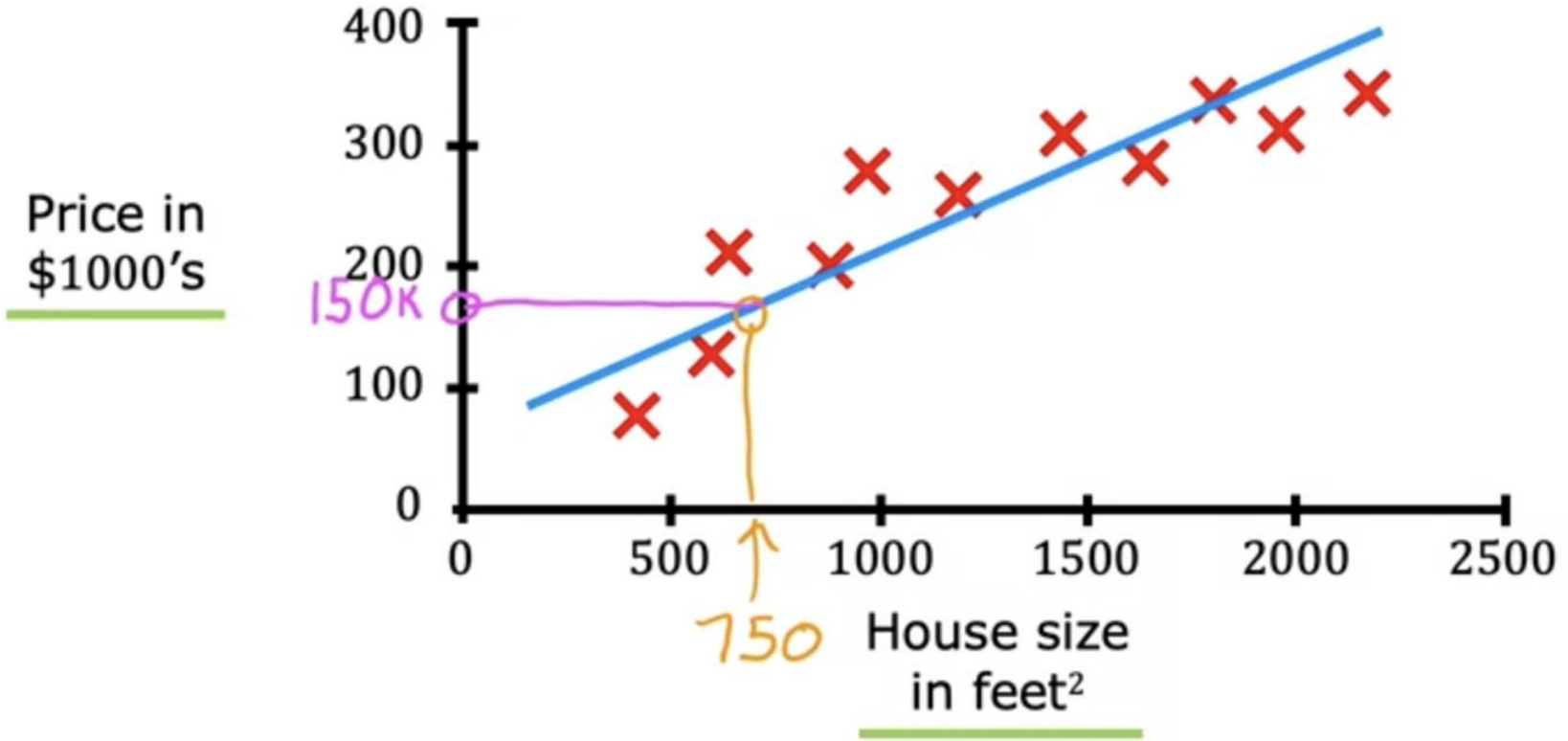
Living area (feet^2)	Price (1000$s)
2104	400
1600	330
2400	369
1416	232
3000	540
⋮	⋮

We can plot this data:

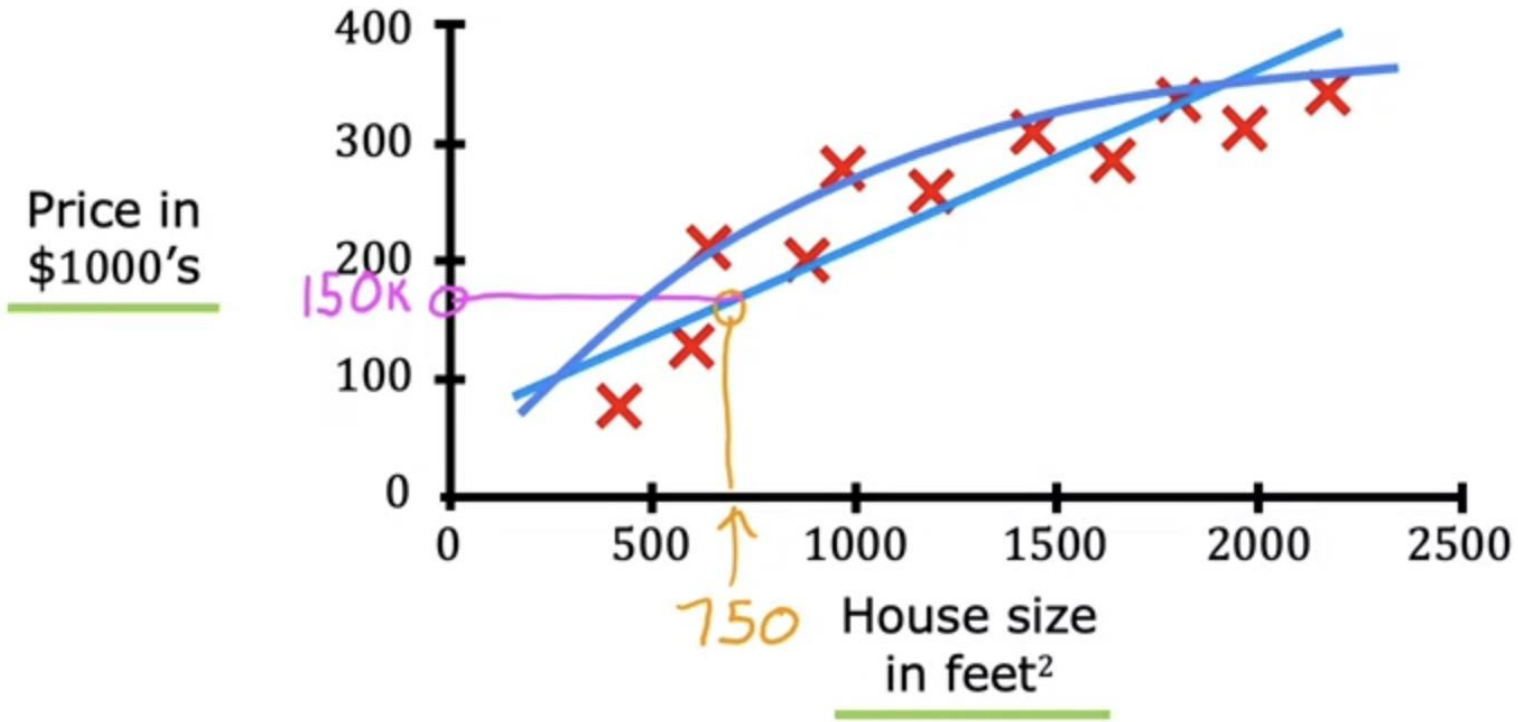


Continuous values – Regression Problem

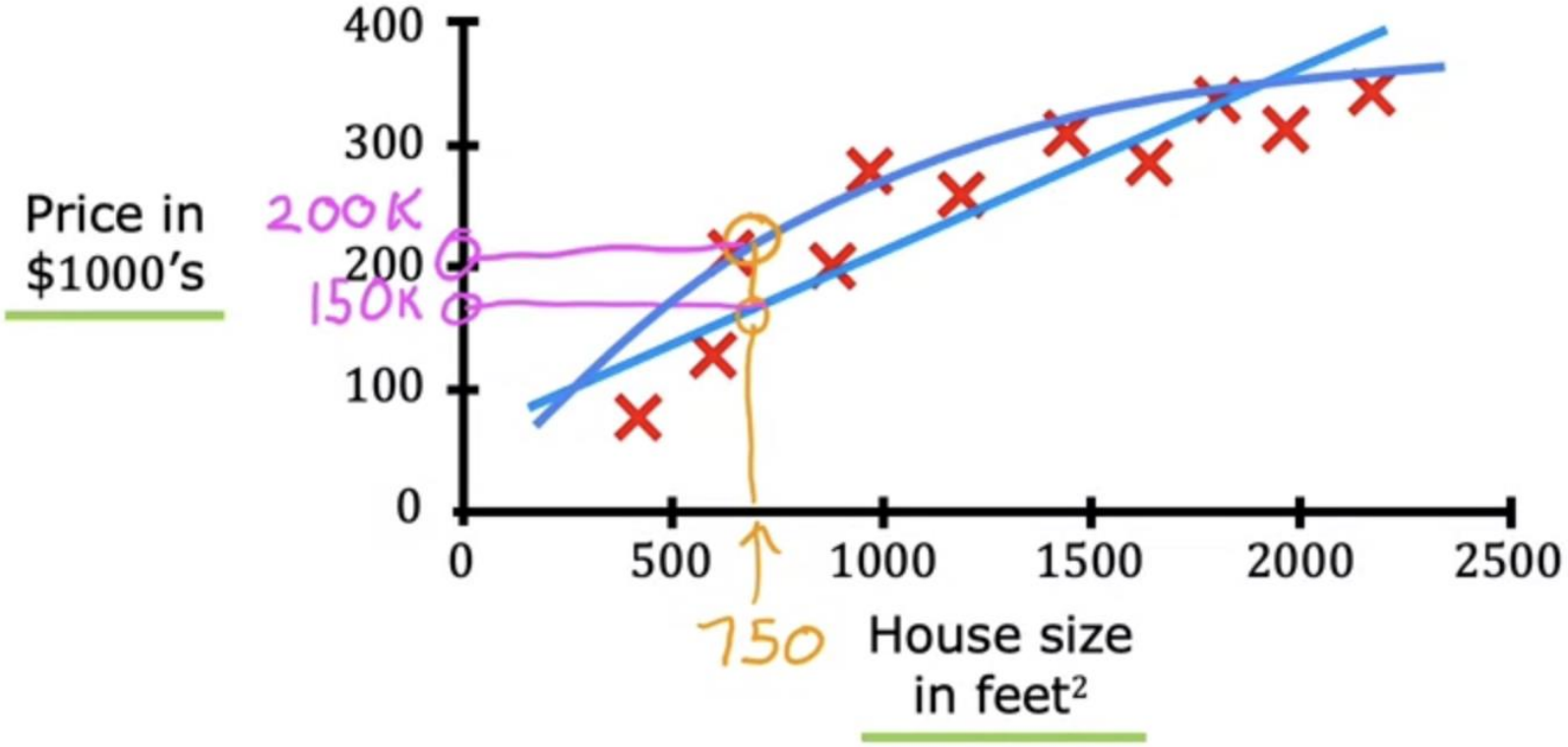
Regression: Housing price prediction



Regression: Housing price prediction

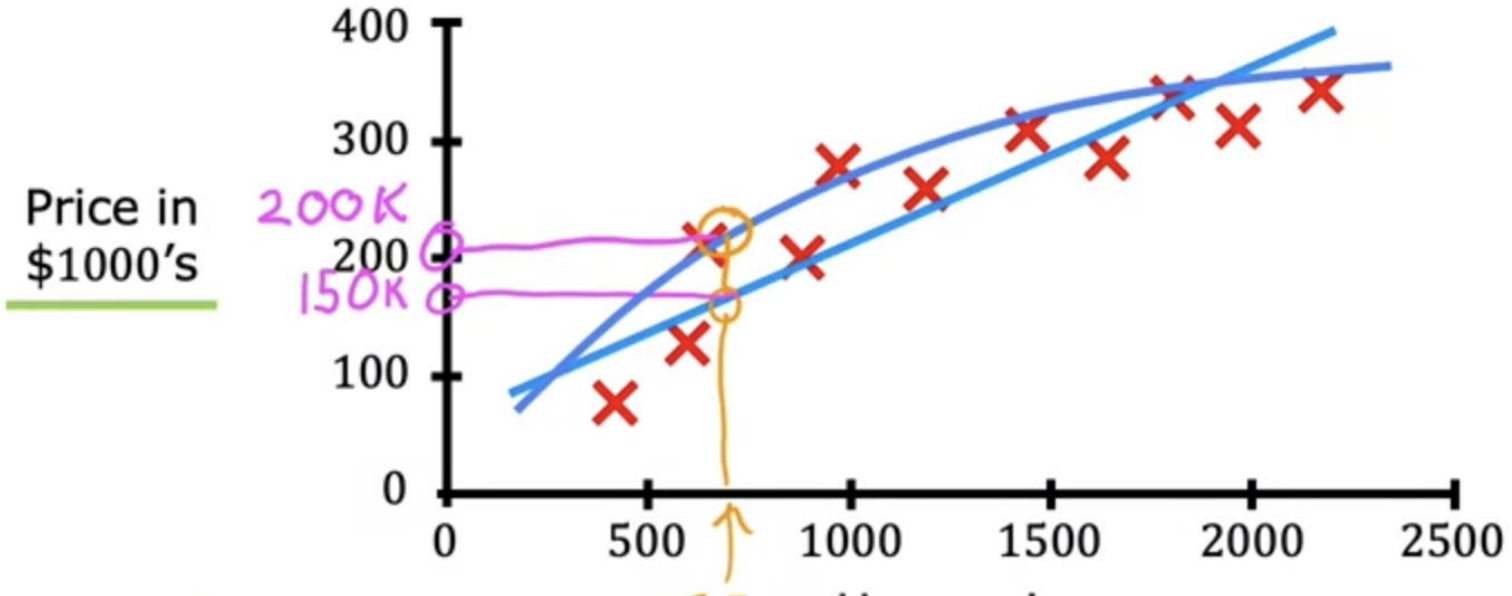


Regression: Housing price prediction



One of the things you see later in this class is how you can decide whether to fit a straight line, a curve, or another function that is even more complex to the data. Now, it doesn't seem appropriate to pick the one that gives your friend the best price, but one thing you see is how to get an algorithm to systematically choose the most appropriate line or curve or other thing to fit to this data.

Regression: Housing price prediction



Regression

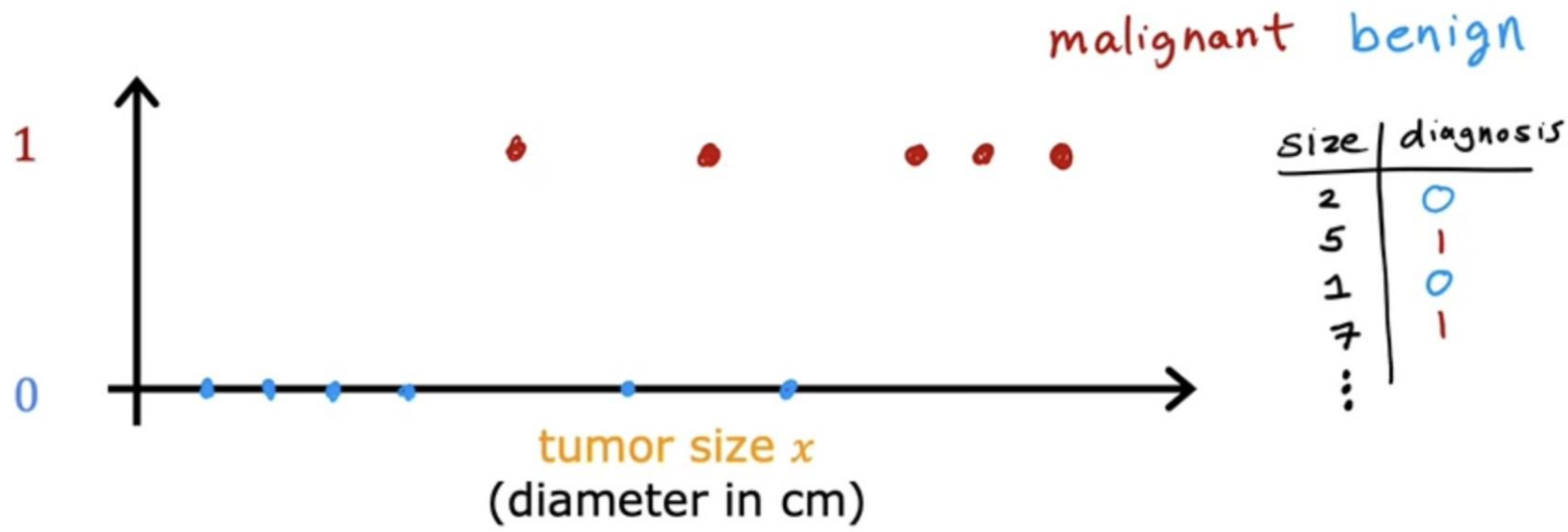
Predict a number

infinitely many possible outputs

- **Goal is to map a relationship between x and y**
- **The value y, which we need to predict, is continuous. Therefore, it is a regression problem.**

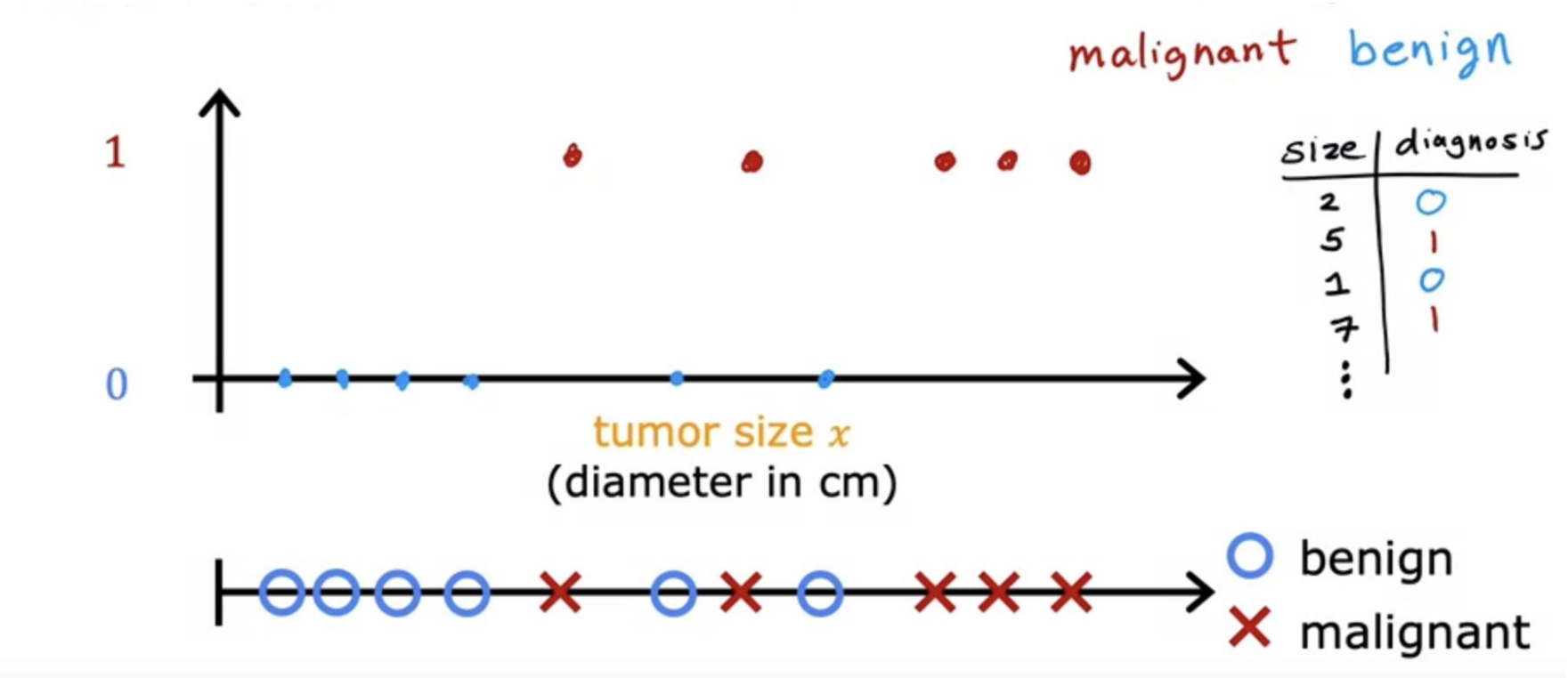
[Video courtesy Dean Pomerleau.]

Supervised Learning – Classification Problem

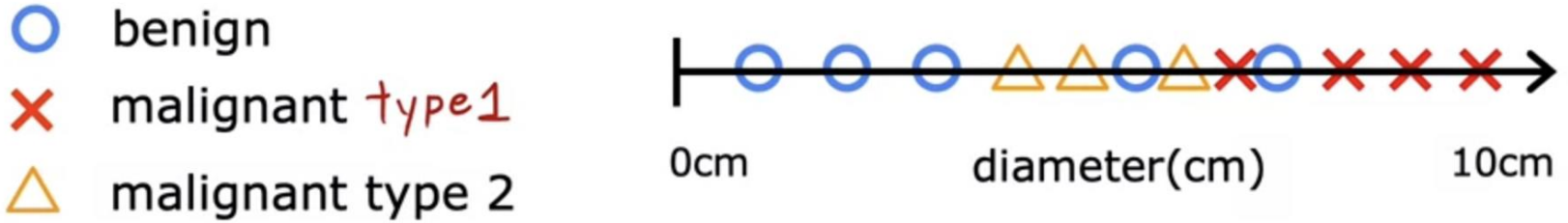


Discrete values – Classification problem
For example - 5 types of different cancers – discrete value

Cancer Detection



Cancer Detection



class category

Classification

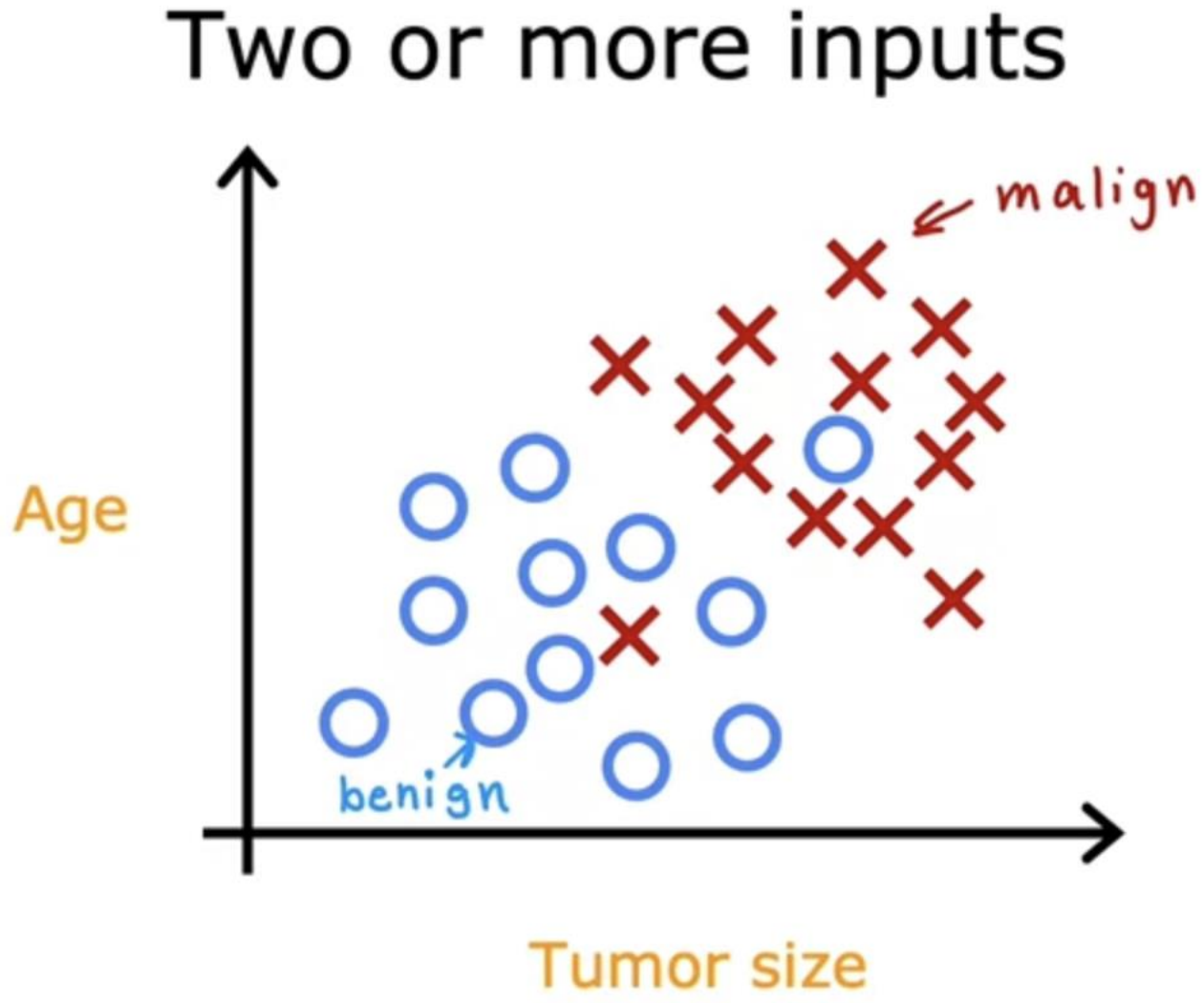
predict categories cat dog benign malignant 0, 1, 2

small number of possible outputs

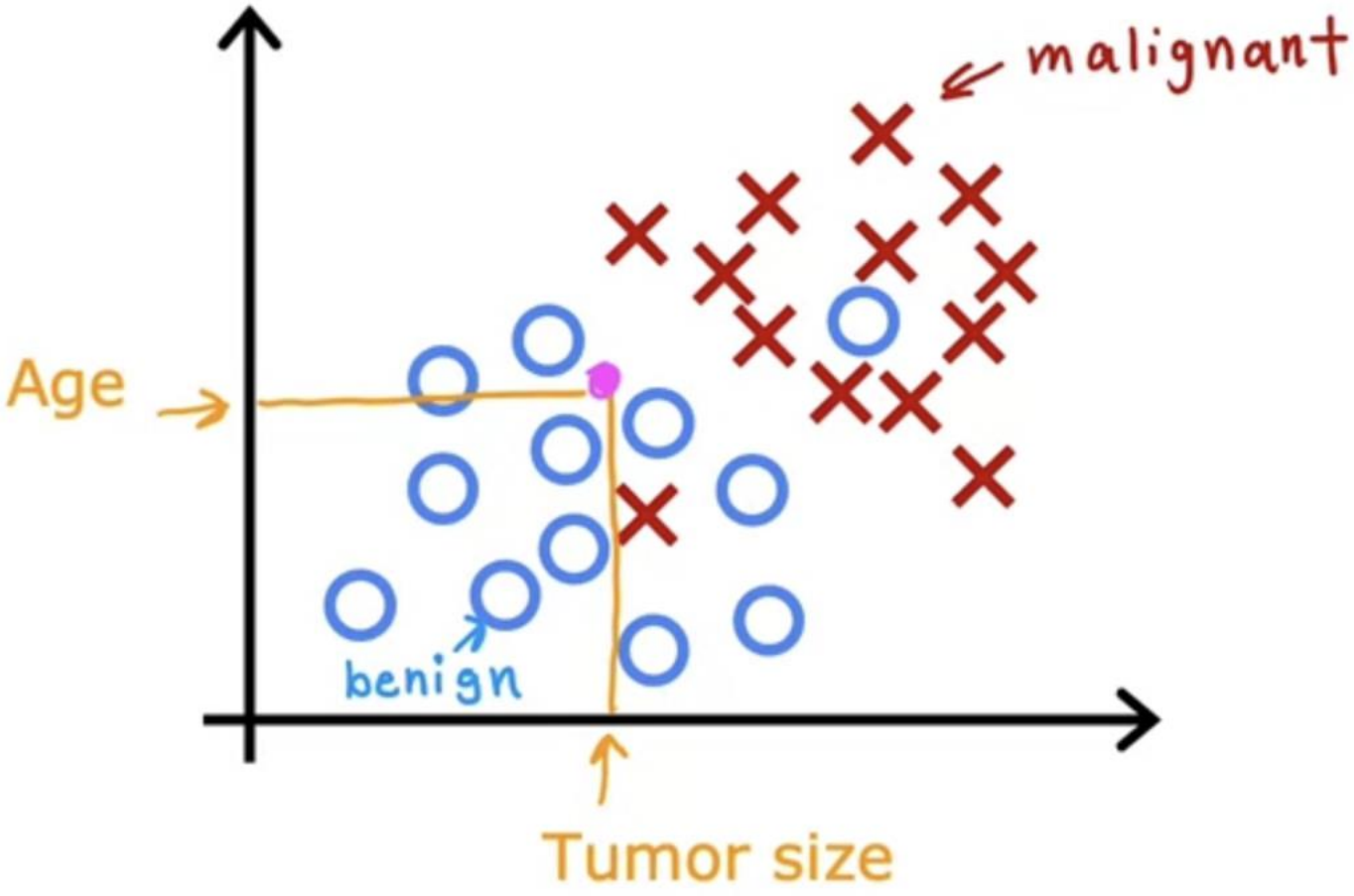
Single value of x -> Single feature
Multiple values of x -> Multi feature (Support Vector Machine uses infinite no of features or dimension vector) – Computers have limited memory

For example – Tumor size and age of the patient – Logistic regression algorithm
We cannot plot the data higher than three dimension

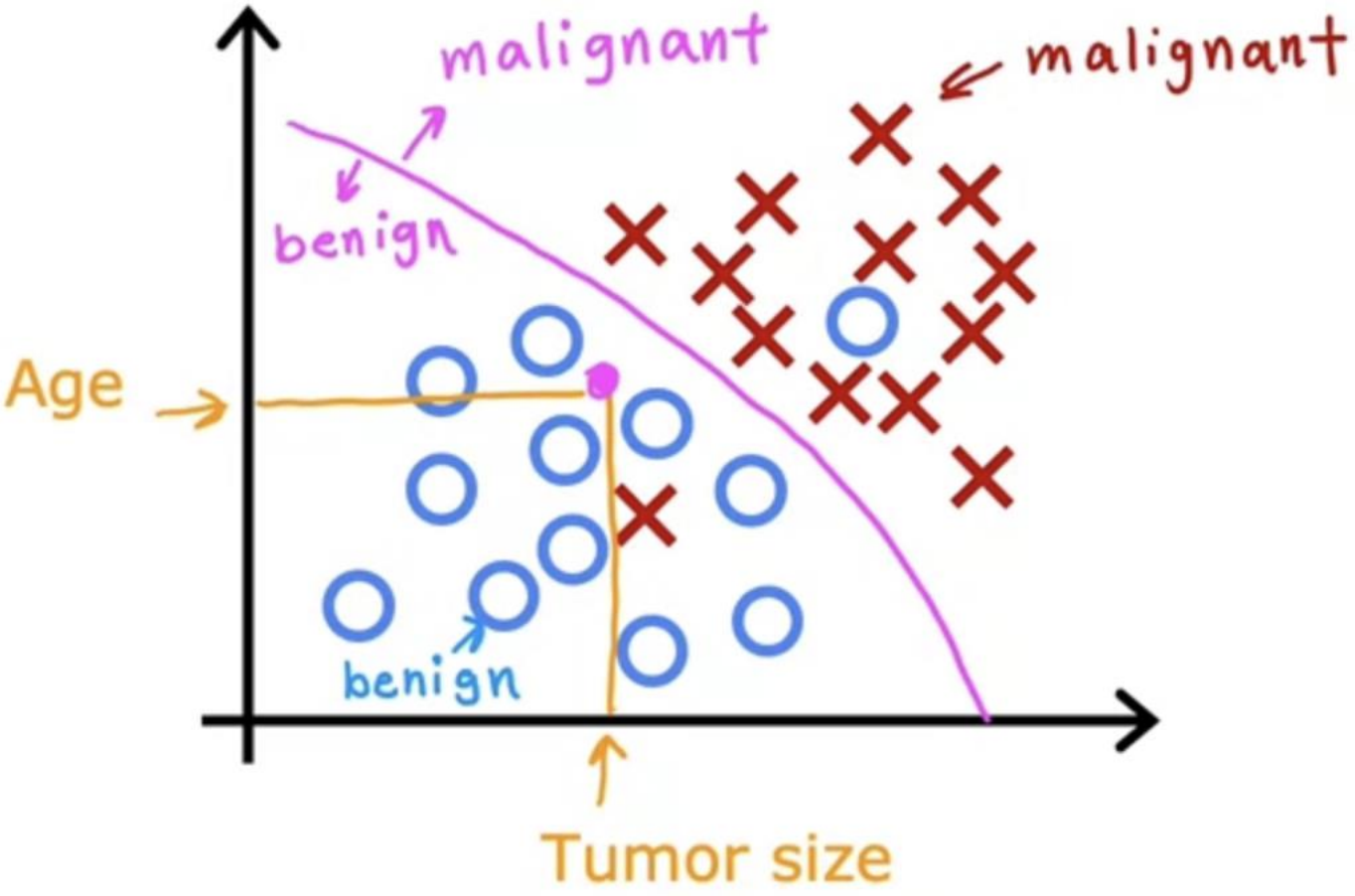
The state of the patient is represented by one or two or multiple features



Two or more inputs



Two or more inputs



The job of the learning algorithm has to decide how to fit a boundary line through this data. The boundary line found by the learning algorithm would help the doctor with the diagnosis.

Supervised learning

Learns from being given "right answers"

Regression

Predict a number

infinitely many possible outputs

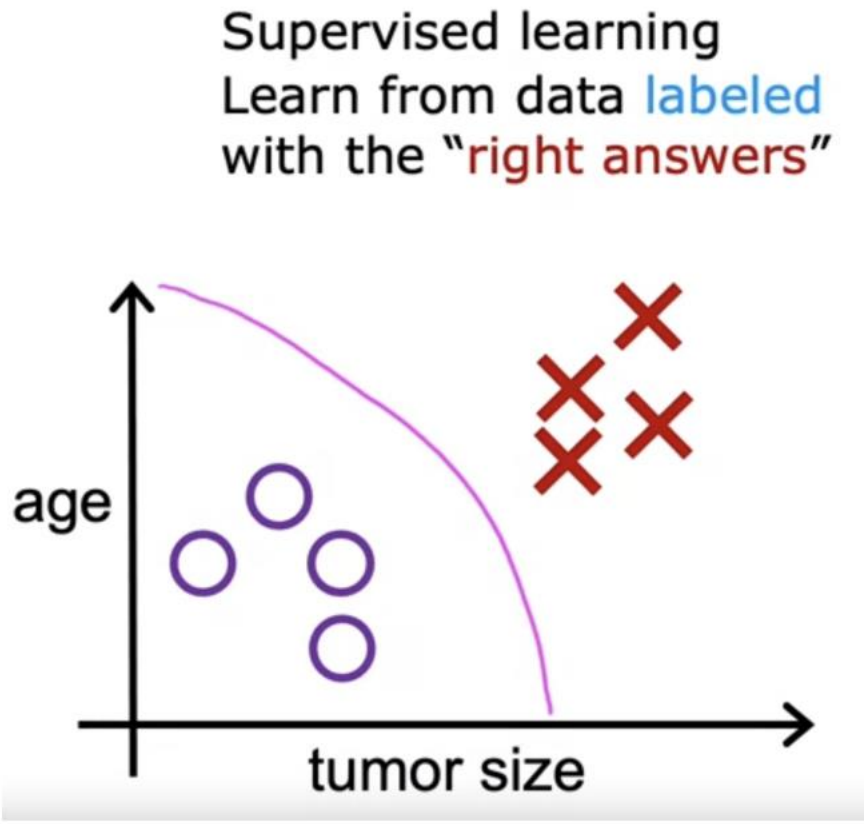
Classification

predict categories

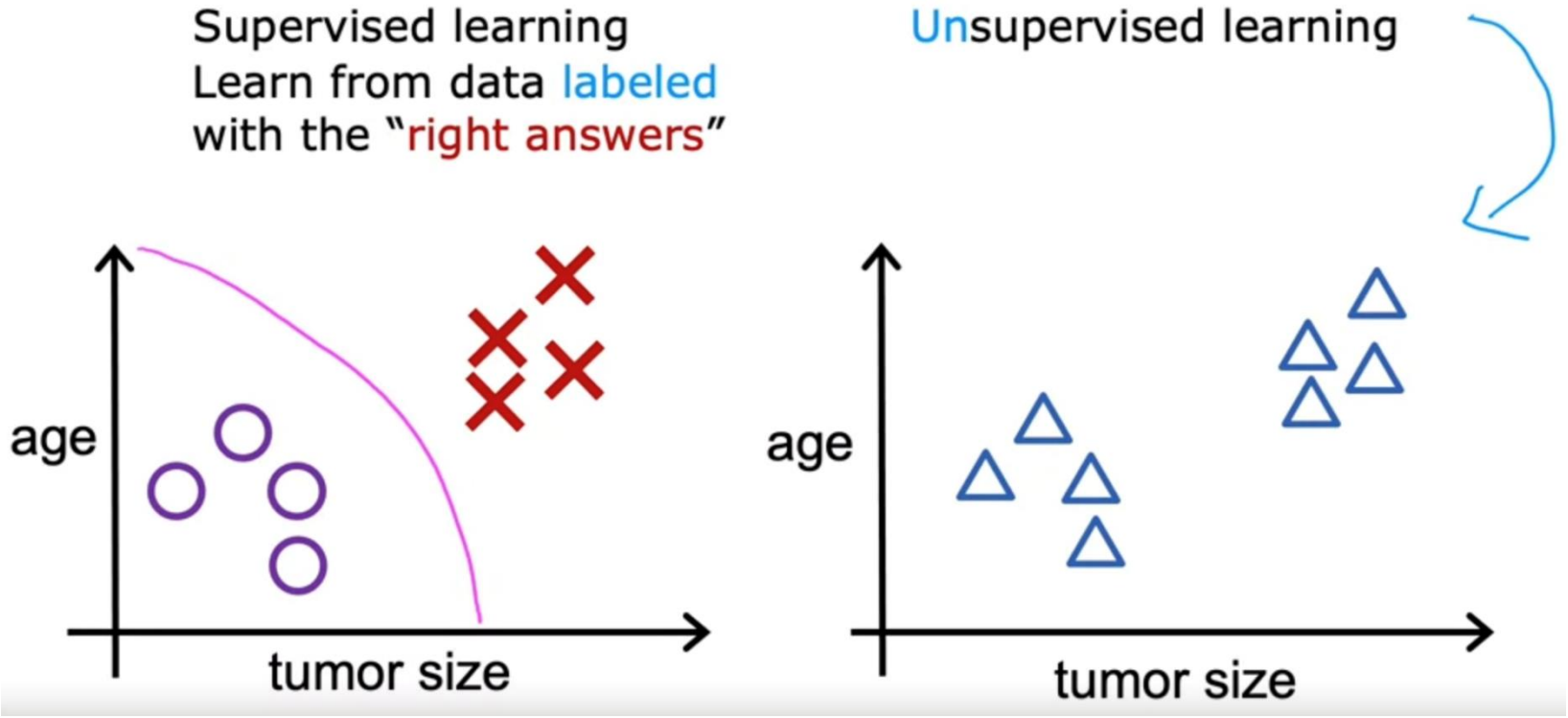
small number of possible outputs

Unsupervised Learning

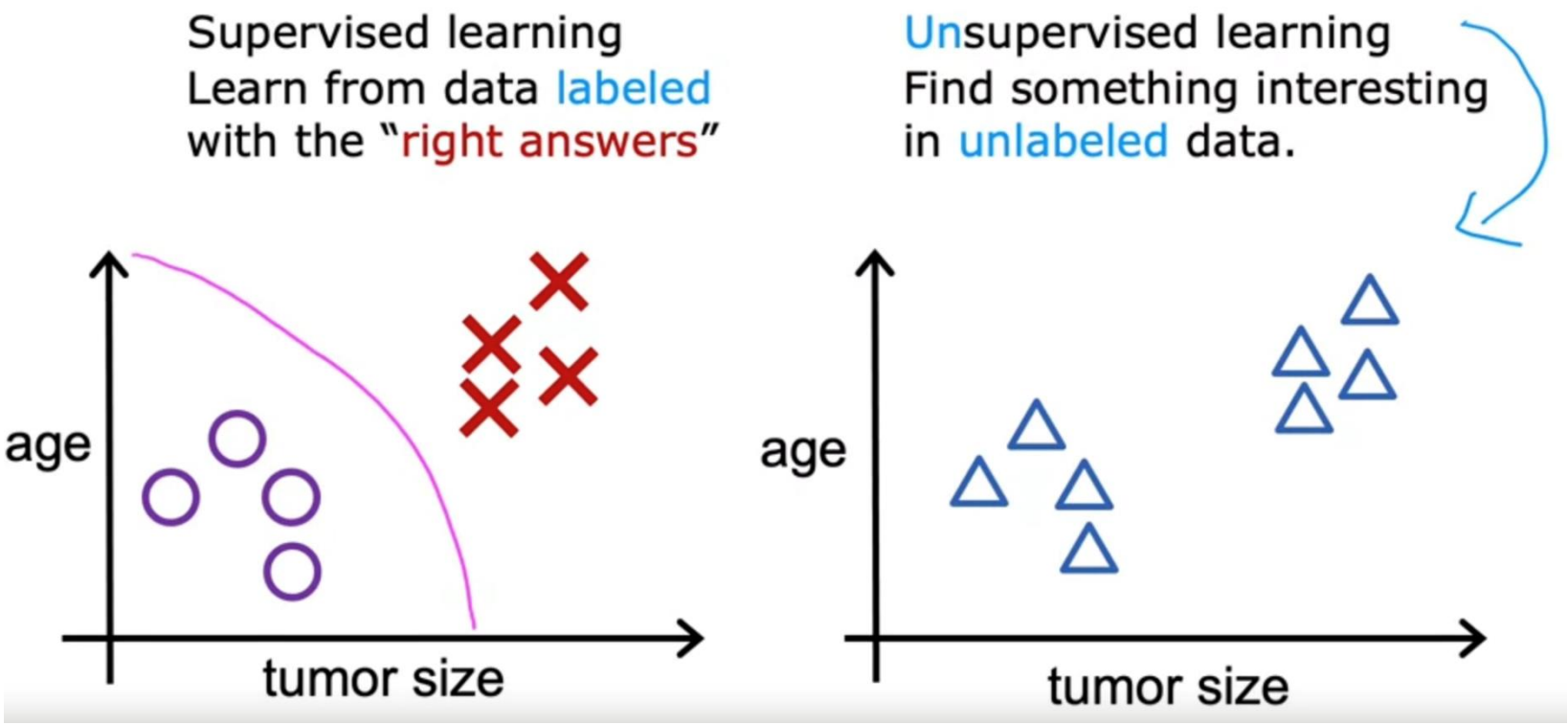
Input is given, hoverer, no output variable for mapping
For example - Google news



Each example, was associated with an output label y such as benign or malignant, designated by the poles and crosses.

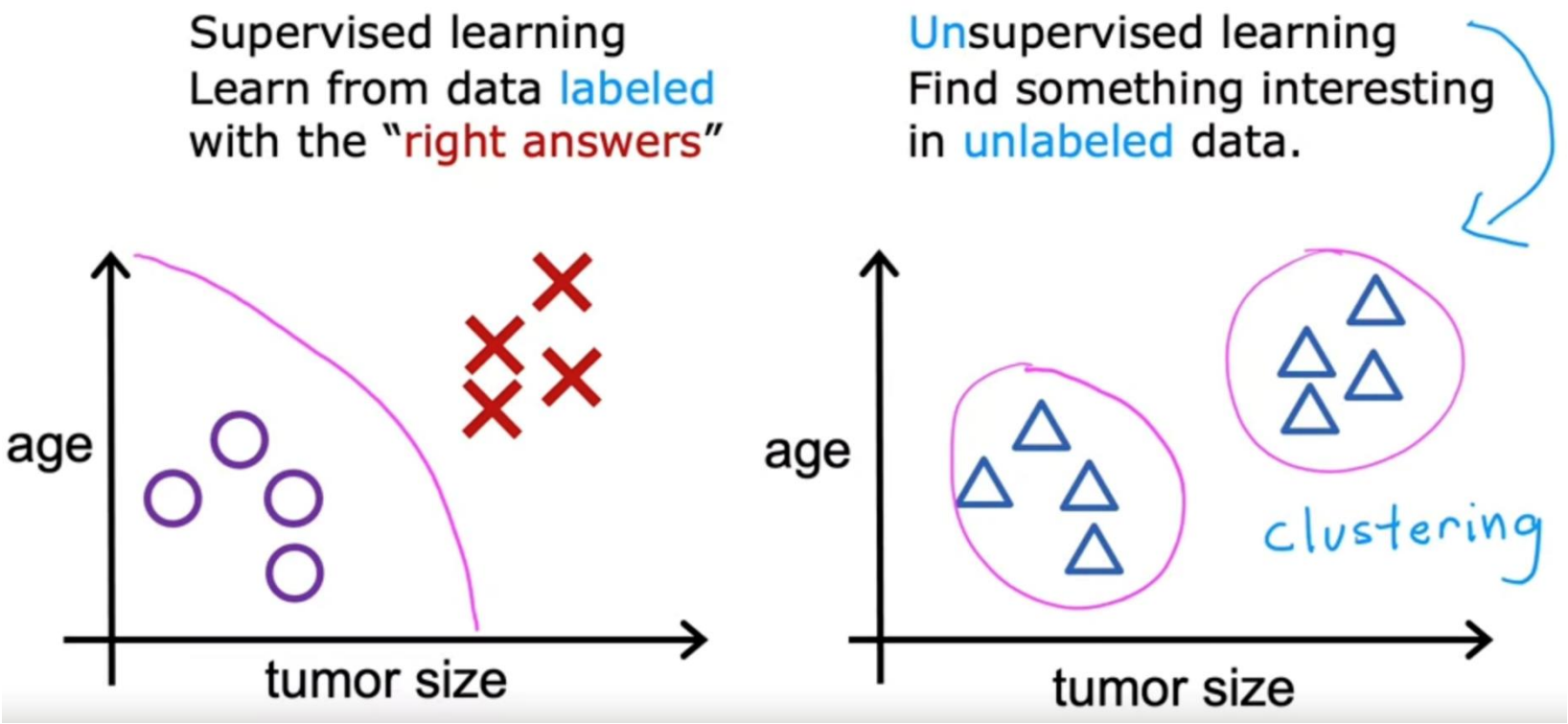


In unsupervised learning, the given data that isn't associated with any output labels y, say you're given data on patients and their tumor size and the patient's age. But not whether the tumor was benign or malignant, so the dataset looks like this on the right. We're not asked to diagnose whether the tumor is benign or malignant, because we're not given any labels instead, **our job is to find some structure or some pattern or just find something interesting in the data.**



This is unsupervised learning, we call it unsupervised because we're not trying to supervise the algorithm. To give some right answer for every input, instead, we asked the algorithm to figure out all by yourself what's interesting. Or what patterns or structures that might be in this data, with this particular data set.

An unsupervised learning algorithm, **might decide that the data can be assigned to two different groups or two different clusters**.



This is a particular type of unsupervised learning, called a **clustering algorithm**. Because it places the unlabeled data, into different clusters and this turns out to be used in many applications.

Google News

news.google.com

Web Images Videos Maps **News** Shopping Gmail more ▼ | Web History | Settings ▼ | Sign out

Google news

Search News | Search the Web

Advanced news search

U.S. edition ▼ Add a section »

Top Stories
- Deepwater Horizon
- Fed meeting
- Foreign exchange market
- Lindsay Lohan
- IBM
- Tom Brady
- Toronto International Film Festival
- Paris Hilton
- Iran
- Hurricane Igor

Starred
San Francisco Bay Area
World
U.S.
Business
Sci/Tech
More Top Stories
Spotlight
Health
Sports
Entertainment

All news
Headlines
Images

Top Stories

Christine O'Donnell »

White House official denies Tea Party-focused ad campaign

CNN International - Ed Henry - 1 hour ago

Democratic sources say the White House is not considering an ad campaign tying Republicans to the Tea Party. Washington (CNN) -- A top White House official sharply denied a report that claims President Obama's political advisers are weighing a national ...

Tea Party is misplacing the blame, former President Bill Clinton claims New York Daily News

GOP tea party backer defends Christine O'Donnell The Associated Press

Atlanta Journal Constitution - Politics Daily - MyFox Washington DC - Salon

all 726 news articles »

US Stocks Climb After Recession Called Over, Homebuilders Gain

MarketWatch - Kristina Peterson - 16 minutes ago

NEW YORK (MarketWatch) -- US stocks climbed Monday, gaining speed after a key nonprofit organization officially called the recession over, giving investors a boost of confidence in the gradual economic recovery.

Longest recession since 1930s ended in June 2009, group says Los Angeles Times

Downturn Was Longest in Decades, Panel Confirms New York Times

Wall Street Journal - AFP - CNN - USA Today

all 276 news articles »

Deepwater Horizon »

BP Oil Well, Site of National Catastrophe, Dies at One

Vanity Fair - Juli Weiner - 22 minutes ago

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

Video: Blown-out BP Well Finally Killed in Gulf The Associated Press

Weiss Doubts BP Would End Operations in Gulf of Mexico Video Bloomberg

CNN International - Wall Street Journal (blog) - The Guardian - New York Times

all 2,292 news articles »

Recent

Recession officially ended in June 2009
CNNMoney - Chris Isidore - 39 minutes ago

Hurricane Igor lashes Bermuda
USA Today - Gerry Broome - 5 minutes ago

'Explain what you want from us,' reads front-page editorial
msnbc.com - Olivia Torres - 10 minutes ago

Crisis response: Pakistan floods

San Francisco Bay Area - Edit

Clorox »
Bay Biz Buzz: Clorox close to selling STP, Armor All
San Jose Mercury News - 48 minutes ago - all 24 articles »

Google's official beekeeper keeps the company buzzing with excitement
San Jose Mercury News - Bruce Newman - 1 hour ago

Jon Sylva »
Martinez man still unconscious as police investigate weekend shooting
San Jose Mercury News - Robert Salonga - 48 minutes ago - all 6 articles »

Spotlight

Sarkozy rages at EU 'humiliation'
Financial Times - Peggy Hollinger - Sep 15, 2010

Google News

news.google.com

Web Images Videos Maps **News** Shopping Gmail more ▾ | Web History | Settings ▾ | Sign out

Google news

Search News | Search the Web

Advanced news search

U.S. edition ▾ Add a section »

Top Stories
- Deepwater Horizon
- Fed meeting
- Foreign exchange market
- Lindsay Lohan
- IBM
- Tom Brady
- Toronto International Film Festival
- Paris Hilton
- Iran
- Hurricane Igor

Starred

San Francisco Bay Area

World

U.S.

Business

Sci/Tech

More Top Stories

Spotlight

Health

Sports

Entertainment

All news

Headlines

Images

Top Stories

Christine O'Donnell »

White House official denies Tea Party-focused ad campaign

CNN International - Ed Henry - 1 hour ago

Democratic sources say the White House is not considering an ad campaign tying Republicans to the Tea Party. Washington (CNN) -- A top White House official sharply denied a report that claims President Obama's political advisers are weighing a national ...

CNN Interna...

Tea Party is misplacing the blame, former President Bill Clinton claims New York Daily News

GOP tea party backer defends Christine O'Donnell The Associated Press

Atlanta Journal Constitution - Politics Daily - MyFox Washington DC - Salon

all 726 news articles »

US Stocks Climb After Recession Called Over, Homebuilders Gain

MarketWatch - Kristina Peterson - 16 minutes ago

NEW YORK (MarketWatch) -- US stocks climbed Monday, gaining speed after a key nonprofit organization officially called the recession over, giving investors a boost of confidence in the gradual economic recovery.

MyFox Phila...

Longest recession since 1930s ended in June 2009, group says Los Angeles Times

Downturn Was Longest in Decades, Panel Confirms New York Times

Wall Street Journal - AFP - USA Today

all 276 news articles »

Deepwater Horizon »

BP Oil Well, Site of National Catastrophe, Dies at One

Vanity Fair - Juli Weiner - 22 minutes ago

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

Reuters

Video: Blown-out BP Well Finally Killed in Gulf The Associated Press

Weiss Doubts BP Would End Operations in Gulf of Mexico Video Bloomberg

CNN International - Wall Street Journal (blog) - The Guardian - New York Times

all 1,292 news articles »

Recent

Recession officially ended in June 2009
CNNMoney - Chris Isidore - 39 minutes ago

Hurricane Igor lashes Bermuda
USA Today - Gerry Broome - 5 minutes ago

'Explain what you want from us,' reads front-page editorial
msnbc.com - Olivia Torres - 10 minutes ago

Crisis response: Pakistan floods

San Francisco Bay Area - Edit

Clorox »
Bay Biz Buzz: Clorox close to selling STP, Armor All
San Jose Mercury News - 48 minutes ago - all 24 articles »

Google's official beekeeper keeps the company buzzing with excitement
San Jose Mercury News - Bruce Newman - 1 hour ago

Ion Sylvia »
Martinez man still unconscious as police investigate weekend shooting
San Jose Mercury News - Robert Salonga - 48 minutes ago - all 6 articles »

Spotlight

Sarkozy rages at EU 'humiliation'
Financial Times - Peggy Hollinger - Sep 16, 2010

BP oil spill cost hits nearl...

www.guardian.co.uk/environment/2010/sep/20/bp-oil-spill-deepwater-horizon-costs-10bn

Mobile site | Sign in | Register | A Text larger | smaller | About us | Today's paper | Zeitgeist

guardian.co.uk

Search | Business | Search

News | Sport | Comment | Culture | Business | Money | Life & style | Travel | Environment | TV | Video | Community | Blogs | Jobs

Business > BP

BP oil spill cost hits nearly $10bn

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

(3)

Tweet this (68)

Comments (10)

Julia Kollewe
guardian.co.uk, Monday 20 September 2010 08.33 BST
Article history

A larger | smaller

BP's costs for the Deepwater Horizon disaster have hit $10bn. Photograph: Ho/Reuters

Business
BP

Environment
BP oil spill · Oil · Oil spills

World news
United States

More news

More on this story

US government

BP oil spill news on Twitter

Latest news on the BP oil spill in the Gulf of Mexico

BP_America: Find fact sheets, open house info and e-mail alert sign-ups at @EPAgov's oil spill community page: http://bit.ly/dIuHcH
about 3 weeks ago

guardianeco: UN report on Nigeria oil spills relies too much on data from Shell | Nnimmo Bassey http://bit.ly/dBd7Ru
about 3 weeks, 5 days ago

BP_America: Newly discovered microbe thriving from consumption of #oil in the #Gulf of Mexico: http://bit.ly/9kQYwa
about 3 weeks, 5 days ago

- Archive page: read more BP oil spill tweets
- Follow BP oil spill news with our Twitter list
- Full BP oil spill coverage from guardian.co.uk

On Business

Most viewed | Zeitgeist | Latest

Last 24 hours

1. Britain keeps AAA credit rating

BP Kills Macondo, But Its ...

blogs.wsj.com/source/2010/09/20/bp-kills-macondo-but-its-legacy-lives-on/

THE WALL STREET JOURNAL. Digital Network | WSJ.com | MarketWatch | BARRON'S | All Things Digital | FINS | SmartMoney | More | SEARCH

THE WALL STREET JOURNAL.

Log In • Register For Free • Subscribe Now, Get 2 Weeks Free

« PREVIOUS

THE SOURCE

NEXT »

Financial Services | Transport | Leisure | Insurance | Oil & Gas | Sport | Caught on the Web | Betting | Technology

SEPTEMBER 20, 2010, 12:44 PM GMT

BP Kills Macondo, But Its Legacy Lives On

Search The Source SEARCH

Article | Comments (2)

THE SOURCE HOME PAGE »

Email | Print | Permalink | Like 2 | More | Text

By James Herron

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.

The most immediate worry for BP and its shareholders is how the authorities will apportion blame for the spill. BP's own investigation spread responsibility across

Associated Press

Fire boat response crews battled the blazing remnants of the off shore oil rig Deepwater Horizon on April 21, 2010

About The Source

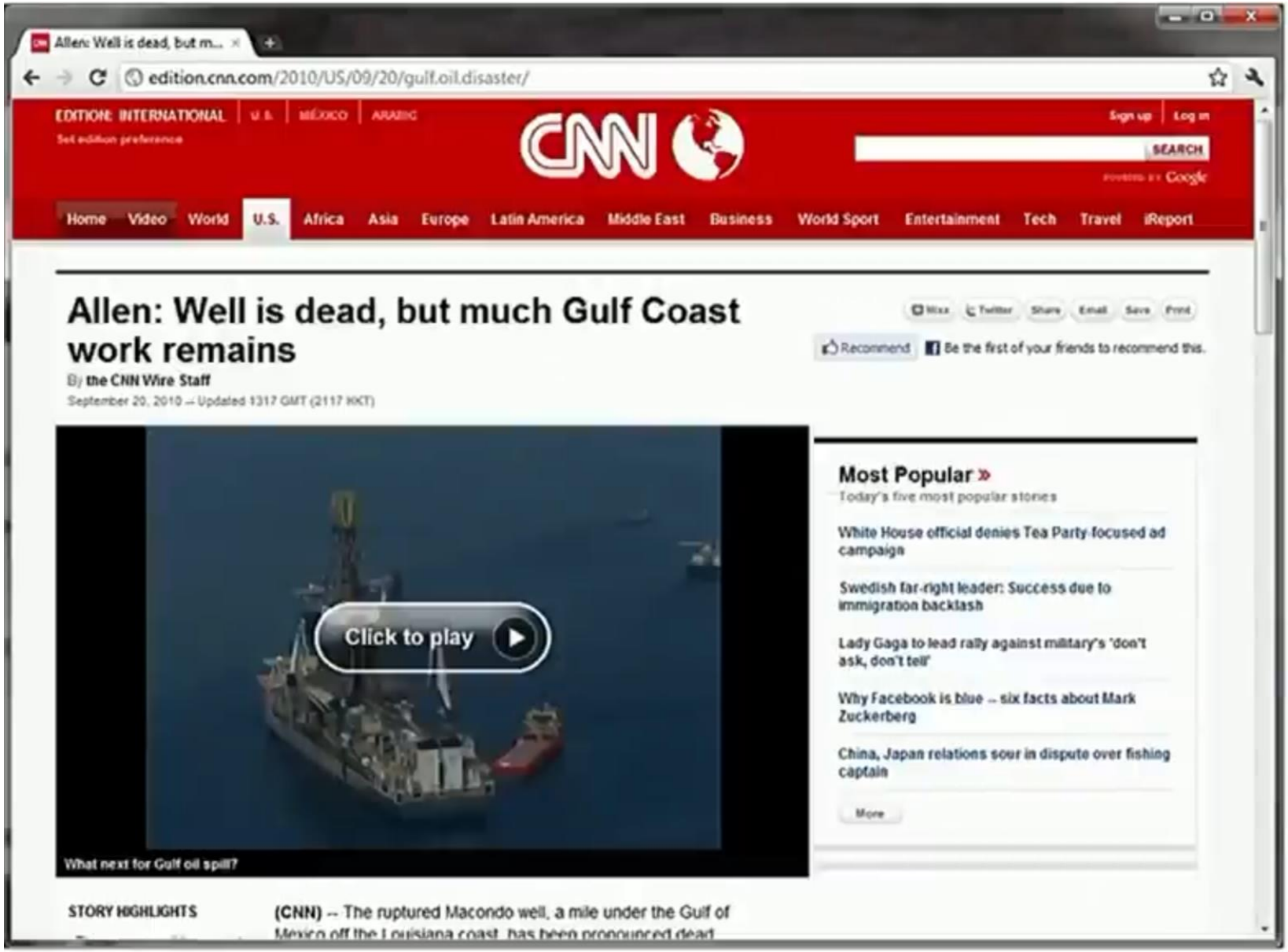
Follow Us

The Source is WSJ.com Europe's home for rapid-fire analysis of the day's big business and finance stories. It is edited by Lauren Mills, based in London.

Most Recent

Articles | Comments

1. Who Needs Plaza II Anyway
2. Will Banks Be Forced to Split Retail And Banking Arms?
3. Timing of Ratings Award Intriguing
4. BP Kills Macondo, But Its Legacy Lives On
5. We Already Need a Sequel to Basel III


Allen: Well is dead, but m...
edition.cnn.com/2010/US/09/20/gulf.oil.disaster/
EDITION: INTERNATIONAL
U.S.
MÉXICO
ARABIC
Set edition preference
CNN
Sign up
Log in
SEARCH
Home
Video
World
U.S.
Africa
Asia
Europe
Latin America
Middle East
Business
World Sport
Entertainment
Tech
Travel
iReport
Allen: Well is dead, but much Gulf Coast work remains
By the CNN Wire Staff
September 20, 2010 -- Updated 1317 GMT (2117 HKT)
Recommend
Be the first of your friends to recommend this.
Click to play
What next for Gulf oil spill?
Most Popular
Today's five most popular stories
White House official denies Tea Party-focused ad campaign
Swedish far-right leader: Success due to immigration backlash
Lady Gaga to lead rally against military's 'don't ask, don't tell'
Why Facebook is blue -- six facts about Mark Zuckerberg
China, Japan relations sour in dispute over fishing captain
More
STORY HIGHLIGHTS
(CNN) -- The ruptured Macondo well, a mile under the Gulf of

Clustering: Google news

Clustering: Google news

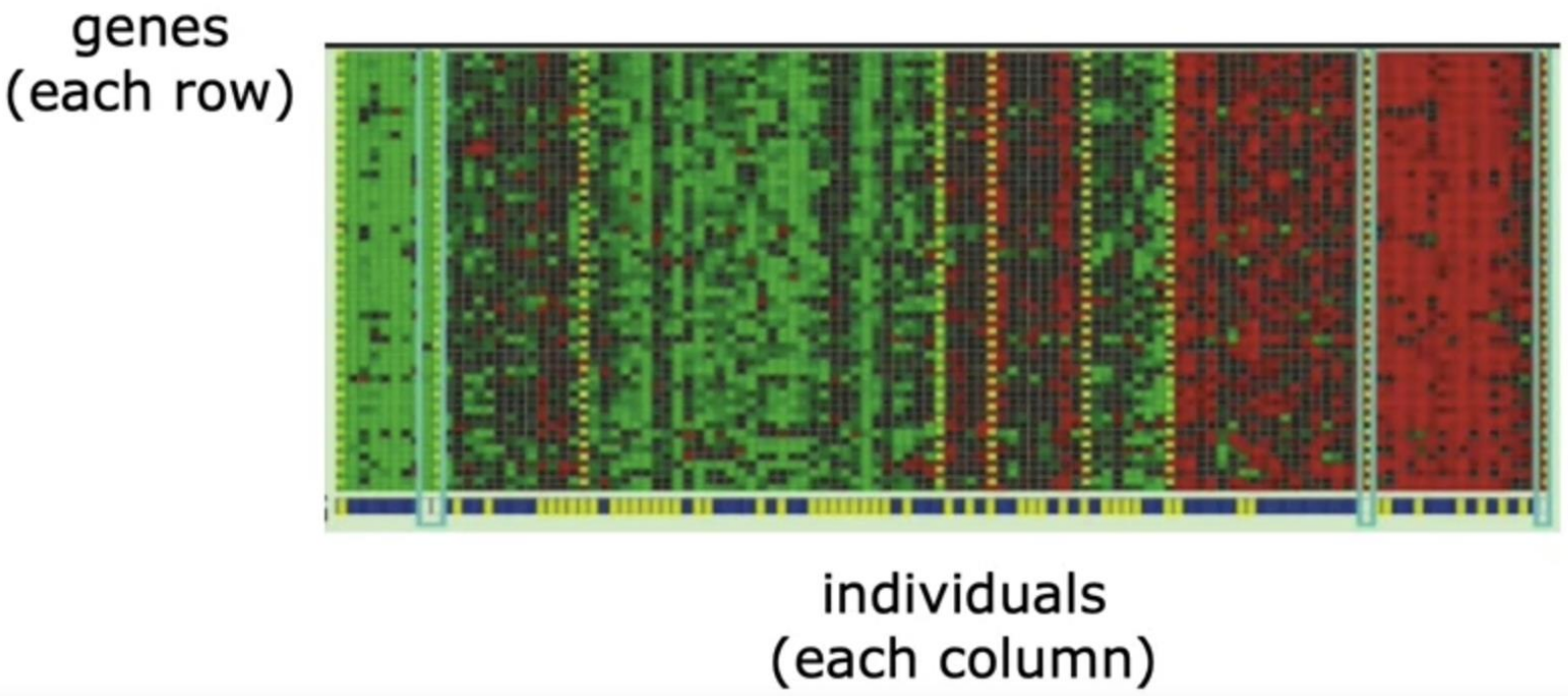
Now, what's cool is that this clustering algorithm figures out on his own which words suggest, that certain articles are in the same group. What it mean is there isn't an employee at google news who's telling the algorithm to find articles that the word panda, twins and zoo to put them into the same cluster.

The **news topics change every day**. And there are so many news stories, it just isn't feasible to people doing this every single day for all the topics that use covers.

Instead the **algorithm has to figure out on his own without supervision**, what are the clusters of news articles today.

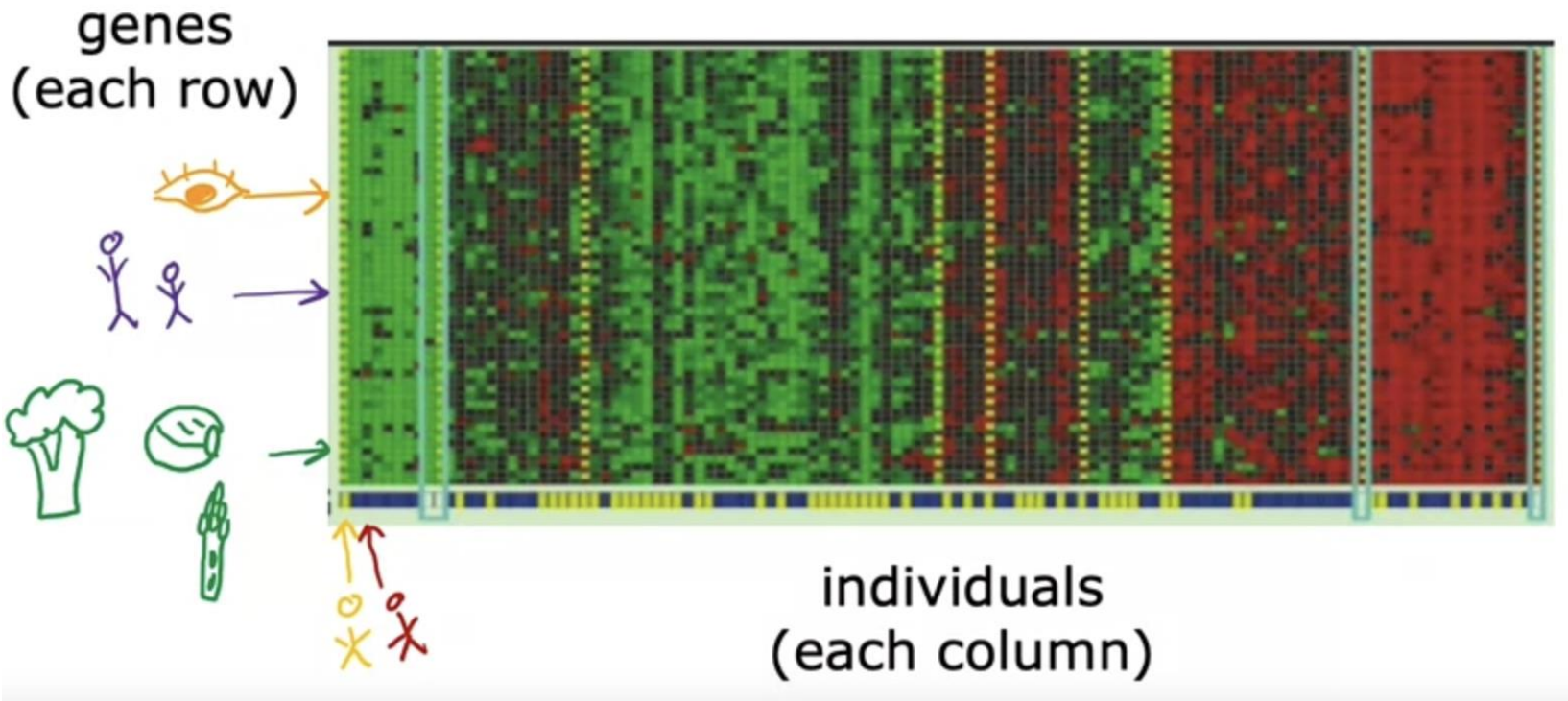
So that's why this clustering algorithm, is a type of unsupervised learning algorithm.

Clustering: DNA microarray



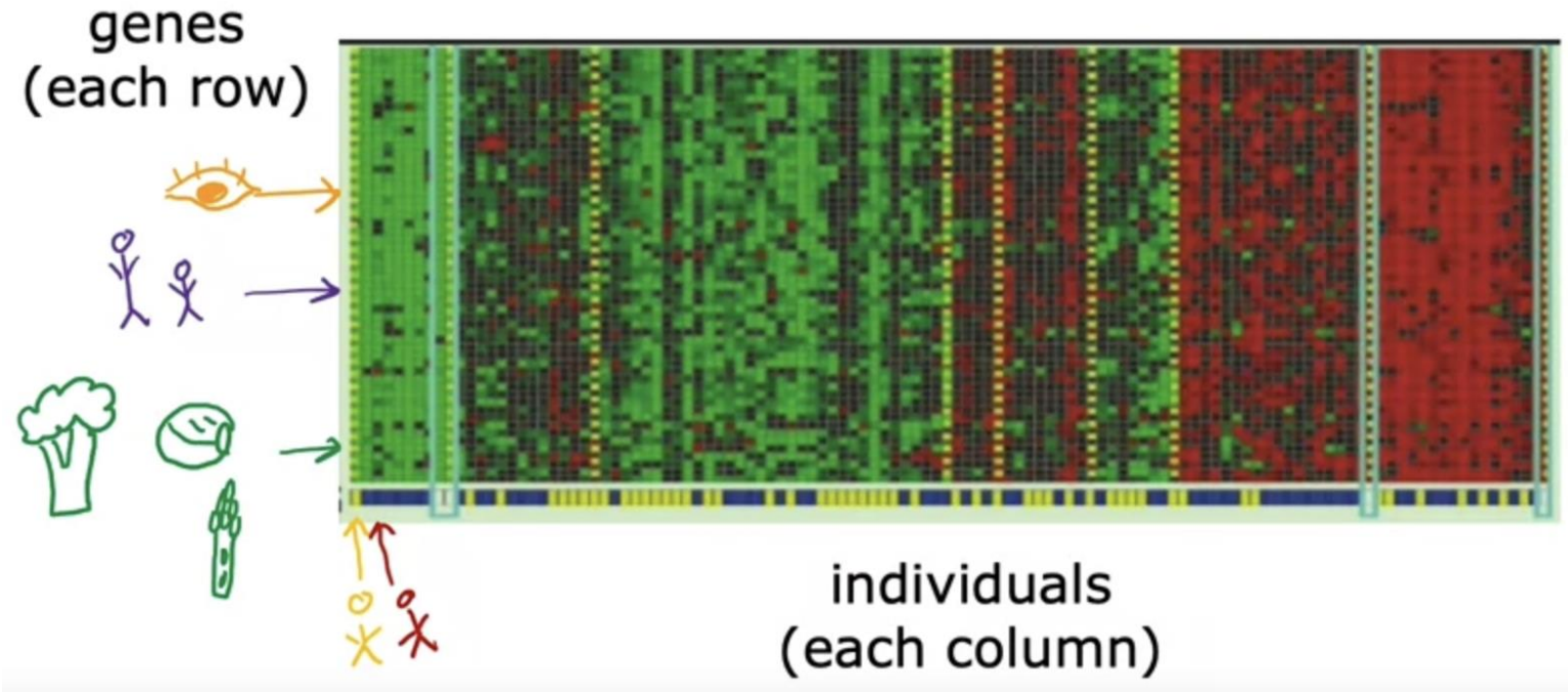
Let's look at the second example of unsupervised learning applied to clustering genetic or DNA data. This image shows a picture of DNA micro array data, these look like tiny grids of a spreadsheet and each tiny column represents the genetic or DNA activity of one person.

Clustering: DNA microarray

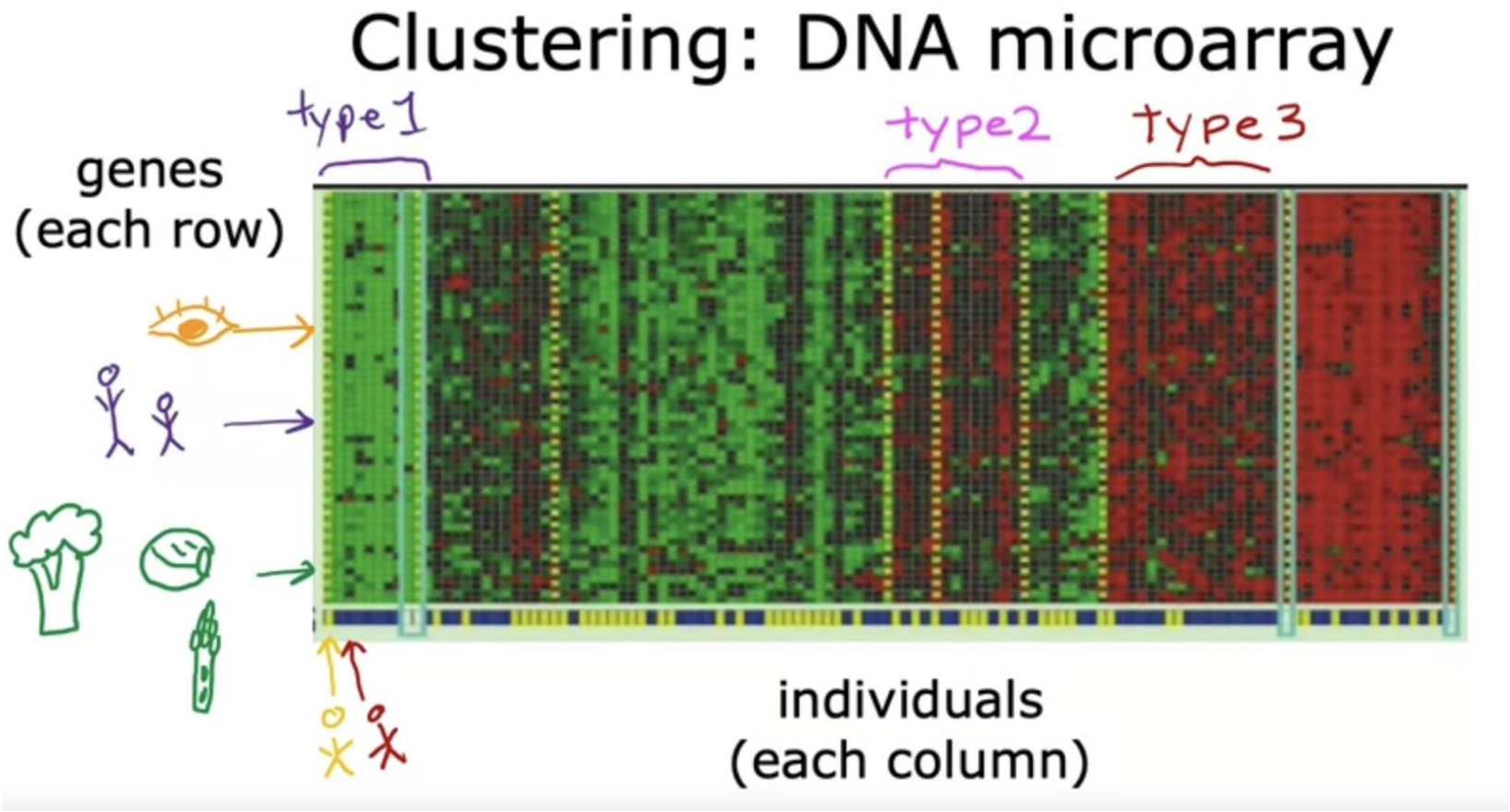


For example, this entire Column here is from one person's DNA. And this other column is of another person, each row represents a particular gene. So just as an example, perhaps this row here might represent a gene that affects eye color, or this row here is a gene that affects how tall someone is. Researchers have even found a genetic link to whether someone dislikes certain vegetables, such as broccoli, or brussels sprouts, or asparagus.

Clustering: DNA microarray

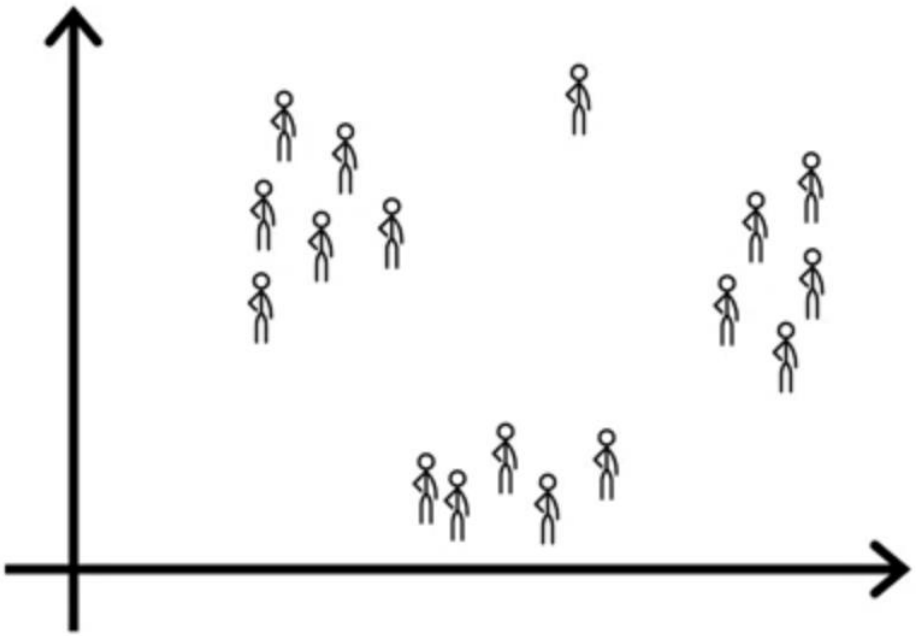


These colors red, green, gray, and so on, show the degree to which different individuals do, or do not have a specific gene active. And what you can do is then run a clustering algorithm to group individuals into different categories or different types of people.



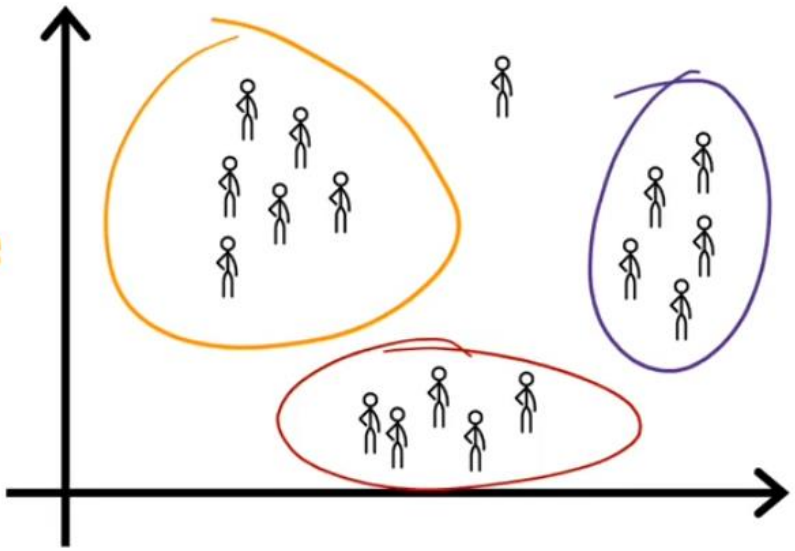
Let's just call this type one, type two, and type three. This is unsupervised learning, because we're not telling the algorithm in advance, that there is a type one person with certain characteristics. Or a type two person with certain characteristics, instead what we're saying is here's a bunch of data. I don't know what the different types of people are but can you automatically find structure into data and automatically figure out what are the major types of individuals, since we're not giving the algorithm the right answer for the examples in advance. This is unsupervised learning,

Clustering: Grouping customers

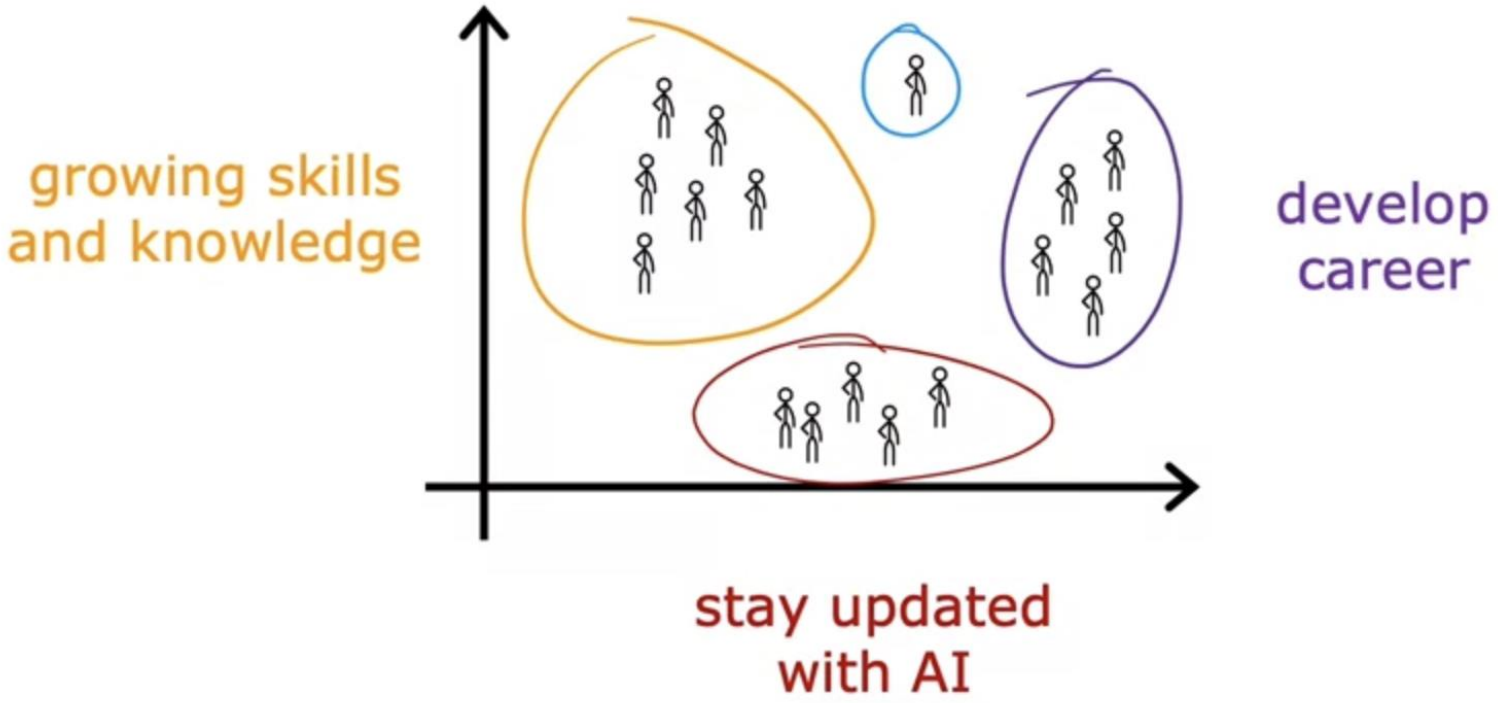


Here's the third example, many companies have huge databases of customer information given this data. Can you automatically group your customers, into different market segments so that you can more efficiently serve your customers?

Clustering: Grouping customers



Clustering: Grouping customers



Unsupervised learning

Data only comes with inputs x, but not output labels y.
Algorithm has to find structure in the data.

Clustering
Group similar data points together.

Dimensionality reduction
Compress data using fewer numbers.

Anomaly detection
Find unusual data points.

Unsupervised learning algorithm, takes data without labels and tries to automatically group them into clusters.

Unsupervised learning

Data only comes with inputs x, but not output labels y.
Algorithm has to find structure in the data.

Clustering
Group similar data points together.

Dimensionality reduction
Compress data using fewer numbers.

Anomaly detection
Find unusual data points.

You'll learn about clustering as well as two other types of unsupervised learning. One is called anomaly detection, which is used to detect unusual events. This turns out to be really important for fraud detection in the financial system, where unusual events, unusual transactions could be signs of fraud and for many other applications.

You also learn about dimensionality reduction. This lets you take a big data-set and almost magically compress it to a much smaller data-set while losing as little information as possible.

Question

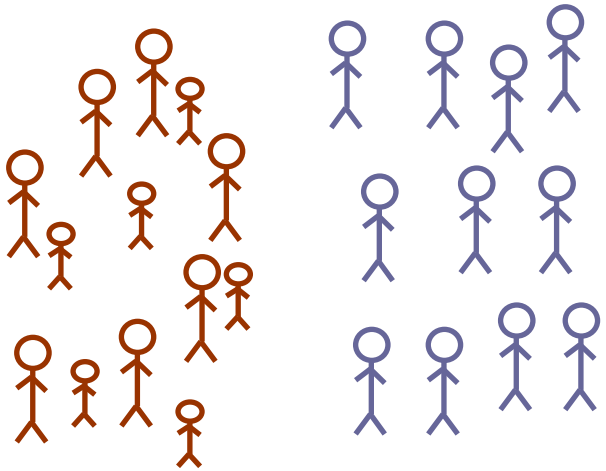
Of the following examples, which would you address using an unsupervised learning algorithm?

- [ ] Given email labeled as spam/not spam, learn a spam filter.
- [ ] Given a set of news articles found on the web, group them into sets 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

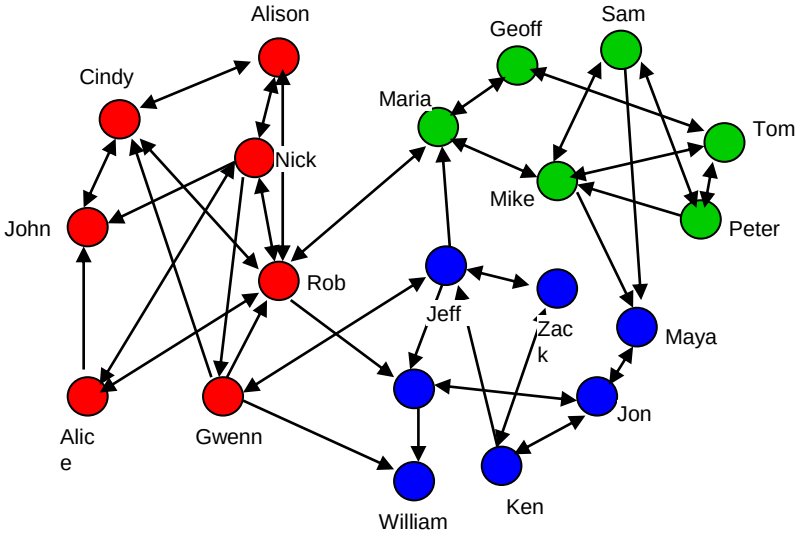
Question

Of the following examples, which would you address using an unsupervised learning algorithm?

- ☒ Given email labeled as spam/not spam, learn a spam filter.
- ☑ Given a set of news articles found on the web, group them into sets 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



Market segmentation

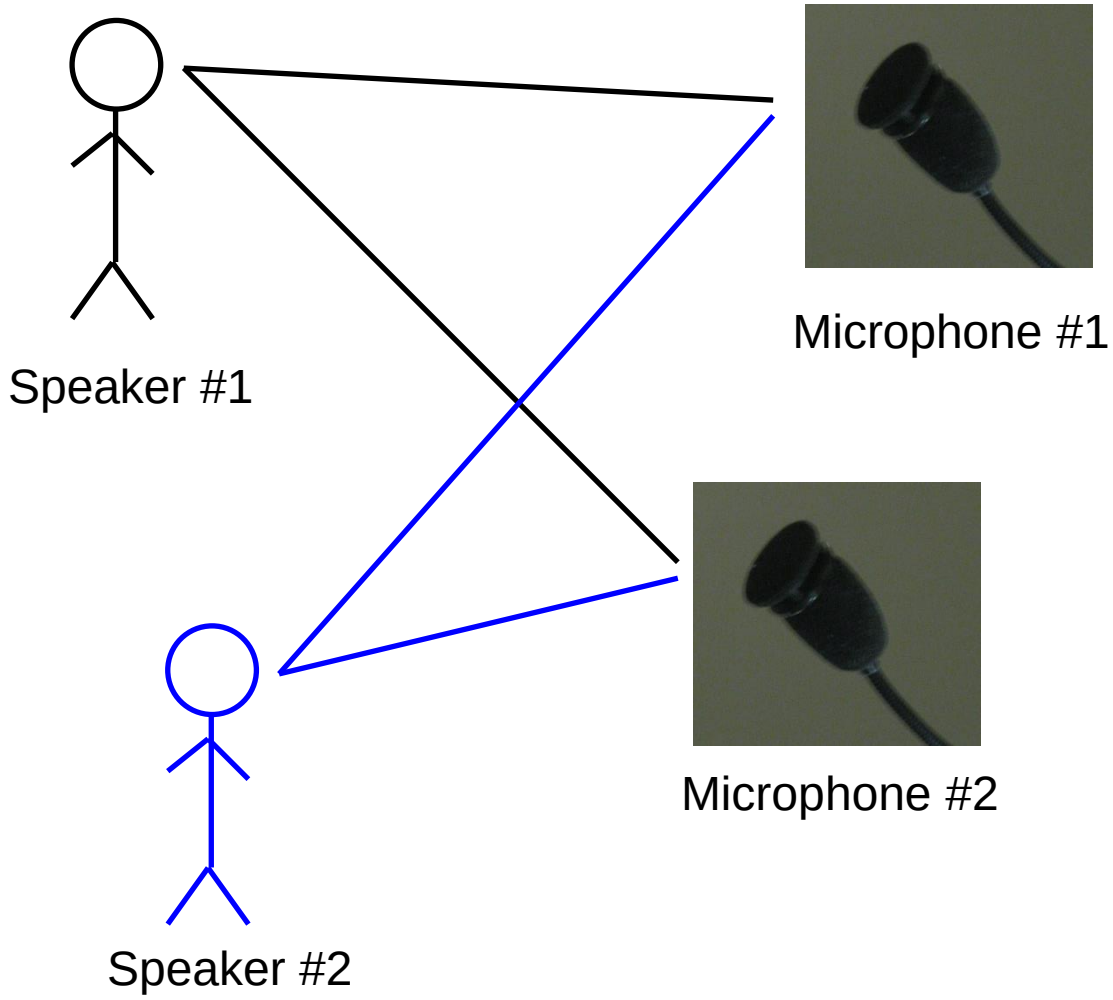


Social network analysis

Organize computing clusters

Astronomical data analysis

Cocktail party problem



Microphone #1:

Output #1:

Microphone #2:

Output #2:

Microphone #1:

Output #1:

Microphone #2:

Output #2:

[Audio clips courtesy of Te-Won Lee.]

ICA algorithm

```
[W,s,v] = svd((repmat(sum(x.*x,1),size(x,1),1).*x)*x');
```

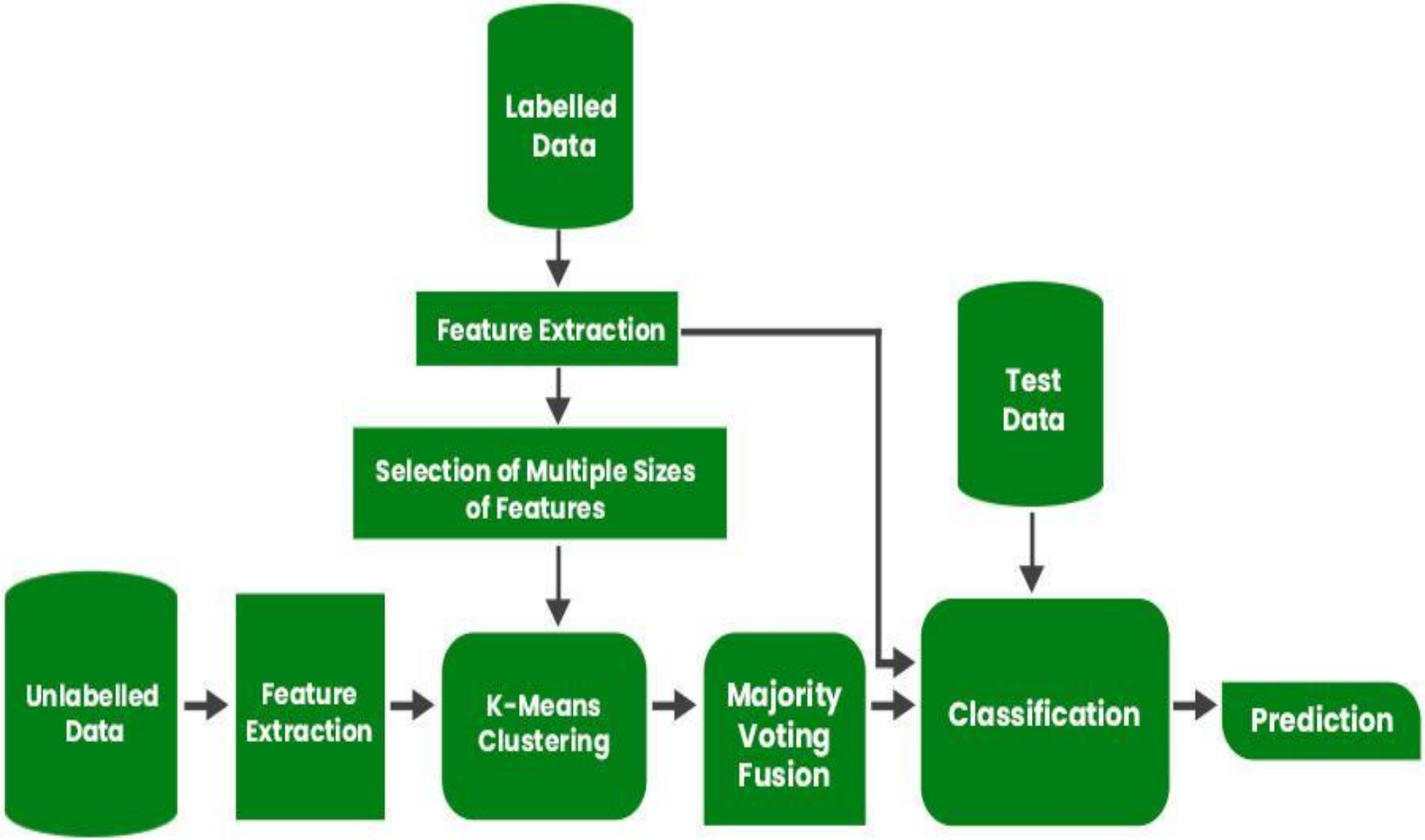
[Source: Sam Roweis, Yair Weiss & Eero Simoncelli]

What is Semi-Supervised Learning?

Semi-supervised learning is a type of machine learning that falls in between supervised and unsupervised learning. It is a method that uses a small amount of labeled data and a large amount of unlabeled data to train a model.

The goal of semi-supervised learning is to learn a function that can accurately predict the output variable based on the input variables, similar to supervised learning. However, unlike supervised learning, the algorithm is trained on a dataset that contains both labeled and unlabeled data.

Semi-supervised learning is particularly useful when there is a large amount of unlabeled data available, but it’s too expensive or difficult to label all of it.


Labelled Data
Feature Extraction
Selection of Multiple Sizes of Features
Test Data
Unlabelled Data
Feature Extraction
K-Means Clustering
Majority Voting Fusion
Classification
Prediction

Examples of Semi-Supervised Learning

- **Text classification**: In text classification, the goal is to classify a given text into one or more predefined categories. Semi-supervised learning can be used to train a text classification model using a small amount of labeled data and a large amount of unlabeled text data.
- **Image classification**: In image classification, the goal is to classify a given image into one or more predefined categories. Semi-supervised learning can be used to train an image classification model using a small amount of labeled data and a large amount of unlabeled image data.
- **Anomaly detection**: In anomaly detection, the goal is to detect patterns or observations that are unusual or different from the norm

Assumptions followed by Semi-Supervised Learning

A Semi-Supervised algorithm assumes the following about the data

1. **Continuity Assumption:** The algorithm assumes that the points which are closer to each other are more likely to have the same output label.
2. **Cluster Assumption:** The data can be divided into discrete clusters and points in the same cluster are more likely to share an output label.
3. **Manifold Assumption:** The data lie approximately on a manifold of a much lower dimension than the input space. This assumption allows the use of distances and densities which are defined on a manifold.

Applications of Semi-Supervised Learning

1. **Speech Analysis:** Since labeling audio files is a very intensive task, Semi-Supervised learning is a very natural approach to solve this problem.
2. **Internet Content Classification:** Labeling each webpage is an impractical and unfeasible process and thus uses Semi-Supervised learning algorithms. Even the Google search algorithm uses a variant of Semi-Supervised learning to rank the relevance of a webpage for a given query.
3. **Protein Sequence Classification:** Since DNA strands are typically very large in size, the rise of Semi-Supervised learning has been imminent in this field.

Disadvantages of Semi-Supervised Learning

The most basic disadvantage of any **Supervised Learning** algorithm is that the dataset has to be hand-labeled either by a Machine Learning Engineer or a Data Scientist. This is a very *costly process*, especially when dealing with large volumes of data. The most basic disadvantage of any **Unsupervised Learning** is that its **application spectrum is limited**.

To counter these disadvantages, the concept of **Semi-Supervised Learning** was introduced. In this type of learning, the algorithm is trained upon a combination of labeled and unlabelled data. Typically, this combination will contain a very small amount of labeled data and a very large amount of unlabelled data. The basic procedure involved is that first, the programmer will cluster similar data using an unsupervised learning algorithm and then use the existing labeled data to label the rest of the unlabelled data. The typical use cases of such type of algorithm have a common property among them – The acquisition of unlabelled data is relatively cheap while labeling the said data is very expensive.

Reinforcement Learning

Reinforcement learning is an area of Machine Learning. It is about taking suitable action to maximize reward in a particular situation. It is employed by various software and machines to find the best possible behavior or path it should take in a specific situation.

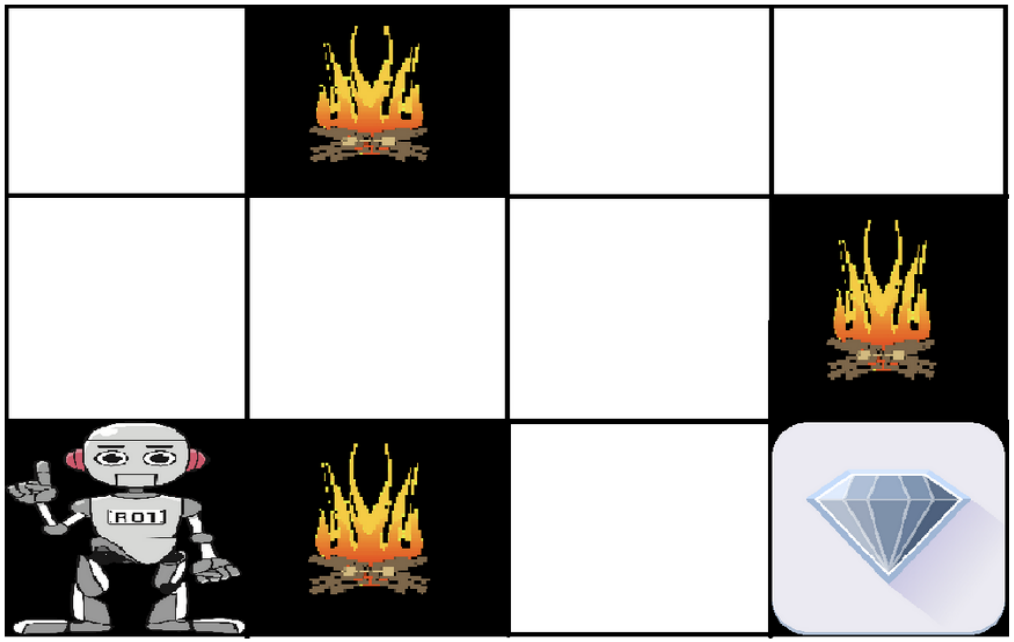
Reinforcement learning differs from supervised learning in a way that in supervised learning the training data has the answer key with it so the model is trained with the correct answer itself whereas in reinforcement learning, there is no answer but the reinforcement agent decides what to do to perform the given task. In the absence of a training dataset, it is bound to learn from its experience.

Reinforcement learning uses algorithms that learn from outcomes and decide which action to take next. After each action, the algorithm receives feedback that helps it determine whether the choice it made was correct, neutral or incorrect. It is a good technique to use for automated systems that have to make a lot of small decisions without human guidance.

Reinforcement learning is an autonomous, self-teaching system that essentially learns by trial and error. It performs actions with the aim of maximizing rewards, or in other words, it is learning by doing in order to achieve the best outcomes.

Example:

The problem is as follows: We have an agent and a reward, with many hurdles in between. The agent is supposed to find the best possible path to reach the reward. The following problem explains the problem more easily.



The above image shows the robot, diamond, and fire. The goal of the robot is to get the reward that is the diamond and avoid the hurdles that are fired. The robot learns by trying all the possible paths and then choosing the path which gives him the reward with the least hurdles. Each right step will give the robot a reward and each wrong step will subtract the reward of the robot. The total reward will be calculated when it reaches the final reward that is the diamond.

Main points in Reinforcement learning –

- Input: The input should be an initial state from which the model will start
- Output: There are many possible outputs as there are a variety of solutions to a particular problem
- Training: The training is based upon the input, The model will return a state and the user will decide to reward or punish the model based on its output.
- The model keeps continues to learn.
- The best solution is decided based on the maximum reward.

Difference between Reinforcement learning and Supervised learning:

Reinforcement learning	Supervised learning
Reinforcement learning is all about making decisions sequentially. In simple words, we can say that the output depends on the state of the current input and the next input depends on the output of the previous input	In Supervised learning, the decision is made on the initial input or the input given at the start
In Reinforcement learning decision is dependent, So we give labels to sequences of dependent decisions	In supervised learning the decisions are independent of each other so labels are given to each decision.
Example: Chess game,text summarization	Example: Object recognition,spam detetction

Types of Reinforcement:

There are two types of Reinforcement:

1. **Positive:** Positive Reinforcement is defined as when an event, occurs due to a particular behavior, increases the strength and the frequency of the behavior. In other words, it has a positive effect on behavior.
   Advantages of reinforcement learning are:

   - Maximizes Performance
   - Sustain Change for a long period of time
   - Too much Reinforcement can lead to an overload of states which can diminish the results

2. **Negative:** Negative Reinforcement is defined as strengthening of behavior because a negative condition is stopped or avoided.
   Advantages of reinforcement learning:
   - Increases Behavior
   - Provide defiance to a minimum standard of performance
   - It Only provides enough to meet up the minimum behavior

Elements of Reinforcement Learning

Reinforcement learning elements are as follows:

1. Policy
2. Reward function
3. Value function
4. Model of the environment

Policy: Policy defines the learning agent behavior for given time period. It is a mapping from perceived states of the environment to actions to be taken when in those states.

Reward function: Reward function is used to define a goal in a reinforcement learning problem.A reward function is a function that provides a numerical score based on the state of the environment

Value function: Value functions specify what is good in the long run. The value of a state is the total amount of reward an agent can expect to accumulate over the future, starting from that state.

Various Practical Applications of Reinforcement Learning –

- RL can be used in robotics for industrial automation.
- RL can be used in machine learning and data processing
- RL can be used to create training systems that provide custom instruction and materials according to the requirement of students.

Advantages of Reinforcement learning

1. Reinforcement learning can be used to solve very complex problems that cannot be solved by conventional techniques.

2. The model can correct the errors that occurred during the training process.

3. In RL, training data is obtained via the direct interaction of the agent with the environment

4. Reinforcement learning can handle environments that are non-deterministic, meaning that the outcomes of actions are not always predictable. This is useful in real-world applications where the environment may change over time or is uncertain.

5. Reinforcement learning can be used to solve a wide range of problems, including those that involve decision making, control, and optimization.

6. Reinforcement learning is a flexible approach that can be combined with other machine learning techniques, such as deep learning, to improve performance.

Disadvantages of Reinforcement learning

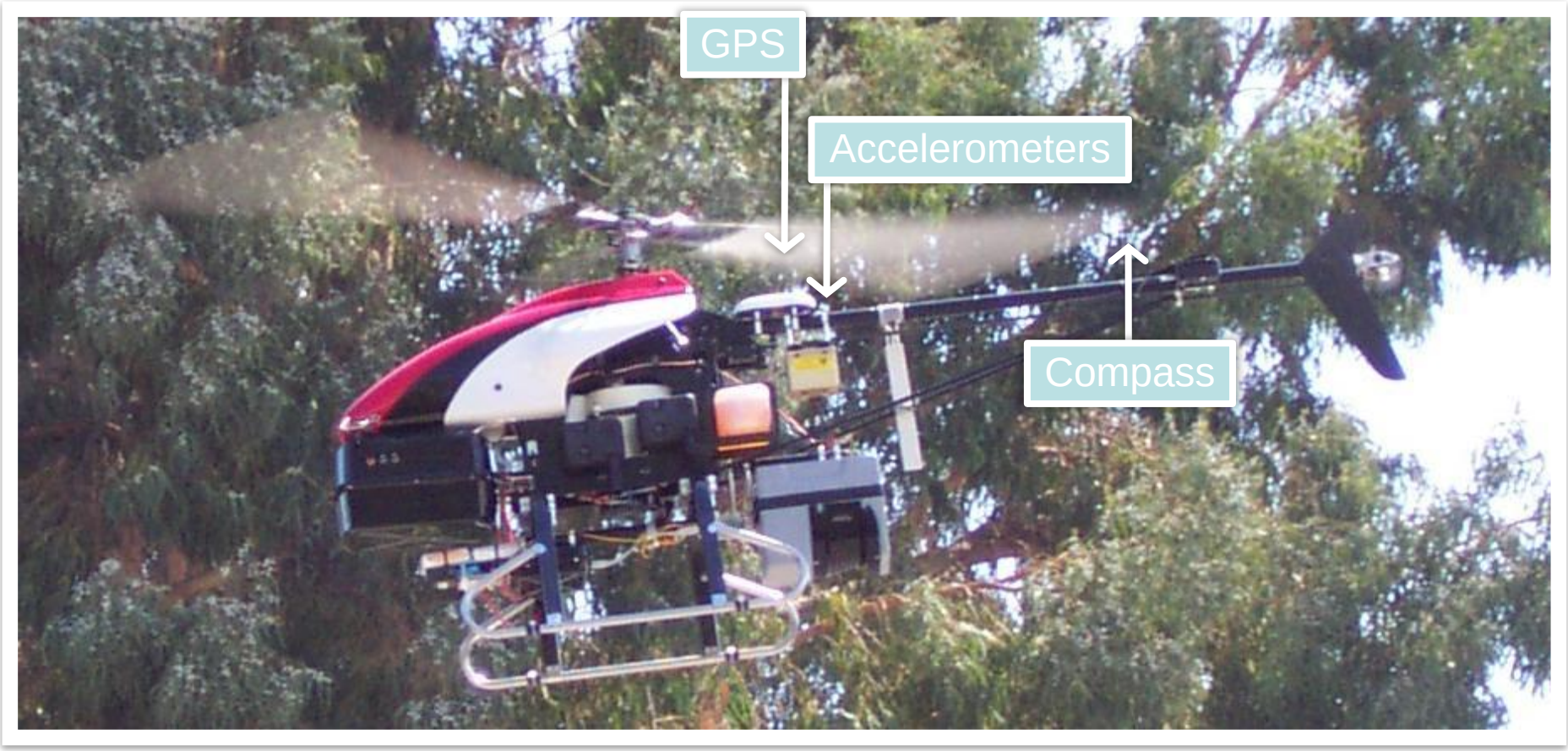
1. Reinforcement learning is not preferable to use for solving simple problems.

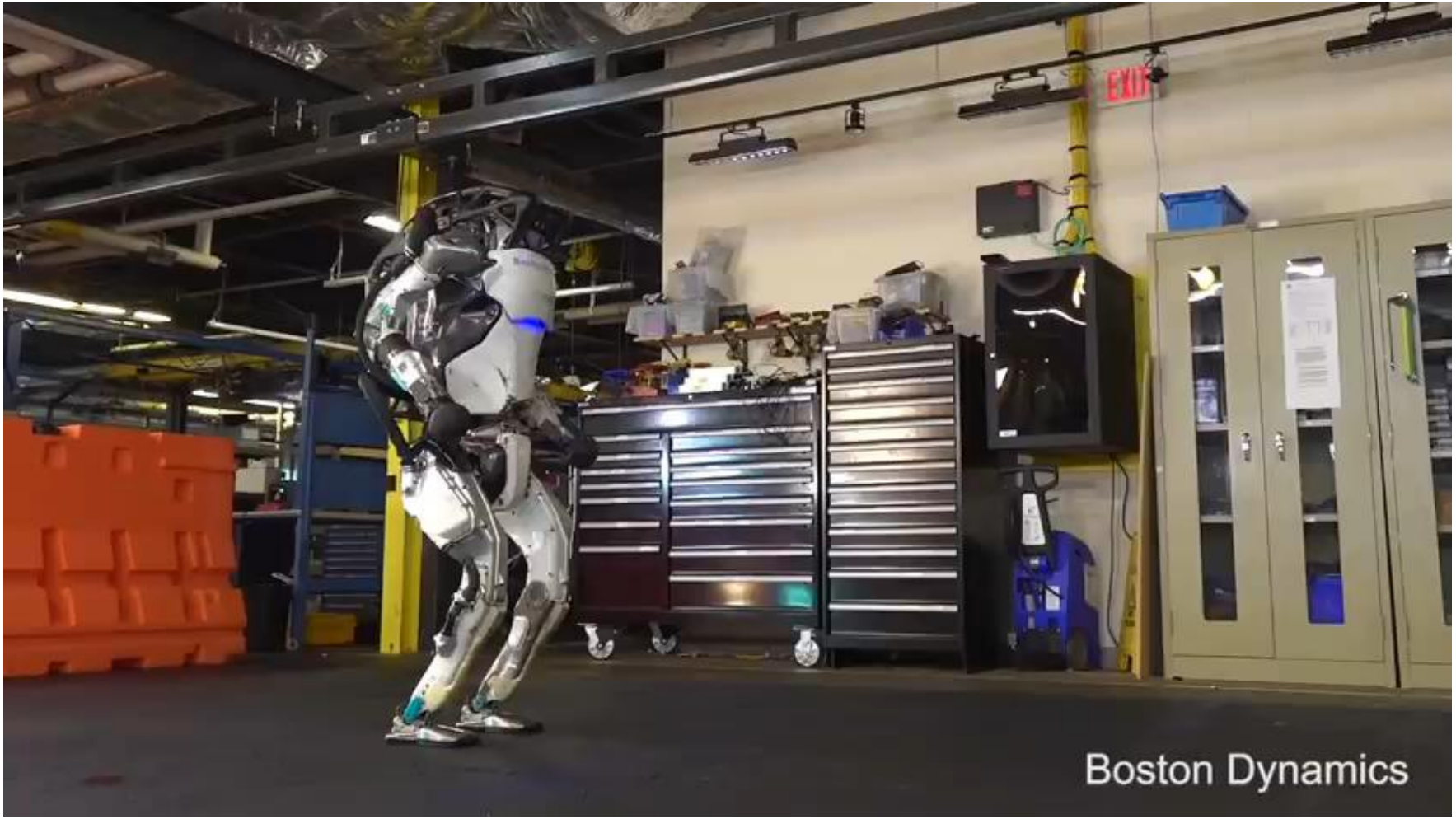
2. Reinforcement learning needs a lot of data and a lot of computation

3. Reinforcement learning is highly dependent on the quality of the reward function. If the reward function is poorly designed, the agent may not learn the desired behavior.

4. Reinforcement learning can be difficult to debug and interpret. It is not always clear why the agent is behaving in a certain way, which can make it difficult to diagnose and fix problems.

Stanford autonomous helicopter




EXIT
Boston Dynamics

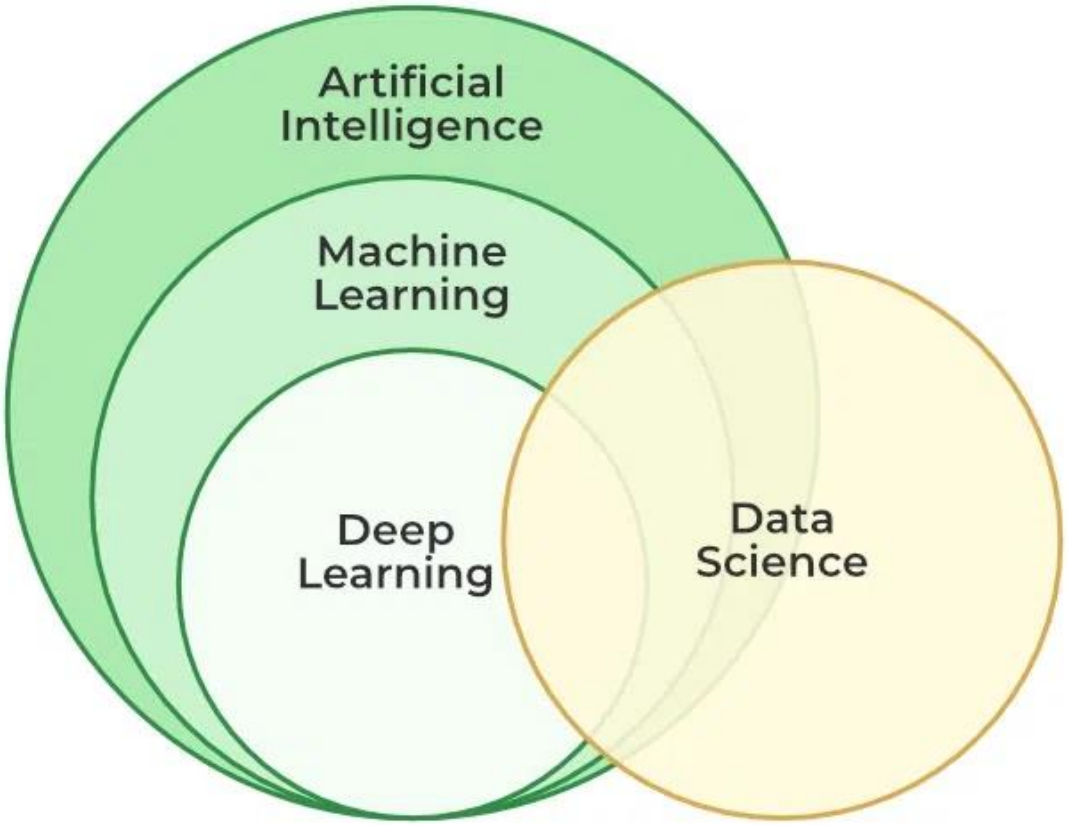
Deep Learning (Neural Networks)

Deep learning is a branch of machine learning which is based on artificial neural networks. It is capable of learning complex patterns and relationships within data. In deep learning, we don’t need to explicitly program everything.

It has become increasingly popular in recent years due to the advances in processing power and the availability of large datasets. Because it is based on artificial neural networks (ANNs) also known as deep neural networks (DNNs). These neural networks are inspired by the structure and function of the human brain’s biological neurons, and they are designed to learn from large amounts of data.

What is Deep Learning?

Deep learning is the branch of machine learning which is based on artificial neural network architecture. An artificial neural network or ANN uses layers of interconnected nodes called neurons that work together to process and learn from the input data.



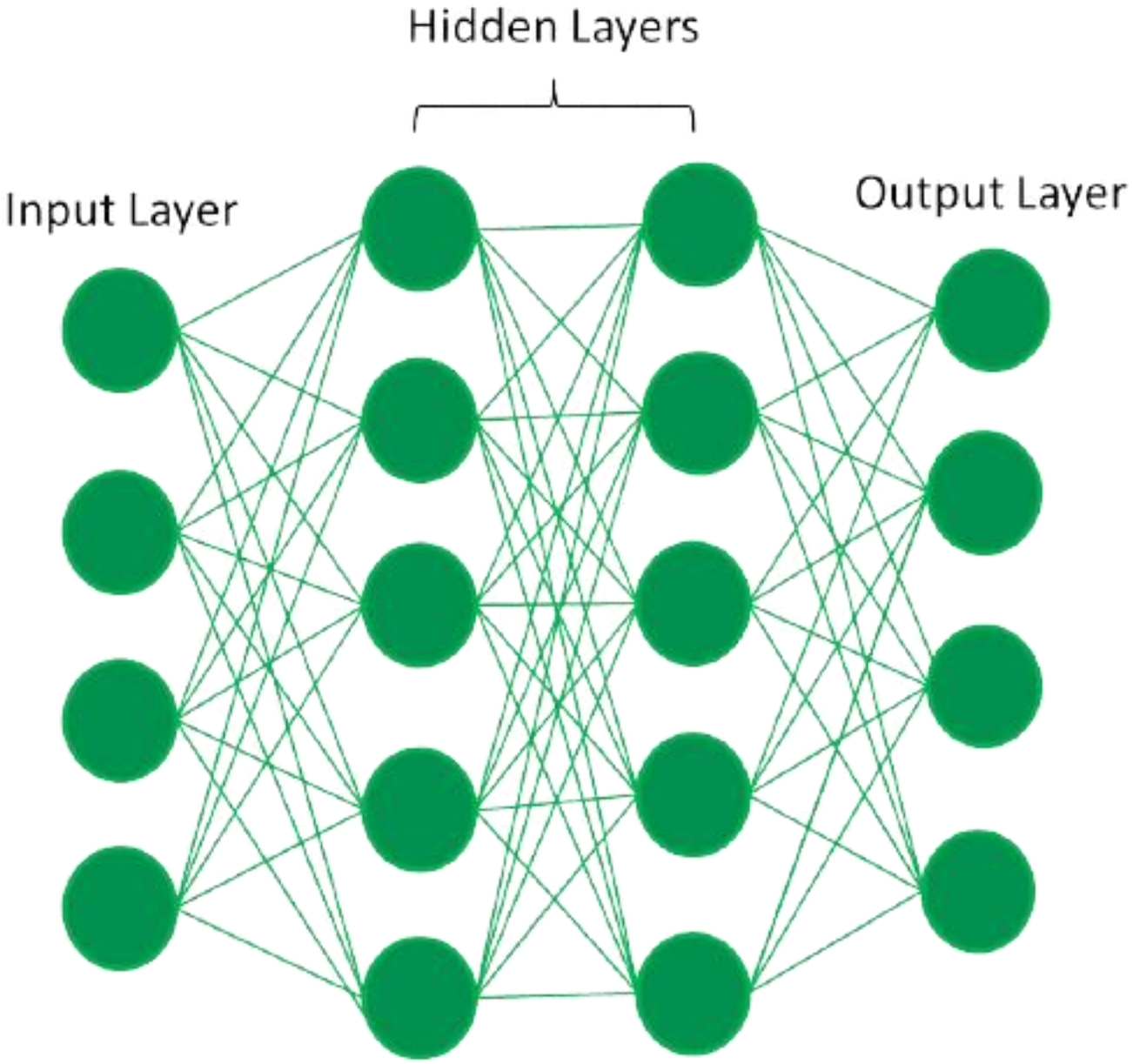
In a fully connected Deep neural network, there is an input layer and one or more hidden layers connected one after the other.

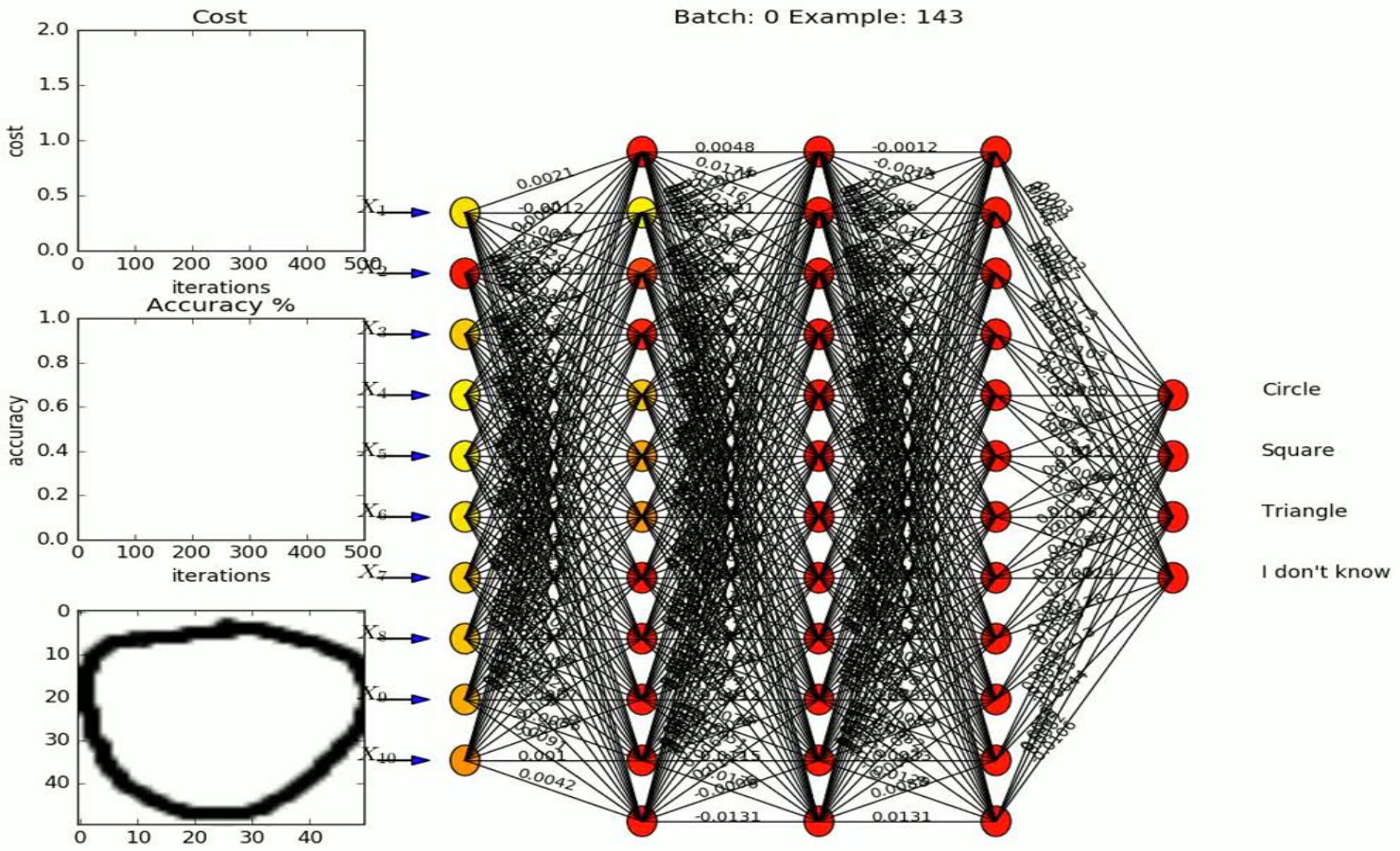
Each neuron receives input from the previous layer neurons or the input layer. The output of one neuron becomes the input to other neurons in the next layer of the network, and this process continues until the final layer produces the output of the network.

The layers of the neural network transform the input data through a series of nonlinear transformations, allowing the network to learn complex representations of the input data.

Artificial neural networks

Artificial neural networks are built on the principles of the structure and operation of human neurons. It is also known as neural networks or neural nets. An artificial neural network's input layer, which is the first layer, receives input from external sources and passes it on to the hidden layer, which is the second layer. Each neuron in the hidden layer gets information from the neurons in the previous layer, computes the weighted total, and then transfers it to the neurons in the next layer. These connections are weighted, which means that the impacts of the inputs from the preceding layer are more or less optimized by giving each input a distinct weight. These weights are then adjusted during the training process to enhance the performance of the model.


Hidden Layers
Input Layer
Output Layer


Cost
cost
iterations
Accuracy %
accuracy
iterations
Batch: 0 Example: 143
Circle
Square
Triangle
I don't know

Machine Learning	Deep Learning
Apply statistical algorithms to learn the hidden patterns and relationships in the dataset.	Uses artificial neural network architecture to learn the hidden patterns and relationships in the dataset.
Can work on the smaller amount of dataset	Requires the larger volume of dataset compared to machine learning
Better for the low-label task.	Better for complex task like image processing, natural language processing, etc.
Takes less time to train the model.	Takes more time to train the model.
A model is created by relevant features which are manually extracted from images to detect an object in the image.	Relevant features are automatically extracted from images. It is an end-to-end learning process.
Less complex and easy to interpret the result.	More complex, it works like the black box interpretations of the result are not easy.
It can work on the CPU or requires less computing power as compared to deep learning.	It requires a high-performance computer with GPU.

Types of neural networks

Deep Learning models are able to automatically learn features from the data, which makes them well-suited for tasks such as image recognition, speech recognition, and natural language processing. The most widely used architectures in deep learning are feedforward neural networks, convolutional neural networks (CNNs), and recurrent neural networks (RNNs).

Feedforward neural networks (FNNs) are the simplest type of ANN, with a linear flow of information through the network. FNNs have been widely used for tasks such as image classification, speech recognition, and natural language processing.

Convolutional Neural Networks (CNNs) are specifically for image and video recognition tasks. CNNs are able to automatically learn features from the images, which makes them well-suited for tasks such as image classification, object detection, and image segmentation.

Recurrent Neural Networks (RNNs) are a type of neural network that is able to process sequential data, such as time series and natural language. RNNs are able to maintain an internal state that captures information about the previous inputs, which makes them well-suited for tasks such as speech recognition, natural language processing, and language translation.

Applications of Deep Learning :

The main applications of deep learning can be divided into computer vision, natural language processing (NLP), and reinforcement learning.

In computer vision, Deep learning models can enable machines to identify and understand visual data. Some of the main applications of deep learning in computer vision include:

- **Object detection and recognition:** Deep learning model can be used to identify and locate objects within images and videos, making it possible for machines to perform tasks such as self-driving cars, surveillance, and robotics.
- **Image classification:** Deep learning models can be used to classify images into categories such as animals, plants, and buildings. This is used in applications such as medical imaging, quality control, and image retrieval.
- **Image segmentation:** Deep learning models can be used for image segmentation into different regions, making it possible to identify specific features within images.

Natural language processing (NLP):

In NLP, the Deep learning model can enable machines to understand and generate human language. Some of the main applications of deep learning in NLP include:

- **Automatic Text Generation** – Deep learning model can learn the corpus of text and new text like summaries, essays can be automatically generated using these trained models.
- **Language translation:** Deep learning models can translate text from one language to another, making it possible to communicate with people from different linguistic backgrounds.
- **Sentiment analysis:** Deep learning models can analyze the sentiment of a piece of text, making it possible to determine whether the text is positive, negative, or neutral. This is used in applications such as customer service, social media monitoring, and political analysis.
- **Speech recognition:** Deep learning models can recognize and transcribe spoken words, making it possible to perform tasks such as speech-to-text conversion, voice search, and voice-controlled devices.

Reinforcement learning:

In reinforcement learning, deep learning works as training agents to take action in an environment to maximize a reward. Some of the main applications of deep learning in reinforcement learning include:

- **Game playing:** Deep reinforcement learning models have been able to beat human experts at games such as Go, Chess, and Atari.
- **Robotics:** Deep reinforcement learning models can be used to train robots to perform complex tasks such as grasping objects, navigation, and manipulation.
- **Control systems:** Deep reinforcement learning models can be used to control complex systems such as power grids, traffic management, and supply chain optimization.

Challenges in Deep Learning

Deep learning has made significant advancements in various fields, but there are still some challenges that need to be addressed. Here are some of the main challenges in deep learning:

1. Data availability: It requires large amounts of data to learn from. For using deep learning it's a big concern to gather as much data for training.
2. Computational Resources: For training the deep learning model, it is computationally expensive because it requires specialized hardware like GPUs and TPUs.
3. Time-consuming: While working on sequential data depending on the computational resource it can take very large even in days or months.
4. Interpretability: Deep learning models are complex, it works like a black box. it is very difficult to interpret the result.
5. Overfitting: when the model is trained again and again, it becomes too specialized for the training data, leading to overfitting and poor performance on new data.

Advantages of Deep Learning:

1. High accuracy: Deep Learning algorithms can achieve state-of-the-art performance in various tasks, such as image recognition and natural language processing.
2. Automated feature engineering: Deep Learning algorithms can automatically discover and learn relevant features from data without the need for manual feature engineering.
3. Scalability: Deep Learning models can scale to handle large and complex datasets, and can learn from massive amounts of data.
4. Flexibility: Deep Learning models can be applied to a wide range of tasks and can handle various types of data, such as images, text, and speech.
5. Continual improvement: Deep Learning models can continually improve their performance as more data becomes available.

Disadvantages of Deep Learning:

1. High computational requirements: Deep Learning models require large amounts of data and computational resources to train and optimize.
2. Requires large amounts of labeled data: Deep Learning models often require a large amount of labeled data for training, which can be expensive and time- consuming to acquire.
3. Interpretability: Deep Learning models can be challenging to interpret, making it difficult to understand how they make decisions.
   Overfitting: Deep Learning models can sometimes overfit to the training data, resulting in poor performance on new and unseen data.
4. Black-box nature: Deep Learning models are often treated as black boxes, making it difficult to understand how they work and how they arrived at their predictions.
   In summary, while Deep Learning offers many advantages, including high accuracy and scalability, it also has some disadvantages, such as high computational requirements, the need for large amounts of labeled data, and interpretability challenges. These limitations need to be carefully considered when deciding whether to use Deep Learning for a specific task.

Practical ML advice

- You have to take many strategics decision before applying machine learning algorithms
- Need to collect more data
- Try different machine learning algorithms – Neural nets or regression
- Try faster GPUs to train algorithms
- Blackbox magic to systematic engineering process