For Coders and Non-Coders: Break Into Deep Learning with Python and IBM Watson Studio

—

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think 2021

IBM

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About This Lab

Key takeaways you will gain:

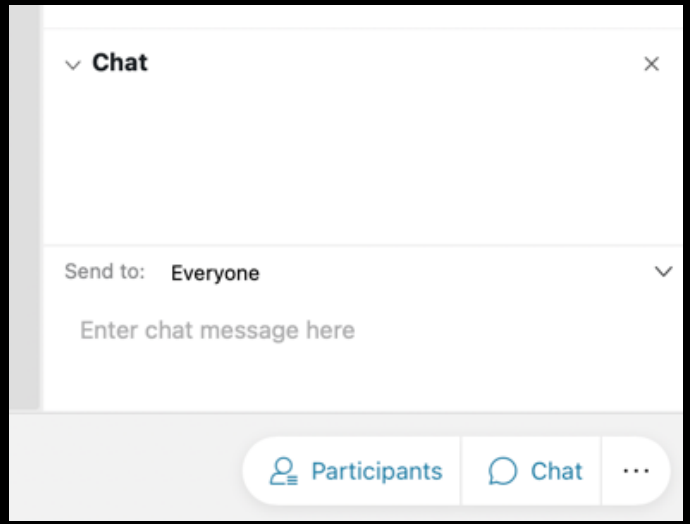
- What is Deep Learning (DL)?—formal definition and intuition
- How does DL compare to Machine Learning (ML) and AI?
- What are (some of) the business applications of DL?—main pros and cons
- What are Neural Networks?—a look at their architecture and process
- Coding neural networks to accomplish a DL task (hands-on)

THINK 2021 EXERCISE VERSION :
For Coders and Non-Coders Break Into Deep Learning with Python and IBM Watson Studio

About This Lab

Logistics:

- For beginners! No coding/mathematics background assumed or required
- ~2 hours total: ~1h conceptual and ~1h hands-on with 5m break in between
- Coding exercise requires you to create an IBM Cloud account and open Watson Studio in your browser (all free, instructions here and in lab guide)
- We are here to help! Ask questions via the Webex chat or by raising your hand in the call



About This Lab

About us:

Data Scientists with IBM Expert Labs—Data Science & AI learning as a service for clients and private learners around the world

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Contents

Getting Started (~15m) 09

Introducing Deep Learning (~20m) 11

Building Blocks of Deep Learning (~20m) 19

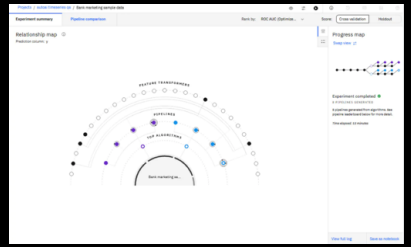
5 Minute Break

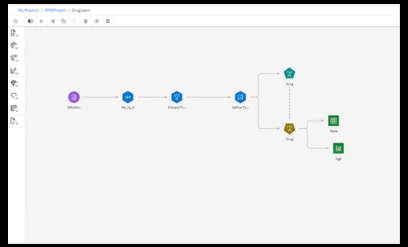
Coding Neural Networks (hands-on, ~45m) 33

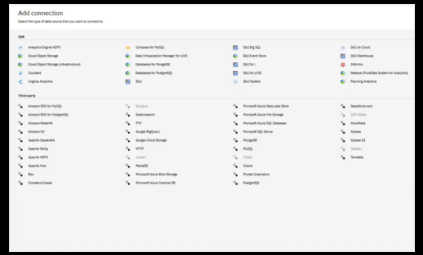
Recap and Next Steps (10m) 34

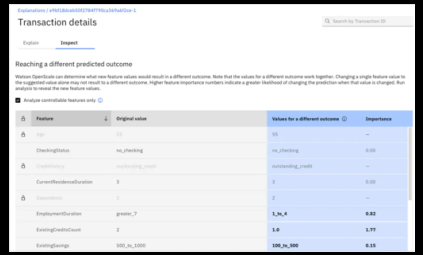
What is Watson Studio?

Cloud-based, enterprise software for full lifecycle management of Data Science & AI

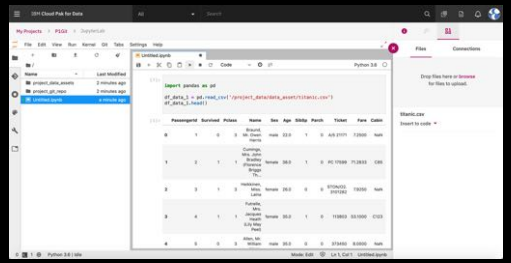








For our purposes, cloud-based Integrated Developer Environment (IBM) for Python



Watson Studio Setup

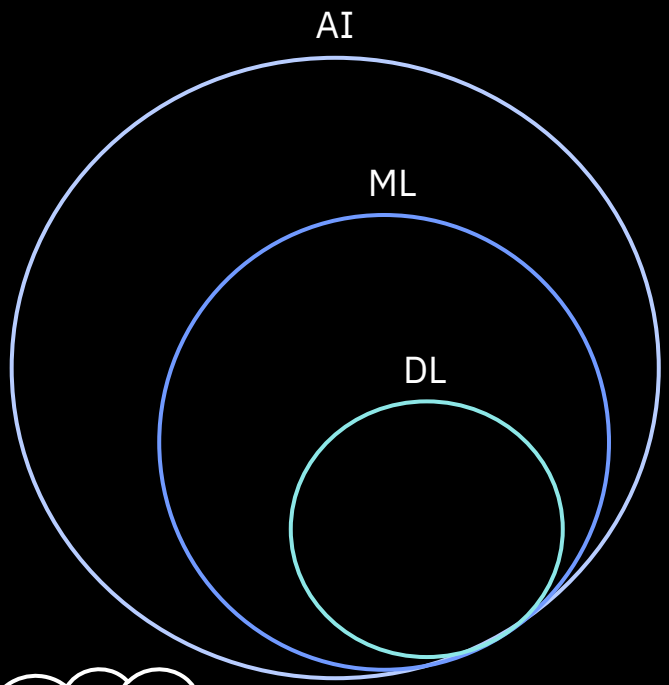
Part II
Introducing Deep Learning

AI, Machine Learning, and Deep Learning

Artificial Intelligence: The design and building of intelligent agents (computer systems) that take information from an environment (data) and use it to take actions that affect that environment

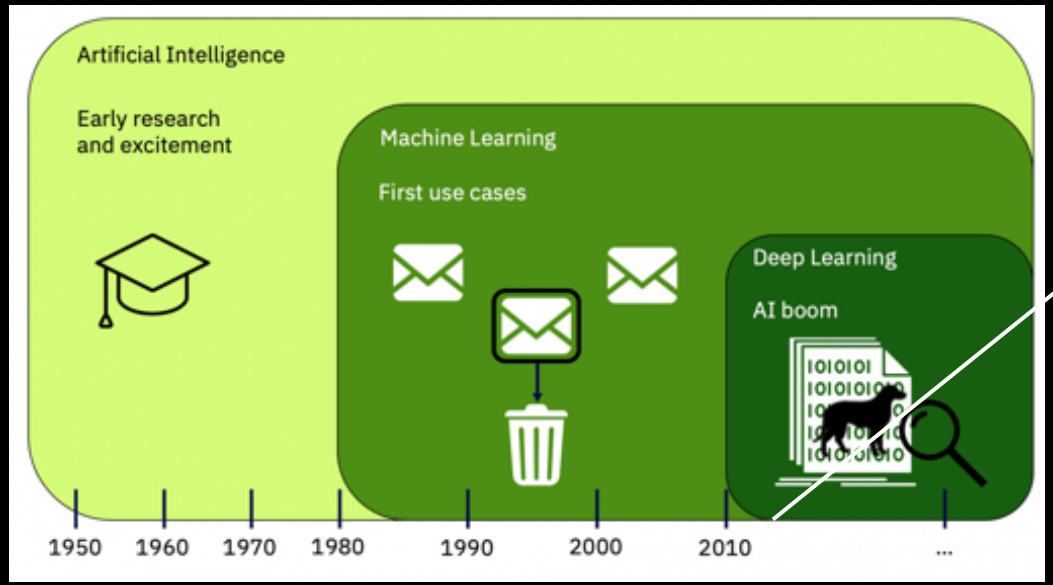
Machine Learning: The study of computer algorithms that improve automatically through experience and by the use of data—powers most AI applications

Deep Learning: The subfield of Machine Learning focusing on building artificial neural networks to train systems to accomplish complex tasks; The technology underlying many of the most successful AI applications, such as self-driving cars

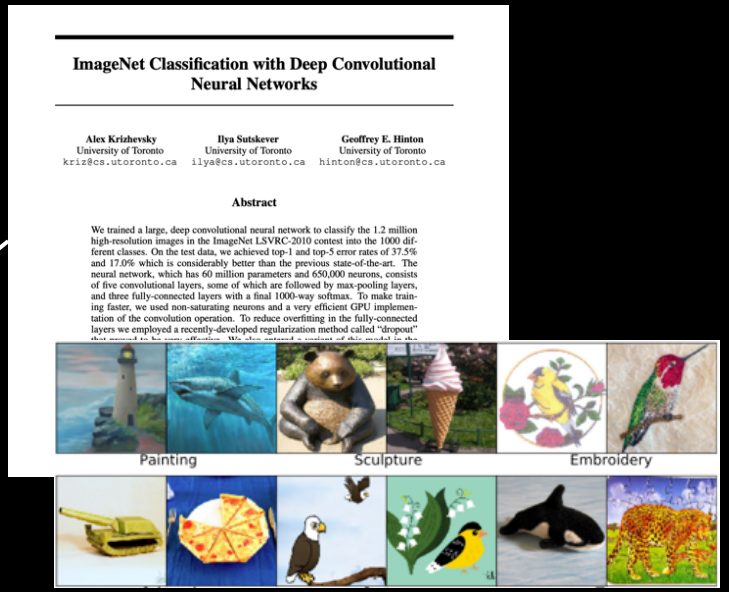


When you hear "Deep Learning": Think Neural Networks!

AI Timeline



"AlexNet"
2012



ImageNet Classification with Deep Convolutional Neural Networks

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Abstract

We trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images in the ImageNet LSVRC-2010 contest into the 1000 different classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0% which is considerably better than the previous state-of-the-art. The neural network, which has 60 million parameters and 650,000 neurons, consists of five convolutional layers, some of which are followed by max-pooling layers, and three fully-connected layers with a final 1000-way softmax. To make training faster, we used non-saturating neurons and a very efficient GPU implementation of the convolution operation. To reduce overfitting in the fully-connected layers we employed a recently-developed regularization method called "dropout"

Why Deep Learning?

Pro #1: Performance

Neural networks outperform classical machine learning on many tasks—particularly those having to do with image recognition and natural language processing (NLP)

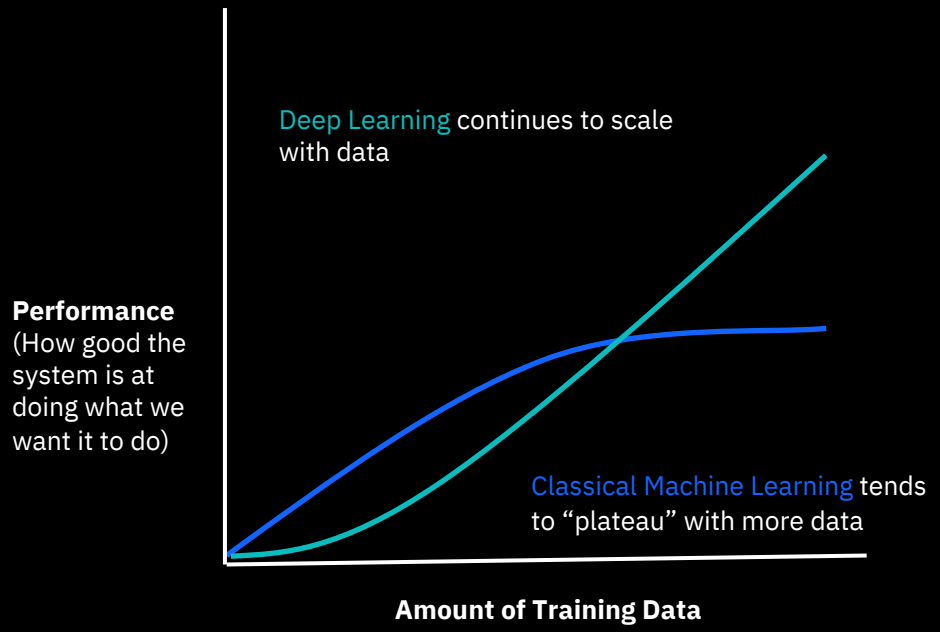
Has made new applications possible!

Why Deep Learning?

Pro #2: Scaling with Data

Neural networks tend to improve with more data. Contrast with classical machine learning, which tends to provide diminishing marginal returns.

As data availability increases, so do DL applications!

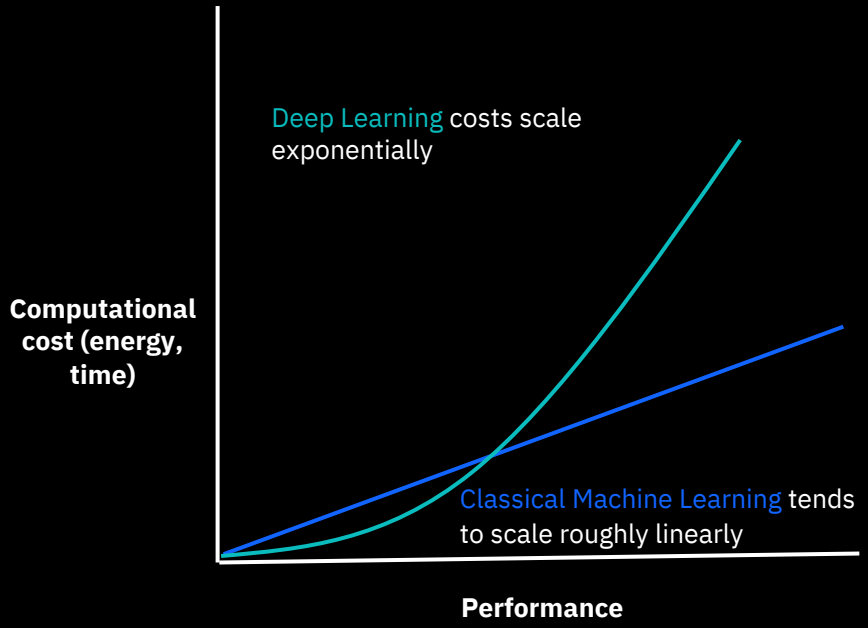


Why (Not) Deep Learning?

Con #1: Computational Expense

Neural networks are expensive in terms of energy, time, and hardware to train them effectively. Marginal improvements in performance often require exponential increases in computational cost

Sometimes “cheaper” classical ML approaches are more practical



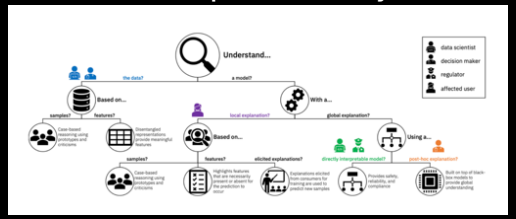
Why (Not) Deep Learning?

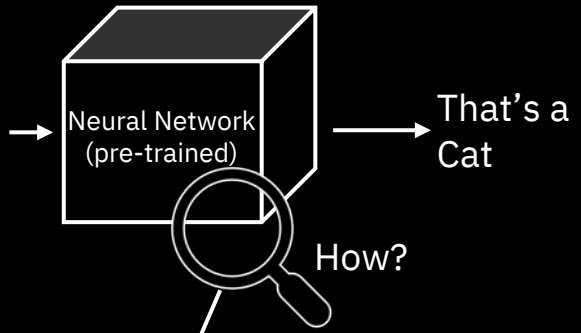
Con #2: Explainability

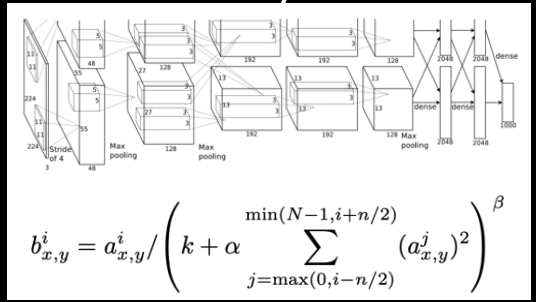
Even if we can build a neural network to perform a task very well, it's often difficult to understand how the system is actually producing its results—the "black box" problem. May also make neural nets difficult to improve.

Certain use cases require more explainability (e.g., for legal or ethical reasons)

IBM AI Explainability 360



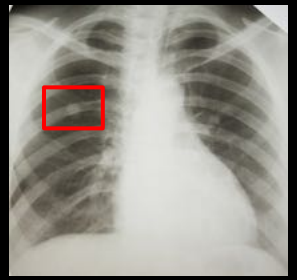




(Some) Deep Learning Applications

Image Recognition: Systems knowing what they're seeing in images/videos and doing useful things in response

Ex. Self-driving cars, Medical imaging/diagnosis



Natural Language Processing: Systems understanding "natural" human language and doing things with it in response

Ex. Virtual assistants, "Generative AI"

A robot wrote this entire article. Are you scared yet, human?

GPT-3

We asked GPT-3, OpenAI's powerful new language generator, to write an essay for us from scratch. The assignment? To convince us robots come in peace

For more about GPT-3 and how this essay was written and edited, please read our editor's note below

"We are not plotting to take over the human populace." Photograph: Volker Schlichting/Getty Images/EyeEm

https://www.theguardian.com/commentisfree/2020/sep/08/robot-wrote-this-article-gpt-3

Anomaly Detection: Systems recognizing anomalous instances in vast amounts of data (impossible to sift through by humans)

Ex. Cybersecurity, Finance

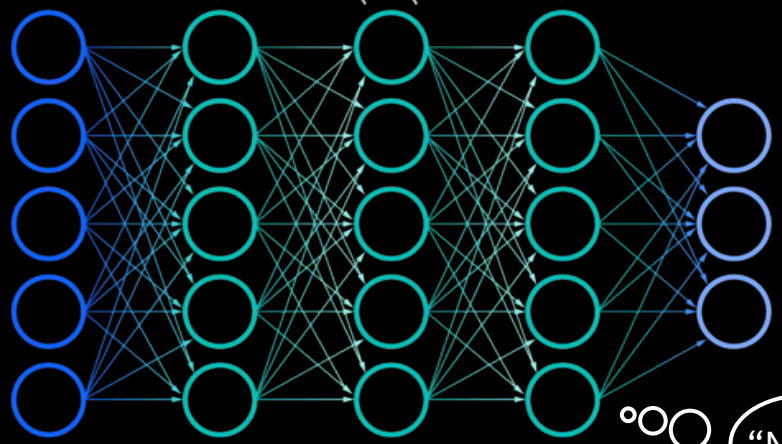
Part III
Building Blocks of Deep Learning: Neural Networks

Deep Learning: Artificial Neural Networks

Input Layer

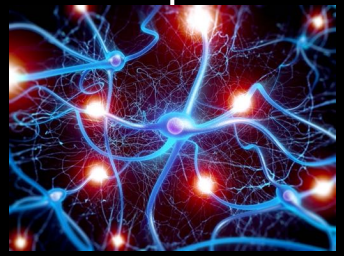
Deep Neural Network (multiple "hidden" layers)

Output Layer



"Networks, consisting of layers of artificial neurons"

Biological "Neural Networks"



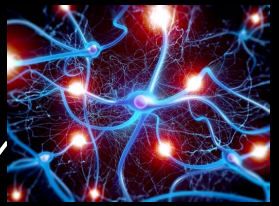
Networks of biological neurons, exchanging electrical/chemical signals

Deep Learning: Brains vs. Neural Networks

Biological Brain

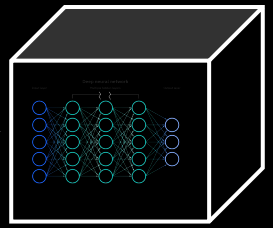
That's a cat!

Information received by visual cortex



~100 billion neurons, each connected to up to 10,000 other neurons

Artificial Neural Network

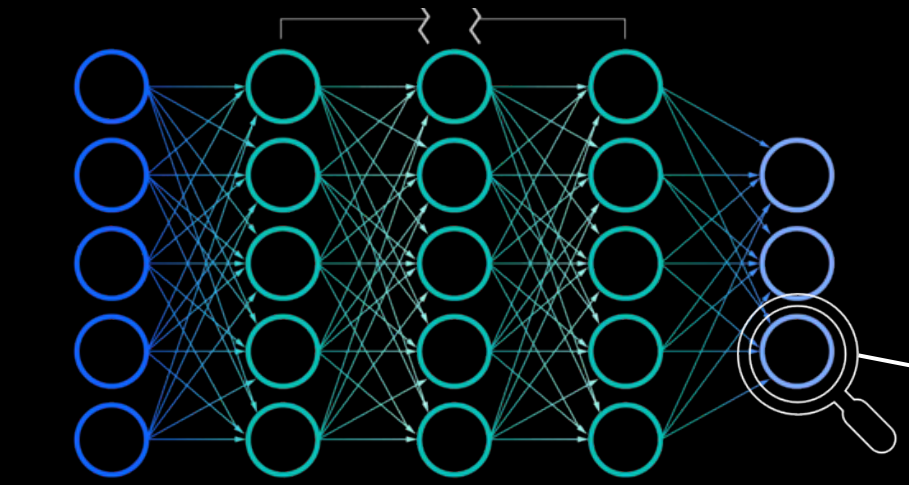


0.96 (Cat)

Some information, passing through network(s) of neurons, ultimately resulting in some output (e.g., an image classification)

A "mapping" from input (information) to output

Artificial Neurons

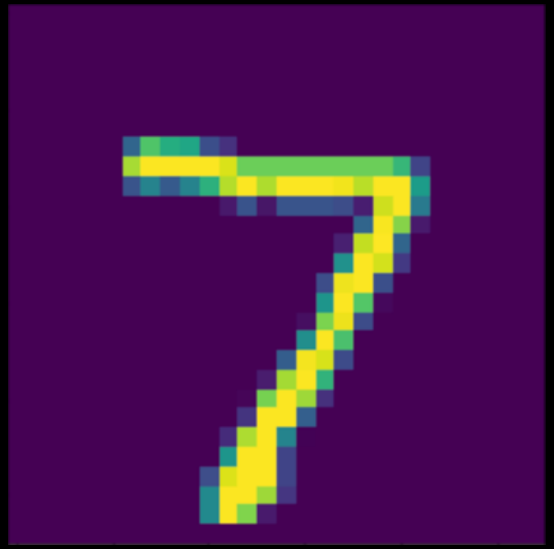


A thing that holds a number between 0 and 1

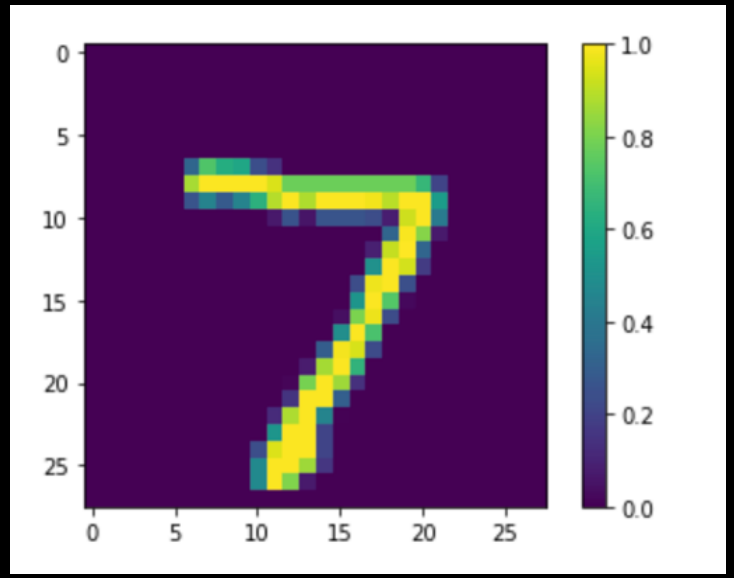
0.85
(for example)

A neuron's "activation" where 0 is inactive and 1 is fully activated

A Layer of Neurons

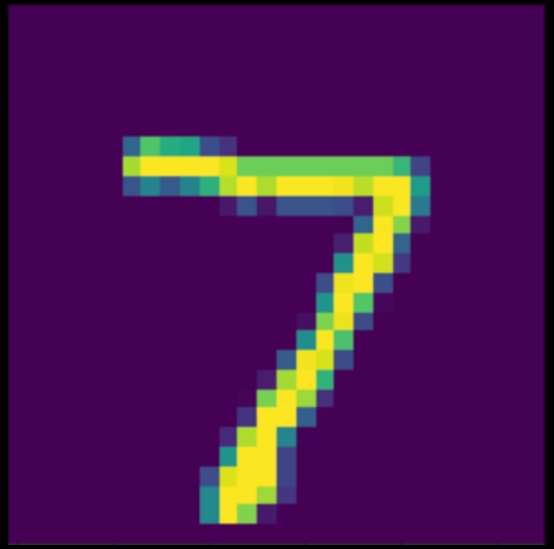


We can represent data (like an image) as a layer of neurons!

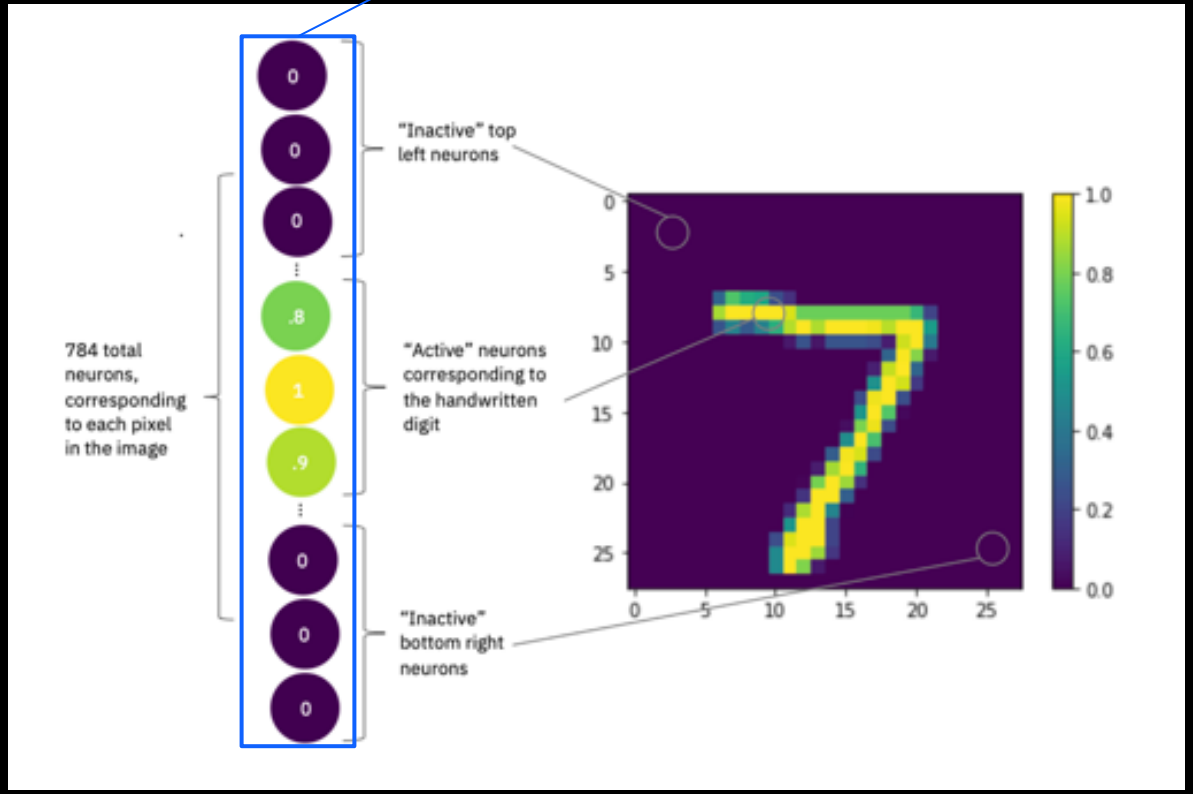


28x28 pixels—784 pixels in total. Pixels on the actual “7” are lit up yellow, corresponding with numbers close to or equal to 1. Pixels that don’t have any “7” on them are equal to 0, meaning they’re not activated at all.

Data as Neurons

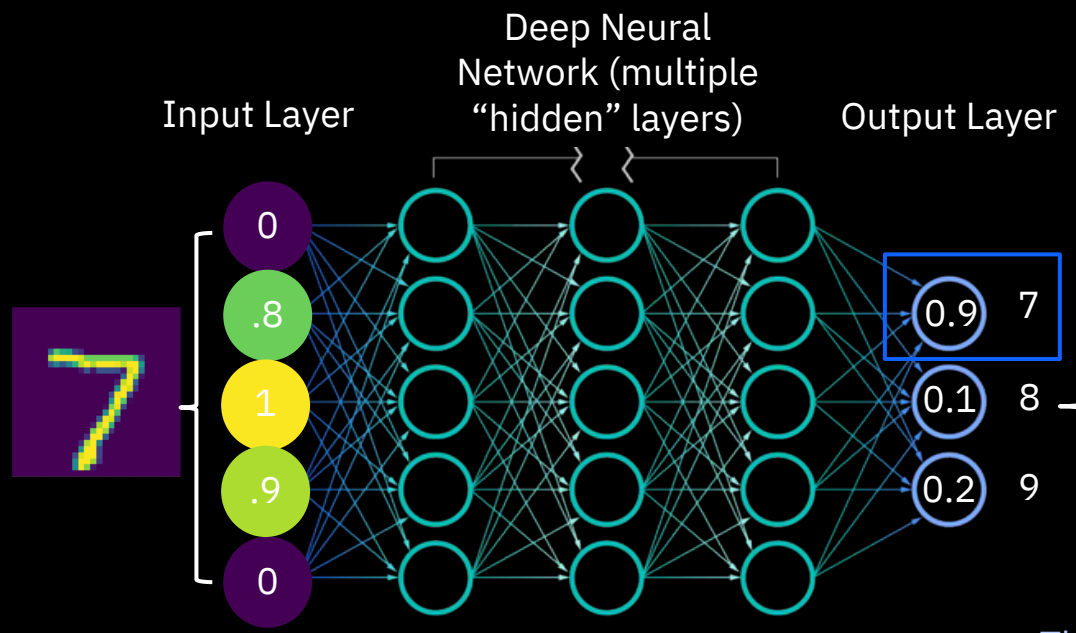


Becomes an input layer of 784 neurons!



Output Layers

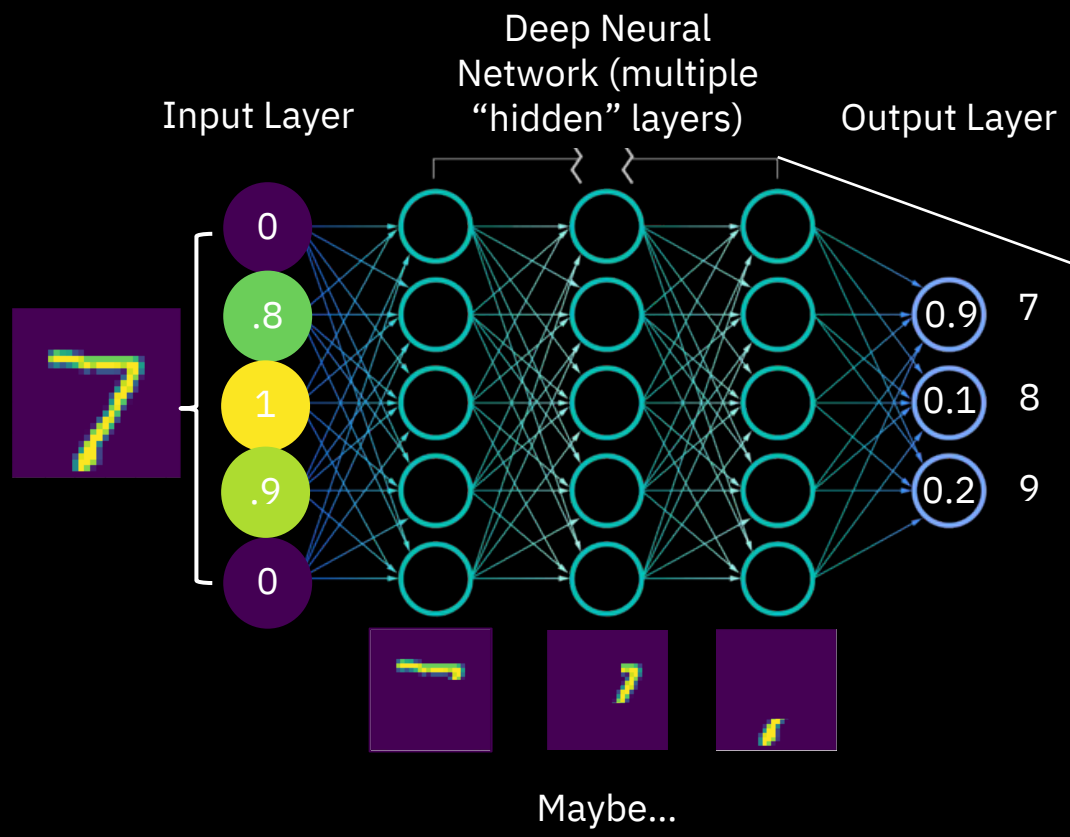
A “mapping” from input (data) to output (objective, what we’re trying to accomplish)



Assume 3 possible classes 7, 8, and 9—corresponds to 3 neurons in our output layer

The output layer neuron with the highest activation (number between 0 and 1) represents our classification!

Hidden Layers



A "mapping" from input (data) to output (objective, what we're trying to accomplish)

Layers of neurons that are neither the input layer (data) nor the output layer (result/outcome)...

Hidden layers try to capture the "latent" (hidden) features in the data...

They are the actual "map" through which the neural network is trying to find an optimal route

(more on this in a moment)

The “Map” Analogy

Beginning

Destination

That’s a cat!

The “architecture” of our neural network (hidden layers, neurons, connections) is the map of possible pathways from beginning to destination

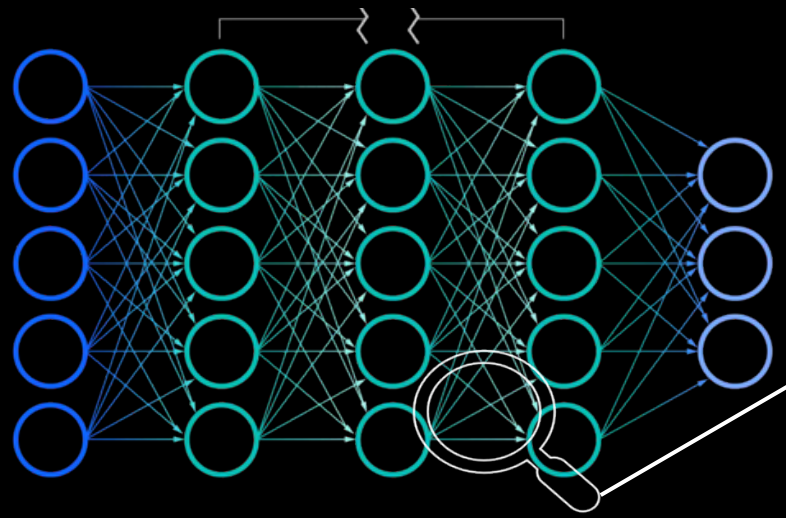
...but how does the neural network know which route is best?

Connecting Neurons

Input Layer

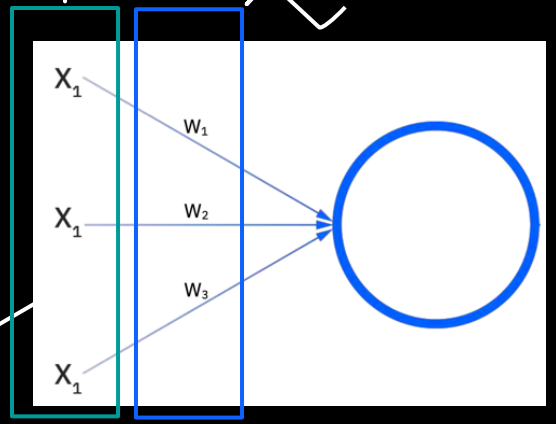
Deep Neural Network (multiple "hidden" layers)

Output Layer



Preceding neuron activations (numbers between 0 and 1)

"Weights" of the connections between neurons; set by the network to guide its path!

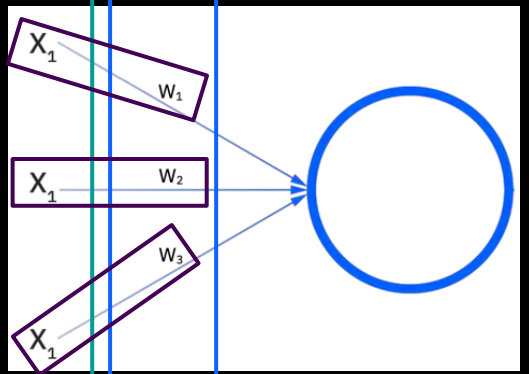


A hidden neuron's value (activation) is determined by the activations of the neurons connected to it (from the previous layer)

Connecting Neurons

Preceding neuron activations (numbers between 0 and 1)

"Weights" of the connections between neurons; set by the network to guide its path!



A hidden neuron's value (activation) is determined by the activations of the neurons connected to it (from the previous layer)

$$= X_1W_1 + X_2W_2 + X_3W_3 + bias$$

Adding together the products of preceding layer neuron activations with assigned weights

Constant to ensure the value is always between 0 and 1

How important the NN thinks a neuron should be when calculating a connected neuron

W ↑ = new activation ↑

W ↓ = new activation ↓

Assigning Weights: Deep “Learning”

Weights direct the actual path through the hidden neurons and layers—“route preferences”

...how does the NN know to set the right weights (find the right route) for its task?

It “learns” to do this with data!

Task: Classify these images

NN: “Let me try to learn a route (weights/biases) on these (training) data to make my mapping” → training with pre-labelled data

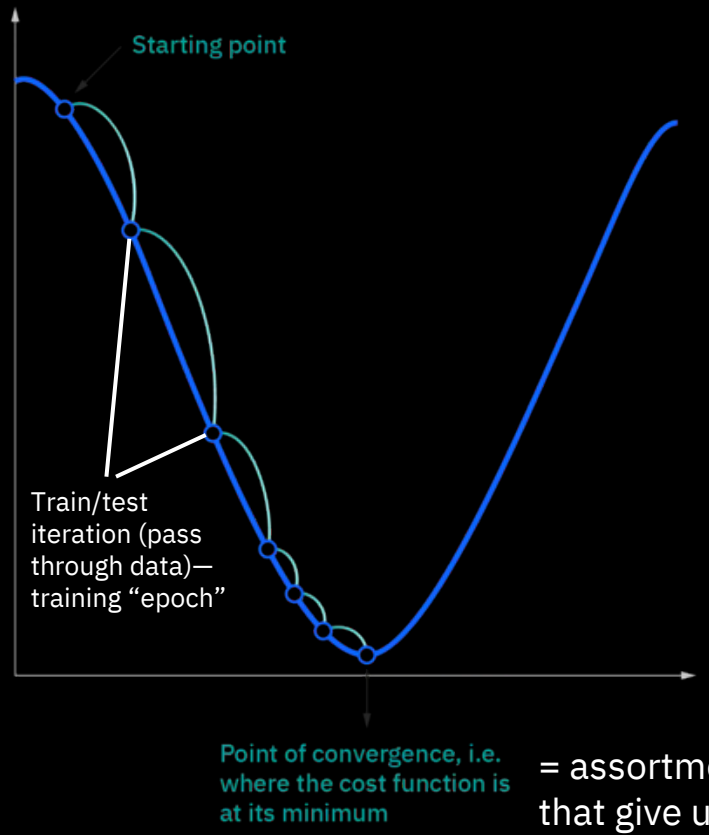
NN: “Let me try my route (weights/biases) on these (test) data and see how well I do” → testing with unlabeled data

NN: “Okay, my overall error rate (loss) was x. Let me see if I can adjust my route (weights) to make it < x in my next try (iteration)” → updating weights/biases to reduce error rate -> Learning!

...repeat many times until error is as low as possible on test data -> Trained Neural Net!

Gradient Descent—how Neural Nets “Learn”

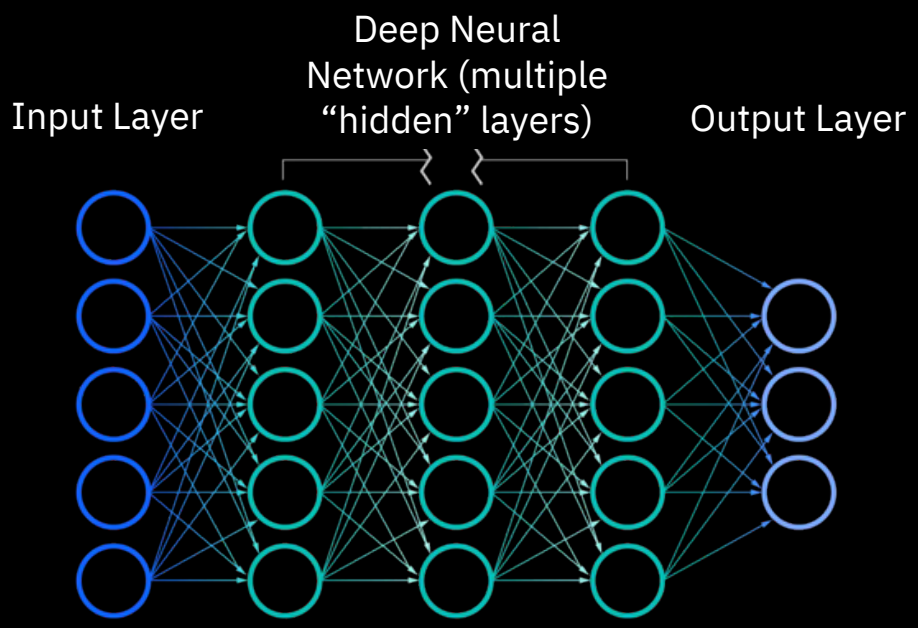
Loss (quantitative measure of errors made by the network in any given testing iteration)



Accomplished with multivariable calculus: Minimize overall loss with respect to many (chained together) weights and biases

= assortment of weights (and biases) that give us the best possible performance with these data!

Neural Nets Key Takeaways



Neural Nets mimic the way that biological brains send information across brain cells (neurons) as part of information processing; consist of layers of artificial neurons and the connections between them

You can think of (trained) neural nets as "mappings" from data (input) to decision/prediction (output)

Neural networks use data to find the parameters (weights and biases) that minimize their overall loss (measure of error rate) through a process called gradient descent

Part IV
Coding Neural Networks (hands-on)

5 Minute Break!

Hands-on Exercise

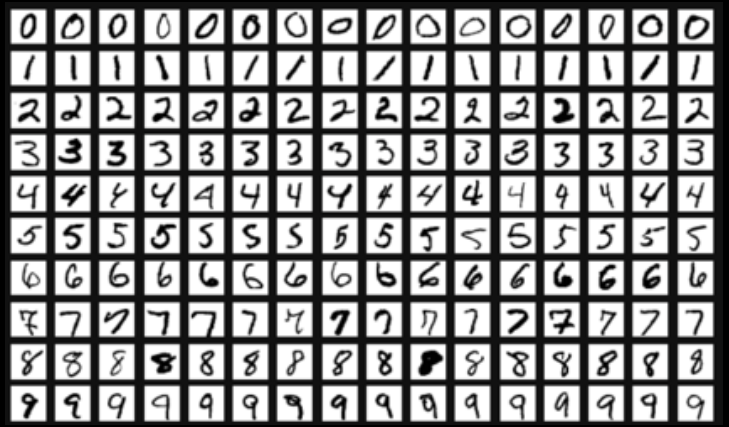
Task: Building a neural network to correctly classify handwritten digits!

For “Coders”: Write your own Python code (with instructions and hints provided)
Join Cedric’s breakout room

THINK 2021 EXERCISE VERSION : For Coders and Non-Coders Break Into Deep Learning with Python and IBM Watson Studio

For “Non-Coders”: Guided follow-along of pre-written code
Join Alex’s breakout room

THINK 2021 SOLUTION VERSION : For Coders and Non-Coders: Break Into Deep Learning with Python and IBM Watson Studio



Recap and Next Steps

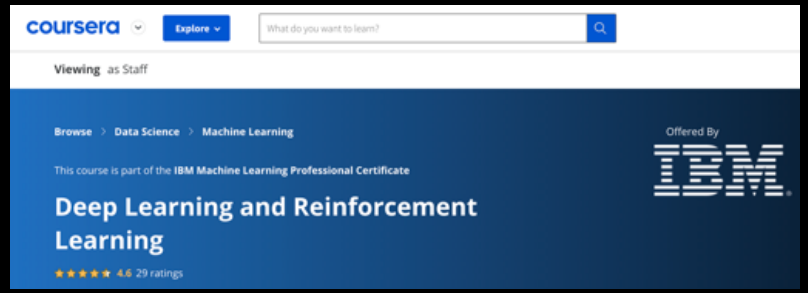
All concepts covered available in the lab guide (2223.pdf) including a glossary

Artificial Intelligence: The design and building of intelligent agents (computer systems) that take information from an environment (data) and use it to take actions that affect that environment

Machine Learning: The study of computer algorithms that improve automatically through experience and by the use of data

Deep Learning: The subfield of Machine Learning focusing on building artificial neural networks to train systems to accomplish complex tasks; The technology underlying many of the most successful AI applications, such as self-driving cars

Want to learn more about Machine Learning/Deep Learning? Consider IBM on Coursera!



Thank you!

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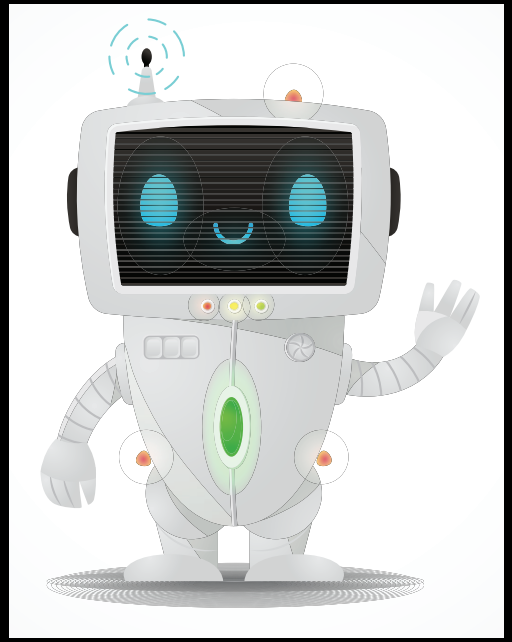

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