Deep Learning

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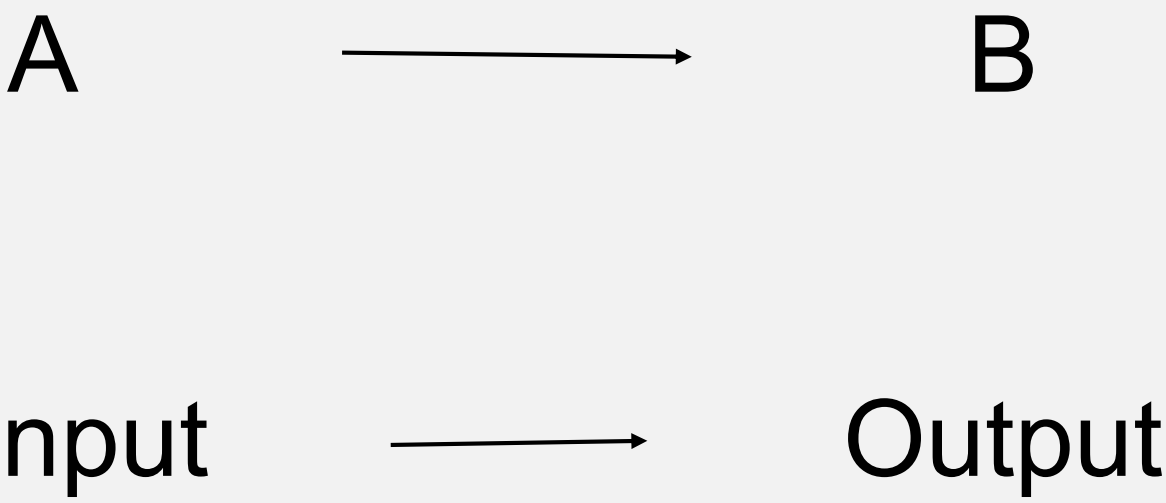
What is AI?
Machine Learning?
Deep Le g

Machine Learning

- The rise of AI has been largely driven by one tool in AI called machine learning.
- In this you'll learn what is machine learning, so that by the end, you hope we will start thinking how machine learning might be applied to your company or to your industry.

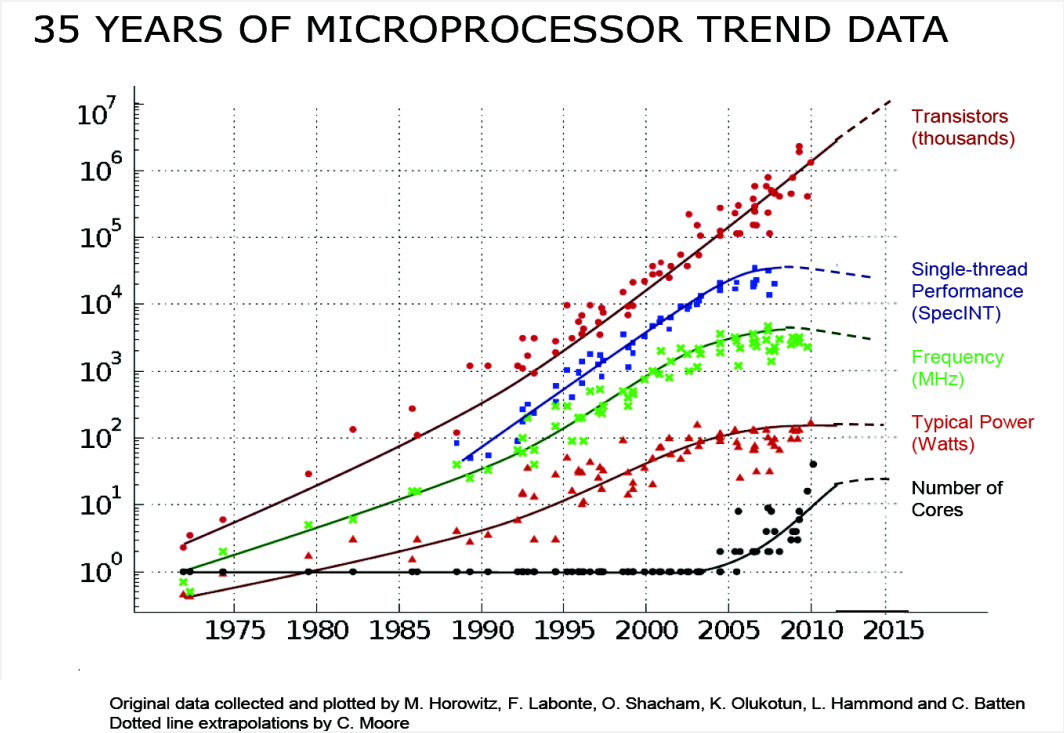
Supervised Learning

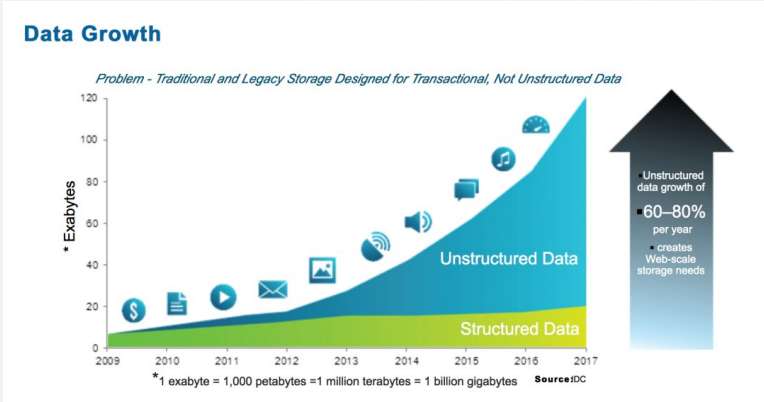


Machine Learning

Input (A) →	Output (B)	Application
email →	spam? (0/1)	spam filtering
audio →	text transcript	speech recognition
English →	Chinese	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

Why Now


35 YEARS OF MICROPROCESSOR TREND DATA
Transistors (thousands)
Single-thread Performance (SpecINT)
Frequency (MHz)
Typical Power (Watts)
Number of Cores
1975 1980 1985 1990 1995 2000 2005 2010 2015
Original data collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond and C. Batten
Dotted line extrapolations by C. Moore


Data Growth
Problem - Traditional and Legacy Storage Designed for Transactional, Not Unstructured Data
* Exabytes
Unstructured Data
Structured Data
Unstructured data growth of
60–80%
per year
creates Web-scale storage needs
*1 exabyte = 1,000 petabytes =1 million terabytes = 1 billion gigabytes
Source: IDC

Machine Learning

- The most important idea in AI has been machine learning, has basically supervised learning, which means A to B, or input to output mappings.

- What enables it to work really well is **data**.

What is AI?
What is [illegible]?

What is data?


DATA
DATABASE
Hadoop
discover
intelligence
organize
pieces
storage
computer
work
private
infrastructure
metadata
visualization
procesing
backup
software
technology
application
MANAGEMENT
ANALYSIS
sets
connections
structured
collect
search
group
INFORMATION
access
large
unstructured
video
web
insight
workload
research
mission critical
applications
social
public
learn
data center
redundant
Business Intelligence
integrity
BIG
management
transmission
modeling
knowledge
algorithm
patterns
files
tools
spreadsheet
system
MINING
networks
Internet
people
fixed
resource
CRM

Example of Table Data (dataset)

size of house (square feet)	# of bedrooms	price (1000$)
523	1	115
645	1	150
708	2	210
1034	3	280
2290	4	355
2545	4	440

B A

A → B

image	label
	cat
	not cat
	cat
	not cat

✓ "Google cat"

× ✓ ×

A B

A → B

Acquiring Data

- Manual labeling

 cat  not cat  cat  not cat

- From observing behaviors

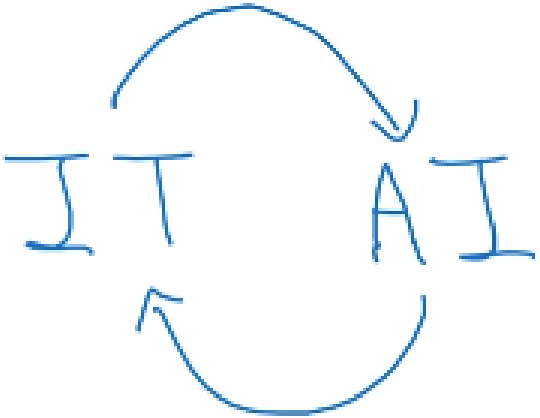
user ID	time	price ($)	purchased
4783	Jan 21 08:15.20	7.95	yes
3893	March 3 11:30.15	10.00	yes
8384	June 11 14:15.05	9.50	no
0931	Aug 2 20:30.55	12.90	yes

machine	temperature (°C)	pressure (psi)	machine fault
17987	60	7.65	N
34672	100	25.50	N
08542	140	75.50	Y
98536	165	125.00	Y

A B

- Download from websites / partnerships

Use and Mis Use Of Data



Don't throw data at an AI team and assume it will be valuable.

nu3.de/blogs/nutrition/food-carbon-footprint-index-2018

Apps | Bookmarks | MEGA | Mango URLs | data_science | hobbies | wedding | freelance_work | primary_schools | holiday_2018 | Other bookmarks

nu3

span.thead-icon.icon-4 34.99 × 34.99

#	Country							
1	Argentina	10.51	37.20	38.66	41.53	55.48	1712.00	1.56
2	Australia	24.14	85.44	46.12	49.54	33.86	1044.85	9.87
3	Albania	10.88	38.51	13.23	14.21	22.50	694.30	15.32
4	Iceland	21.69	76.77	26.87	28.86	13.36	412.26	21.12
5	New Zealand	22.29	78.90	34.98	37.58	22.49	693.99	18.91
6	USA	27.64	97.83	50.01	53.72	36.24	1118.29	0.43
7	Uruguay	16.84	59.61	27.45	29.49	29.10	897.96	8.23
8	Luxembourg	43.58	154.25	21.37	22.96	29.88	922.03	1.67
9	Brazil	12.60	44.60	45.00	48.34	39.25	1211.17	0.62
10	Kazakhstan	10.36	36.67	18.38	19.74	23.38	721.46	9.56
11	Sweden	37.00	130.96	16.64	17.87	24.58	758.49	1.41
12	Bermuda	28.24	99.96	32.62	35.04	33.15	1022.94	2.71
13	Denmark	24.87	88.03	26.75	28.73	28.46	878.22	0.92
14	Finland	36.14	127.92	19.87	21.34	19.22	593.09	0.53
15	Ireland	32.40	114.68	26.26	28.21	22.35	689.67	4.10
16	Greece	28.31	100.20	15.74	16.91	16.10	496.81	12.47
17	France	33.05	116.98	22.93	24.63	23.81	734.73	3.28
18	Canada	22.81	80.74	36.68	39.40	30.25	933.45	0.97
19	Norway	23.51	83.21	21.01	22.57	19.83	611.91	5.34
20	Hong Kong SAR. China	67.11	237.54	54.86	58.93	25.82	796.75	2.22
21	French Polynesia	14.75	52.21	49.55	53.23	30.90	953.51	2.83

Elements | Console | Sources | Network | Performance | Memory | Application

```
<td colspan="1"> </td>
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<td colspan="2">
  <span class="thead-icon icon-4" title="Pork">
   </span>
</td>
<td colspan="2">
  <span class="thead-icon icon-5" title="Poultry">
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<td colspan="1"> </td>
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<td colspan="2">…</td>
```

... div #s-526c54ab-4ad7-4d4f-9571-4efcafed49b6 div div #nu3-custom-table-1 tbody tr td

Styles

```
:hov .cls
element.
style {
}
food-ca…
.nu3-
custom-
table tr td
{
  text-
    align
    :
    center
  height
    :
    20px;
  -webkit
  transi
```

Console | What's New ×

Highlights from the Chrome 79 update

Debug why a cookie was blocked
Click a resource in the Network panel and go to the updated Cookies tab.

View cookie values
Click a row in the Cookies pane in the Application panel to see the cookie's value.

What is data?

- In this you learned what data is and you also saw how not to misuse data, for example by over-investing in an IT infrastructure in the hope that it will be useful for AI in the future.

- Finally, you saw data is messy.
  - But a good AI team would be the help you deal with all of these problems.

- Now, AI has a complicated terminology when people throw around terms like AI, Machine Learning, Data Science.
  - What do they really mean?

What is AI?
The termin[illegible]of AI

The terminology of AI

- You might have heard terminology from AI, such as machine learning or data science or neural networks or deep learning. What do these terms really mean?

Machine Learning VS Data Science

Home prices

size of house (square feet)	# of bedrooms	# of bathrooms	newly renovated	price (1000$)
523	1	2	N	115
645	1	3	N	150
708	2	1	N	210
1034	3	3	Y	280
2290	4	4	N	355
2545	4	5	Y	440

A

B

ML. A → B

Running AI system
(e.g., websites / mobile app)

DS

Homes with 3 bedrooms are more expensive than homes with 2 bedrooms of a similar size.

Newly renovated homes have a 15% premium.

Machine Learning VS Data Science

Machine learning

"Field of study that gives computers the ability to learn without being explicitly programmed."

software

-Arthur Samuel (1959)

Data science

Science of extracting knowledge and insights from data.

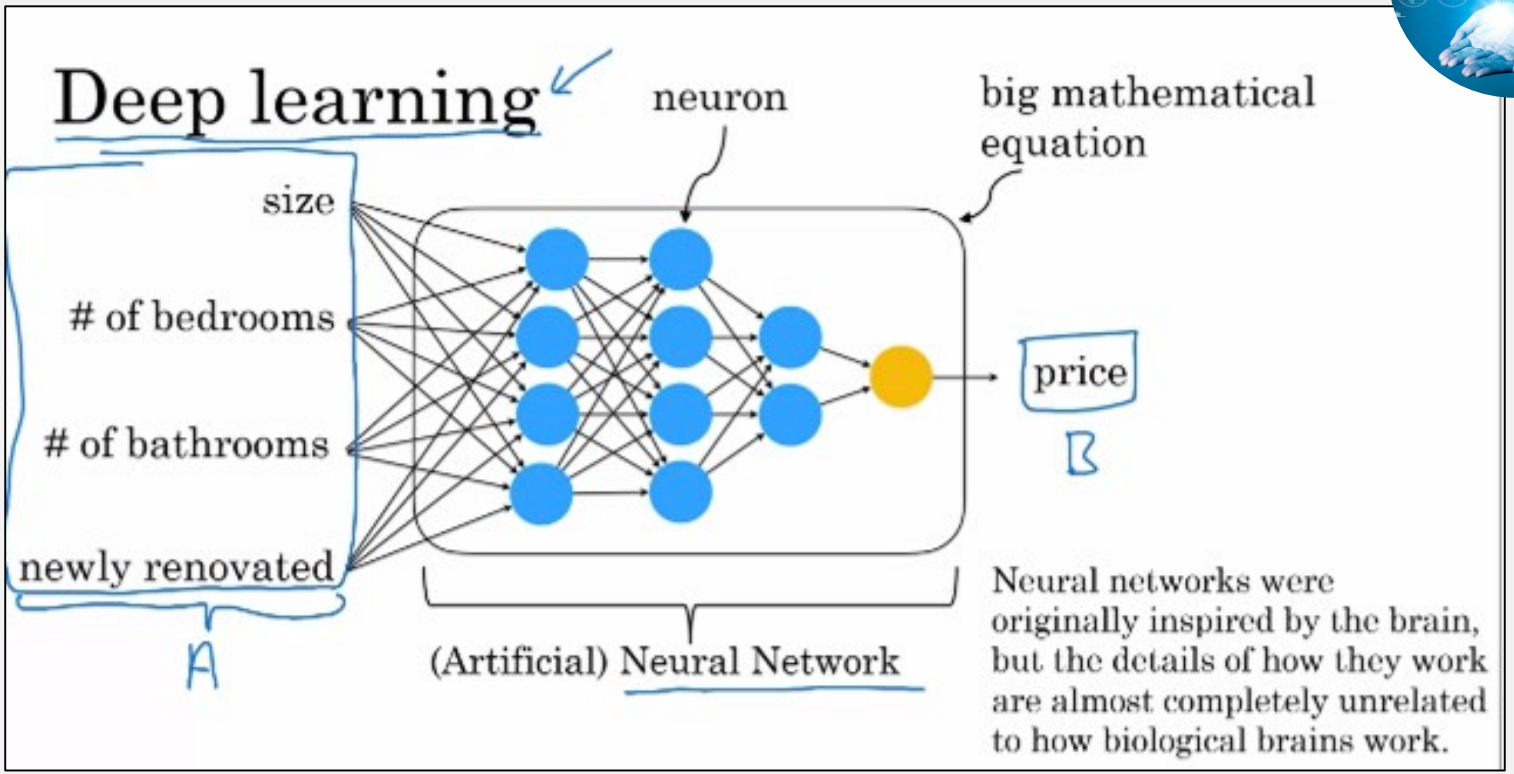
slide deck

The terminology of AI

Let me give an example of machine learning versus data science in the online advertising industry.

- A system that runs 24/7 and determines which Ad a user may click on:
  - **Machine Learning**
- The analysis of this system and the resulting data so you can change the model or pull insights from the data:
  - **Data Science**

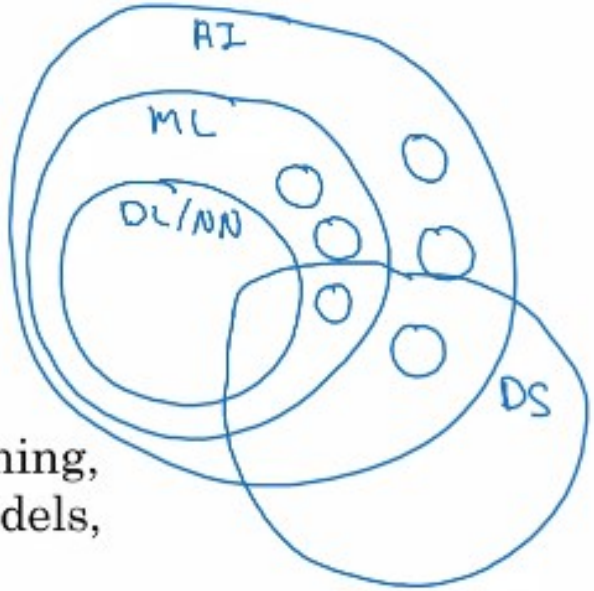
Deep Learning



The terminology of AI

AI has many tools

- Machine learning and data science
- Deep learning / neural network
- Other buzzwords: Unsupervised learning, reinforcement learning, graphical models, planning, knowledge graph, …



What is AI?
What makes an AI company?

What makes an AI company?

- What makes a company good at AI? Perhaps even more importantly, what will it take for your company to become great at using AI?
- What can you do for your company?

What makes an AI company?

A lesson from the rise of the Internet

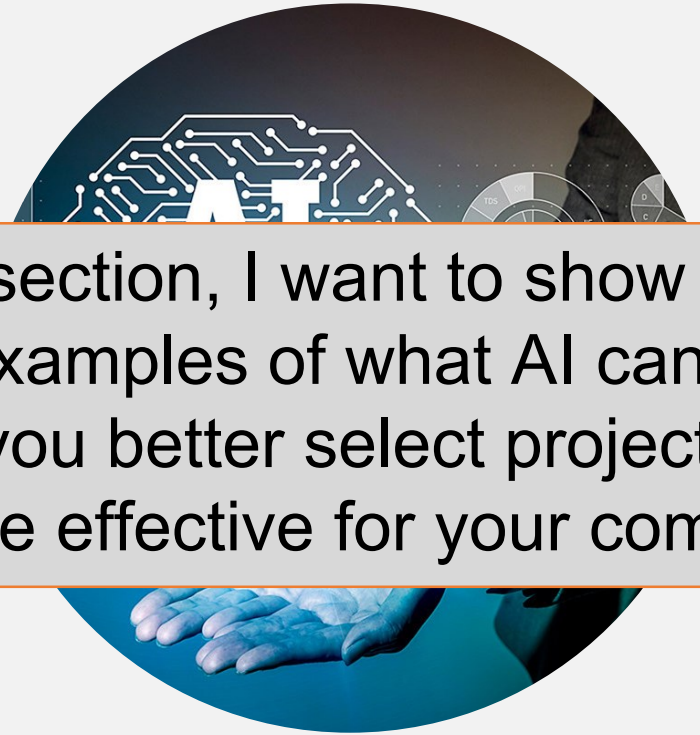
Internet Era	AI era
Shopping mall + website ≠ Internet company	Any company + deep learning ≠ AI company
- A/B testing - Short iteration time - Decision making pushed down to engineers and other specialized roles	- Strategic data acquisition - Unified data warehouse - Pervasive automation - New roles (e.g., MLE) and division of labor

What makes an AI company?

AI Transformation

1. Execute pilot projects to gain momentum
2. Build an in-house AI team
3. Provide broad AI training
4. Develop an AI strategy
5. Develop internal and external communications

What makes an AI company?



- In the next section, I want to show you and give you some examples of what AI can and cannot do, to help you better select projects AI that there may be effective for your company.

What is AI?
What machine learning can and can

What machine learning can and cannot do

- In this section and the next section, I hope to help you develop intuition about what AI can and cannot do.
  - In practice, before you commit to a specific AI project, you'll usually have to do technical diligence on the project to make sure that it is feasible.

- This means: looking at the data, look at the input, and output (A and B), and just thinking through if this is something AI can really do.

What machine learning can and cannot do

- What I've seen unfortunately is that some CEOs can have an inflated expectation of AI and can ask engineers to do things that today's AI just cannot do.

- One of the challenges is that the media, as well as the academic literature, tends to only report on positive results or success stories using AI, and we see a string of success stories and no failure stories, people sometimes think AI can do everything. Unfortunately, that's just not true.

Supervised learning

Input (A)	Output (B)	Application
email	spam? (0/1)	spam filtering
audio	text transcripts	speech recognition
English	Chinese	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

Anything you can do with 1 second of thought, we can probably now or soon automate.

What machine learning can and cannot do

- So for example, in order to determine the position of other cars, that's something that you can do with less than a second. In order to tell if a phone is scratched, you can look at it and you can tell in less than a second.
- In order to understand or at least transcribe what was said, it doesn't take that many seconds of thought.
- While this is an imperfect rule of thumb, it maybe gives you a way to quickly think of some examples of tasks that AI systems can do.

What machine learning can and cannot do

The toy arrived two days late, so I wasn't able to give it to my niece for her birthday.
Can I return it?

"Refund request"

Input text → Refund/Shipping/Other

A → B

Oh, sorry to hear that.
I hope your niece had a good birthday.
Yes, we can help with....

What Happens If You Try?

Input (A)		Output (B)
User email	→	2-3 paragraph response
1000 examples		
"My box was damaged."	→	Thank you for your email.
"Where do I write a review?"	→	Thank you for your email.
"What's the return policy?"	→	Thank you for your email.
"When is my box arriving?"	→	Thank yes now your….

What makes an ML Problem Easier

1. Learning a "simple" concept

   ≤ 1 sec

2. Lots of data available

   A, B

   A → B

What machine learning can and cannot do

- AI is the new electricity and it's transforming every industry, but it's also not magic and it can't do everything under the sun.
- I hope that this started to help you hone your intuitions about what it can and cannot do, and increase the odds of your selecting feasible and valuable projects for maybe your teams to try working on.
- In order to help you continue developing your intuition, I would like to show you more examples of what AI can and cannot do.

What is AI?

More examples of what machine learning can a[illegible]not do

More examples of what machine learning can and cannot do

- One of the challenges of becoming good at recognizing what AI can and cannot do is that it does take seeing a few examples of concrete successes and failures of AI.
- If you work on an average of say, one new AI project a year, then to see three examples would take you three years of work experience and that's just a long time.

More examples of what machine learning can and cannot do

- Let's say you're building a self-driving car, here's something that AI can do pretty well, which is to take a picture of what's in front of your car and maybe just using a camera, maybe using other senses as well such as radar or lidar.
- Then to figure out, what is the position, or where are the other cars.
- So, this would be an AI where the input A, is a picture of what's in front of your car, or maybe both a picture as well as radar and other sensor reading

Self Driving Car

Can do


A → B

10,000

Cannot do



stop | hitchhiker | bike turn left signal

10,000

1. Data
2. Need high accuracy

A → B

More examples of what machine learning can and cannot do

- Say you want to build an AI system to look at X-ray images and diagnose pneumonia. So, all of these are chest X-rays. So, the input A could be the X-ray image and the output B can be the diagnosis.
- Does this patient have pneumonia or not? So, that's something that AI can do.
- Something that AI cannot do would be to diagnose pneumonia from 10 images of a medical textbook chapter explaining pneumonia.

X Ray Diagnosis





Can do	Cannot do
Diagnose pneumonia from ~10,000 labeled images	Diagnose pneumonia from 10 images of a medical textbook chapter explaining pneumonia
A → B	A → B

More examples of what machine learning can and cannot do

- Machine learning tends to work well when you're trying to learn a simple concept, such as something that you could do with less than a second of mental thought, and when there's lots of data available.

- Machine learning tends to work poorly when you're trying to learn a complex concept from small amounts of data

Strengths and Weaknesses Of ML

ML tends to work well when:

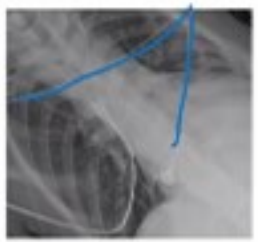
1. Learning a "simple" concept
2. There is lots of data available

ML tends to work poorly when:

1. Learning complex concepts from small amounts of data
2. It is asked to perform on new types of data

A→B



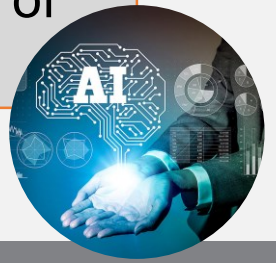
More examples of what machine learning can and cannot do

- I hope these examples are helping you hone your intuitions about what AI can and cannot do.
  - In case the boundary between what it can or cannot do still seems fuzzy to you, don't worry.
- It will take time and technical diligence before forming strong conviction about whether something is feasible or not.

What is AI?
Non-technical explanation of deep learning (Part 1, optional)

Non-technical explanation of deep learning (Part 1, optional)

- The terms deep learning and neural network are used almost interchangeably in AI.
- And even though they're great for machine learning, there's also been a bit of hype and bit of mystique about them.
- This will demystify deep learning, so that you have a sense of what deep learning and neural networks really are.

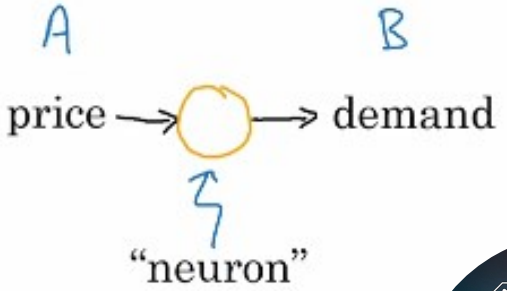


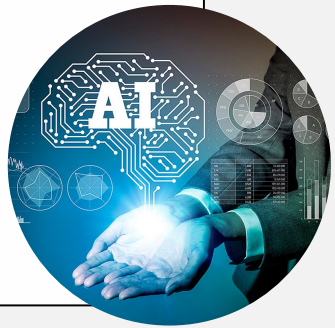
Non-technical explanation of deep learning (Part 1, optional)

- Let's use an example from demand prediction.
  - Let's say you run a website that sells t-shirts.
- And you want to know, based on how you price the t-shirts, how many units you expect to sell, how many t-shirts you expect to sell.
- You might then create a dataset like this, where the higher the price of the t-shirt, the lower the demand.
- So you might fit a straight line to this data, showing that as the price goes up, the demand goes down.

Non-technical explanation of deep learning (Part 1, optional)

Demand prediction

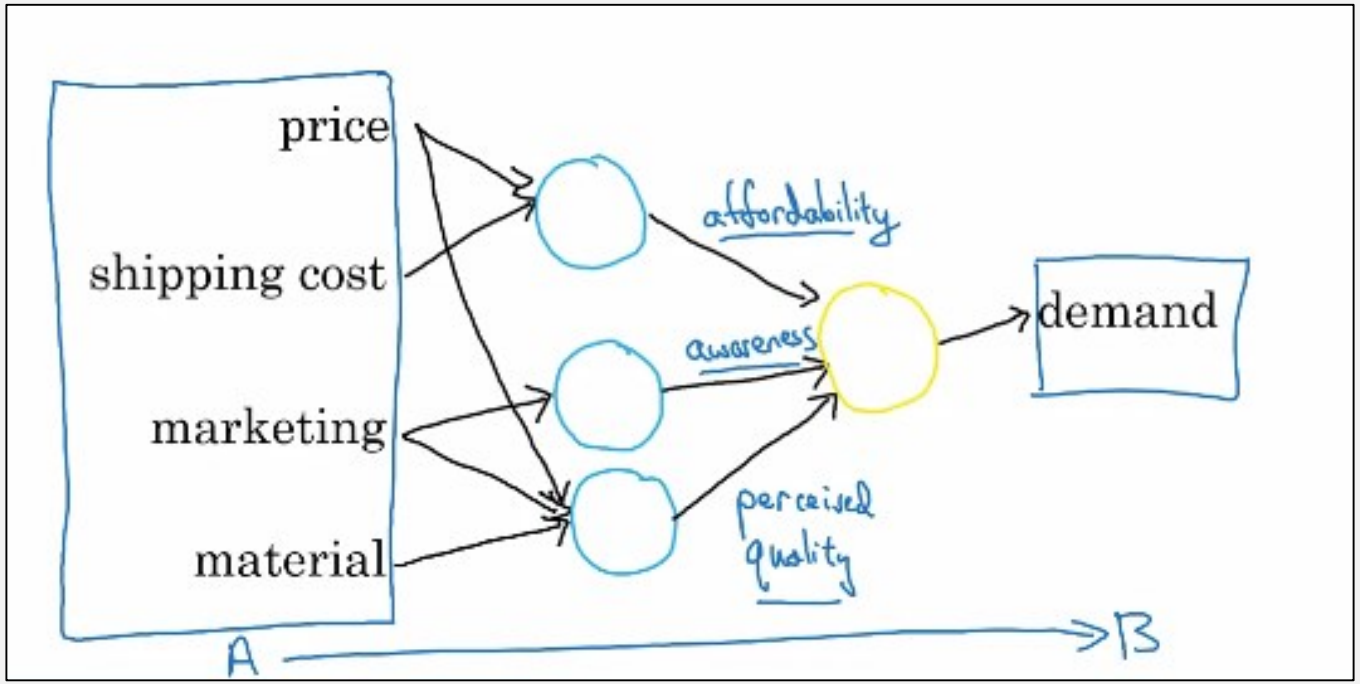




Demand Prediction

- Suppose that instead of knowing only the price of the t-shirts, you also have the shipping costs that the customers will have to pay to get the t-shirts.
- Maybe you spend more or less on marketing in a given lesson, and you can also make the t-shirt out of a thick, heavy, expensive cotton or a much cheaper, more lightweight material.

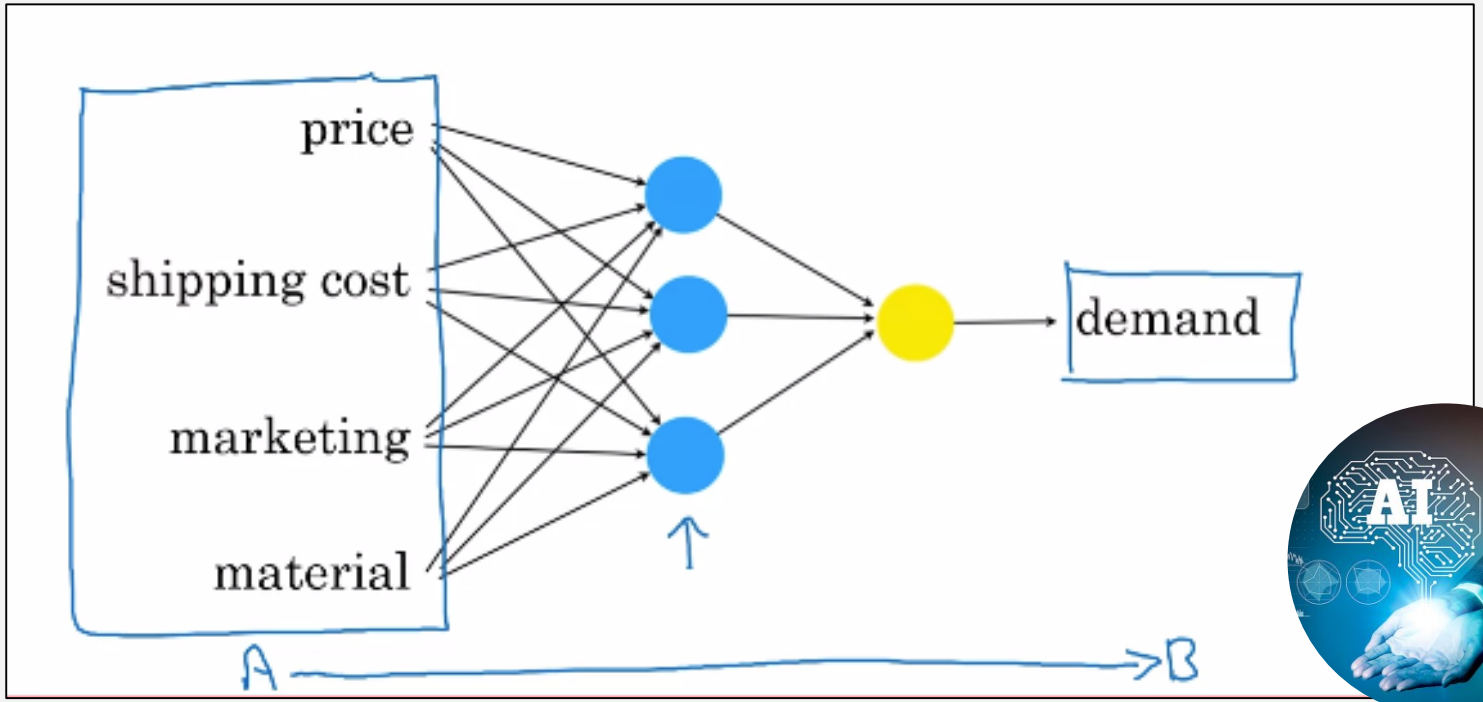
Demand Prediction



Non-technical explanation of deep learning (Part 1, optional)

- So It learns this input output or A to B mapping.
- This is a fairly small neural network with just four artificial neurons.
- In practice, neural networks used today are much larger, with easily thousands, tens of thousands or even much larger than that numbers of neurons.

Demand Prediction



Non-technical explanation of deep learning (Part 1, optional)

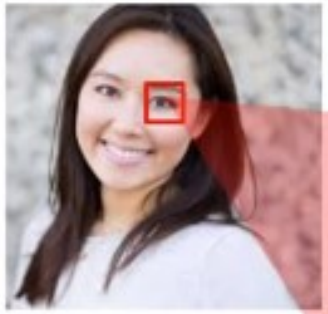
- So that's a neural network, is a group of artificial neurons each of which computes a relatively simple function.
- But when you stack enough of them together like Lego bricks, they can compute incredibly complicated functions that give you very accurate mappings from the input A to the output B.
- Now, in this you saw an example of neural networks applied to demand prediction.

What is AI?
More Deep Learning...

Non-technical explanation of deep learning (Part 2, optional)

- In the last, you saw how a neural network can be applied to demand prediction, but how can the neural network look at the picture and figure out what's in the picture?
    - Or listen to an audio clip and understand what is said in an audio clip?
- Let's take a look at a more complex example of applying a neural network to face recognition.

Face Recognition

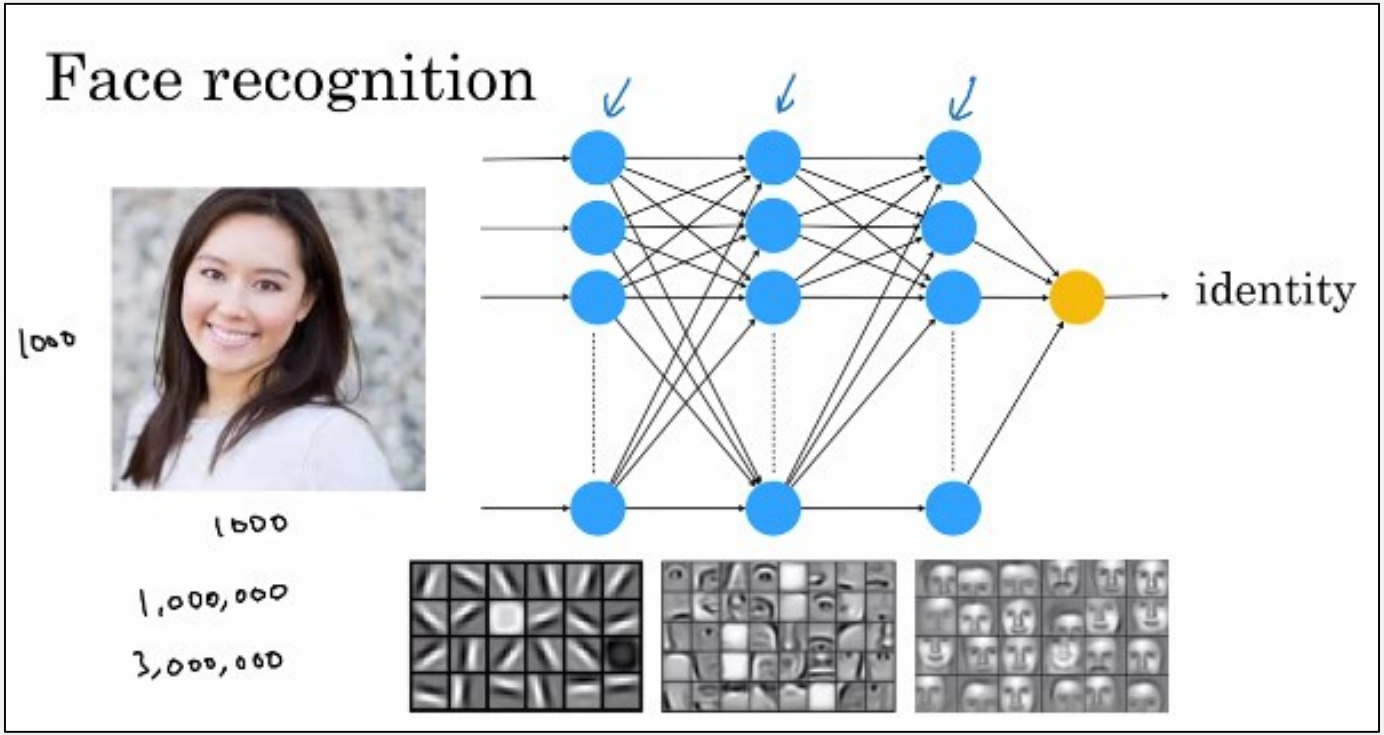


30	32	22	12	10	10	12	33	35	30
12	11	12	234	170	176	13	15	12	12
234	222	220	230	200	222	230	234	56	78
190	220	186	112	110	110	112	180	30	32
49	250	250	250	4	2	254	200	44	6
55	250	250	250	3	1	250	245	25	3
189	195	199	150	110	110	182	190	199	55
200	202	218	222	203	200	200	208	215	222
219	215	220	220	222	214	215	210	220	220
220	220	220	220	221	220	221	220	220	222

Non-technical explanation of deep learning (Part 2, optional)

- You saw how a neural network can take as input four numbers corresponding to the price, shipping costs, amounts of marketing, and cloth material of a T-shirt and output demand.
- In this example, the neural network just has to input a lot more numbers corresponding to all of the pixel brightness values of this picture.
- If the resolution of this picture is 1000 pixels by 1000 pixels, then that's a million pixels.

Non-technical explanation of deep learning (Part 2, optional)



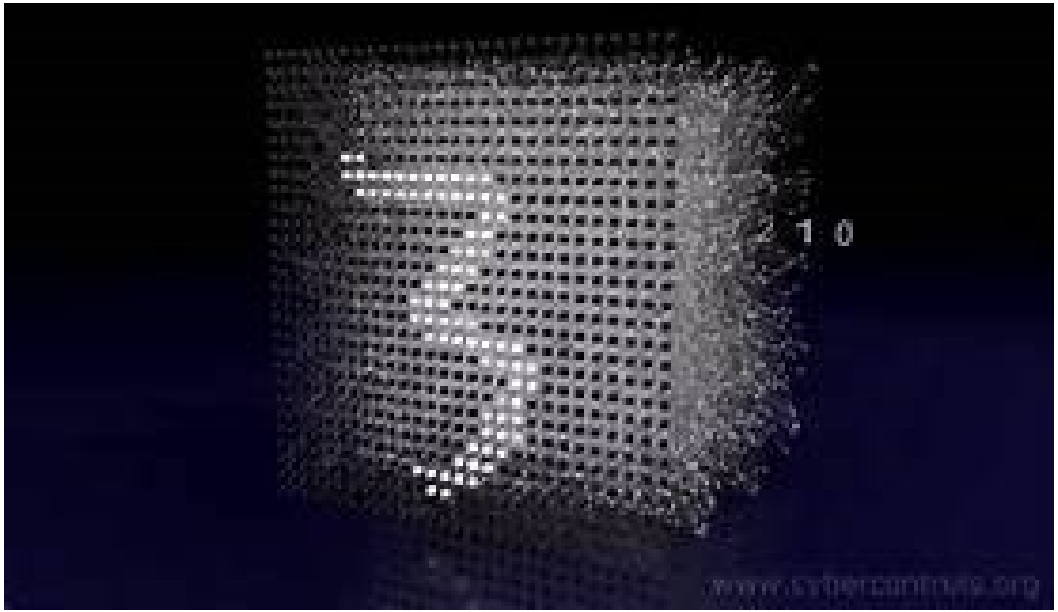
Non-technical explanation of deep learning (Part 2, optional)

Congratulations on finishing this. You now know how machine learning and data science work.

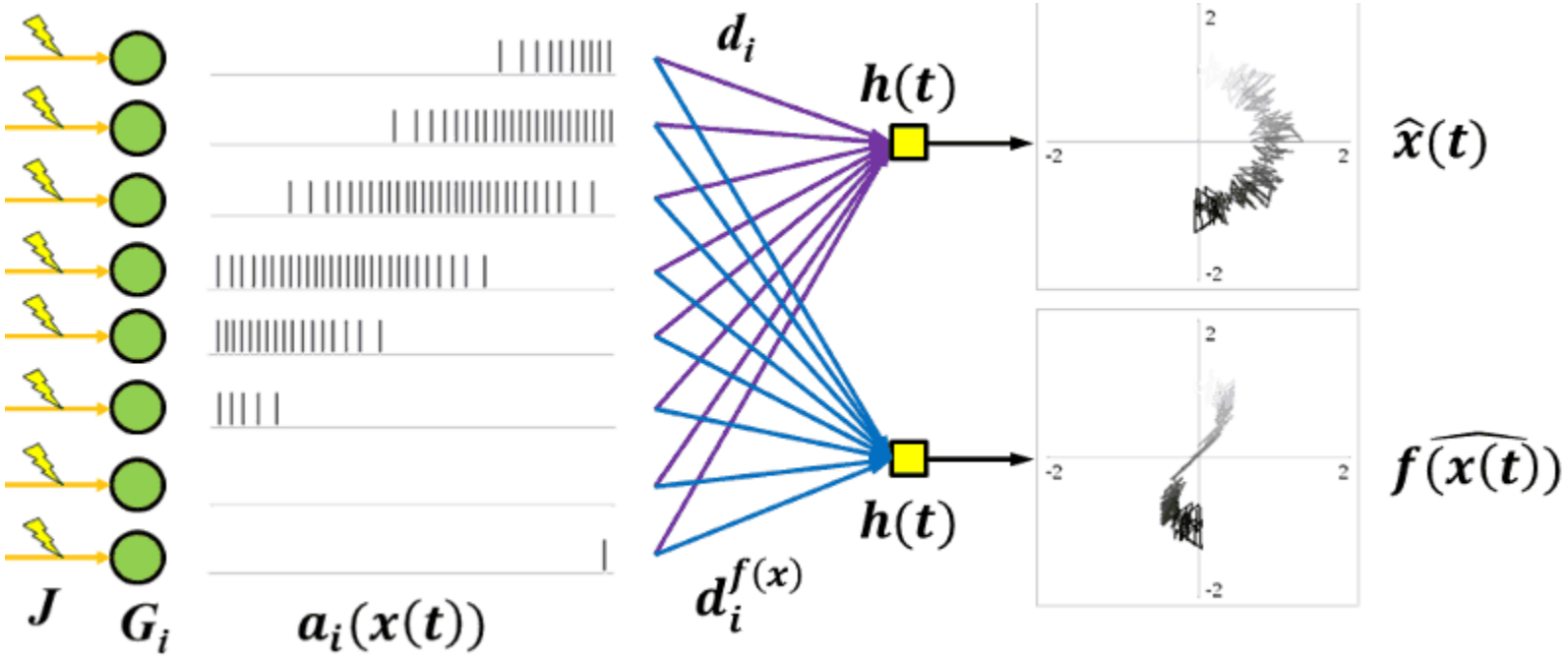
- Next, you'll learn how to build your own machine learning or data science project.

Intuition

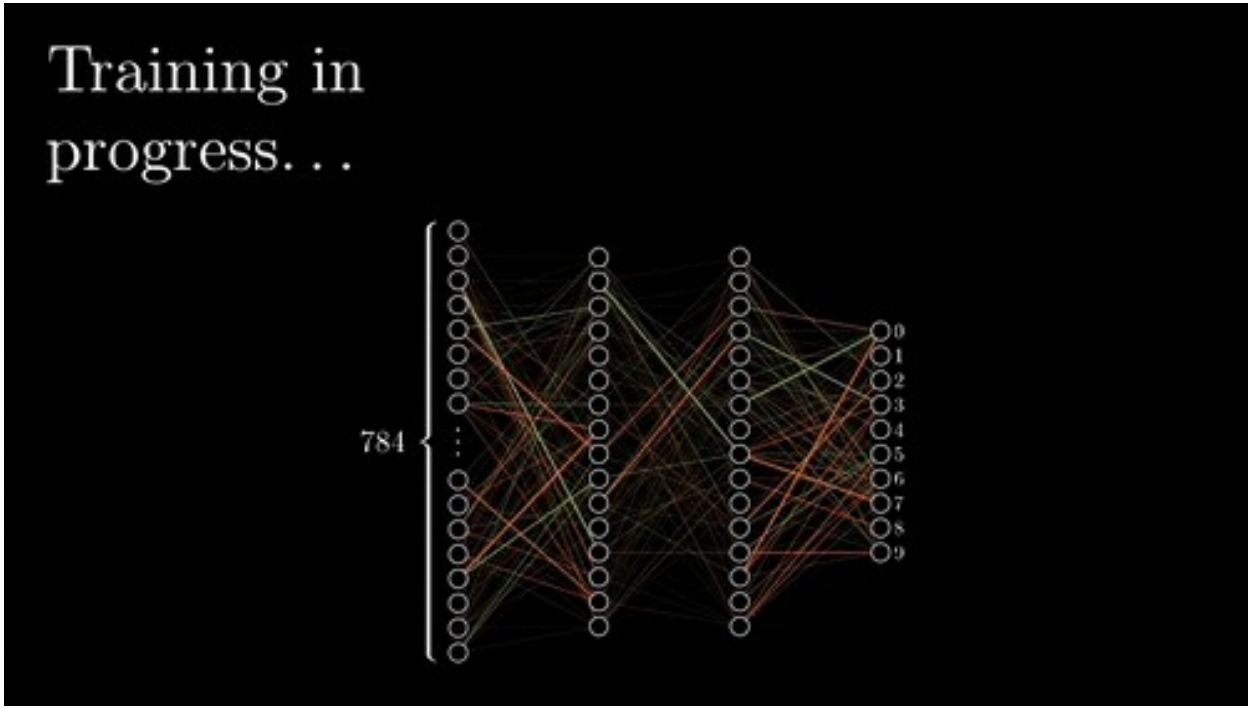
Neural Networks

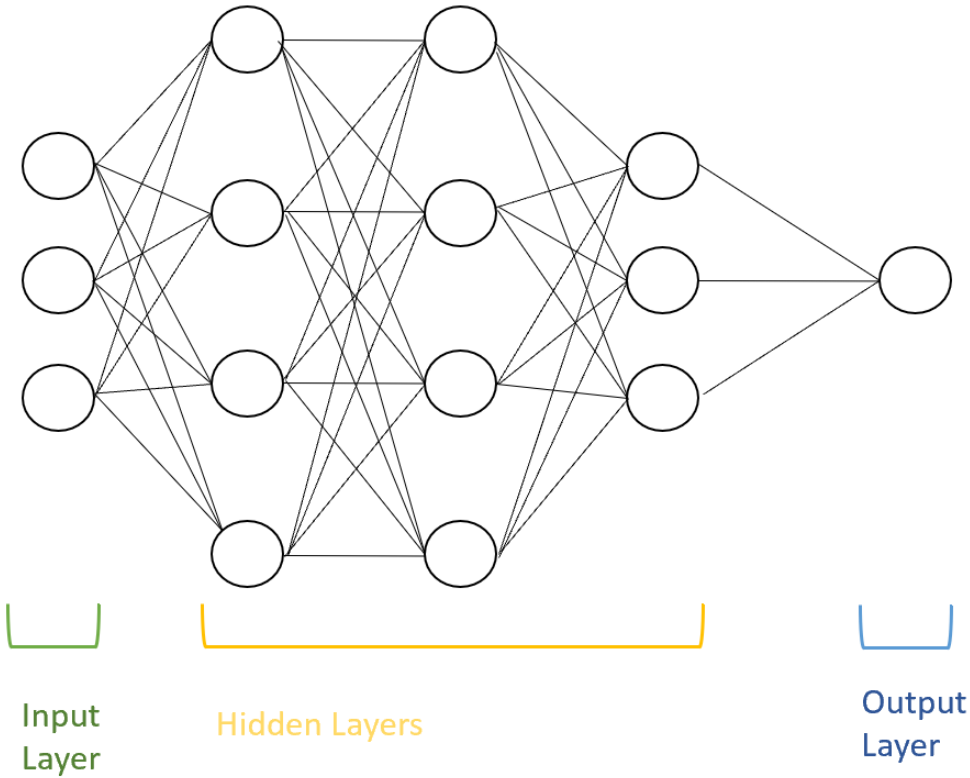


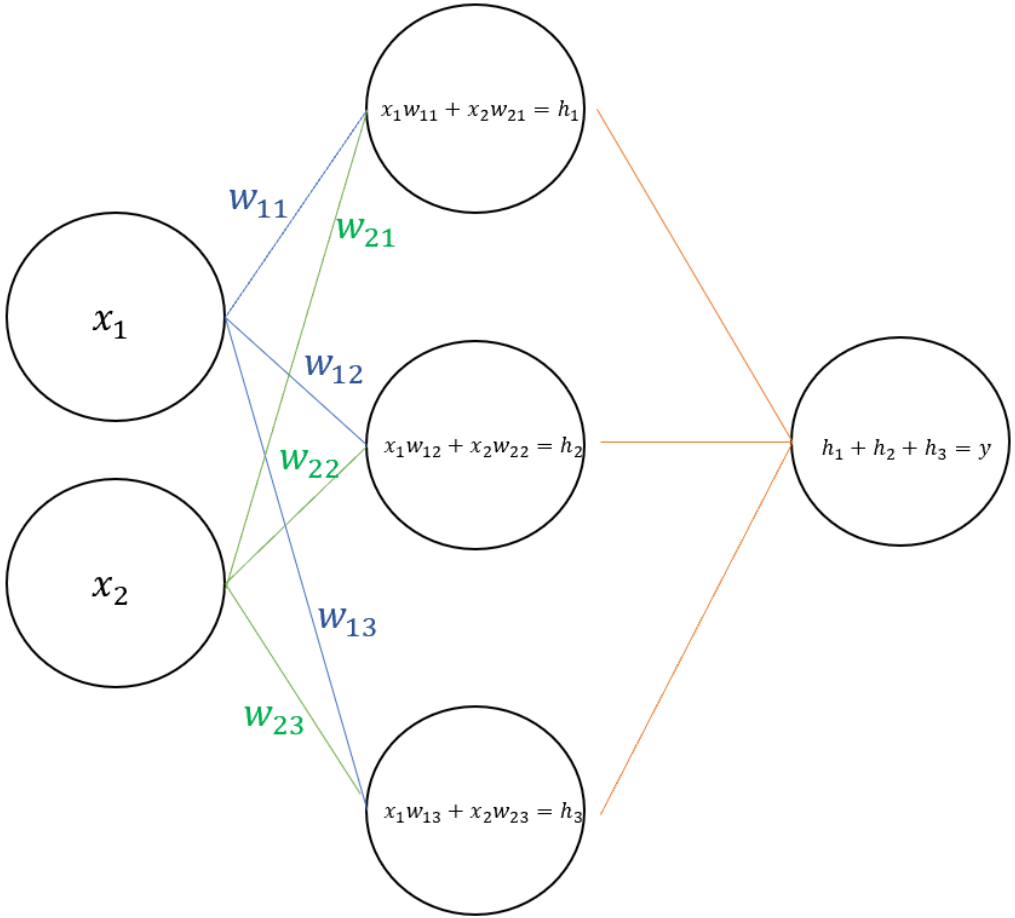
Neural Networks are Flexible



Neural Networks without Math



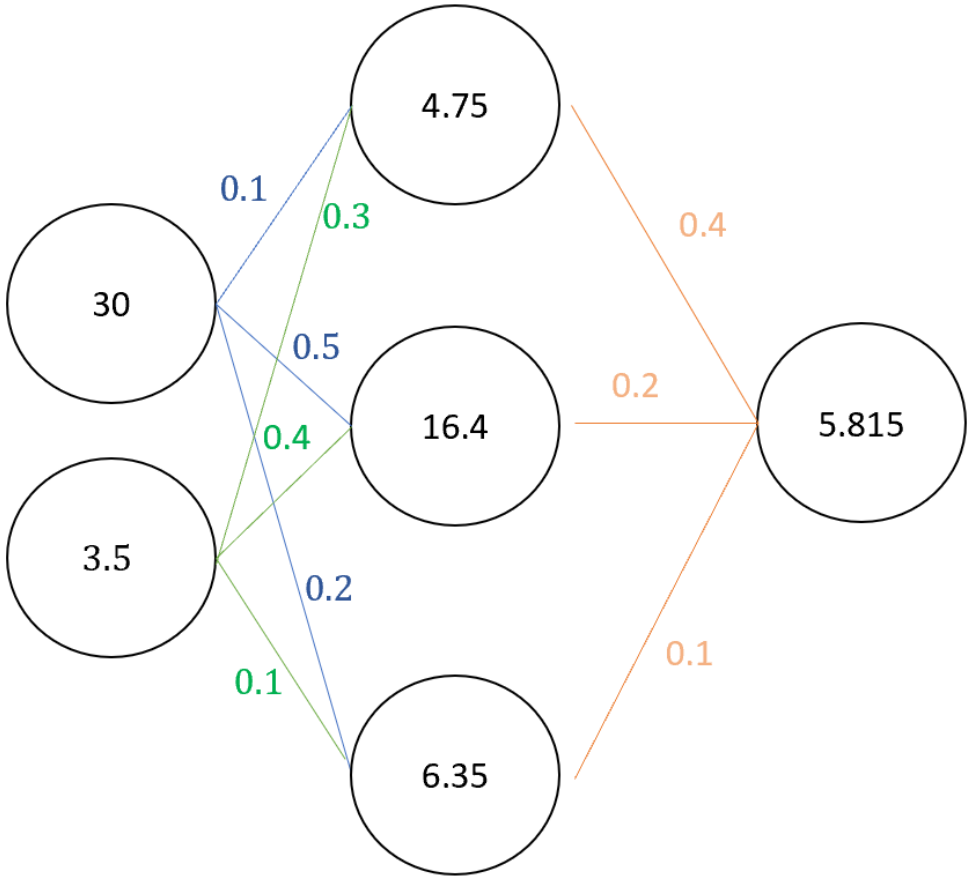

Input
Layer
Hidden Layers
Output
Layer

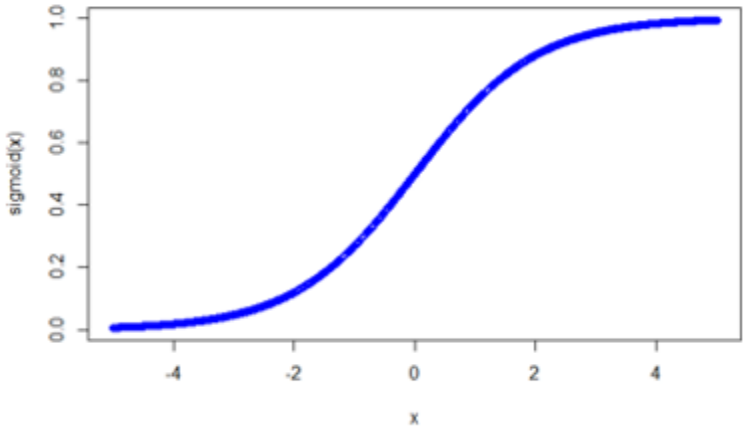

$x_1 w_{11} + x_2 w_{21} = h_1$
w_{11}
w_{21}
x_1
w_{12}
$x_1 w_{12} + x_2 w_{22} = h_2$
$h_1 + h_2 + h_3 = y$
w_{22}
x_2
w_{13}
w_{23}
$x_1 w_{13} + x_2 w_{23} = h_3$

$$\begin{bmatrix} x_1 & x_2 \end{bmatrix} \begin{bmatrix} w_{11} & w_{12} & w_{13} \\ w_{21} & w_{22} & w_{23} \end{bmatrix} = \begin{bmatrix} x_1 w_{11} + x_2 w_{21} \\ x_1 w_{12} + x_2 w_{22} \\ x_1 w_{13} + x_2 w_{23} \end{bmatrix}' = \begin{bmatrix} h_1 \\ h_2 \\ h_3 \end{bmatrix}'$$

$$\begin{bmatrix} h_1 \\ h_2 \\ h_3 \end{bmatrix}' \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = h_1 + h_2 + h_3 = y$$

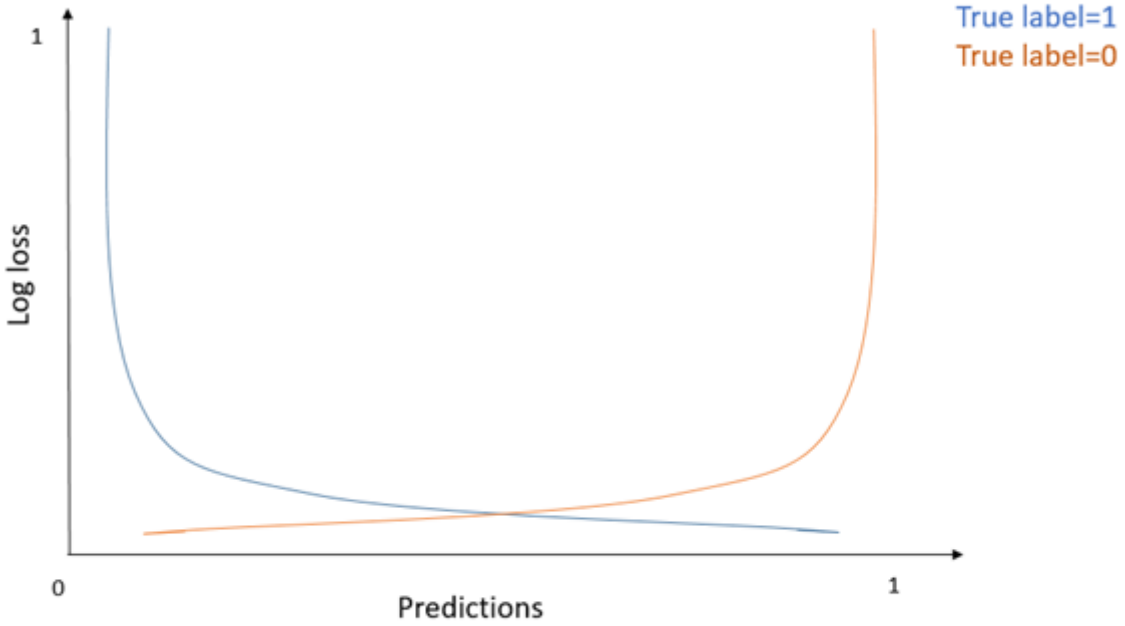
Hours of study	GPA	Exam result
30	3.5	‘pass’
12	2	‘fail’
10	2.2	‘fail’
34	4	‘pass’


4.75
30
3.5
16.4
6.35
5.815
0.1
0.3
0.4
0.5
0.4
0.2
0.2
0.1
0.1

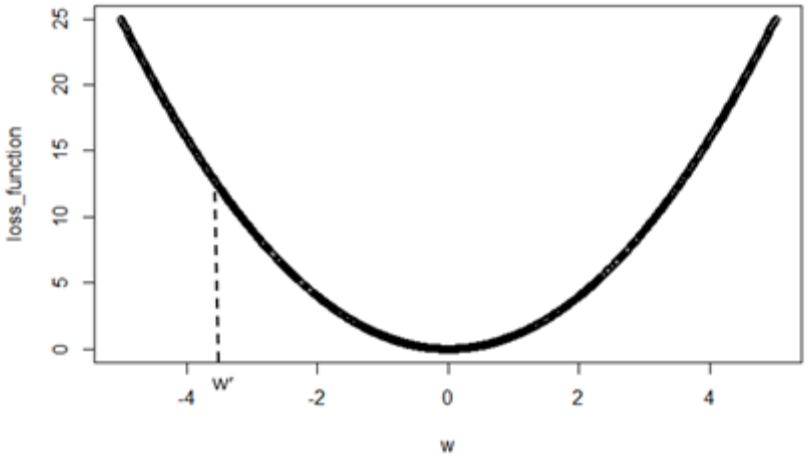


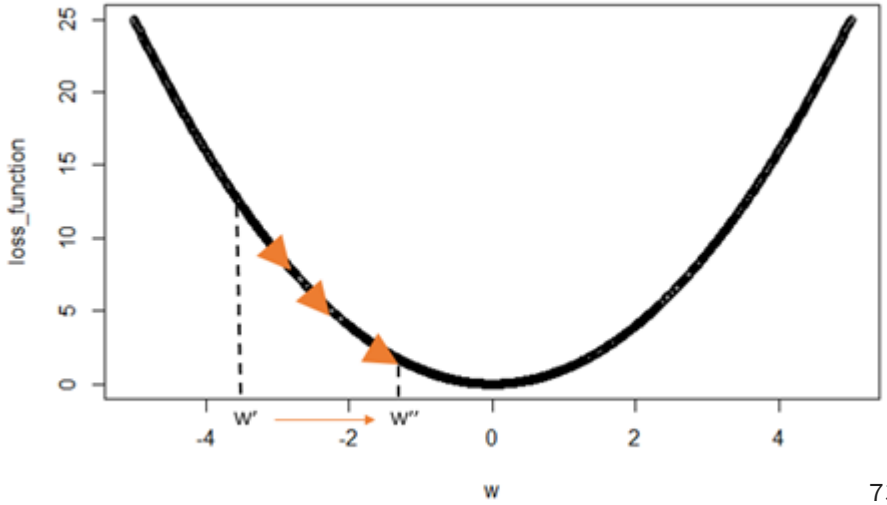
$$S(x) = \frac{1}{1 + e^{-x}}$$

$$Cross\ Entropy = -[ylog(p) + (1-y)\log(1-p)]$$



$$w_i' = w_i - \frac{\delta L}{\delta w_i}$$


loss_function
0
5
10
15
20
25
-4
w'
-2
0
2
4
w


loss_function
0
5
10
15
20
25
-4
w'
-2
w''
0
2
4
w

Summary

https://bit.ly/2YAHBlM