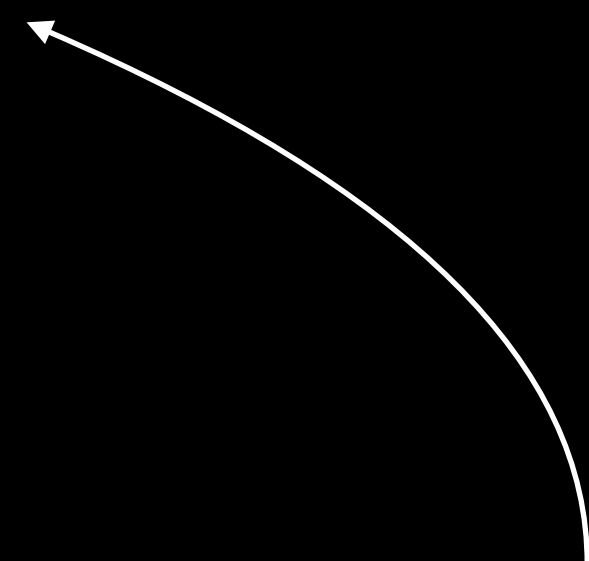


Deep Learning with



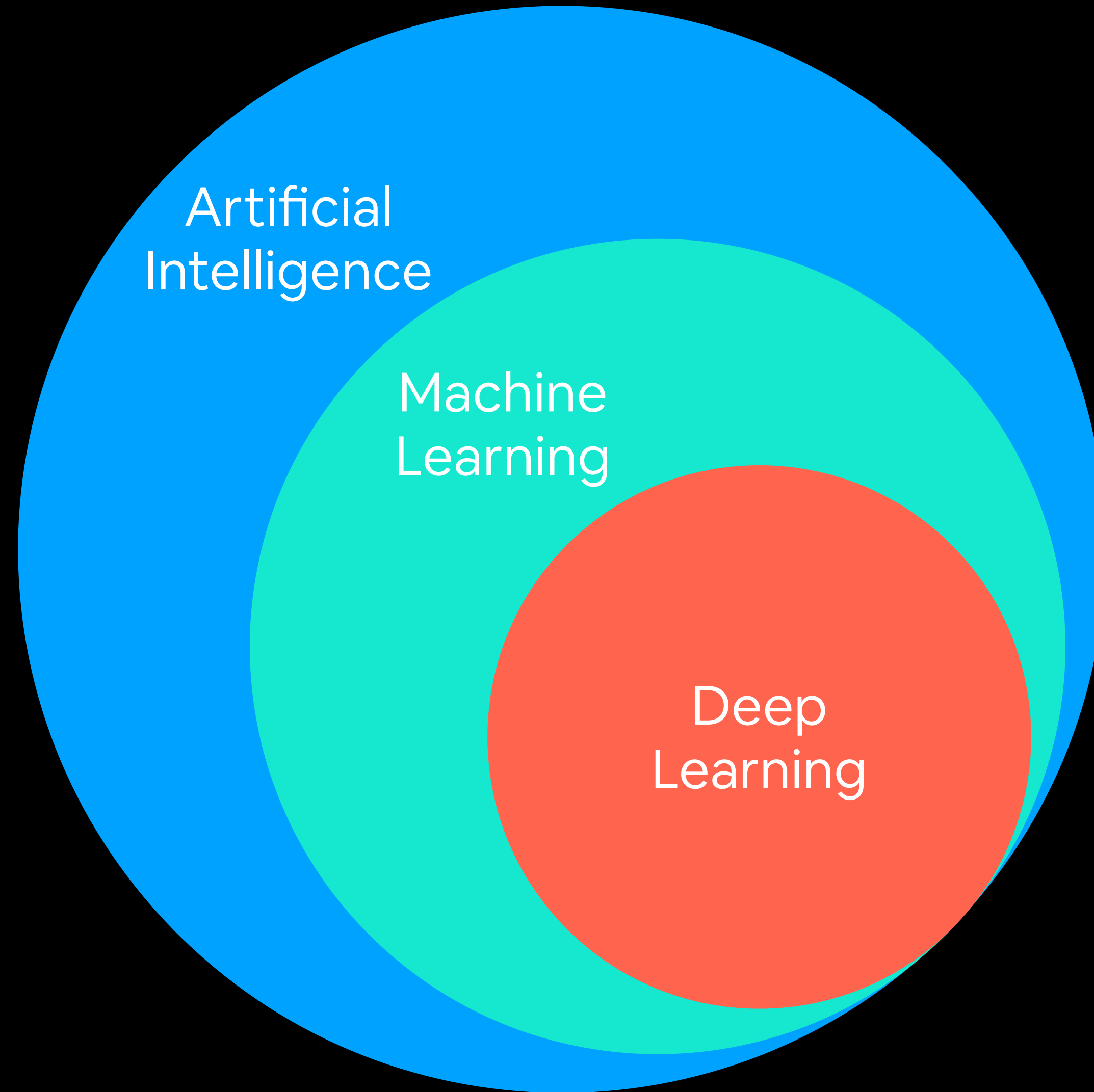
“What is deep learning?”

Machine learning is turning things (data) into numbers and **finding patterns** in those numbers.



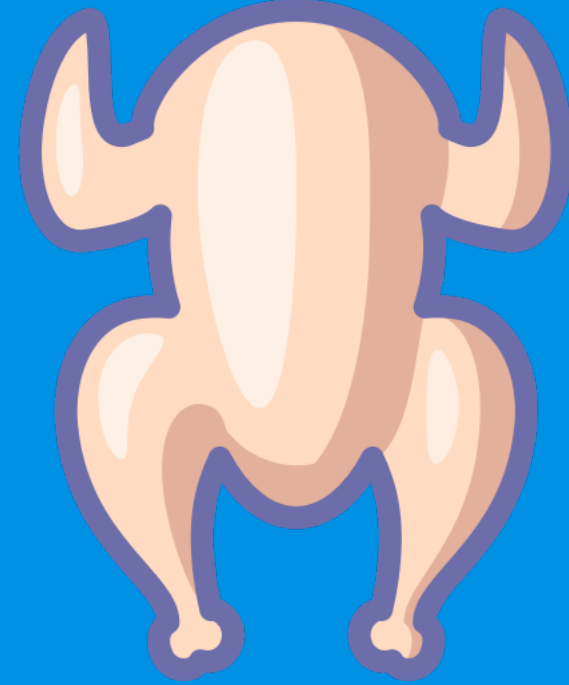
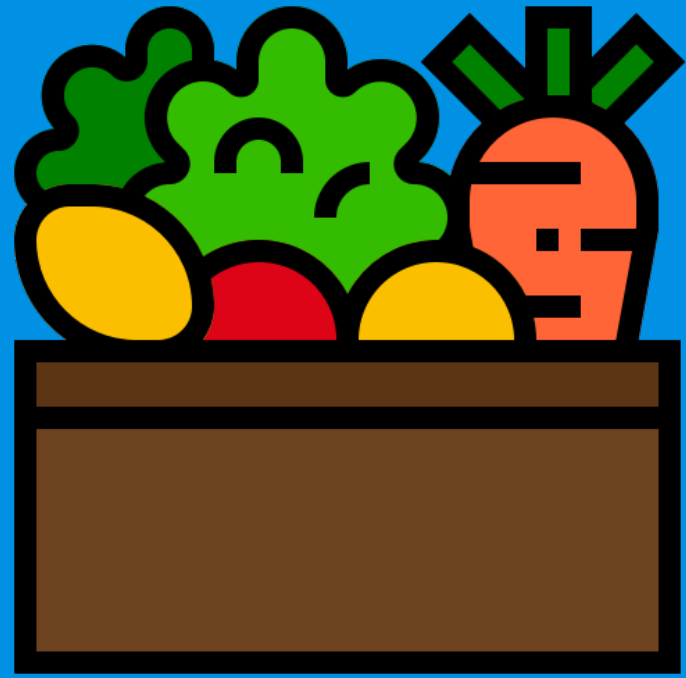
The computer does this part.
How?
Code & math.
We're going to be writing the code.

Machine Learning vs. Deep Learning



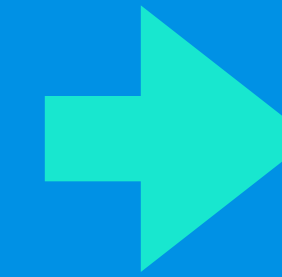
Traditional programming

Inputs

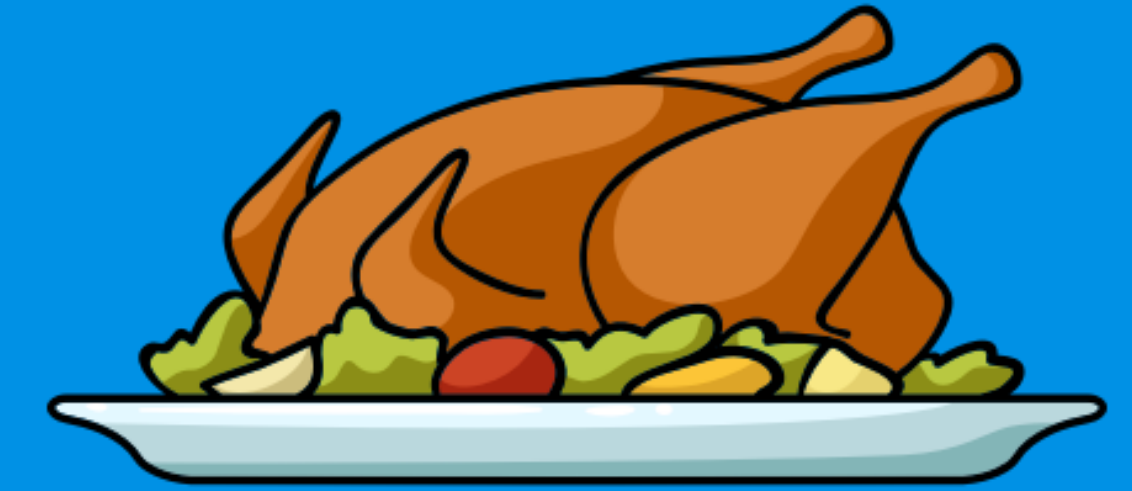


Rules

1. Cut vegetables
2. Season chicken
3. Preheat oven
4. Cook chicken for 30-minutes
5. Add vegetables



Output

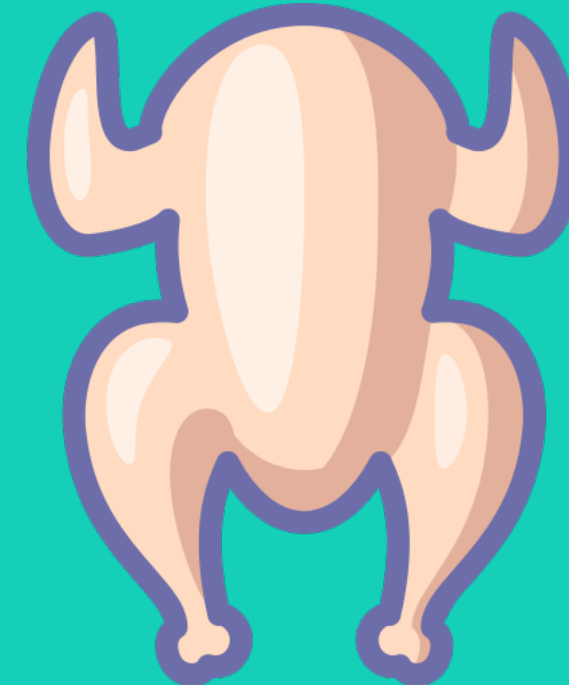


Starts with

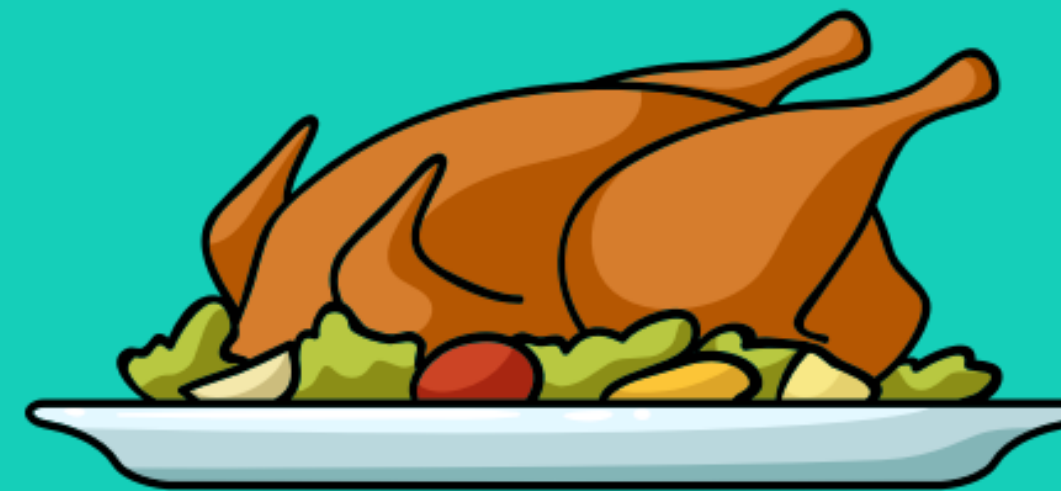
Makes

Machine learning algorithm

Inputs



Output



Rules

1. Cut vegetables
2. Season chicken
3. Preheat oven
4. Cook chicken for 30-minutes
5. Add vegetables

Starts with

Figures out

“Why use machine learning (or deep learning)?”

Good reason: ~~Why not?~~

Better reason: For a complex problem, can you think of all the rules?

(probably not)

(maybe not very simple...)

“If you can build a **simple rule-based** system that doesn't require machine learning, do that.”

— A wise software engineer... (actually rule 1 of [Google's Machine Learning Handbook](#))

What deep learning is good for

- **Problems with long lists of rules**—when the traditional approach fails, machine learning/deep learning may help.
- **Continually changing environments**—deep learning can adapt (‘learn’) to new scenarios.
- **Discovering insights within large collections of data**—can you imagine trying to hand-craft rules for what 101 different kinds of food look like?

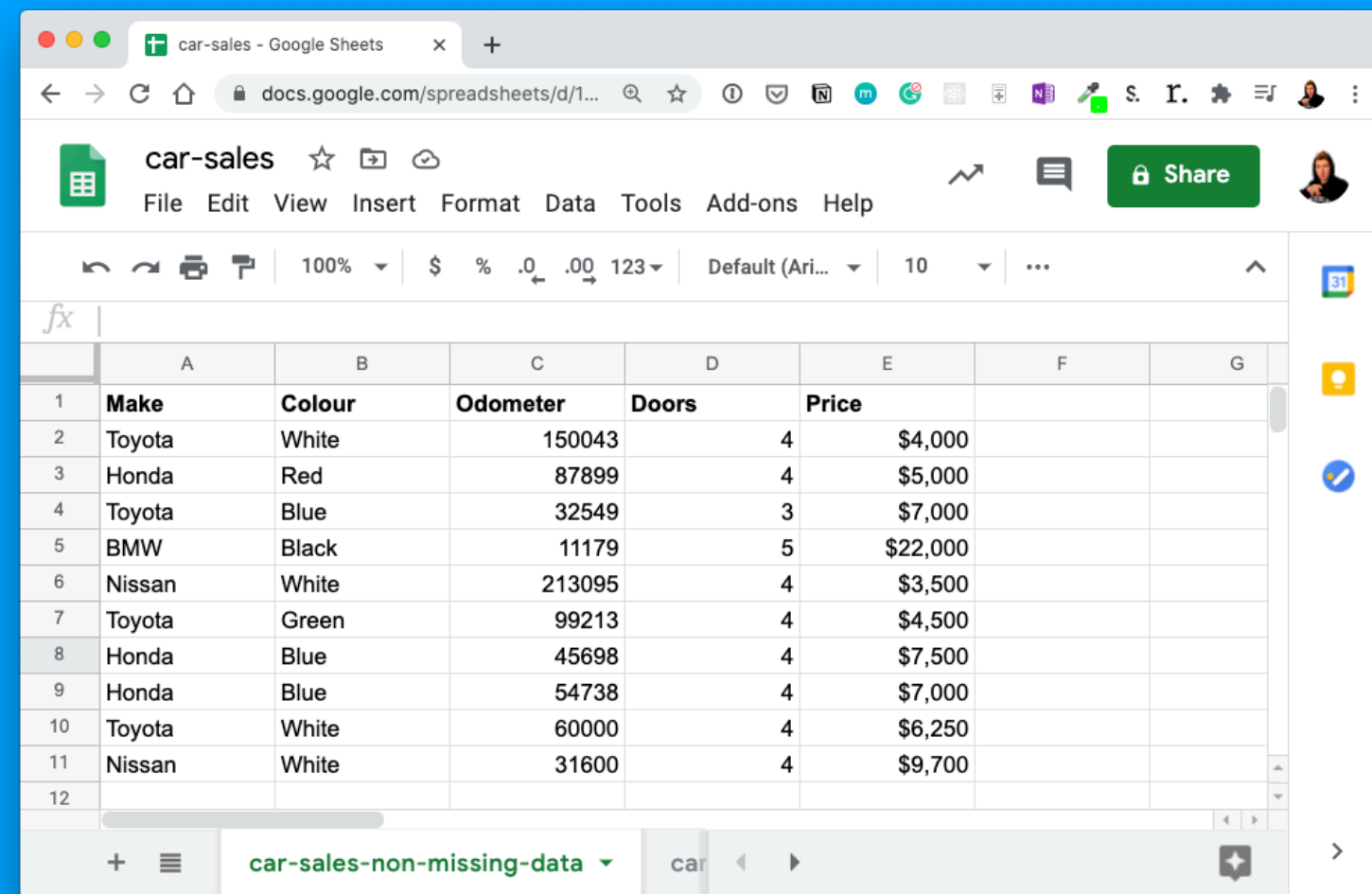
What deep learning is ^(typically) not good for

- **When you need explainability**—the patterns learned by a deep learning model are typically uninterpretable by a human.
- **When the traditional approach is a better option** — if you can accomplish what you need with a simple rule-based system.
- **When errors are unacceptable** — since the outputs of deep learning model aren't always predictable.
- **When you don't have much data** — deep learning models usually require a fairly large amount of data to produce great results.

(though we'll see how to get great results without huge amounts of data)

Machine Learning vs. Deep Learning

Machine Learning



	A	B	C	D	E	F	G
1	Make	Colour	Odometer	Doors	Price		
2	Toyota	White	150043	4	\$4,000		
3	Honda	Red	87899	4	\$5,000		
4	Toyota	Blue	32549	3	\$7,000		
5	BMW	Black	11179	5	\$22,000		
6	Nissan	White	213095	4	\$3,500		
7	Toyota	Green	99213	4	\$4,500		
8	Honda	Blue	45698	4	\$7,500		
9	Honda	Blue	54738	4	\$7,000		
10	Toyota	White	60000	4	\$6,250		
11	Nissan	White	31600	4	\$9,700		
12							

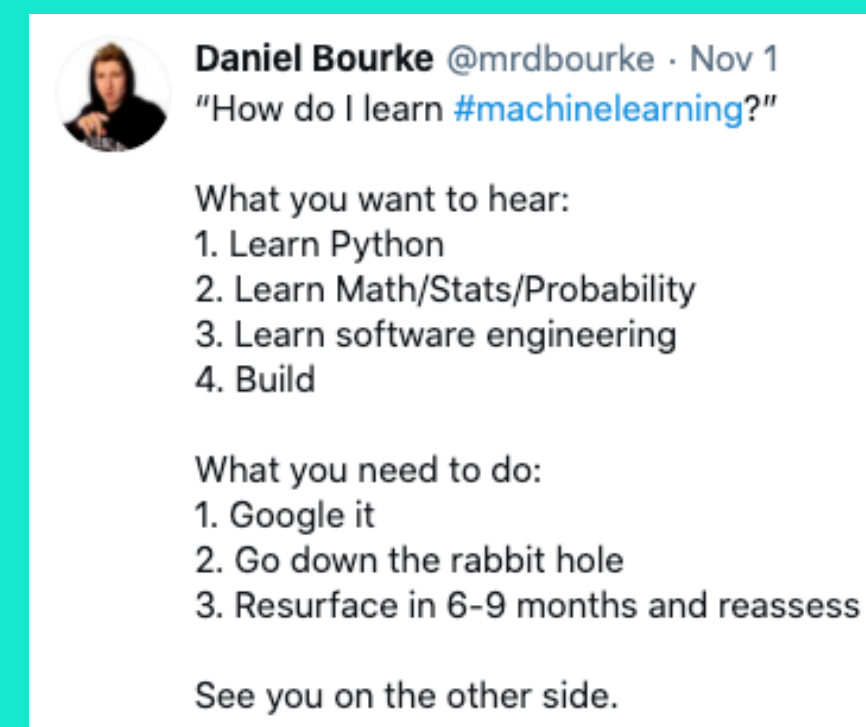
Algorithm: gradient boosted machine

dmlc XGBoost



Structured data

Deep Learning



Daniel Bourke @mrdbourke · Nov 1
"How do I learn #machinelearning?"

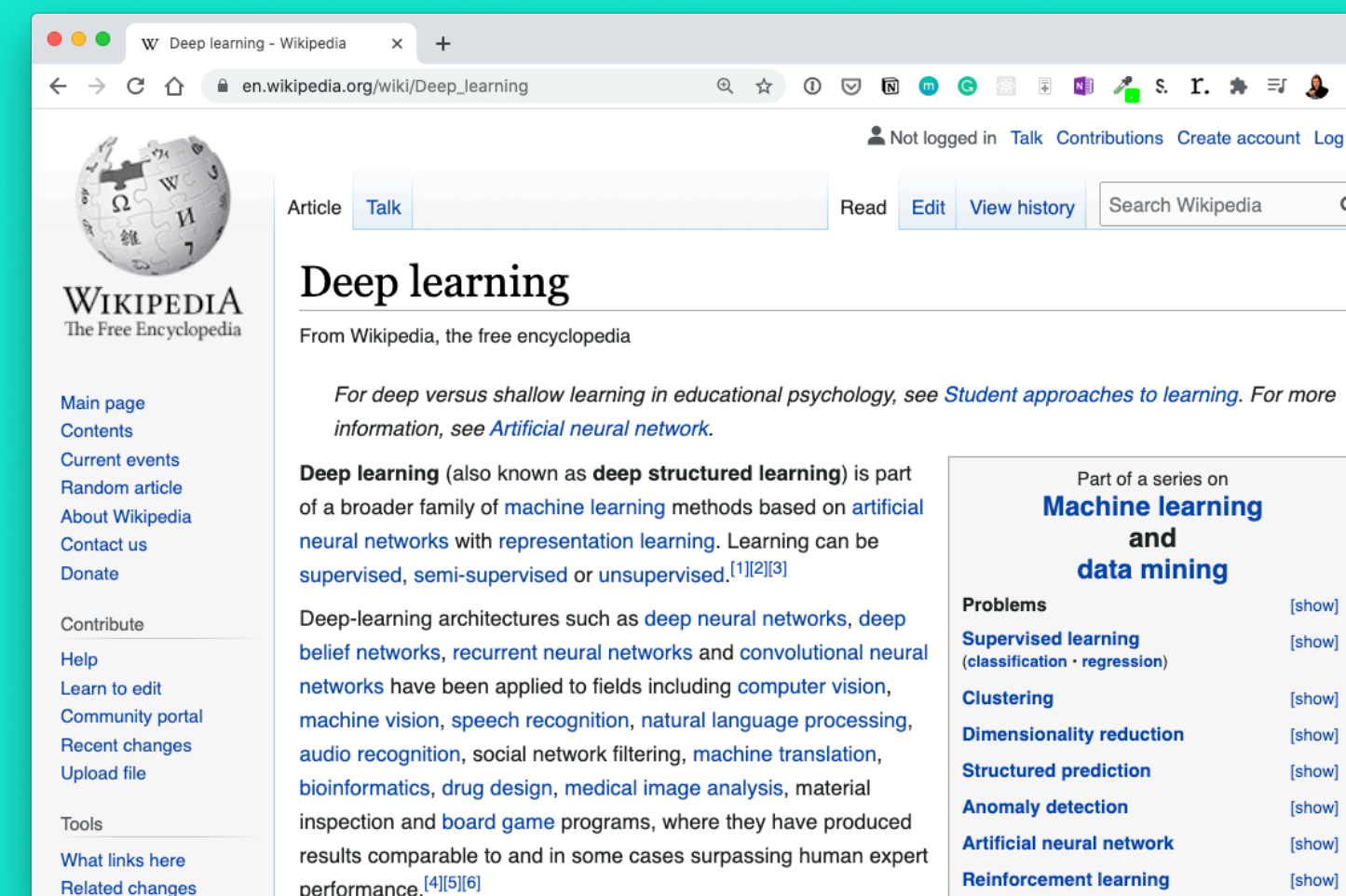
What you want to hear:

1. Learn Python
2. Learn Math/Stats/Probability
3. Learn software engineering
4. Build

What you need to do:

1. Google it
2. Go down the rabbit hole
3. Resurface in 6-9 months and reassess

See you on the other side.



Deep learning - Wikipedia

From Wikipedia, the free encyclopedia

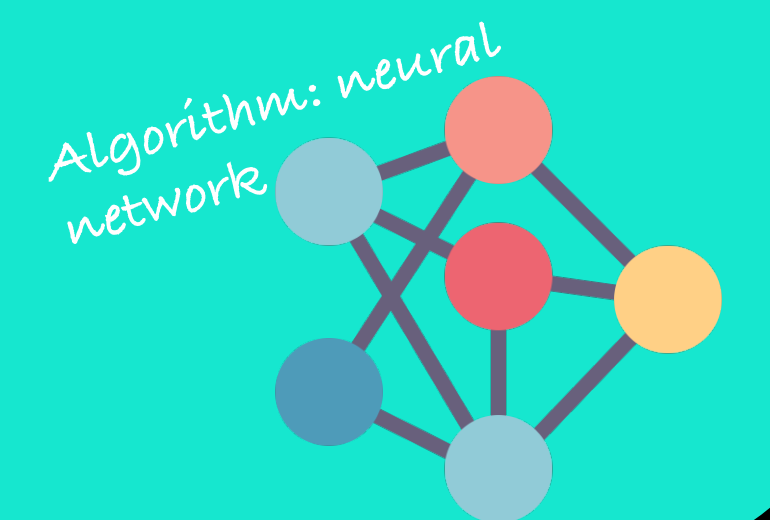
For deep versus shallow learning in educational psychology, see Student approaches to learning. For more information, see Artificial neural network.

Deep learning (also known as **deep structured learning**) is part of a broader family of machine learning methods based on artificial neural networks with representation learning. Learning can be supervised, semi-supervised or unsupervised.^{[1][2][3]}

Deep-learning architectures such as deep neural networks, deep belief networks, recurrent neural networks and convolutional neural networks have been applied to fields including computer vision, machine vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation, bioinformatics, drug design, medical image analysis, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance.^{[4][5][6]}

Part of a series on **Machine learning and data mining**

- Problems [show]
- Supervised learning (classification · regression) [show]
- Clustering [show]
- Dimensionality reduction [show]
- Structured prediction [show]
- Anomaly detection [show]
- Artificial neural network [show]
- Reinforcement learning [show]



Unstructured data

Machine Learning vs. Deep Learning

(common algorithms)

- Random forest
- Gradient boosted models
- Naive Bayes
- Nearest neighbour
- Support vector machine
- ...many more

(since the advent of deep learning these are often referred to as "shallow algorithms")

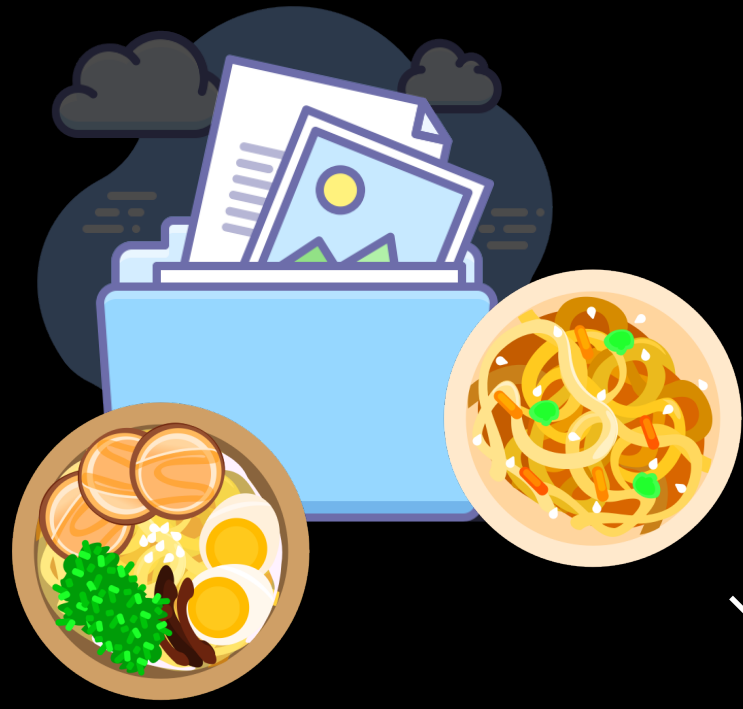
- Neural networks
- Fully connected neural network
- Convolutional neural network
- Recurrent neural network
- Transformer
- ...many more

What we're focused on building
(with PyTorch)

Structured data ← *(depending how you represent your problem, many algorithms can be used for both)* → Unstructured data

“What are neural networks?”

Neural Networks



(before data gets used with a neural network, it needs to be turned into numbers)

Daniel Bourke @mrdbourke · Nov 1
"How do I learn #machinelearning?"

What you want to hear:

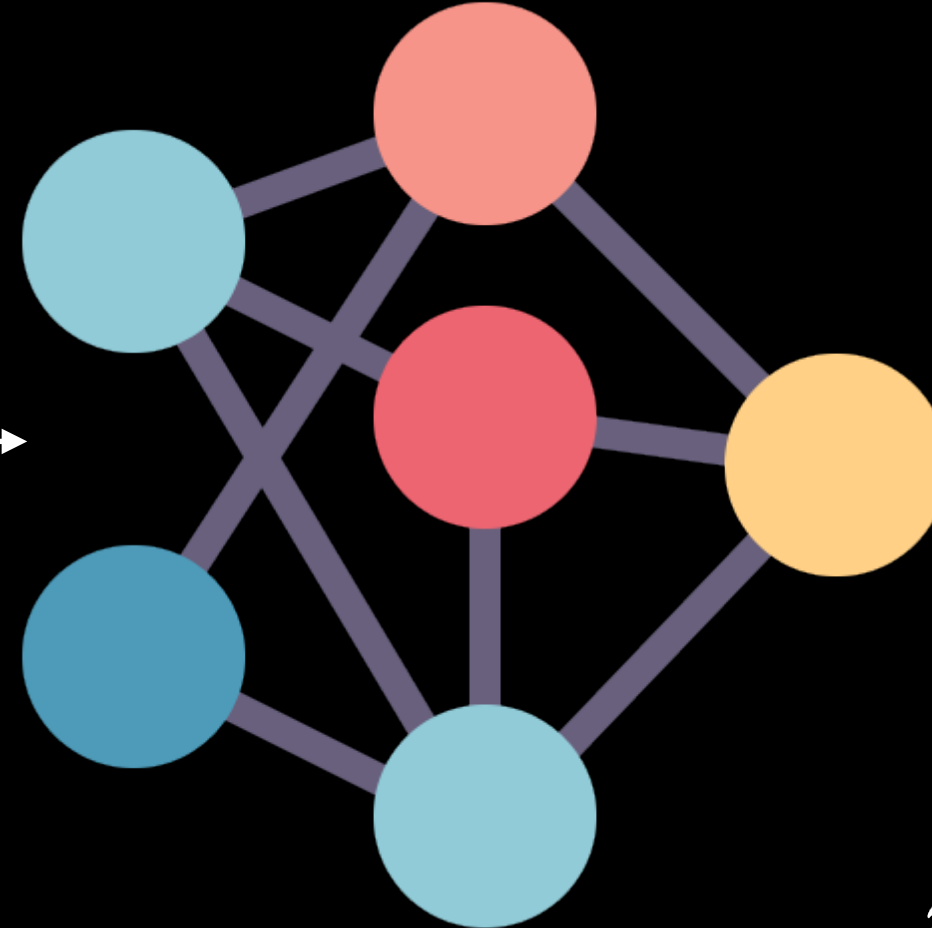
1. Learn Python
2. Learn Math/Stats/Probability
3. Learn software engineering
4. Build

What you need to do:

1. Google it
2. Go down the rabbit hole
3. Resurface in 6-9 months and reassess

See you on the other side.

$[[116, 78, 15],$
 $[117, 43, 96],$
 $[125, 87, 23],$
...



Each of these nodes is called a "hidden unit" or "neuron".

(choose the appropriate neural network for your problem)

$[[0.983, 0.004, 0.013],$
 $[0.110, 0.889, 0.001],$
 $[0.023, 0.027, 0.985],$
...

(a human can understand these)

Ramen, Spaghetti

Not a diaster

"Hey Siri, what's the weather today?"



Inputs

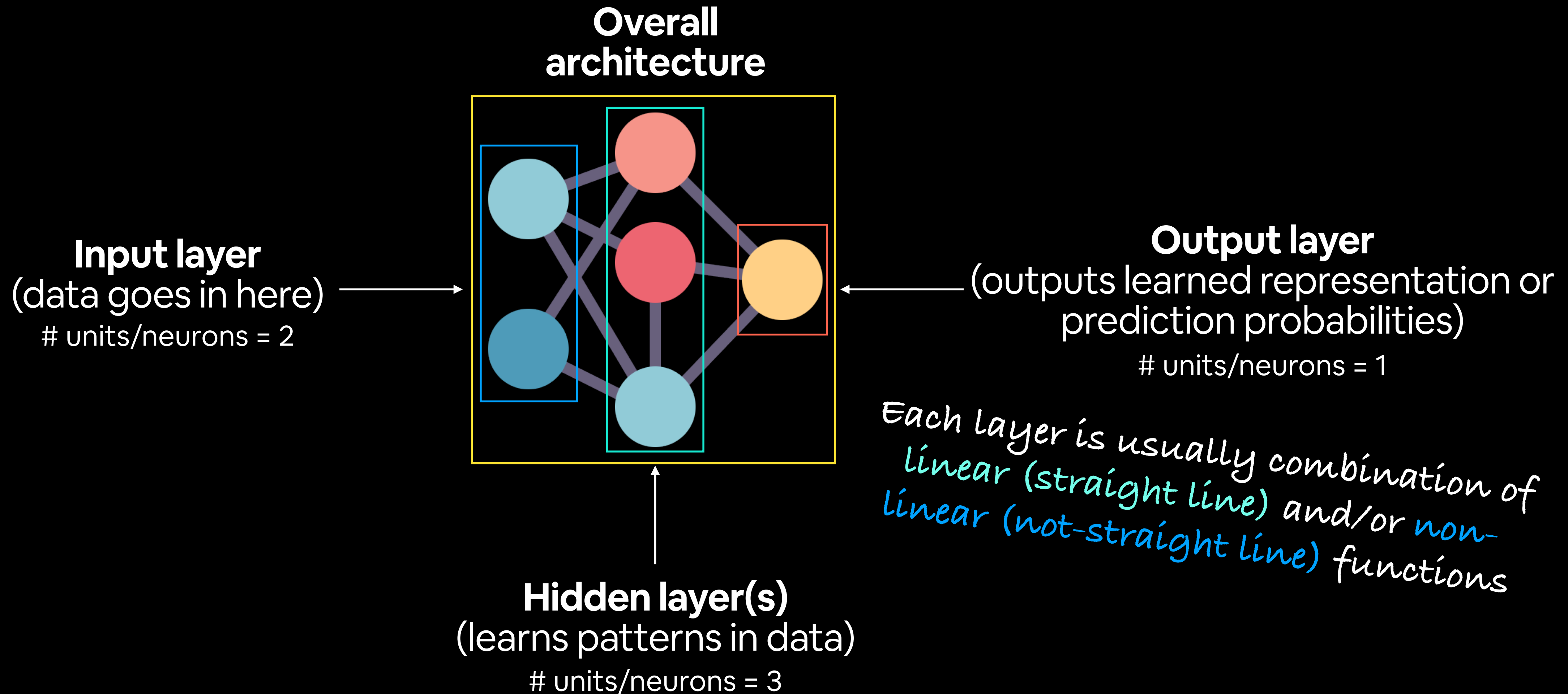
Numerical encoding

Learns representation (patterns/features/weights)

Representation outputs

Outputs

Anatomy of Neural Networks



Note: “patterns” is an arbitrary term, you’ll often hear “embedding”, “weights”, “feature representation”, “feature vectors” all referring to similar things.

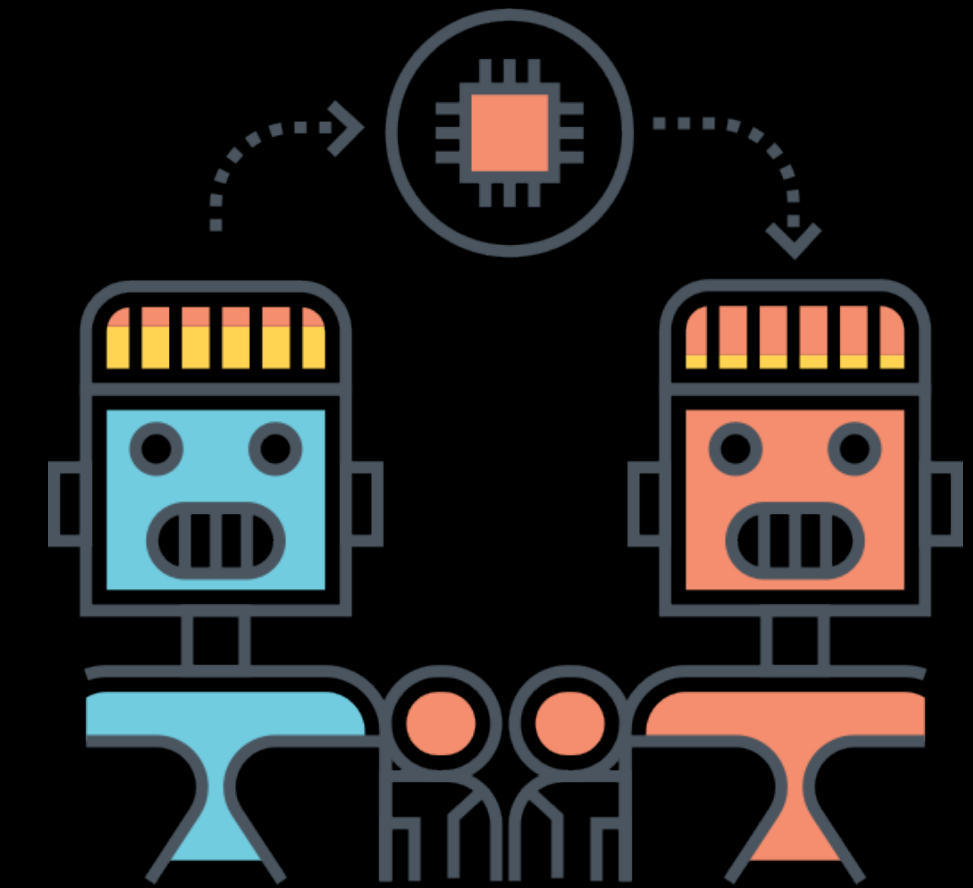
Types of Learning



Supervised Learning



Unsupervised & Self-supervised Learning



Transfer Learning

We'll be writing code to do these,
but the style of code can be adopted across learning paradigms.

“What is deep learning actually used for?”



Yashaswi Kulshreshtha commented on your video



2020 Machine Learning Roadmap

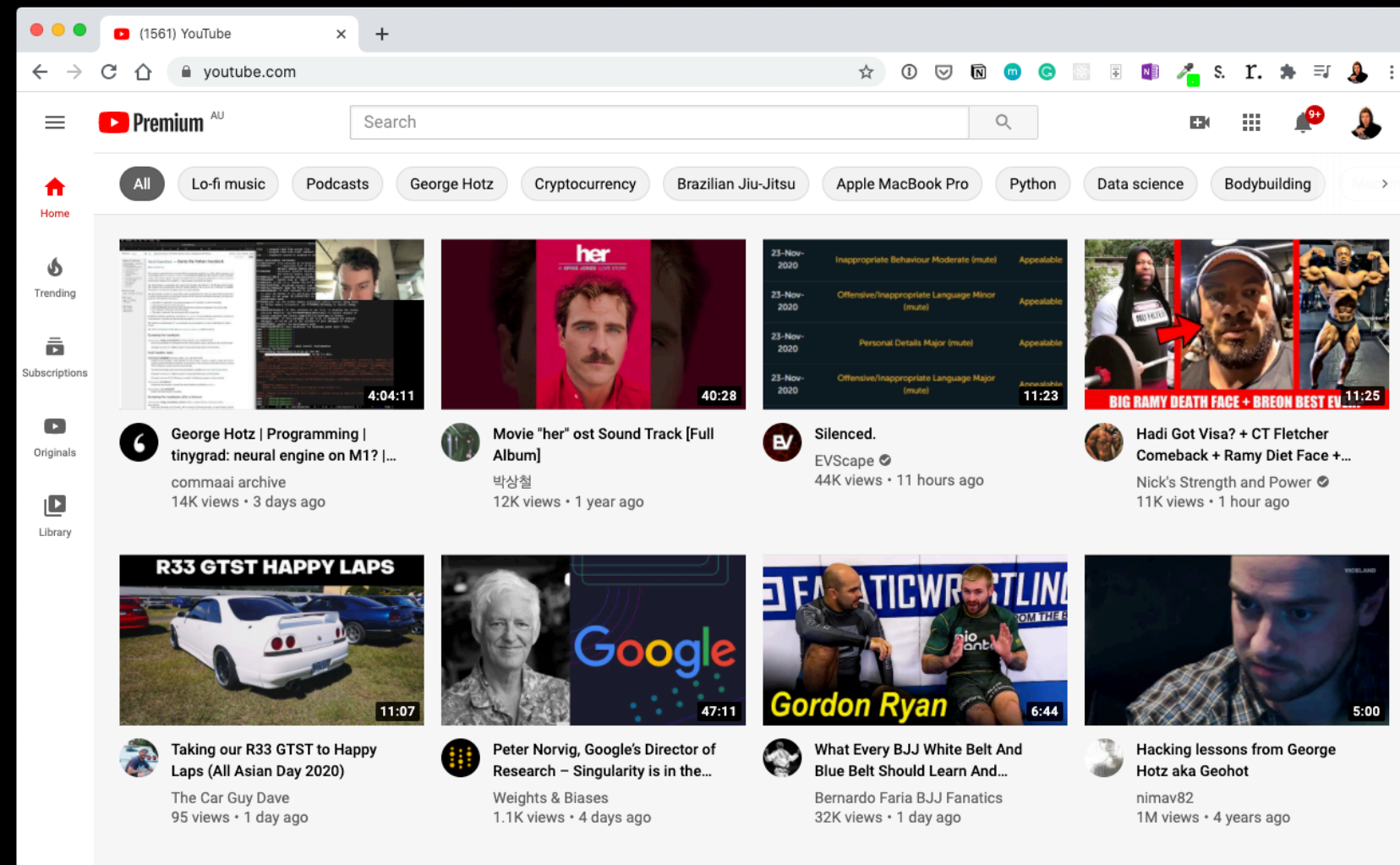


Yashaswi Kulshreshtha

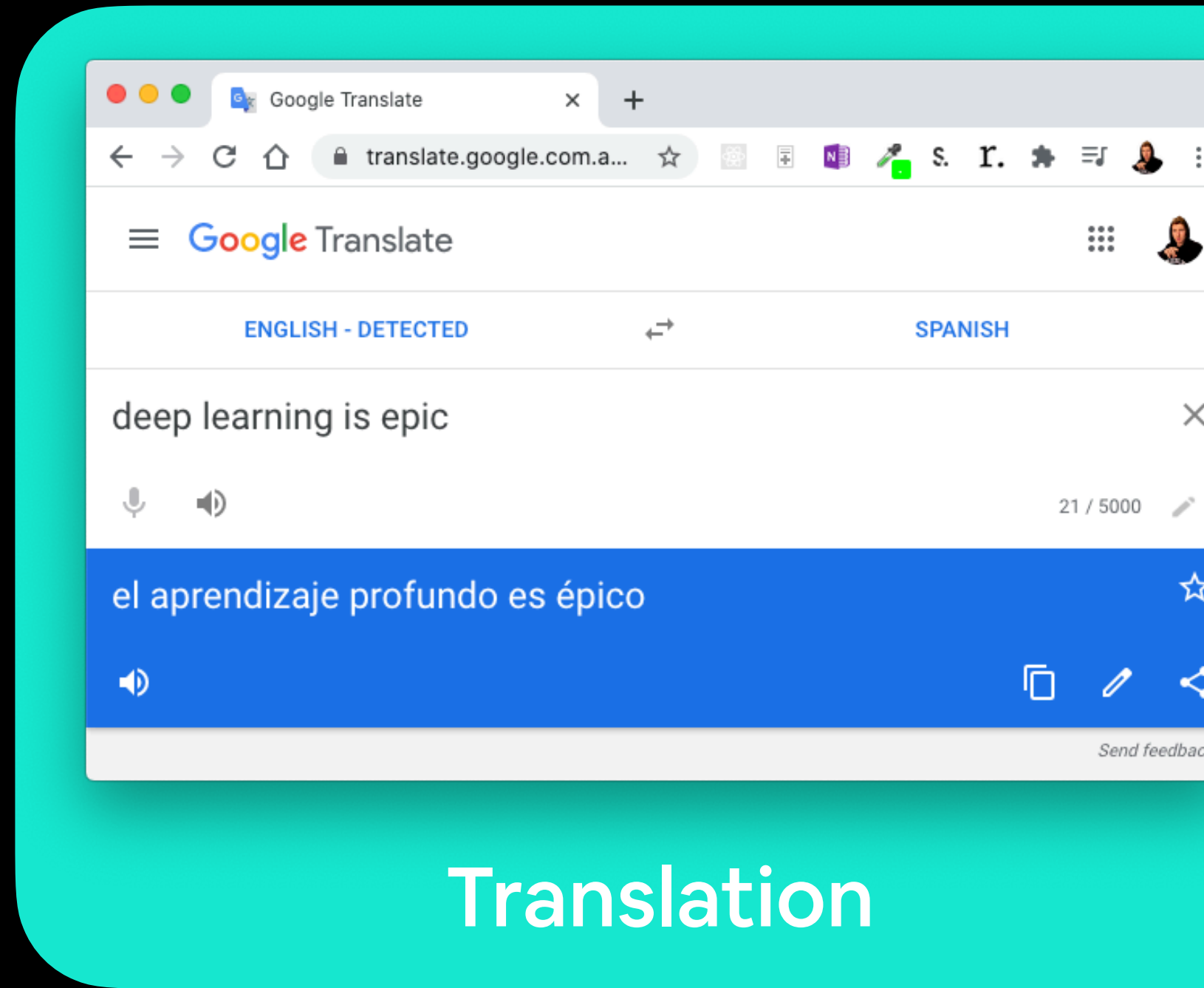
I think you can use ML for literally anything as long as you can convert it into numbers and program it to find patterns. Literally it could be anything any input or output from the universe

Source: [2020 Machine Learning Roadmap video](#).

(some) Deep Learning Use Cases



Recommendation



Translation



“Hey Siri, who’s the biggest big dog of them all?”

Speech recognition



Computer Vision

To: daniel@mrdbourke.com
Hey Daniel,

This deep learning course is incredible!
I can't wait to use what I've learned!

Not spam

To: daniel@mrdbourke.com
Hay daniel...

C0ngratu1ations! U win \$1139239230

Spam

Natural Language Processing (NLP)

Sequence to sequence (seq2seq)

Classification/regression



“What is PyTorch?”

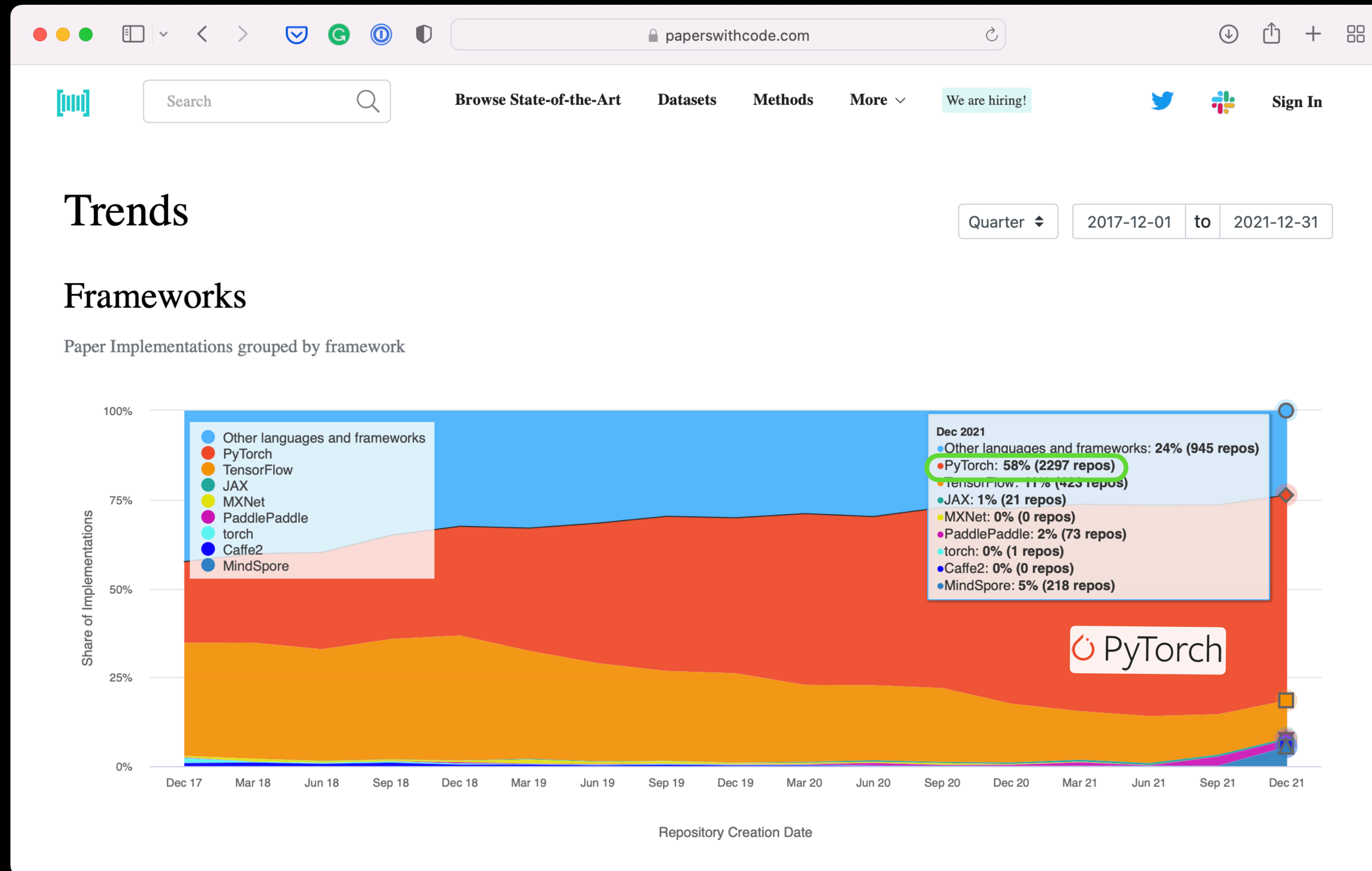


What is PyTorch?



- Most popular research deep learning framework*
- Write fast deep learning code in Python (able to run on a GPU/many GPUs)
- Able to access many pre-built deep learning models (Torch Hub/[torchvision.models](#))
- Whole stack: preprocess data, model data, deploy model in your application/cloud
- Originally designed and used in-house by Facebook/Meta (now open-source and used by companies such as Tesla, Microsoft, OpenAI)

Why PyTorch?



Research favourite

Why PyTorch?



François Chollet ✓

@fchollet

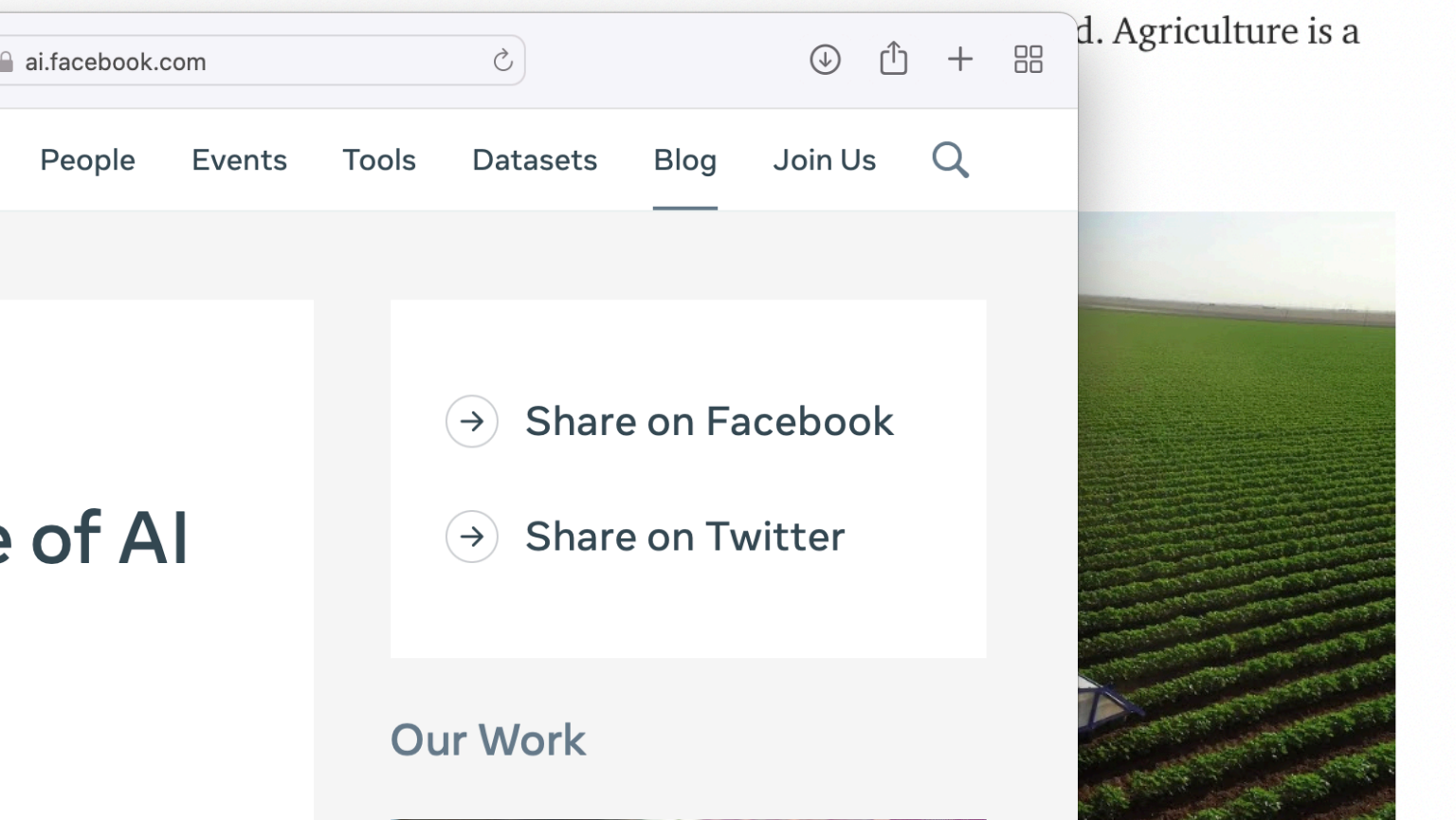
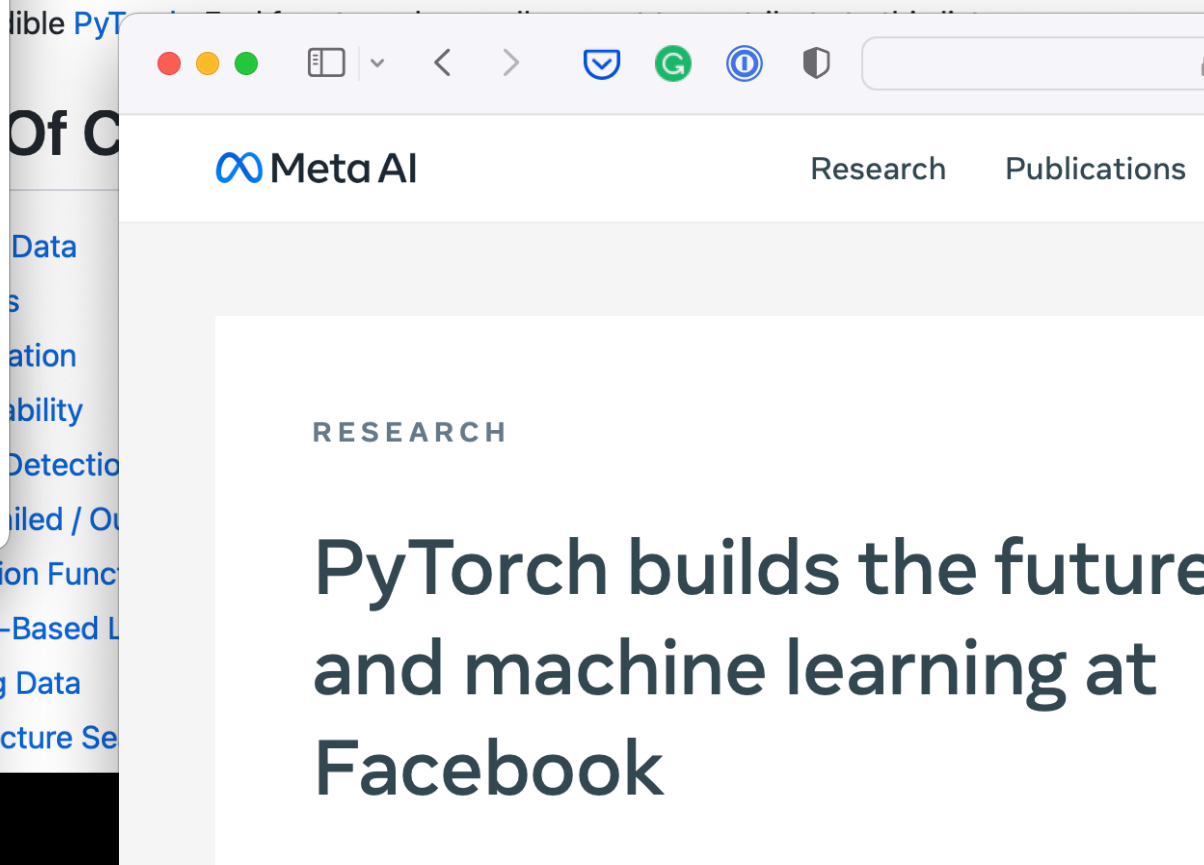
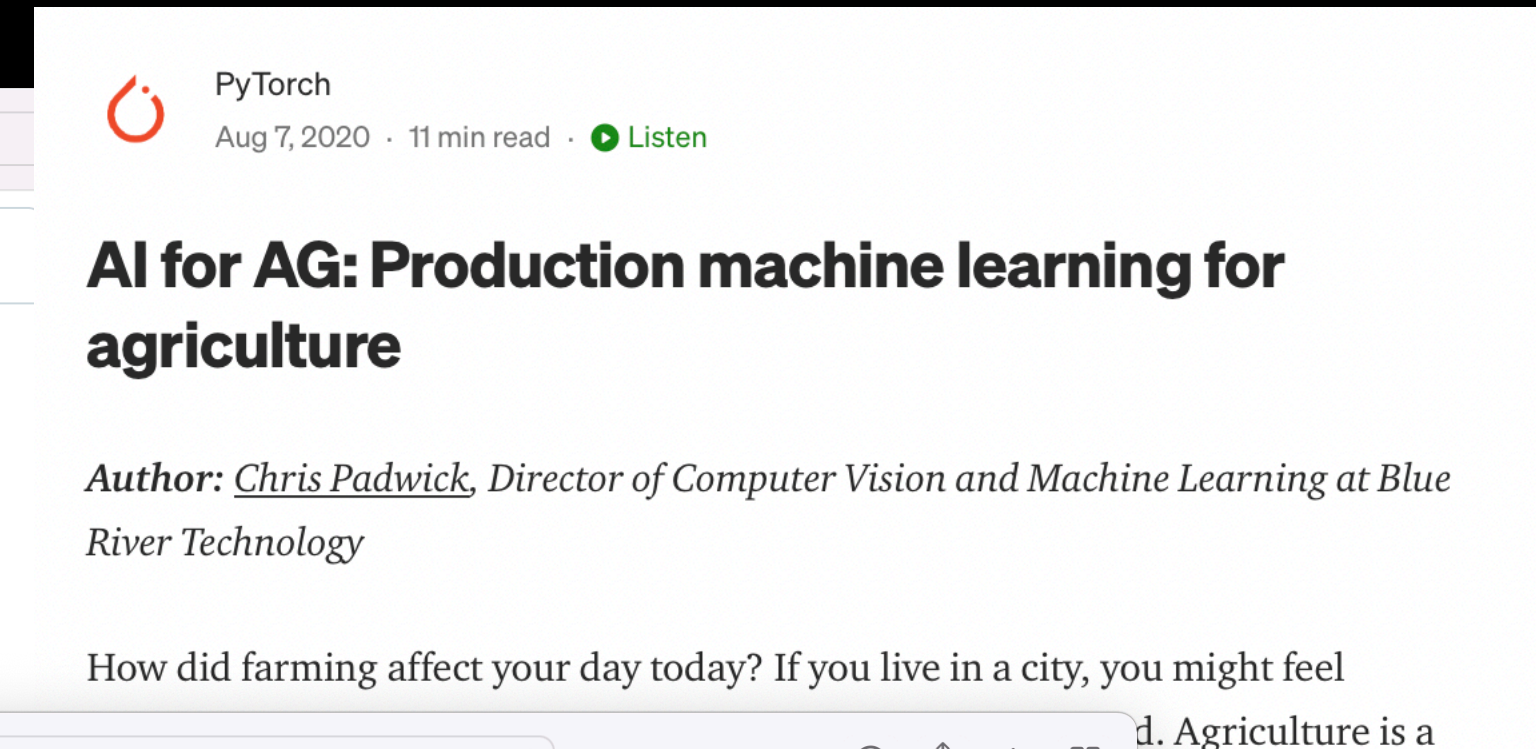
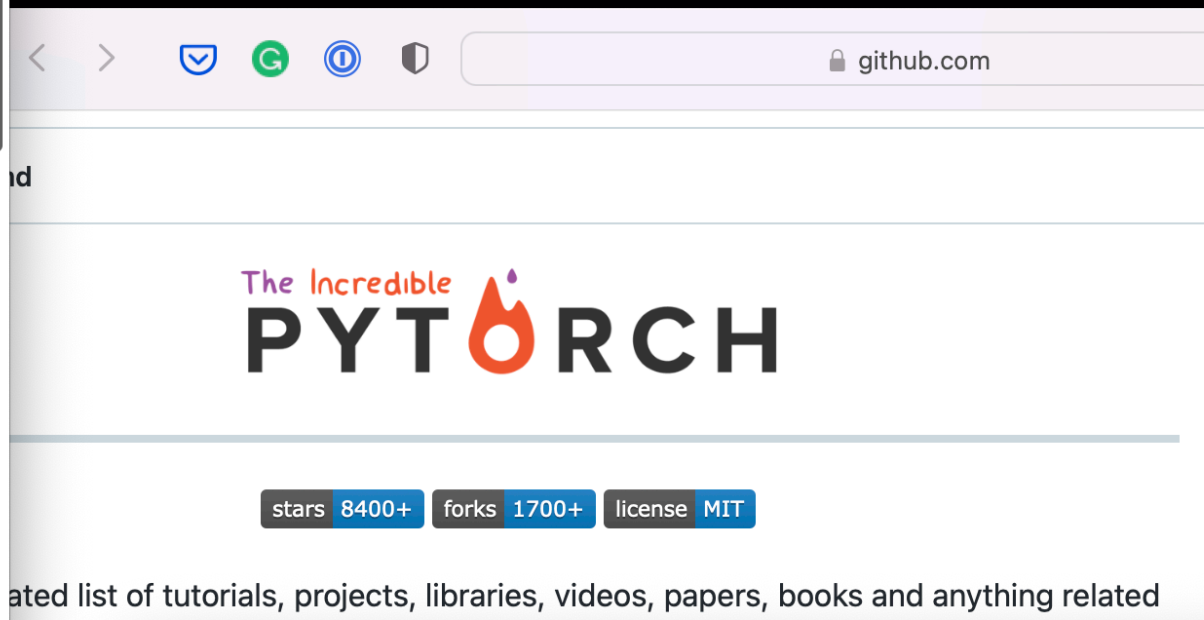
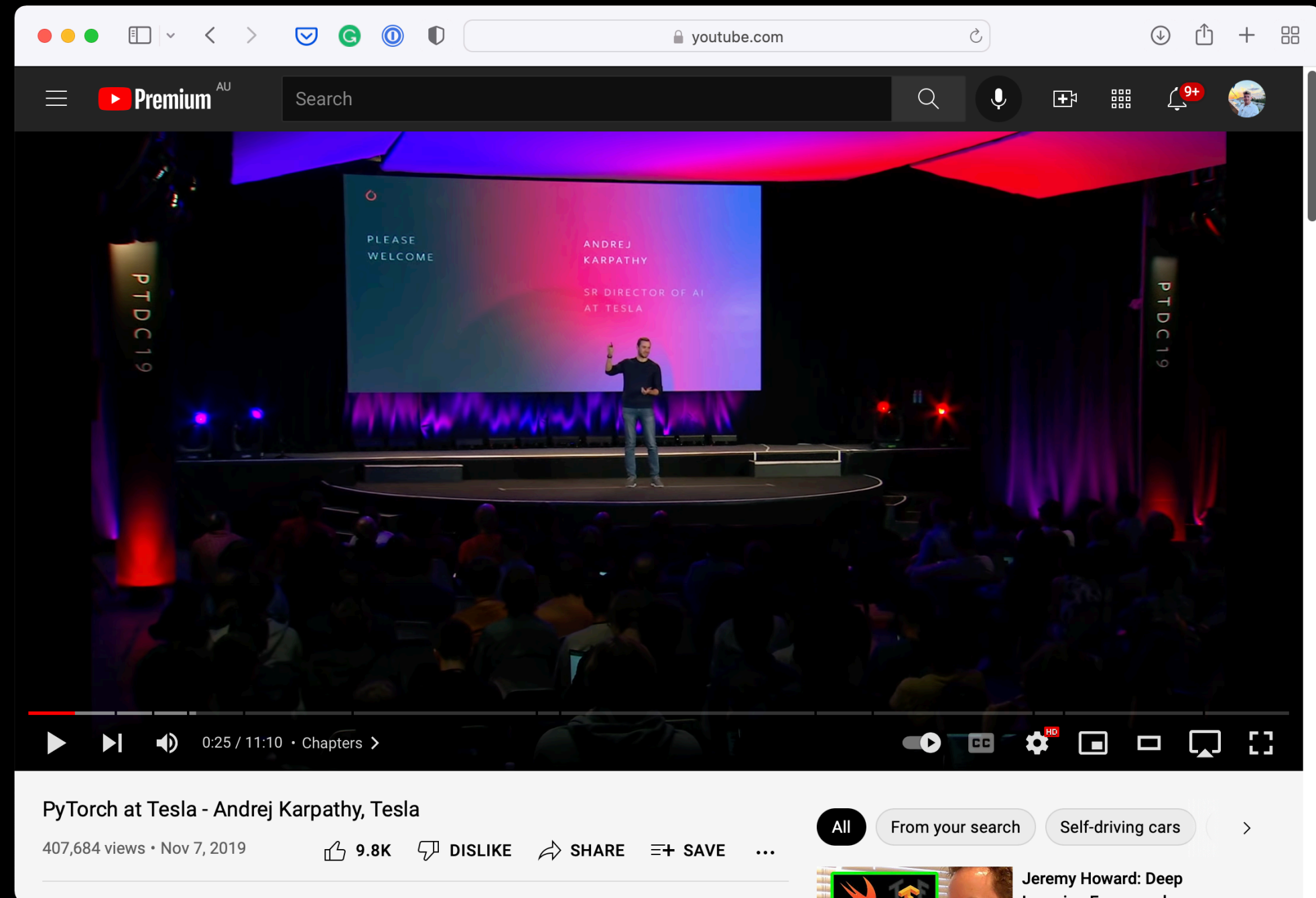
and PyTorch ...

With tools like Colab, Keras, and TensorFlow, virtually anyone can solve in a day, with no initial investment, problems that would have required an engineering team working for a quarter and \$20k in hardware in 2014

7:03 AM · Nov 21, 2020 · Twitter for Android

Source: [@fchollet](https://twitter.com/fchollet) Twitter

Why PyTorch?



OpenAI Standardizes on PyTorch

We are standardizing OpenAI's deep learning framework on PyTorch. In the past, we implemented projects in many frameworks depending on their relative strengths. We've now chosen to standardize to make it easier for our team to create and share optimized implementations of our models.

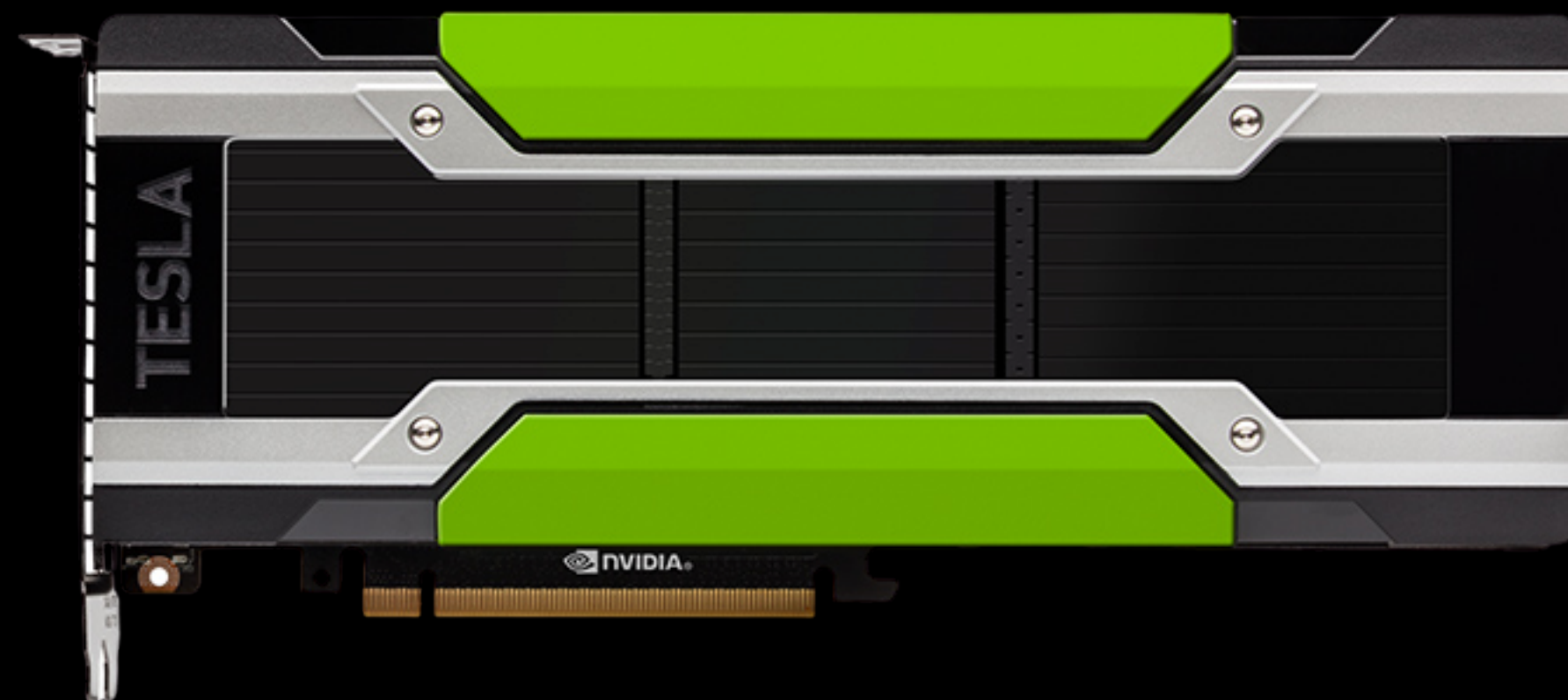
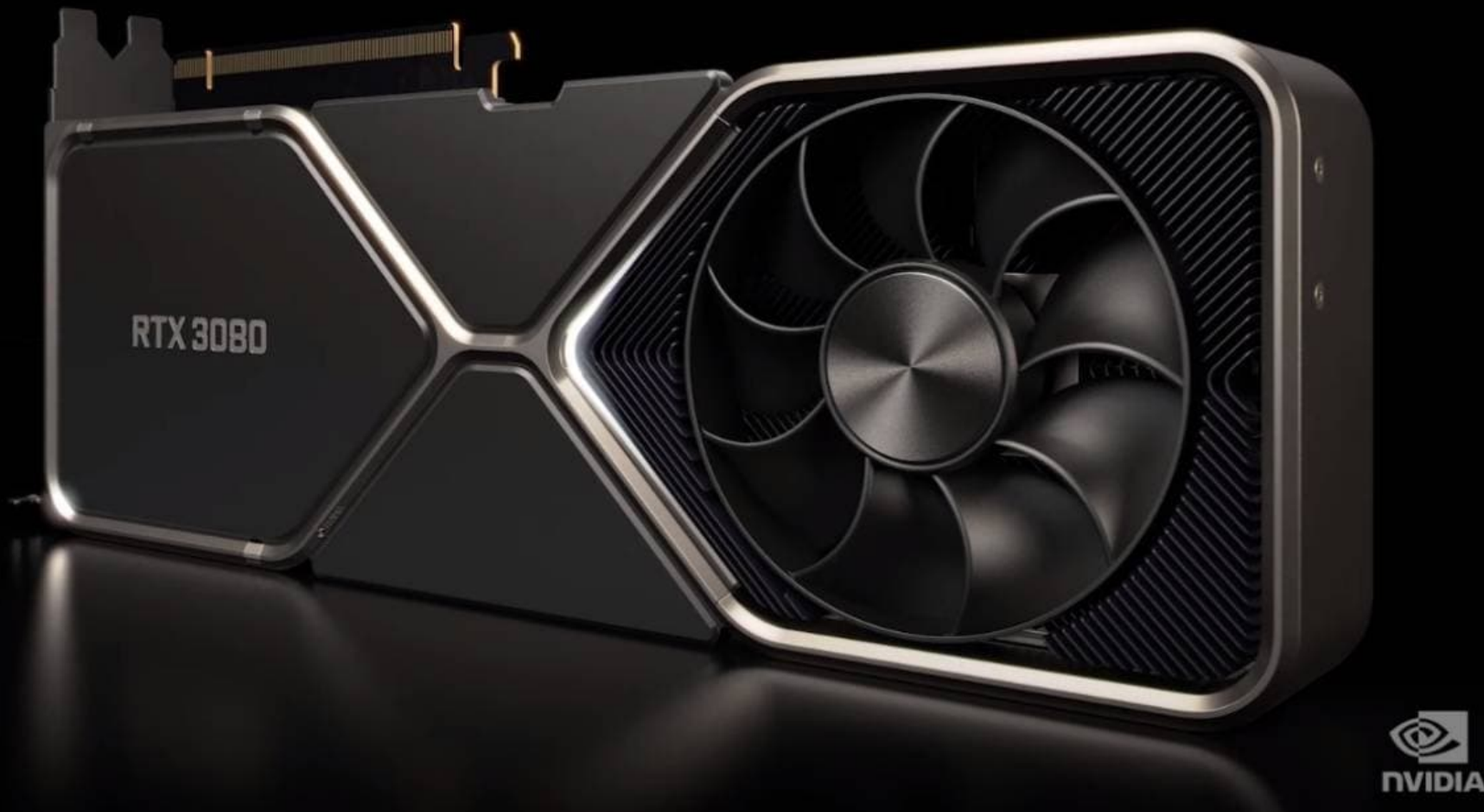
January 30, 2020
1 minute read



Microsoft

Facebook's AI models perform trillions of inferences for the billions of people that use our technology. This workload demand means we have to continue to invest in our systems to PyTorch. Which is why, today we're announcing that we're moving our systems to PyTorch.

What is a GPU/TPU?



GPU (Graphics Processing Unit)



TPU (Tensor Processing Unit)

“What is a tensor?”

Neural Networks



(before data gets used with an algorithm, it needs to be turned into numbers)

Daniel Bourke @mrdbourke · Nov 1
"How do I learn #machinelearning?"

What you want to hear:

1. Learn Python
2. Learn Math/Stats/Probability
3. Learn software engineering
4. Build

What you need to do:

1. Google it
2. Go down the rabbit hole
3. Resurface in 6-9 months and reassess

See you on the other side.

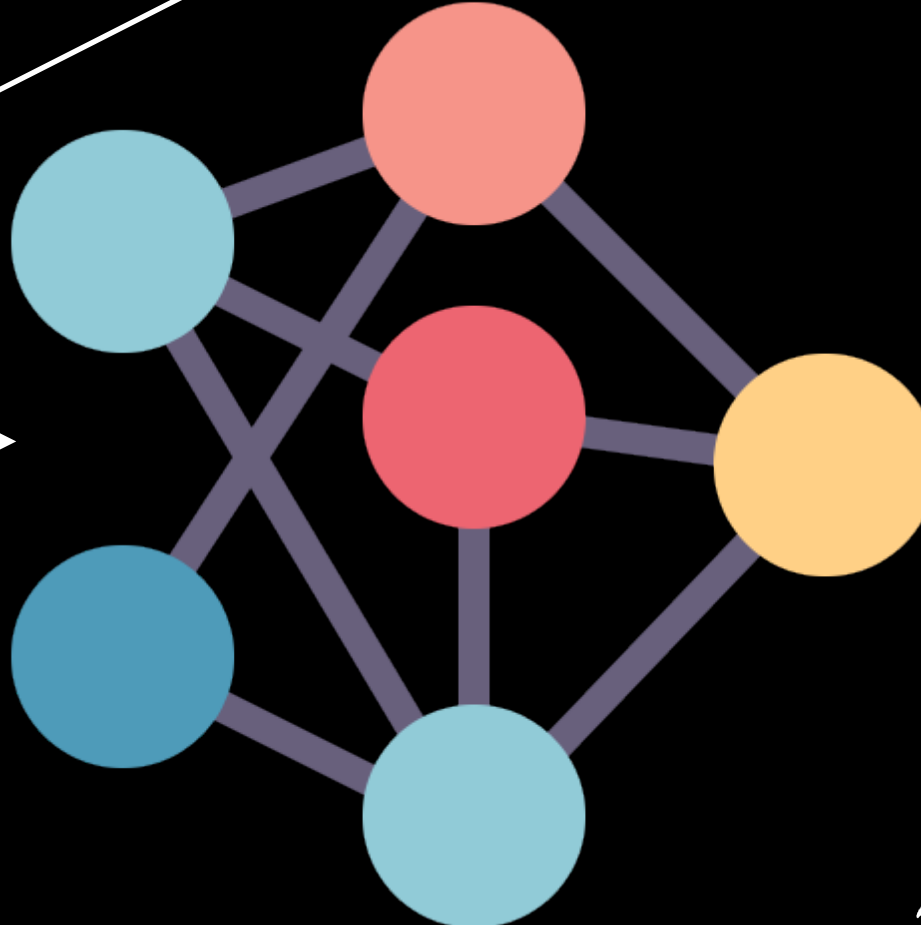


Inputs

Numerical encoding

```
[[116, 78, 15],  
 [117, 43, 96],  
 [125, 87, 23],  
 ... ,
```

Learns representation (patterns/features/weights)



(choose the appropriate neural network for your problem)

Representation outputs

```
[[0.983, 0.004, 0.013],  
 [0.110, 0.889, 0.001],  
 [0.023, 0.027, 0.985],  
 ... ,
```

Outputs

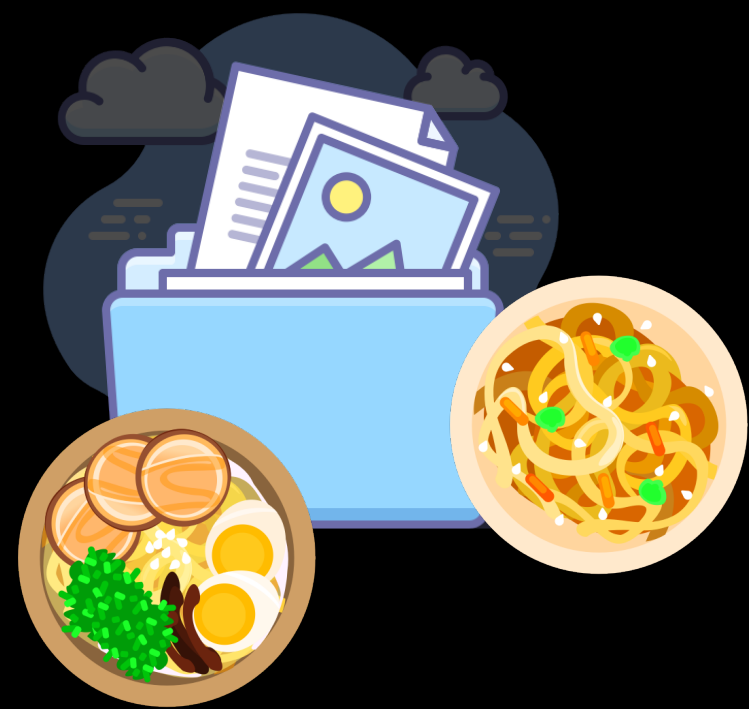
These are tensors!

(a human can understand these)

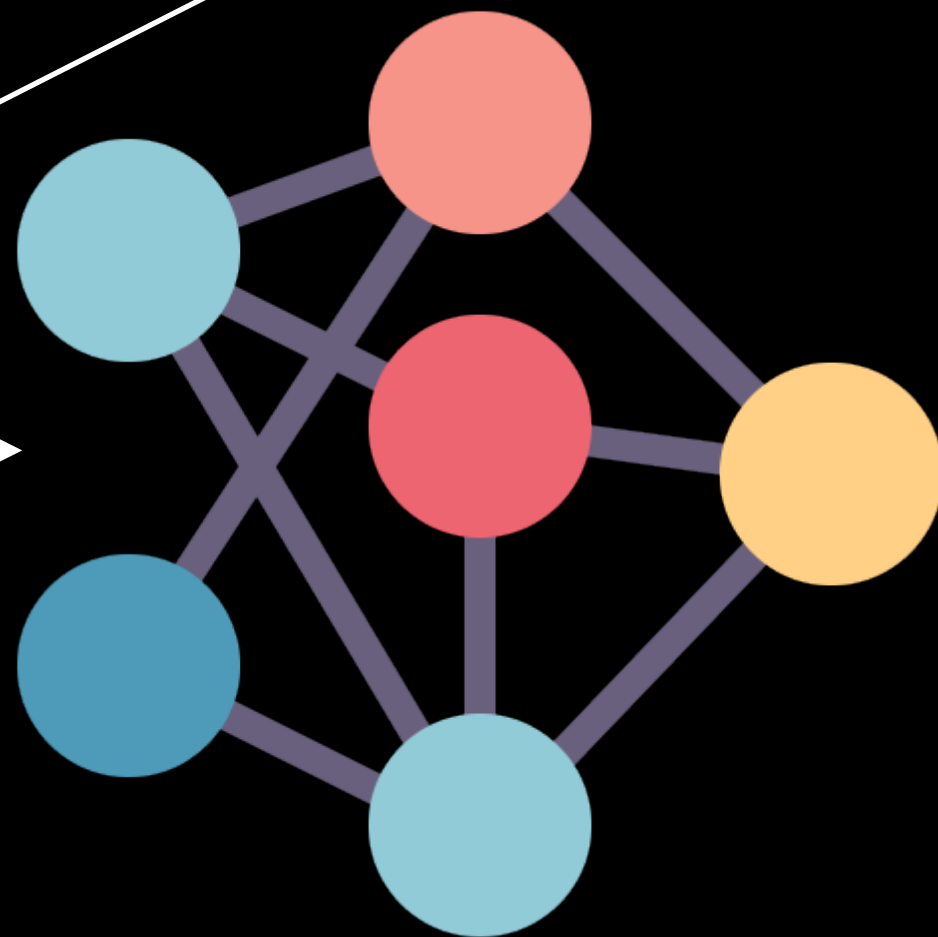
Ramen, Spaghetti

Not spam

"Hey Siri, what's the weather today?"



```
[[116, 78, 15],  
 [117, 43, 96],  
 [125, 87, 23],  
 ... ,
```



```
[[0.983, 0.004, 0.013],  
 [0.110, 0.889, 0.001],  
 [0.023, 0.027, 0.985],  
 ... ,
```

Ramen,
Spaghetti

These are tensors!

Inputs

**Numerical
encoding**

**Learns
representation
(patterns/features/weights)**

**Representation
outputs**

Outputs

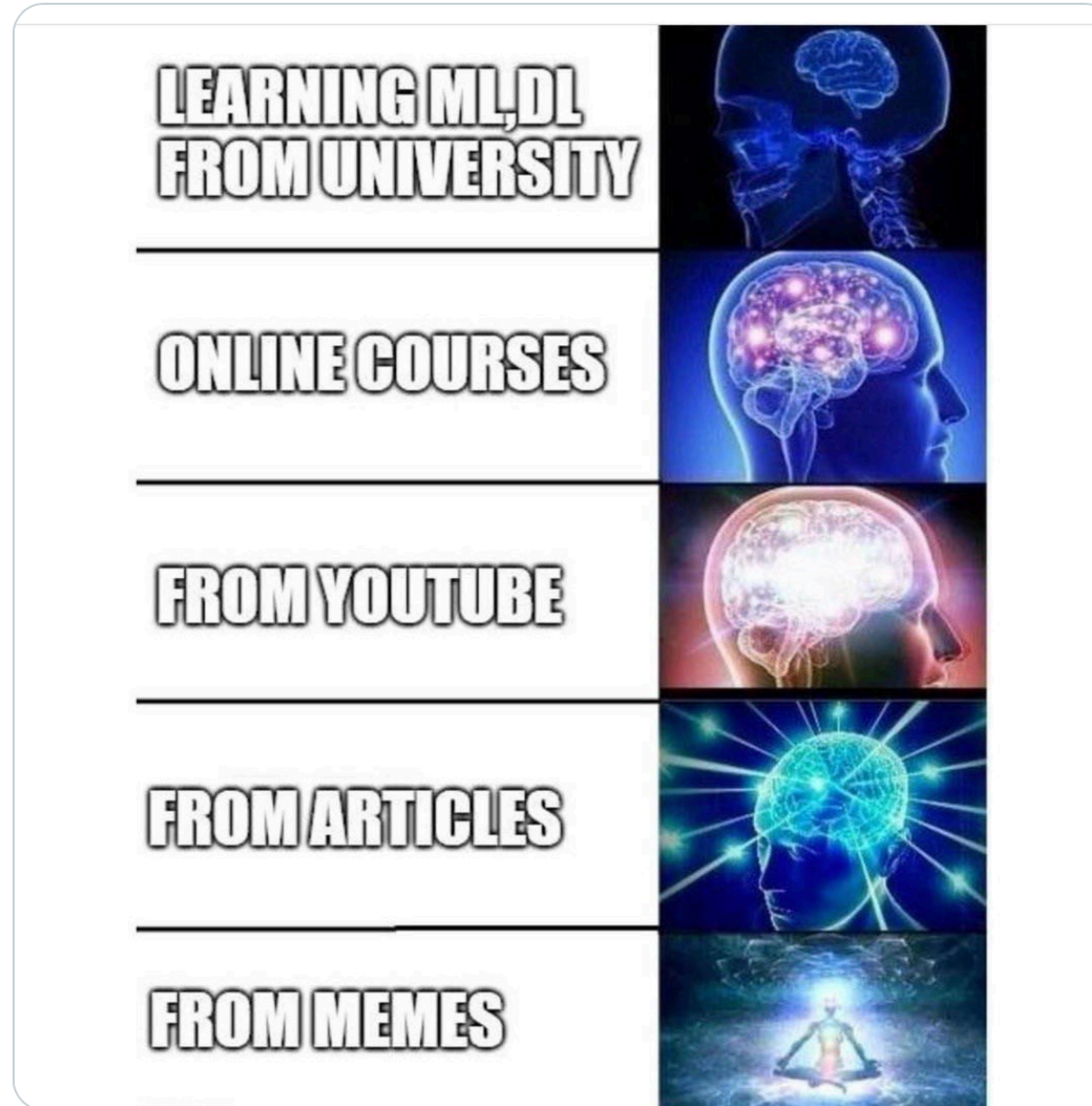
**“What are we going to
cover?”**



Elon Musk 
@elonmusk

⋮

Deus ex machine learning



8:07 AM · Nov 18, 2020 · Twitter for iPhone

14.9K Retweets 2.3K Quote Tweets 188.4K Likes

Source: [@elonmusk](https://twitter.com/elonmusk) Twitter

What we're going to cover

(broadly)

- Now:
 - PyTorch basics & fundamentals (dealing with tensors and tensor operations)
- Later:
 - Preprocessing data (getting it into tensors)
 - Building and using pretrained deep learning models
 - Fitting a model to the data (learning patterns)
 - Making predictions with a model (using patterns)
 - Evaluating model predictions
 - Saving and loading models
 - Using a trained model to make predictions on custom data

(we'll be cooking up lots of code!)

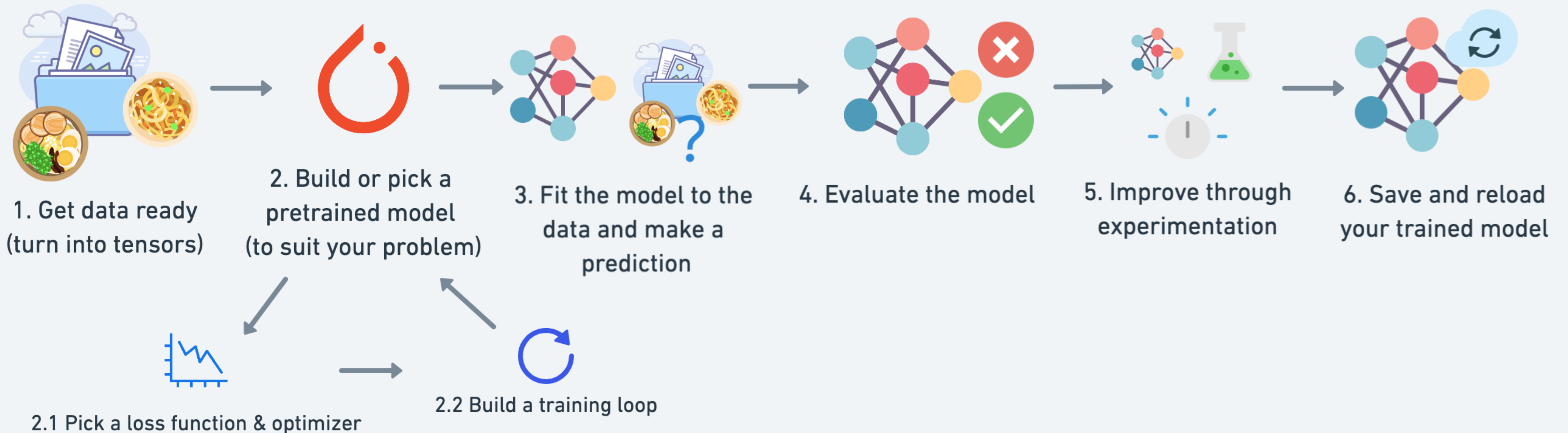
How:



What we're going to cover

A PyTorch workflow

(one of many)



**“How should I approach
this course?”**

How to approach this course

```
1 # 1. Construct a model class that subclasses nn.Module
2 class CircleModelV0(nn.Module):
3     def __init__(self):
4         super().__init__()
5         # 2. Create 2 nn.Linear layers
6         self.layer_1 = nn.Linear(in_features=2, out_features=5)
7         self.layer_2 = nn.Linear(in_features=5, out_features=1)
8
9     # 3. Define a forward method containing the forward pass computation
10    def forward(self, x):
11        # Pass the data through both layers
12        return self.layer_2(self.layer_1(x))
13
14 # 4. Create an instance of the model and send it to target device
15 model_0 = CircleModelV0().to(device)
16 model_0
```

1. Code along

Motto #1: if in doubt, run the code!



4. Ask questions

(including the "dumb" ones)

*Motto #2:
Experiment, experiment,
experiment!*



2. Explore and experiment



5. Do the exercises

*Motto #3:
visualize, visualize, visualize!*



3. Visualize what you don't understand



6. Share your work

How **not** to approach this course

Avoid:

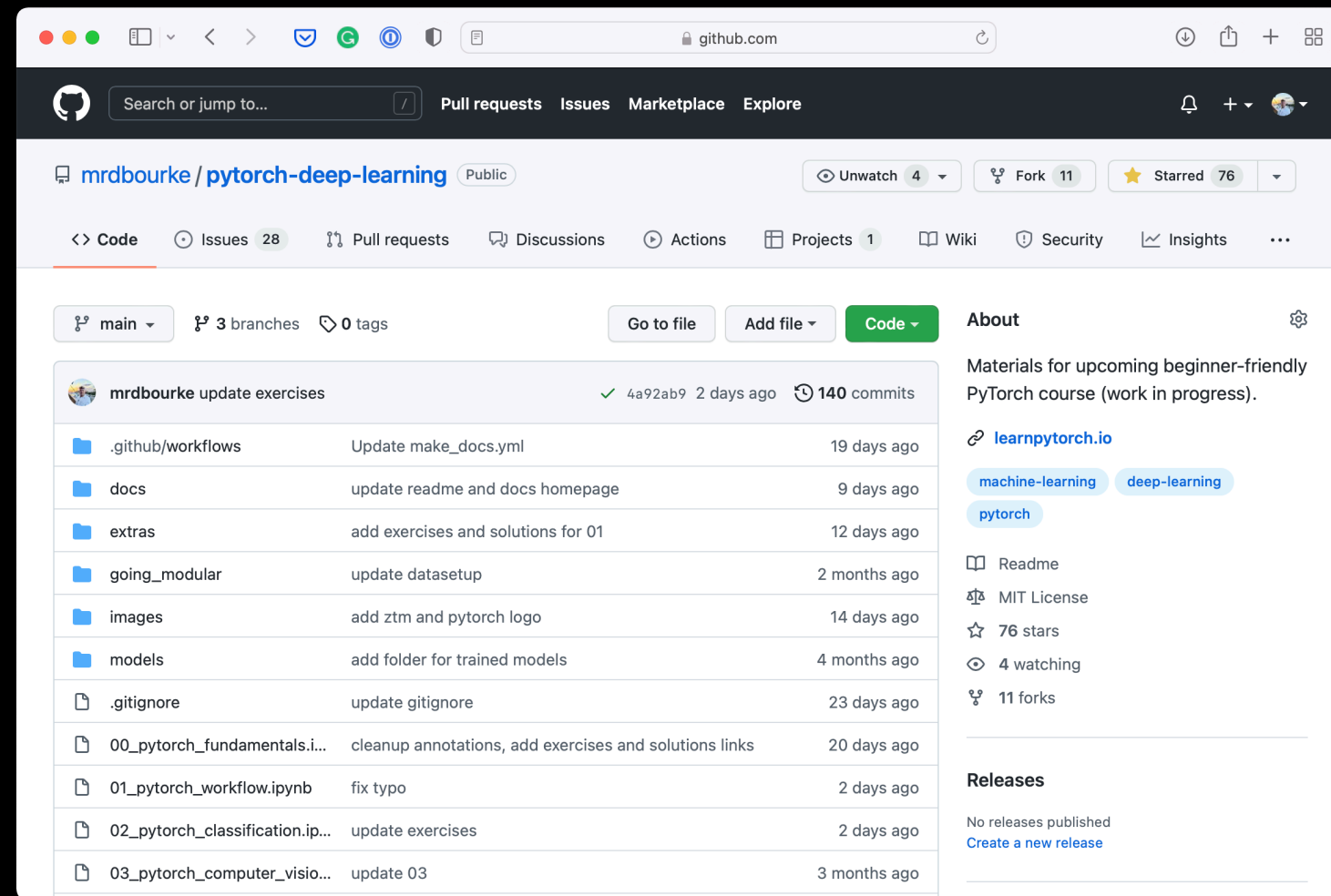


**“~~I can't~~ learn
”**

Resources

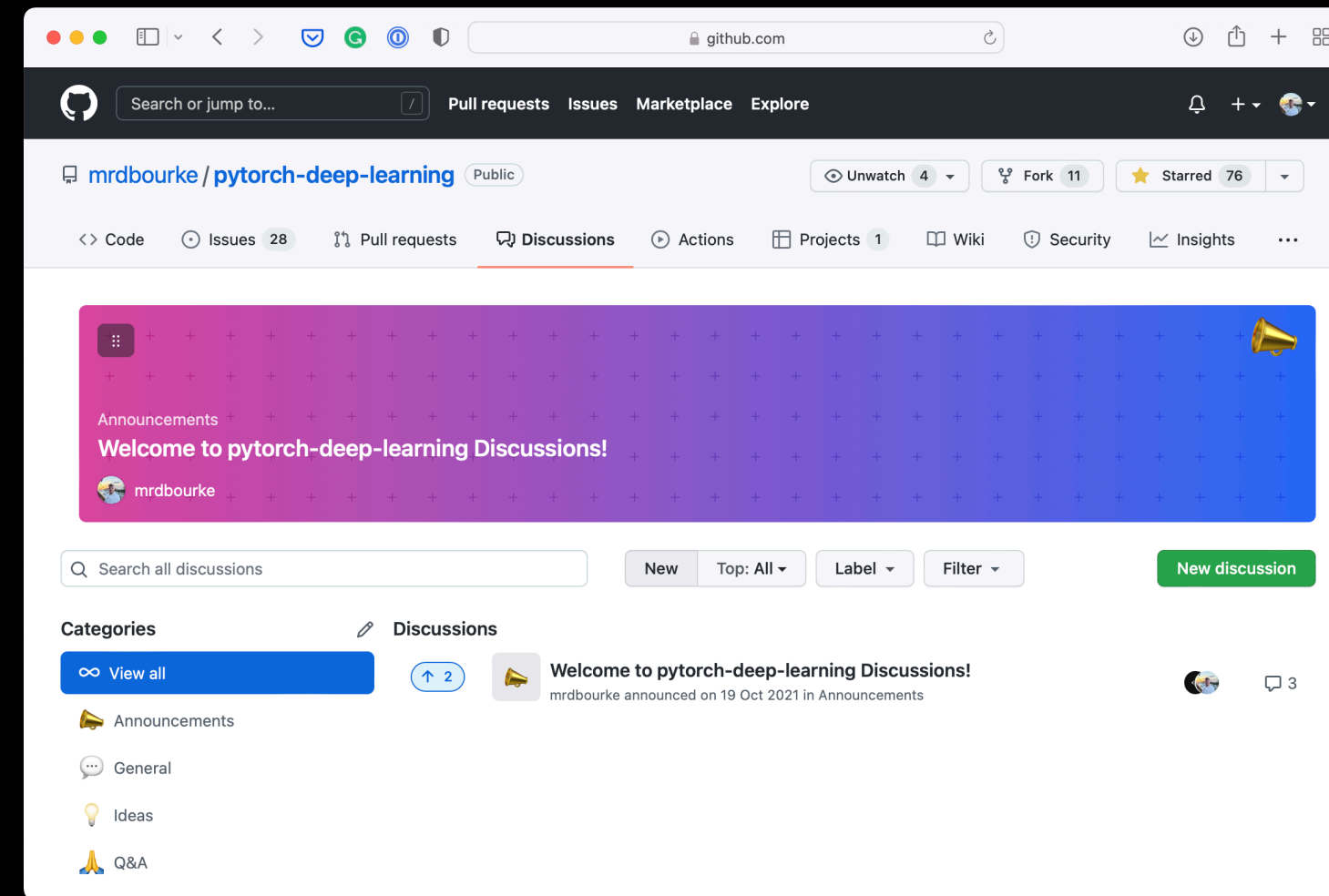
This course

Course materials



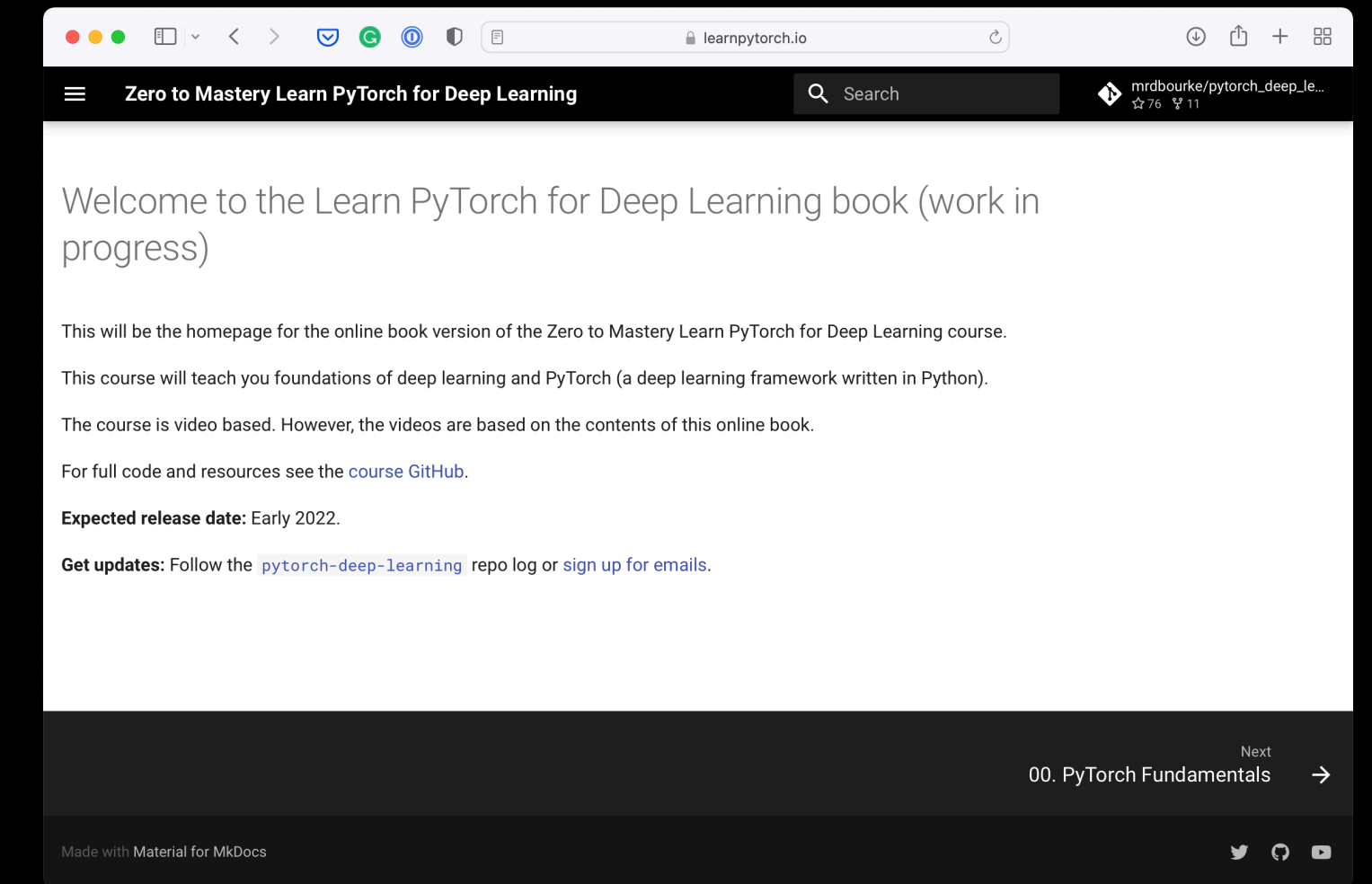
<https://www.github.com/mrdbourke/pytorch-deep-learning>

Course Q&A



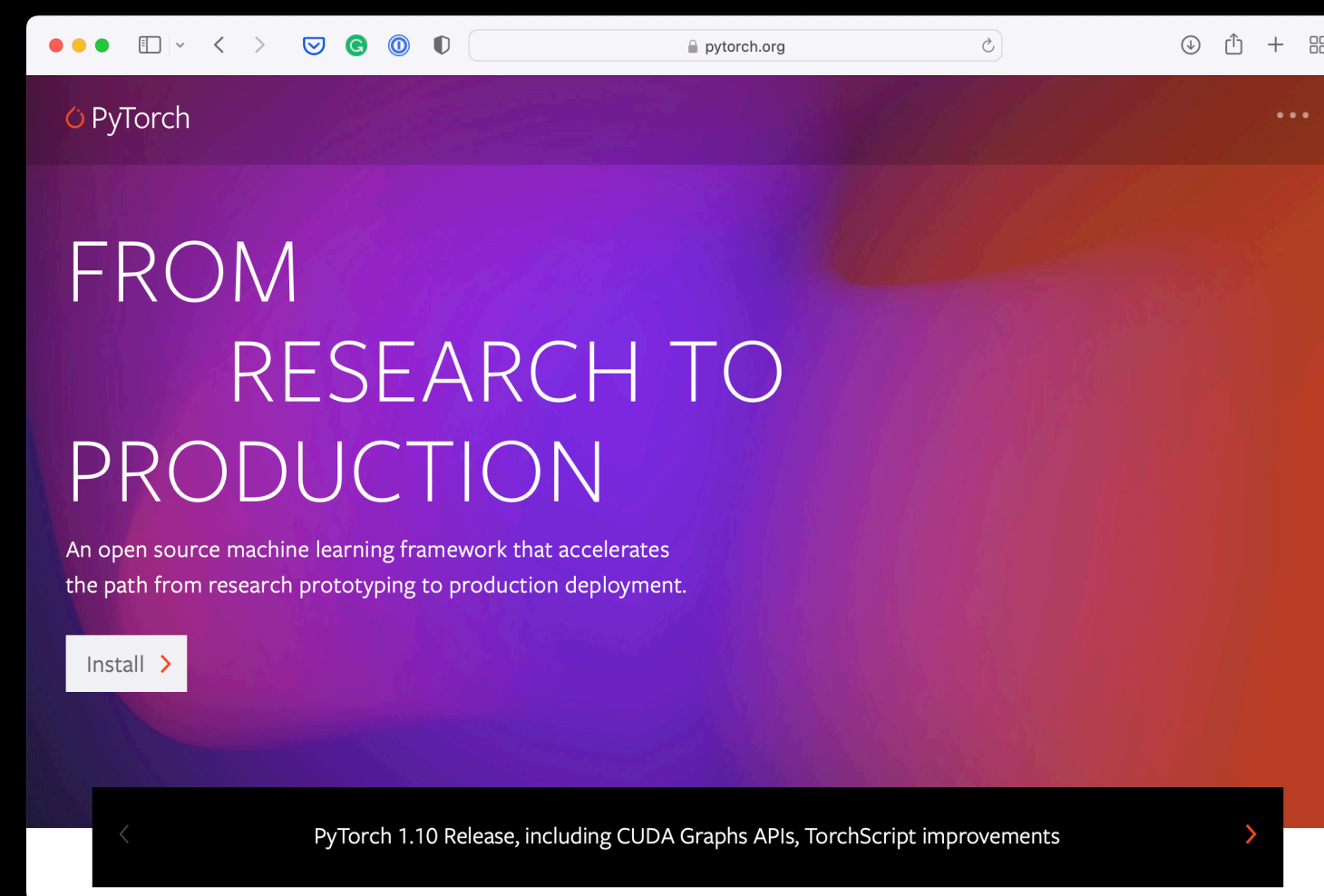
<https://www.github.com/mrdbourke/pytorch-deep-learning/discussions>

Course online book

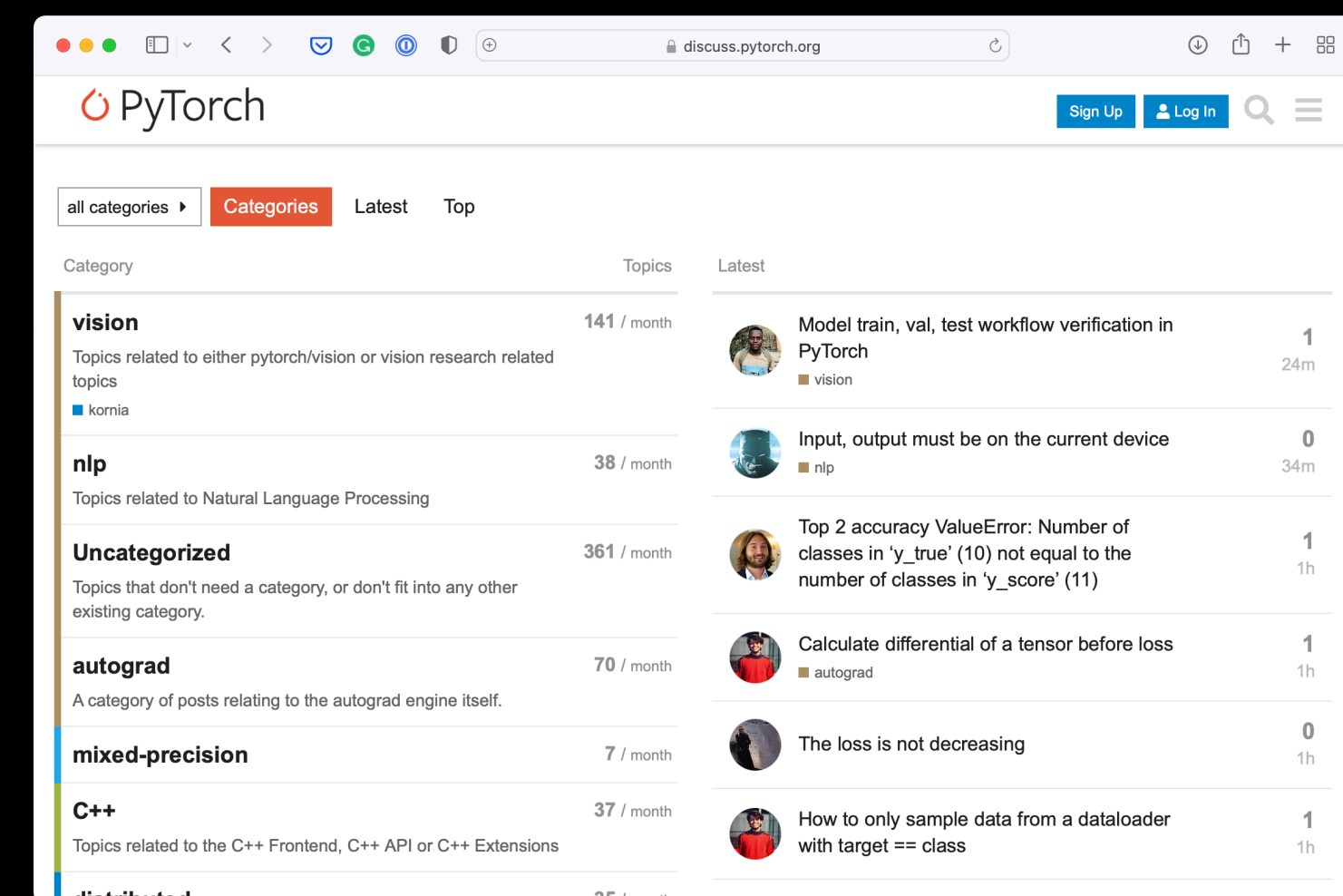


<https://learnpytorch.io>

PyTorch website & forums

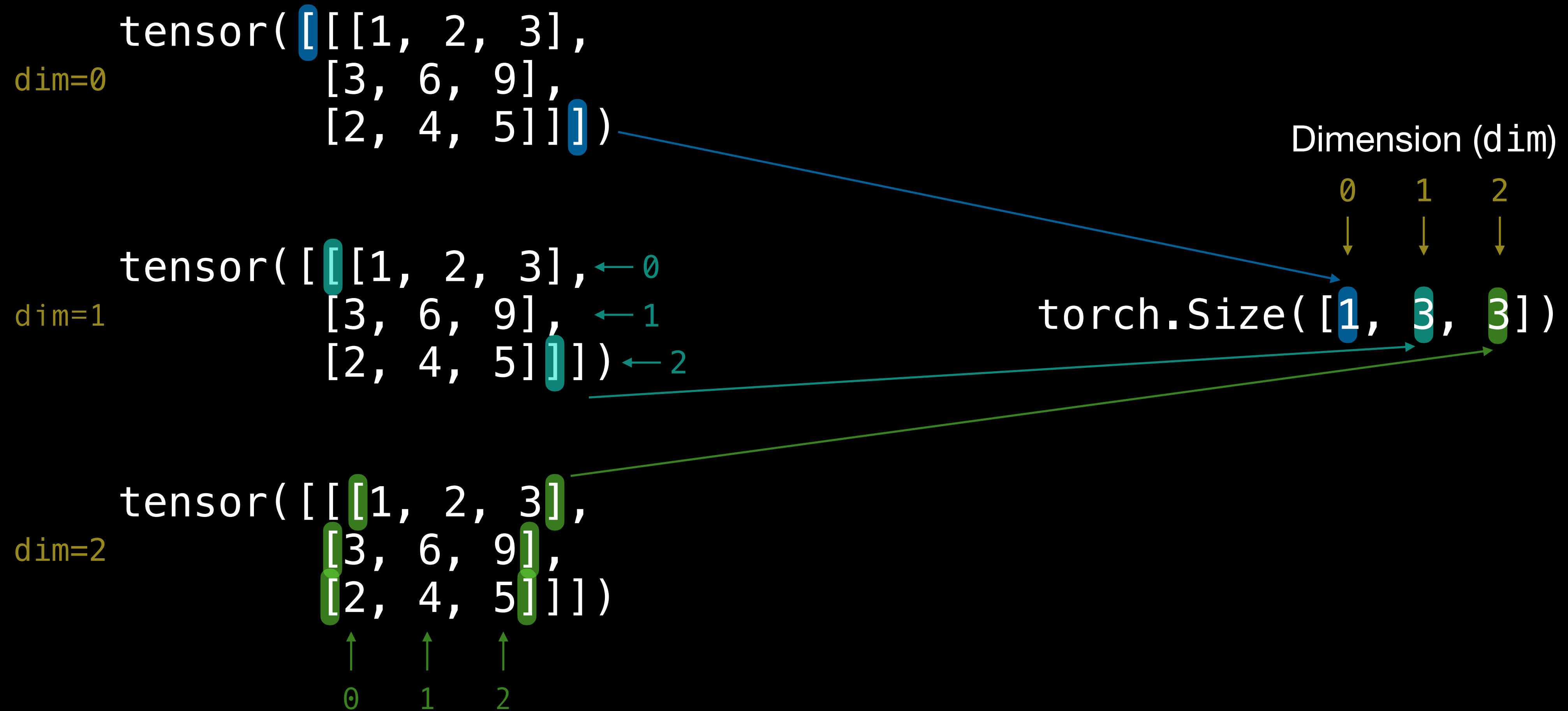


All things PyTorch

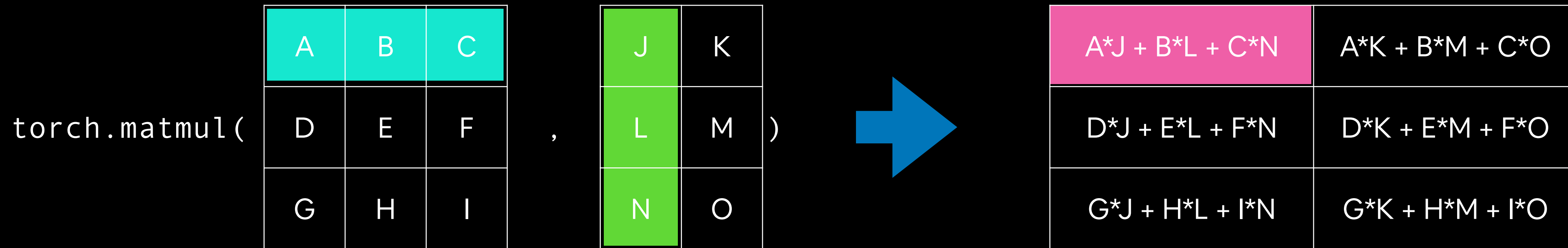


Let's code!

Tensor dimensions



Dot product



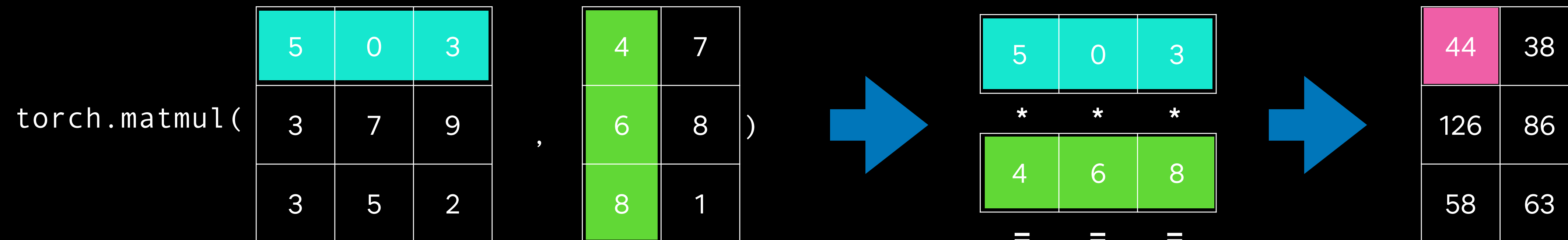
3x3

3x2

Numbers on the inside must match

3x2

New size is same as outside numbers



3x3

3x2

$$20 + 0 + 24 = 44$$

3x2

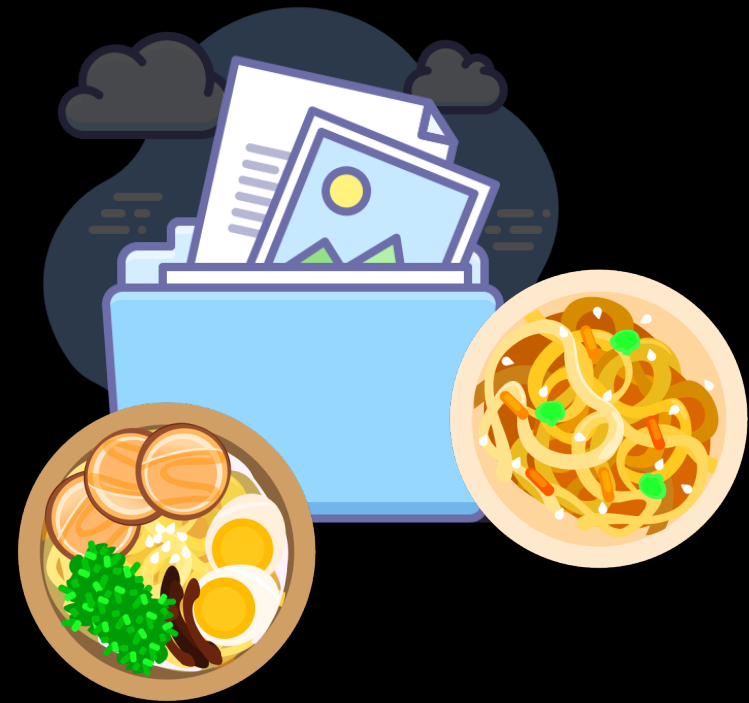
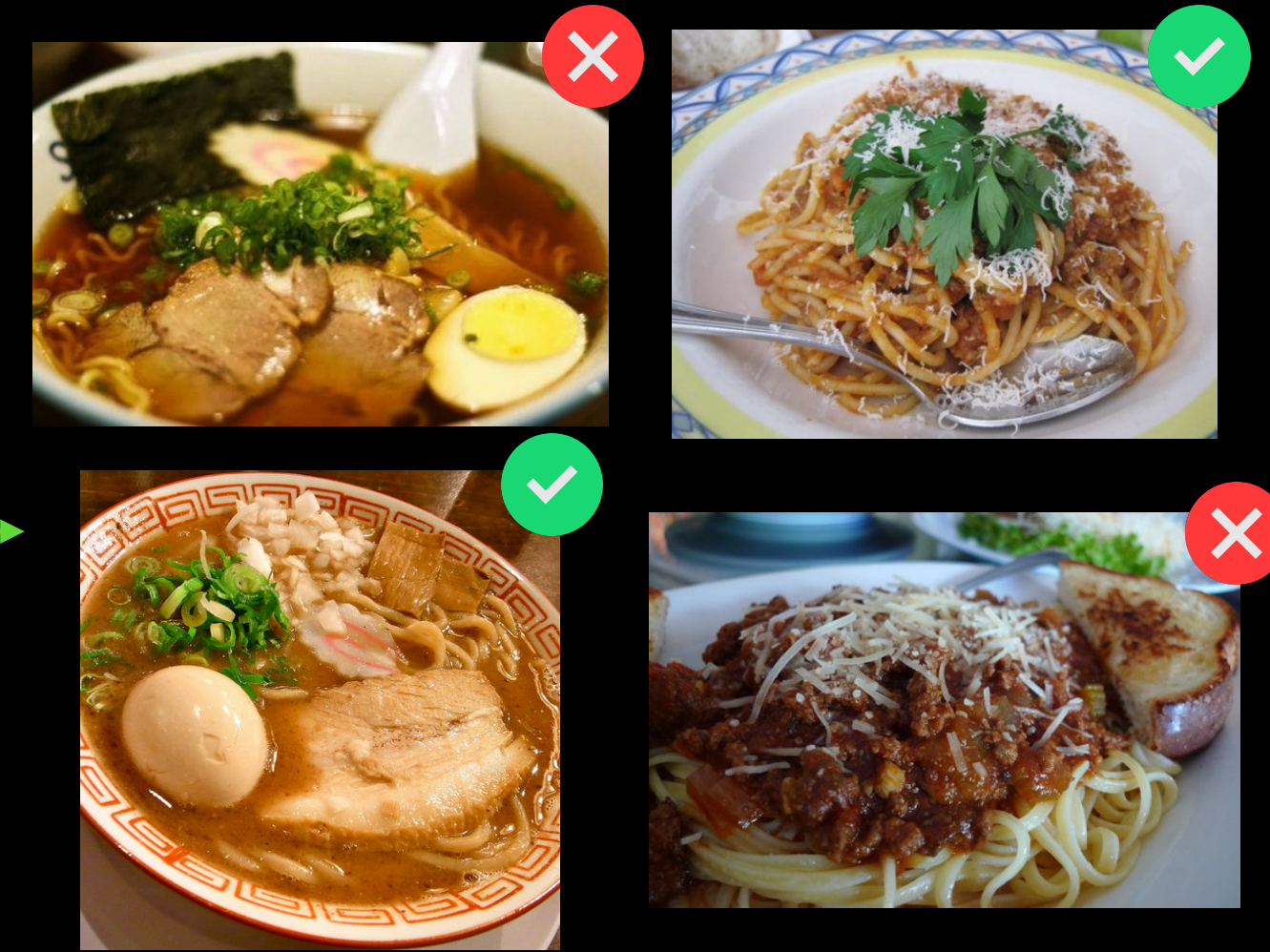
For a live demo, checkout www.matrixmultiplication.xyz

Supervised learning (overview)

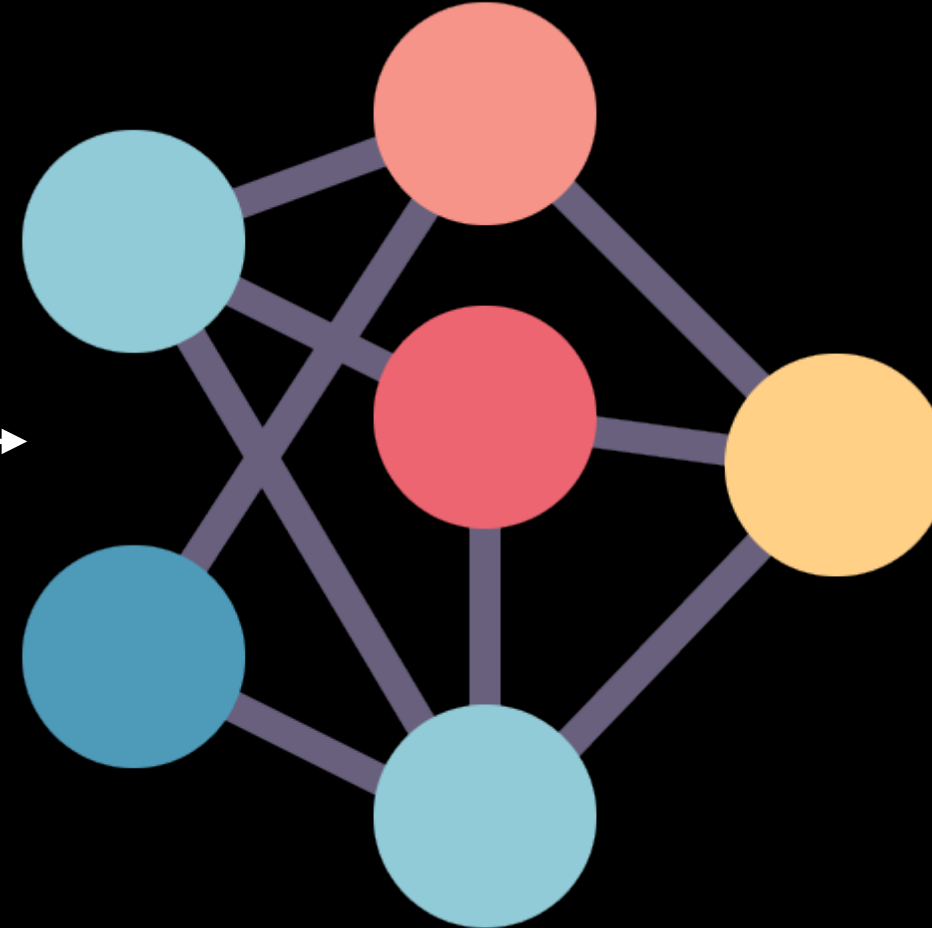
1. Initialise with random weights (only at beginning)

$[[0.092, 0.210, 0.415],$
 $[0.778, 0.929, 0.030],$
 $[0.019, 0.182, 0.555],$
...

2. Show examples



$[[116, 78, 15],$
 $[117, 43, 96],$
 $[125, 87, 23],$
...



$[[0.983, 0.004, 0.013],$
 $[0.110, 0.889, 0.001],$
 $[0.023, 0.027, 0.985],$
...

Ramen,
Spaghetti

3. Update representation outputs

4. Repeat with more examples

Inputs

Numerical encoding

Learns representation (patterns/features/weights)

Representation outputs

Outputs

Tensor attributes

Attribute	Meaning	Code
Shape	The length (number of elements) of each of the dimensions of a tensor.	<code>tensor.shape</code>
Rank/dimensions	The total number of tensor dimensions. A scalar has rank 0, a vector has rank 1, a matrix is rank 2, a tensor has rank n.	<code>tensor.ndim</code> or <code>tensor.size()</code>
Specific axis or dimension (e.g. "1st axis" or "0th dimension")	A particular dimension of a tensor.	<code>tensor[0]</code> , <code>tensor[:, 1]</code> ...

