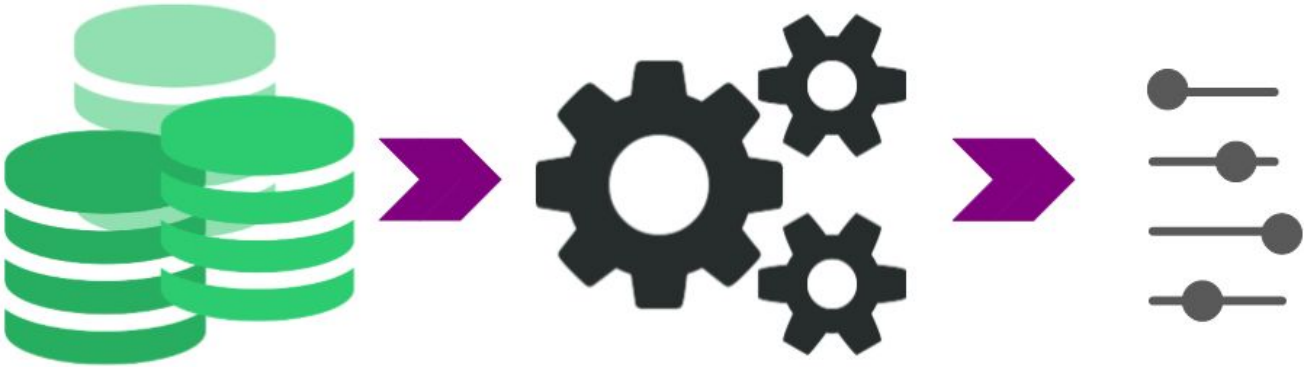
Machine Learning

What is Machine Learning?

What is Machine Learning?

- A type of artificial intelligence (AI) algorithms that learn and improve automatically from experience without human intervention.
- Optimizes performance through example data or past experience.



What is Machine Learning?

Study, design, and development of models and algorithms that give computers the capability to learn from data, instead of requiring explicit programming of hard-coded rules/logic.

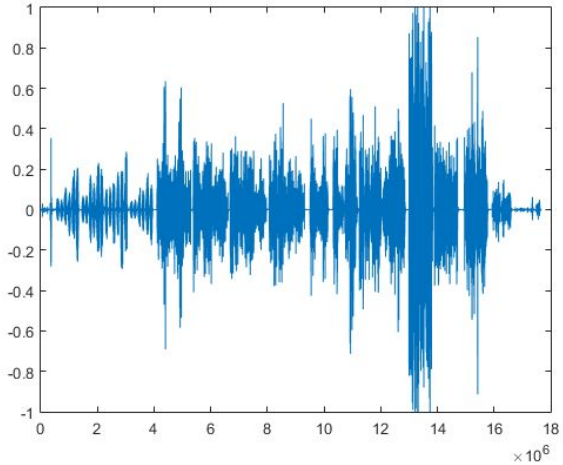
- Traditional modeling applies a predefined model to the data that hopefully explains the relationship between the data and the answers/labels.
- Machine learning uses algorithms and computational power to determine (learn) if a relationship exists between the data and the answers/labels.

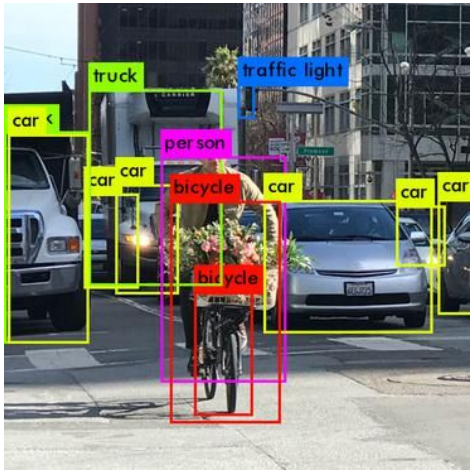
Where does Machine Learning shine?

1. Tasks that are almost impossible to program with rules
2. Tasks that cannot be accomplished by human
3. Huge amount of data
4. Adaptivity

Machine Learning works on various types of data

timestamp	value	anomaly	change point	trend	noise	12 hour seasonality	daily seasonality	weekly seasonality
1422237600	4333.43	0	0	4599	1.81	-190.95	-128.86	52.44
1422241200	4316.14	0	0	4602	-14.65	-220.5	-105.21	54.51
1422244800	4403.20	0	0	4605	7.04	-190.95	-74.39	56.51
1422248400	4531.20	0	0	4608	13.52	-110.25	-38.51	58.43
1422252000	4967.50	1	0	4911	-3.77	-6.91	-2.33	60.27





500M
of tweets are sent

4PB
*of data created by Facebook Including **350m** photos & **100m** hours of video watch time*

65BN
of messages sent over Whatsapp

3.5BN
Searches made a day from Google

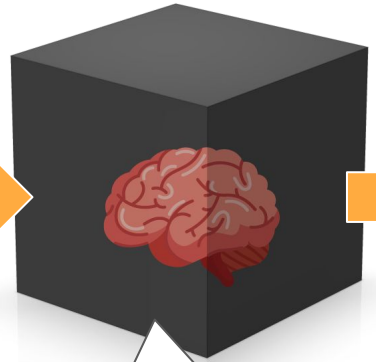
1. Introduction

We as humans are actively bombarded with visual information in a given day. And yet we are still able to retain and highlight key personal experiences in the context of who, what, where, and when of salient events that are added to our long-term memory. Inspired by nature, we ambitously aim to build a computationally efficient system that can automatically highlight certain salient events from long-term video data in a compact representation of just a few salient images and generated sentences. These samples then form a compressed diary that represents the video seqeuence. We deploy this on the real-time embedded TX1 [1].

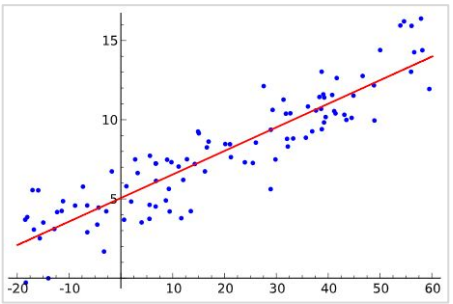
As a long term vision, our eventual goal is to allow people to wear the camera module for extended lengths of time

What is a Machine Learning model?

Input



Output/ Response



$$\hat{y} = b_0 + b_1 x$$

.

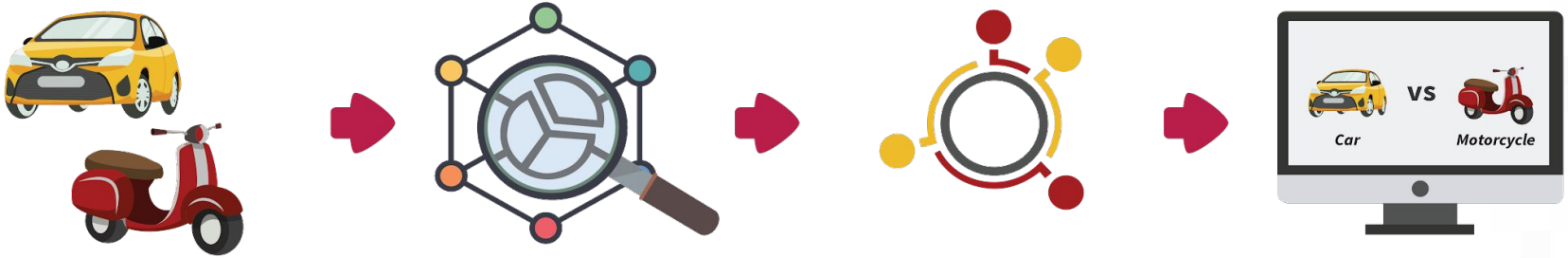
.

.

.

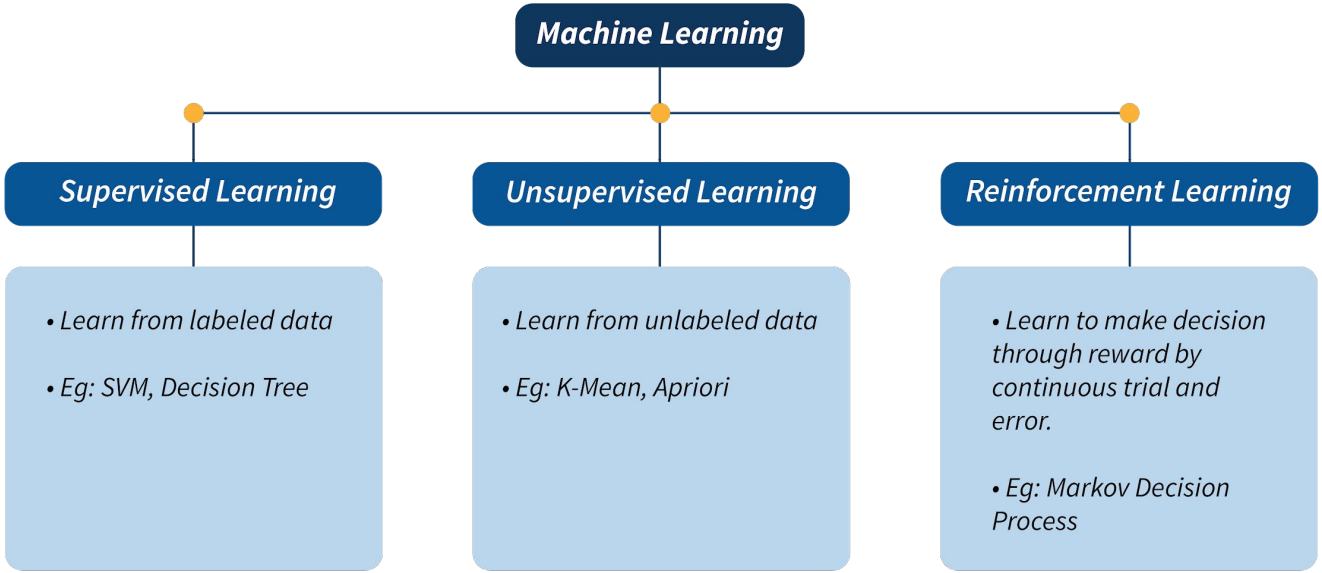
$$\hat{y} = 1.05 + 2x$$

Process to implement Machine Learning



Data → **Feature Extraction** → **Model Training / Evaluation** → **Deploy**

How Does A Model Learn?



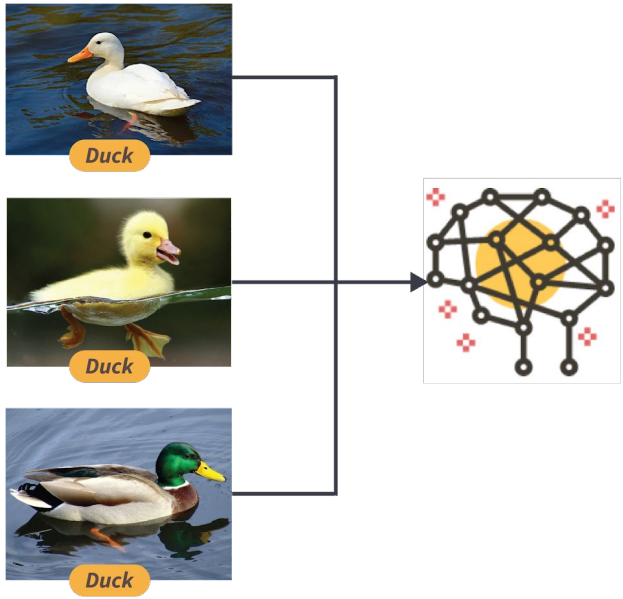
Machine Learning

Supervised and Unsupervised Learning

Supervised Learning (Classification)

Step 1

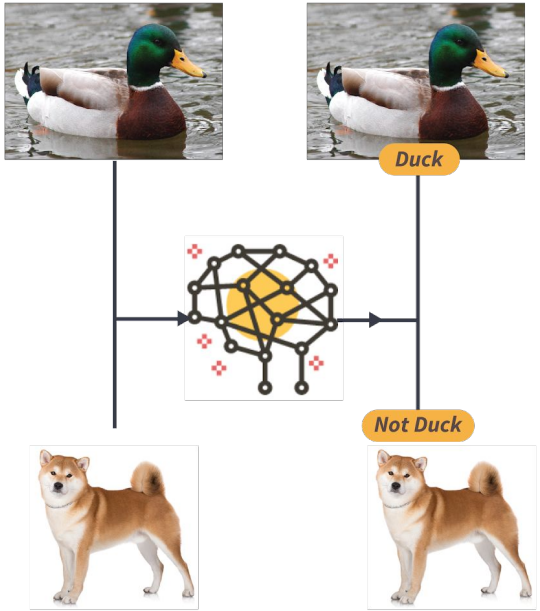
Provide the machine learning algorithm with "labeled" input data to learn.



Images labeled with "Duck"

Step 2

Feed the algorithm with "unlabeled" data to see if it labels the data correctly.



Supervised learning requires annotated dataset

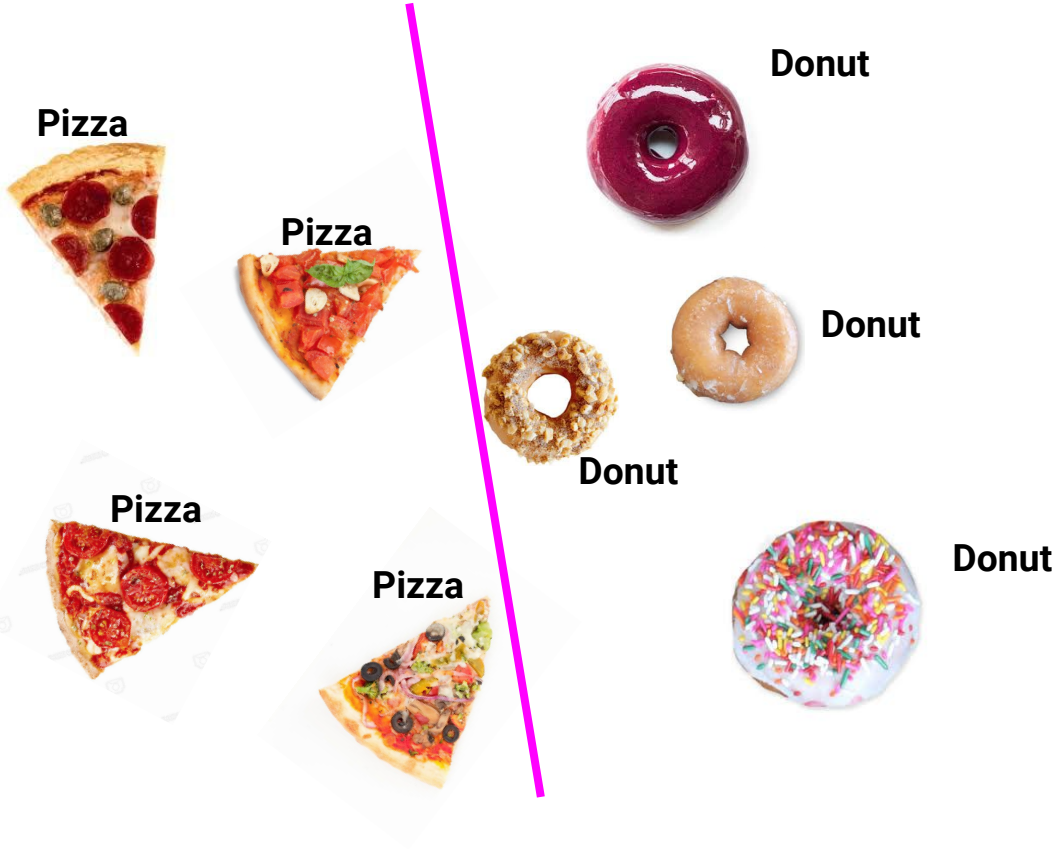
Features/Attributes/Dimension/Descriptors

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	class
b	30.83	0	u	g	w	v	1.25	t	t	1	f	g	202	0	+
a	58.67	4.46	u	g	q	h	3.04	t	t	6	f	g	43	560	+
a	24.5	0.5	u	g	q	h	1.5	t	f	0	f	g	280	824	+
b	27.83	1.54	u	g	w	v	3.75	t	t	5	t	g	100	3	+
b	20.17	5.625	u	g	w	v	1.71	t	f	0	f	s	120	0	+
b	32.08	4	u	g	m	v	2.5	t	f	0	t	g	360	0	+
b	33.17	1.04	u	g	r	h	6.5	t	f	0	t	g	164	31285	+
a	22.92	11.585	u	g	cc	v	0.04	t	f	0	f	g	80	1349	+
b	54.42	0.5	y	p	k	h	3.96	t	f	0	f	g	180	314	+
b	42.5	4.915	y	p	w	v	3.165	t	f	0	t	g	52	1442	+
b	22.08	0.83	u	g	c	h	2.165	f	f	0	t	g	128	0	+
b	29.92	1.835	u	g	c	h	4.335	t	f	0	f	g	260	200	+
a	38.25	6	u	g	k	v	1	t	f	0	t	g	0	0	+
b	48.08	6.04	u	g	k	v	0.04	f	f	0	f	g	0	2690	+
a	45.83	10.5	u	g	q	v	5	t	t	7	t	g	0	0	+
b	36.67	4.415	y	p	k	v	0.25	t	t	10	t	g	320	0	+
a	23.25	5.875	u	g	q	v	3.17	t	t	10	f	g	120	245	+
b	28.25	0.875	u	g	m	v	0.96	t	t	3	t	g	396	0	+

Instance/sample/ observation

Target/Output/Class/Label

Classification: Which category does this belong to?



Other classification examples:

- Fraudulent transaction detection
- Image classification
  - Medical image classification
- Text classification
  - Sentiment analysis
  - Spam detection
- Churn prediction
- Speech recognition
- Human activity recognition

Target class

	A	B	C	D	E
	img_variar	image_ske	image_cur	image_ent	class
	3.6216	8.6661	-2.8073	-0.44699	0
	4.5459	8.1674	-2.4586	-1.4621	0
	3.866	-2.6383	1.9242	0.10645	0
	3.4566	9.5228	-4.0112	-3.5944	0
	0.32924	-4.4552	4.5718	-0.9888	0
	4.3684	9.6718	-3.9606	-3.1625	0
	3.5912	3.0129	0.72888	0.56421	0
	2.0922	-6.81	8.4636	-0.60216	0
0	3.2032	5.7588	-0.75345	-0.61251	0
1	1.5356	9.1772	-2.2718	-0.73535	0
2	1.2247	8.7779	-2.2135	-0.80647	0
3	3.9899	-2.7066	2.3946	0.86291	0
4	1.8993	7.6625	0.15394	-3.1108	0
5	-1.5768	10.843	2.5462	-2.9362	0
6	3.404	8.7261	-2.9915	-0.57242	0
7	4.6765	-3.3895	3.4896	1.4771	0
8	-5.8818	7.6584	0.5558	-2.9155	1
9	-3.7747	2.5162	0.83341	-0.30993	1
10	-2.4198	-0.24418	0.70146	0.41809	1
11	-0.83535	0.80494	-1.6411	-0.19225	1
12	-0.30432	2.6528	-2.7756	-0.65647	1
13	-0.60254	1.7237	-2.1501	-0.77027	1
14	-2.1059	1.1815	-0.53324	-0.82716	1

Regression: How much value should I assign to this instance?

Imagine you work as a data scientist in an e-hailing company.

There are several numbers to be identified, in order to help the business to make more profit while providing a good user experience.

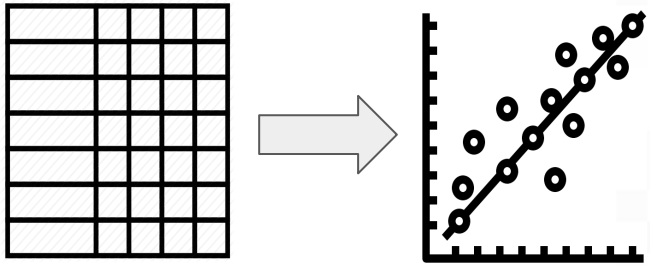
There are a few estimation to be made automatically in the system, which are:

1. Demand forecasting
2. Pricing
3. Estimated Arrival Time

What kind of prediction should your models produce?

Regression

- Function to predict a numerical output instead of a class/label.
- Predicts the dependent variable(y) based on the independent variables(x).
  - Dependent variable(y): House price
  - Independent variables(x): Square footage of house, number of bedrooms, number of toilets etc.



Input data

Output
Any continuous values:

- Price
- Time
- Weight
- etc.

Other regression examples:

Problems that involve predicting a numerical output:

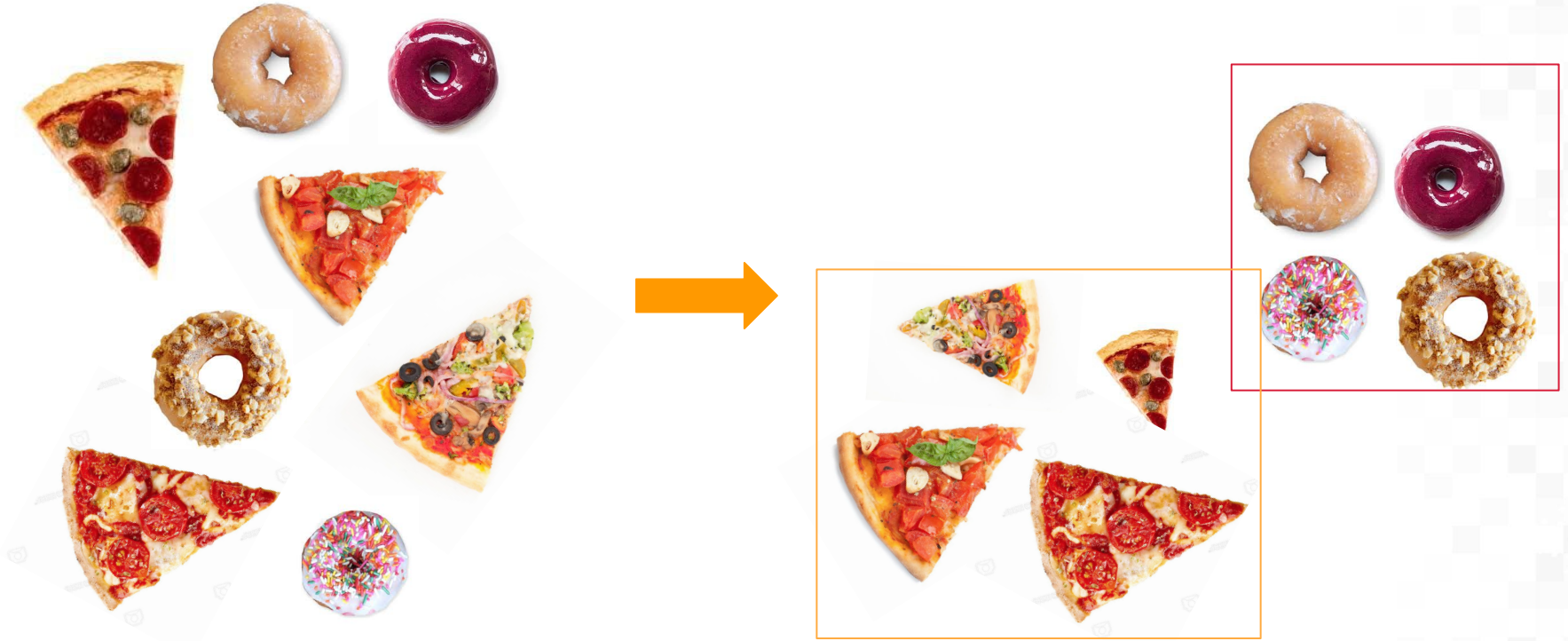
- Predicting stock price
- Predicting weight of a person based on height
- Predicting a house's sale price based on its square footage
- Revenue forecasting
- Call center forecasting

Target values

	A	B	C	D
1	geohash6	day	timestamp	demand
2	qp03wk	31	12:15	0.069298
3	qp03z0	48	5:45	0.14893
4	qp08bm	49	0:15	0.030246
5	qp03wu	10	20:00	0.103816
6	qp0962	13	23:00	0.079846
7	qp099b	49	21:30	0.005114
8	qp096h	49	9:15	0.037733
9	qp09eq	44	6:30	1
10	qp0d19	21	7:30	0.02237
11	qp03ry	38	8:45	0.10385
12	qp09vr	52	3:00	0.029553
13	qp03tt	25	9:30	0.00861
14	qp03ye	43	23:45	0.154701
15	qp06pe	31	0:45	0.088224
16	qp09hz	51	9:00	0.001188
17	qp09sn	43	5:30	0.372317
18	qp09b1	21	14:00	0.060837
19	qp03y9	59	9:45	0.079917

Unsupervised learning - Clustering

Is there any existing meaningful groups in my data?



Application of Clustering

Document Classification

Group documents into different categories based on tags, topics and contents.

Customer Segmentation

Cluster customers based on purchasing habit and provide customize product recommendation.

Insurance Fraud Detection

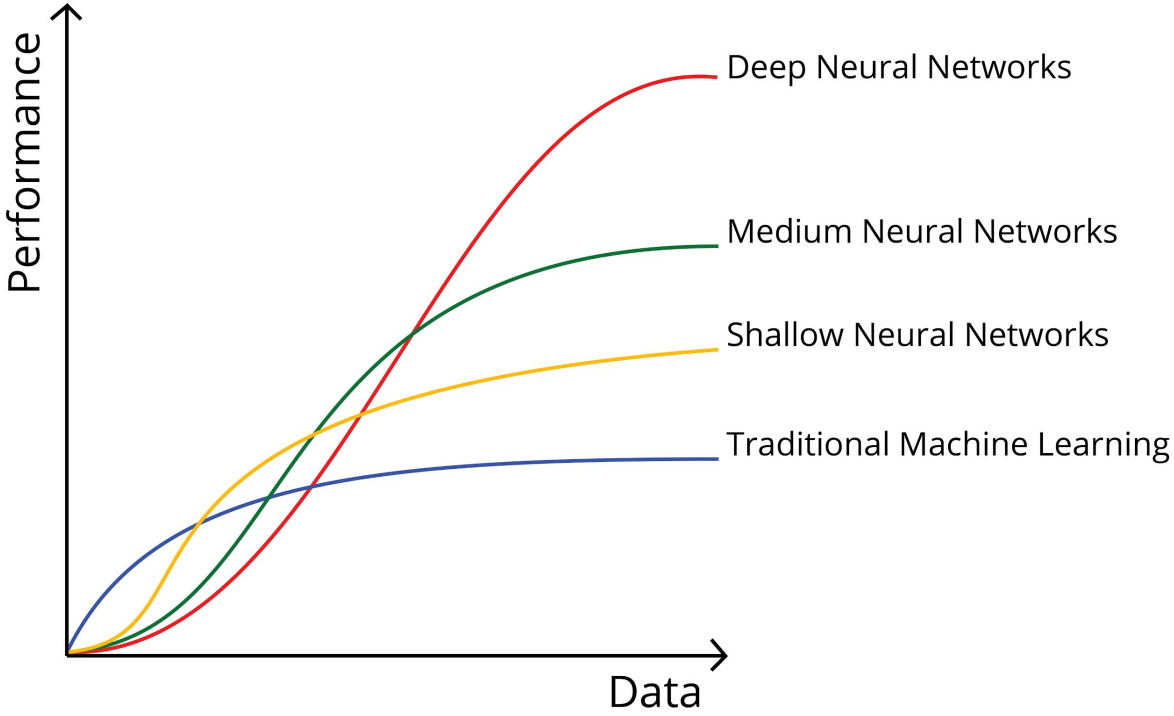
Identify fraudulent claims based on past historical data.

Machine Learning

Neural Networks and Deep Learning

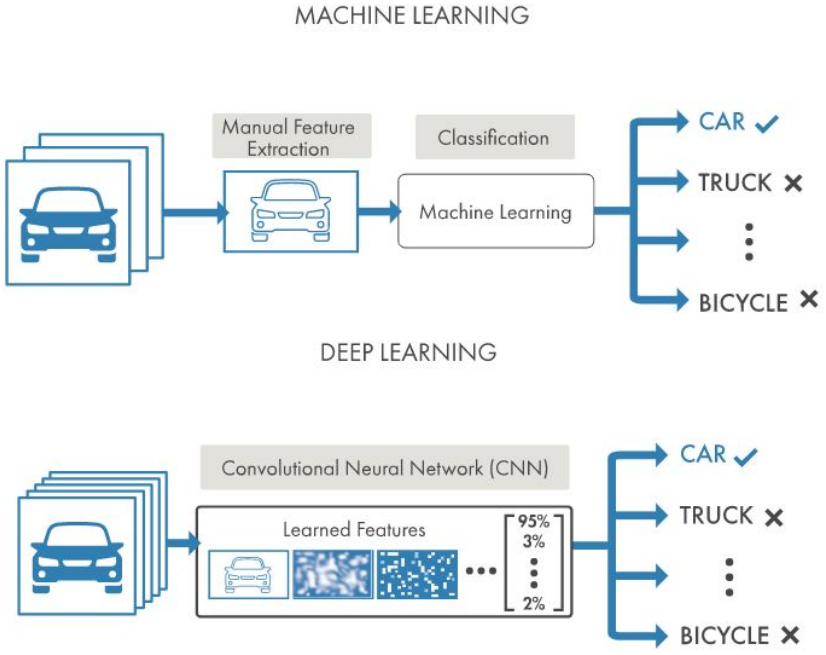
Deep Learning

- Deep learning **performance improve** tremendously when trained on **more data**



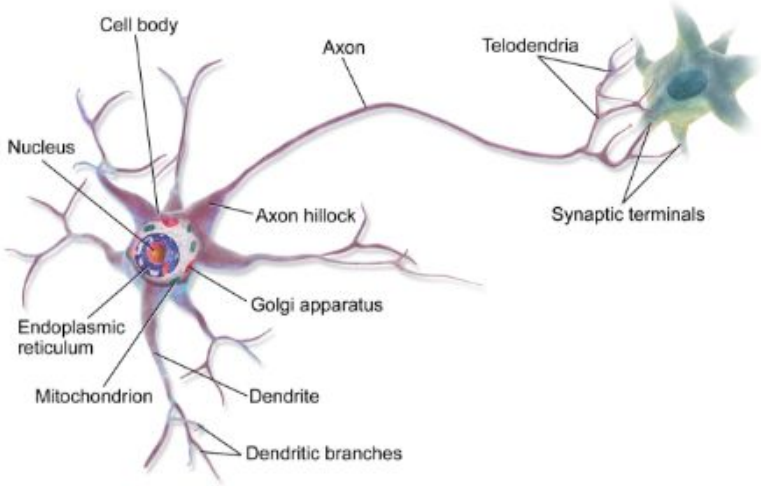
Why Use Deep Learning?

- **Automatic feature extraction**
  Deep learning shines when it comes to complex problems such as image classification, natural language processing, and speech recognition.

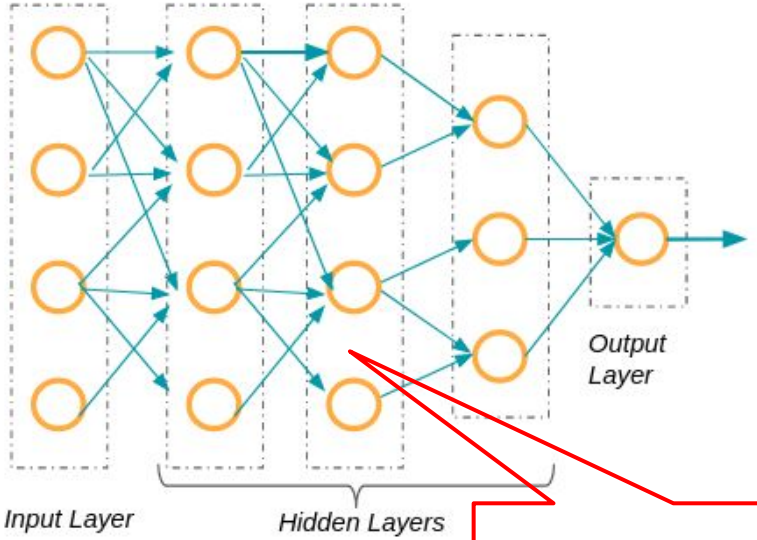


- Images
  - Colors
  - Edges
  - Texture
  - Outline of the object
- Text Data
  - Keywords
  - Numbers
  - Length of the text
- Speech
  - Pitch
  - Pause
  - Use of words

Fundamentals of Deep Learning



A Multipolar Neuron

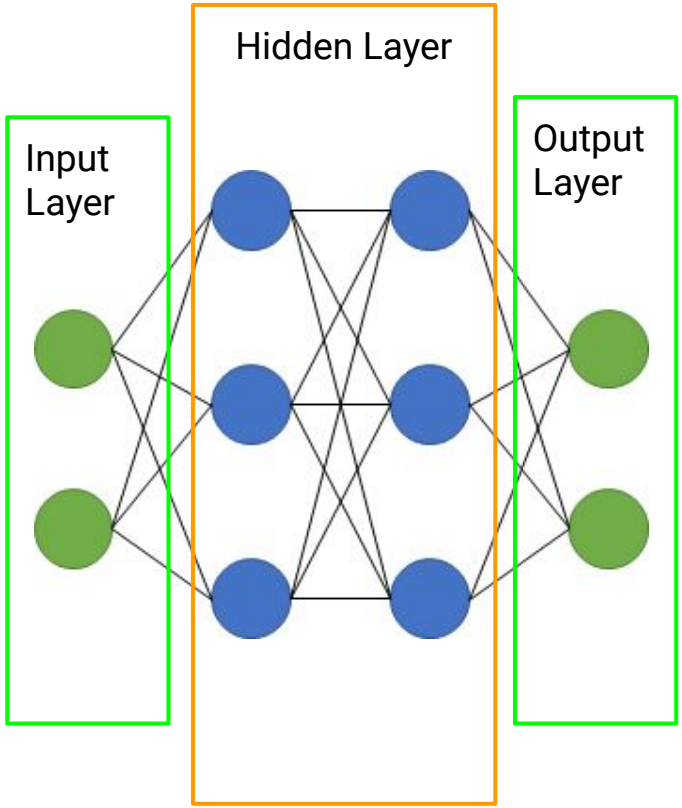


A Neural Network

Deep Learning: more hidden layers enables network to learn complex problem.

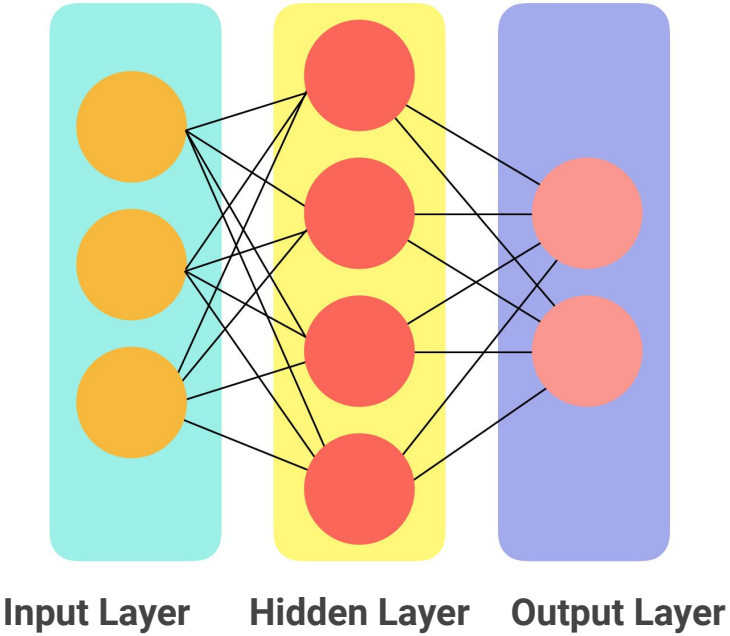
How deep neural network works?

Deep Learning Architecture



Neural Network Topology

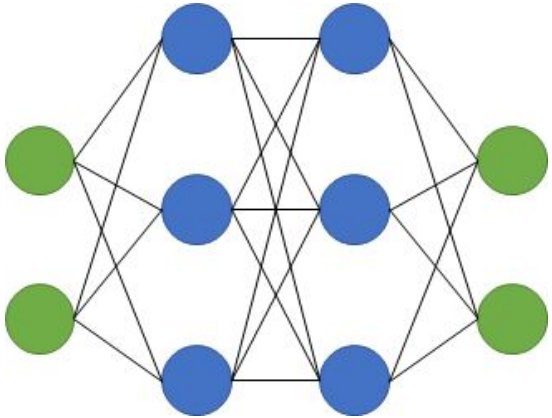
- **Input Layer:** load and store raw input data
- **Hidden Layer:** contained learned information of the raw training data
- **Output Layer:** get prediction from the network



How Deep Neural Network Works?

Deep Learning Architecture

$$\begin{bmatrix} 3.001 \\ 5.601 \\ \vdots \\ 8.941 \end{bmatrix}$$



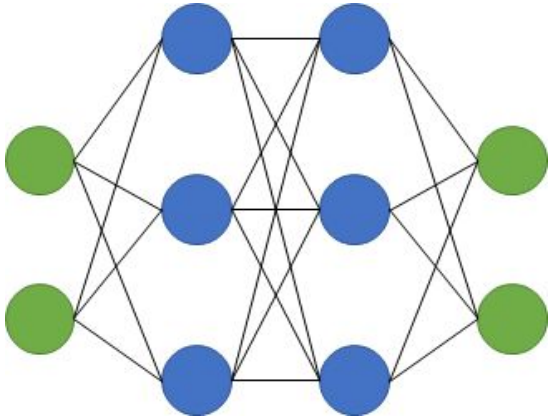
Dog

Cat

How Deep Neural Network Works?

Deep Learning Architecture

$$\begin{bmatrix} 5.782 \\ 8.591 \\ \vdots \\ 6.838 \end{bmatrix}$$

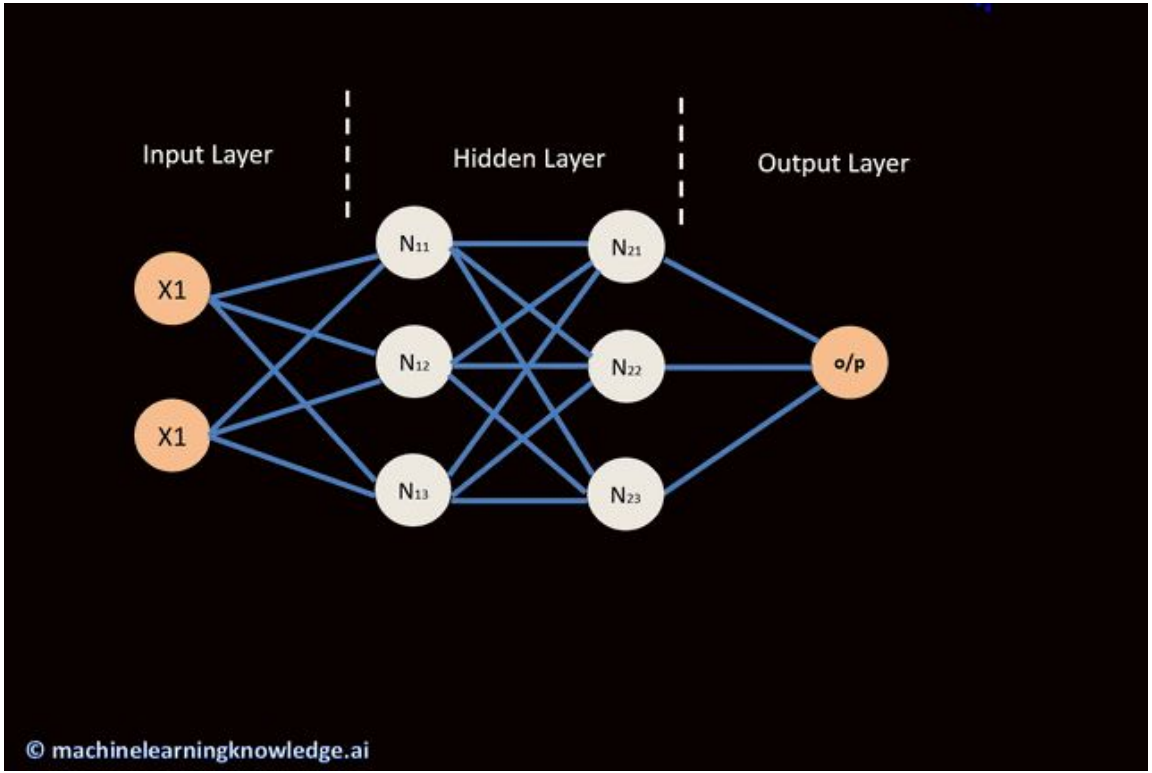


Dog

Cat

How Deep Neural Network Works?

Forward and Backpropagation

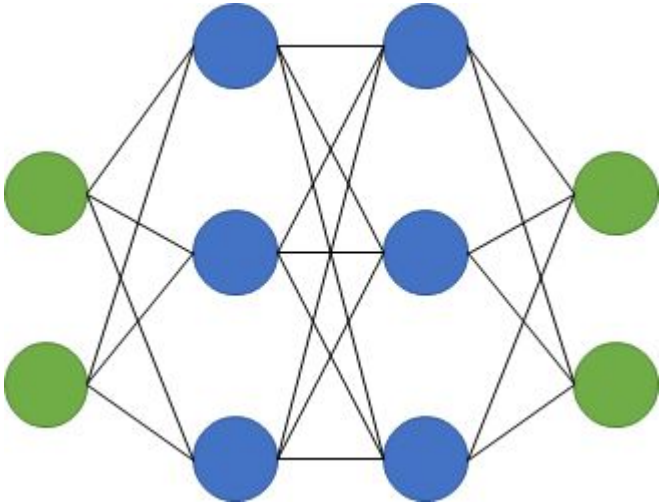


Source: https://machinelearningknowledge.ai

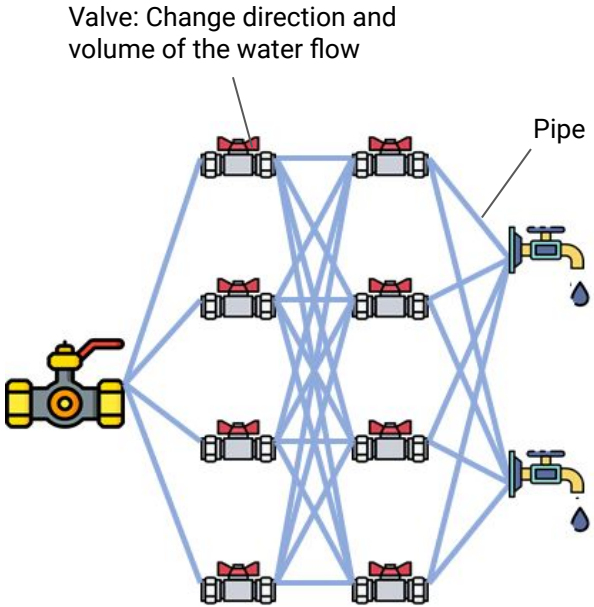
Machine Learning

Understanding Deep Neural Networks

How Deep Neural Network Works?



Deep neural network

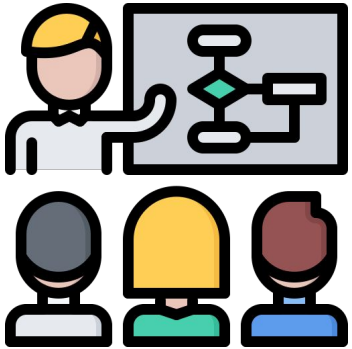


Water pipe network

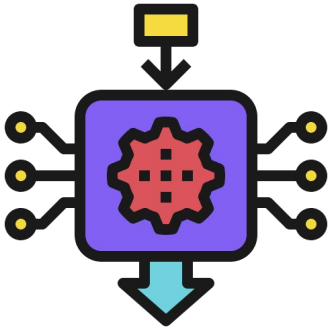
Source: Kai Fu Lee, AI Super Powers

How Deep Neural Network Works?

How to use water pipe networks to recognize handwritten number?



Training



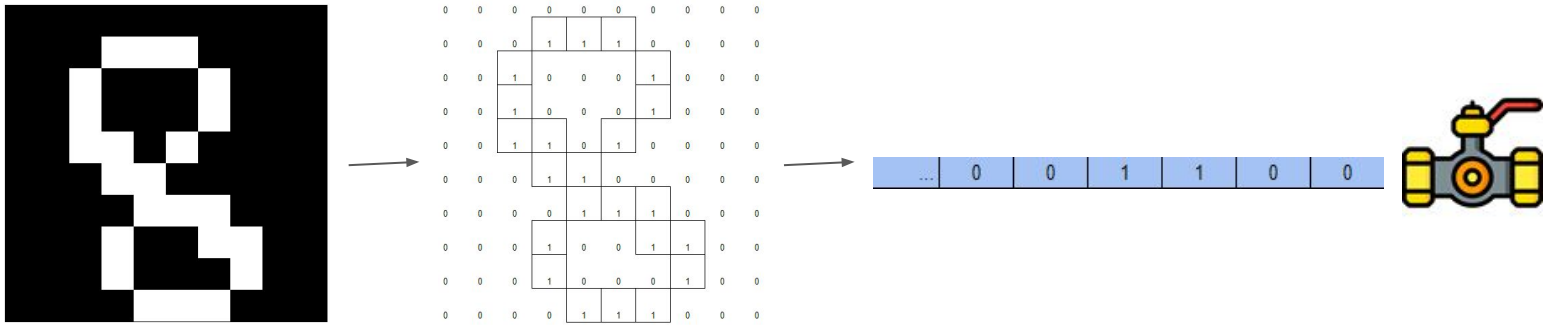
Inference

How Deep Neural Network Works?

How to use water pipe networks to recognize handwritten number?

Training

- For computer, images are made of *0* and *1*
- Now we can turn the image into information “water flow”, and let it flow into water pipe networks.

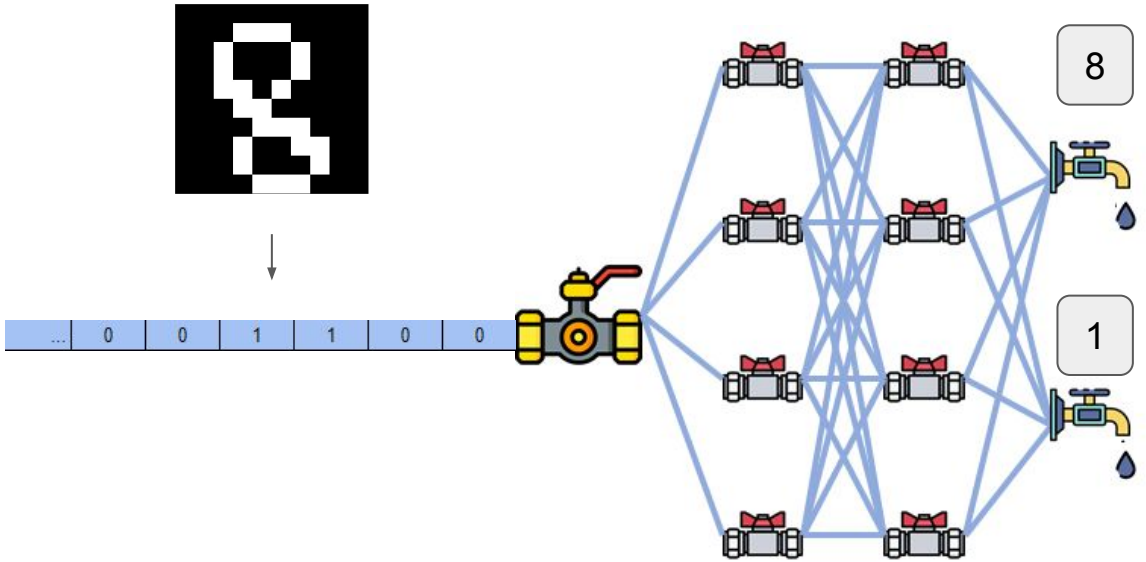


How Deep Neural Network Works?

How to use water pipe networks to recognize handwritten number?

Training

- We can place labels at the output of water pipe networks.
- If we only want our network to recognize *8* and *1*, we can place *8* and *1* at the output.

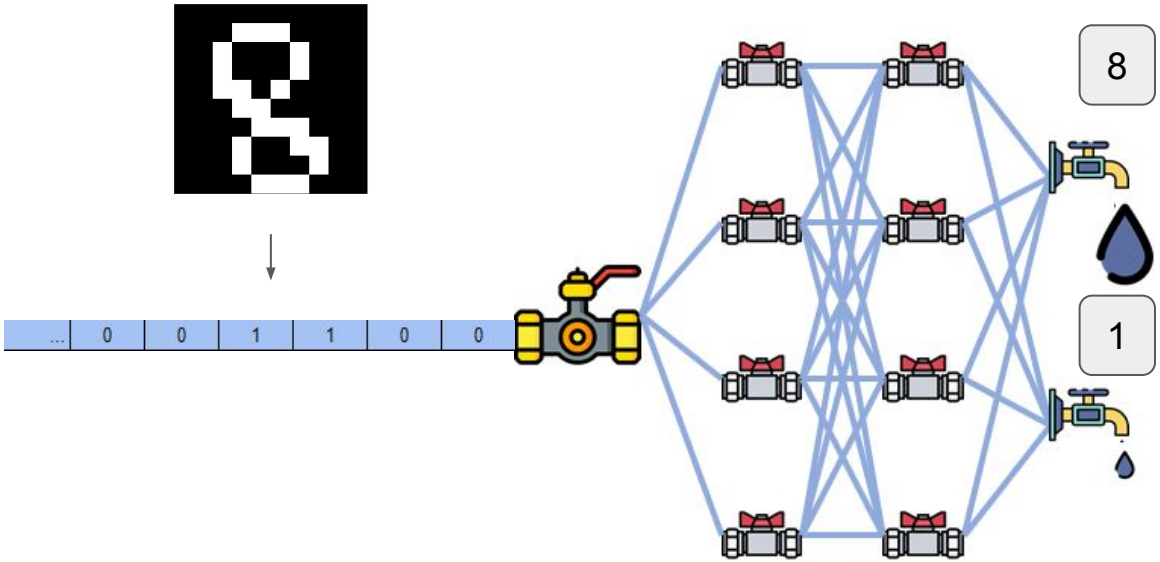


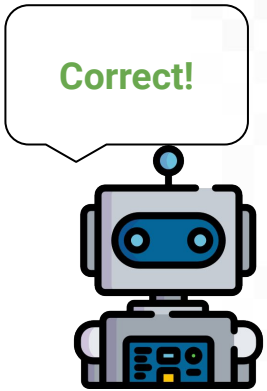
How Deep Neural Network Works?

How to use water pipe networks to recognize handwritten number?

Training

- If we input *8* as our input data
- Computer will check whether the output *8* has the greatest water flow.



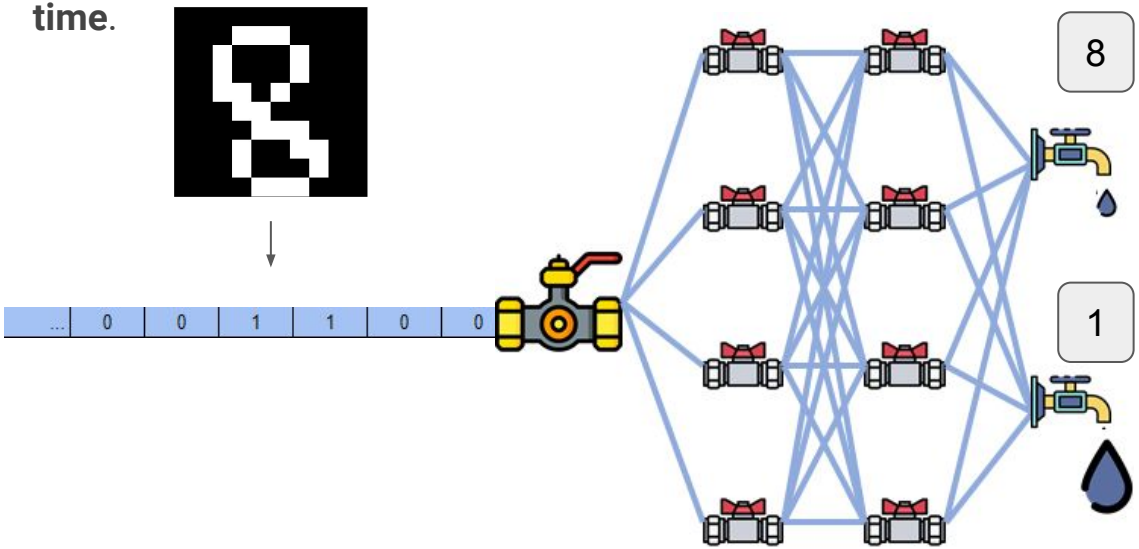


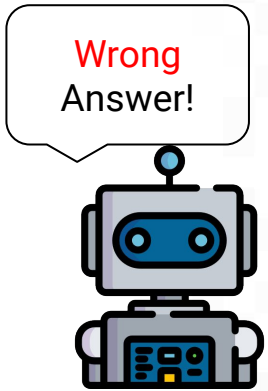
How Deep Neural Network Works?

How to use water pipe networks to recognize handwritten number?

Training

- Else, the computer will fine tune all valves, until the output with label *8* has the greatest water flow.
- In actual scenario, the computer needs to fine tune **billions** of valve! Without computational power and the optimization of training algorithms, it is **hard to accomplish the task in a short time**.



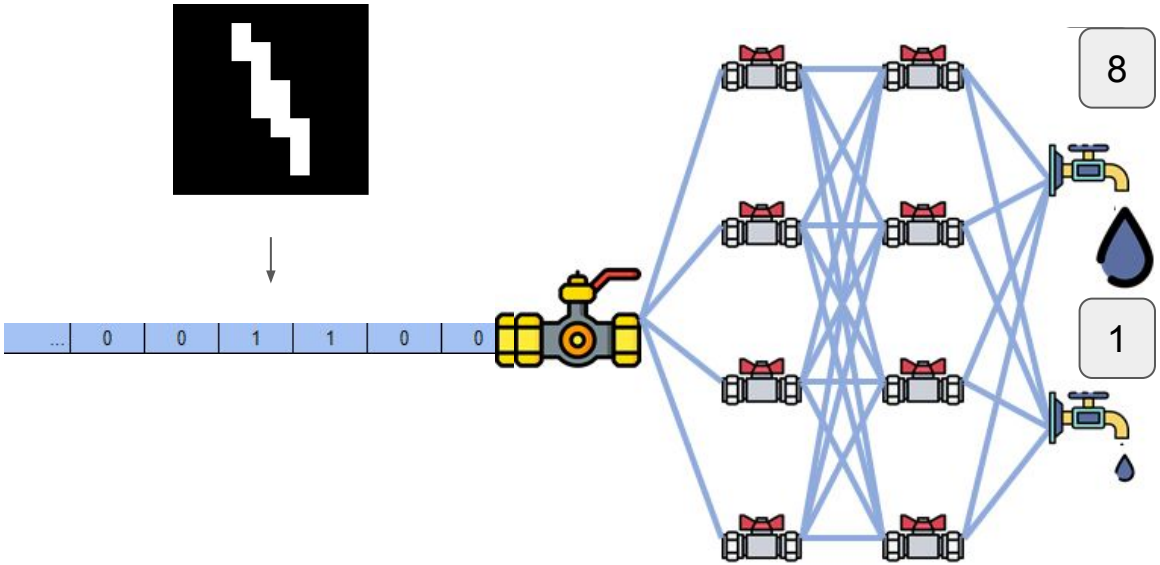


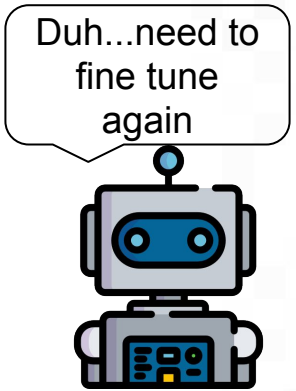
How Deep Neural Network Works?

How to use water pipe networks to recognize handwritten number?

Training

- Now, we can replace *8* with *1*.
- Same as the previous case, we need to make sure that label *1* has the greatest output flow.



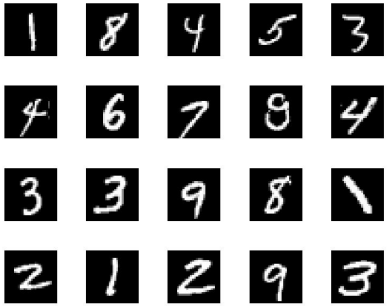


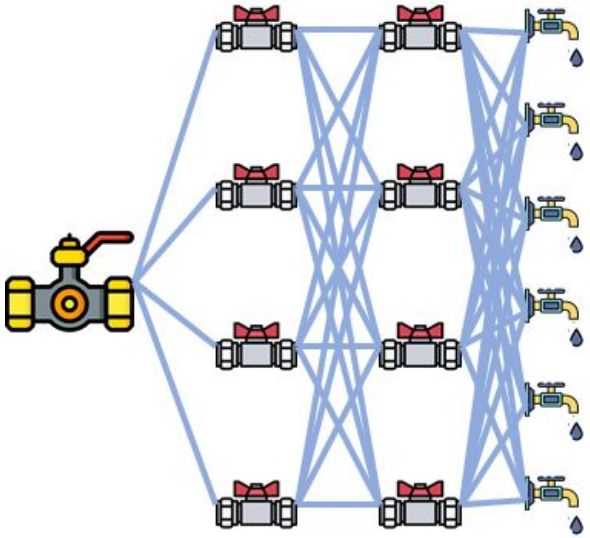
How Deep Neural Network Works?

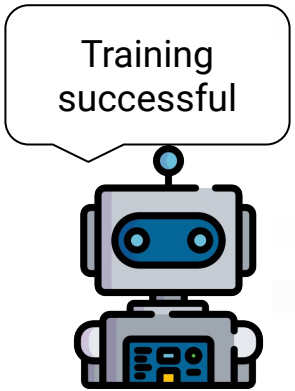
How to use water pipe networks to recognize handwritten number?

Training

- We can repeat the previous steps, until all handwritten digits and their respective water flow can follow the correct ways to flow through the water pipe network.
- When all the directions of water flow are correct, we can say that we successfully trained the water pipe network. (Deep Neural Network)





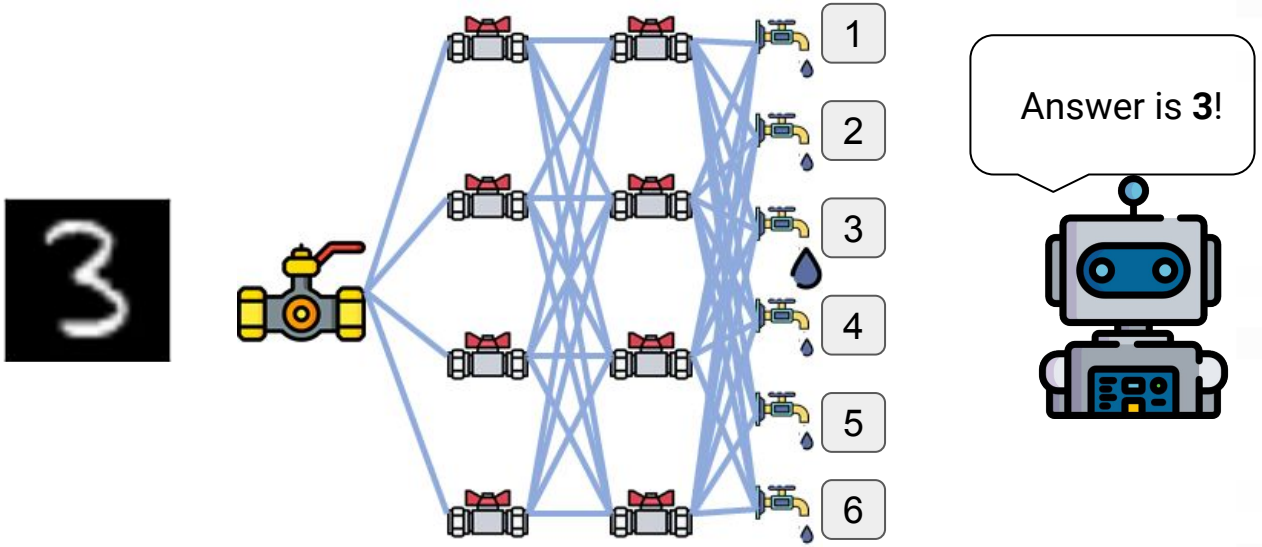


How Deep Neural Network Works?

How to use water pipe networks to recognize handwritten number?

Inference

- Prepare an unknown image, turn it into water flow and let it flow into our water pipe network.
- To know what the number is in the image, the computer will only need to observe the output from the network.



When to Use Deep Learning?

1. **Huge amount of data**: Deep Learning outperforms Machine Learning. With small data size, traditional Machine Learning algorithms are preferable

2. **High End Hardware Infrastructure**: Deep Learning needs to perform highly complex computations.

3. **Complex problems/data**: Such as image classification, speech recognition, and natural language processing