A Dive into Deep Learning

An essential skill for the next decade

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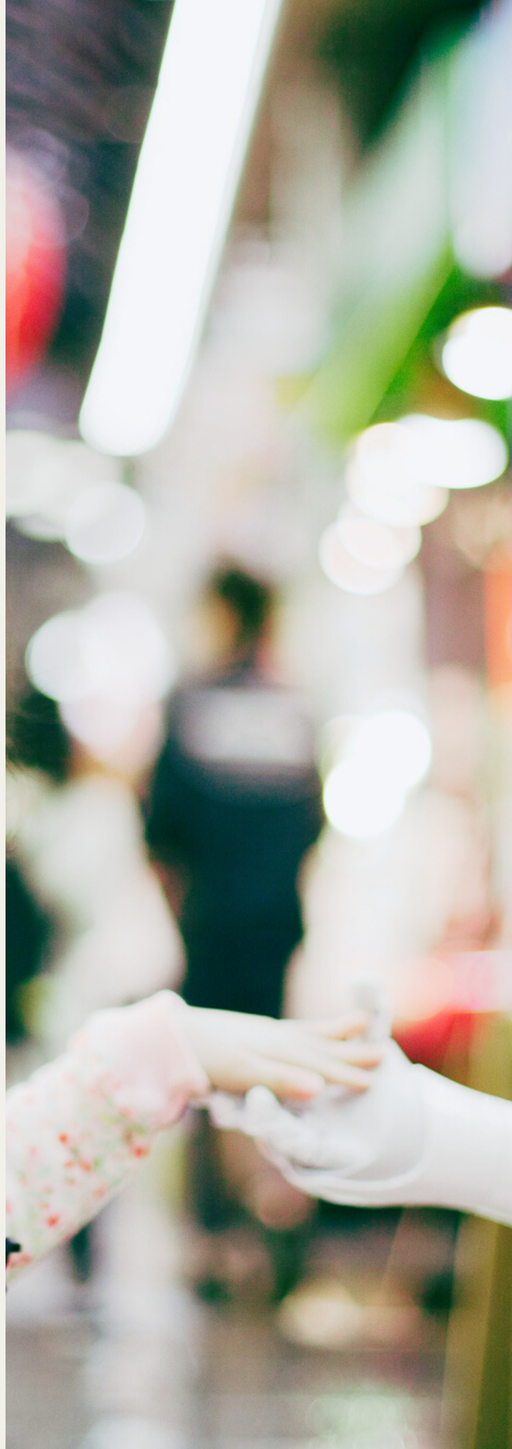
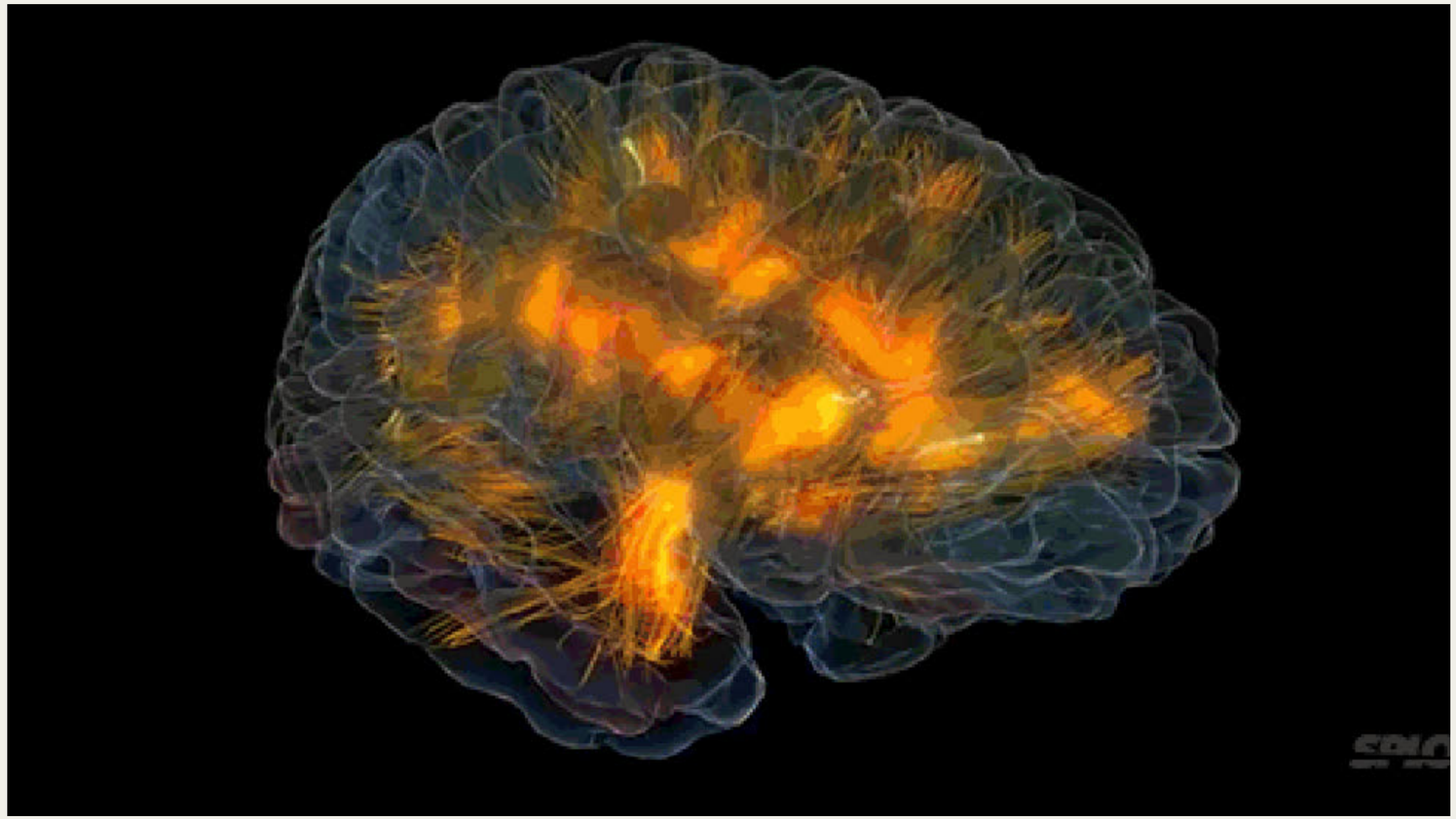


Lineup

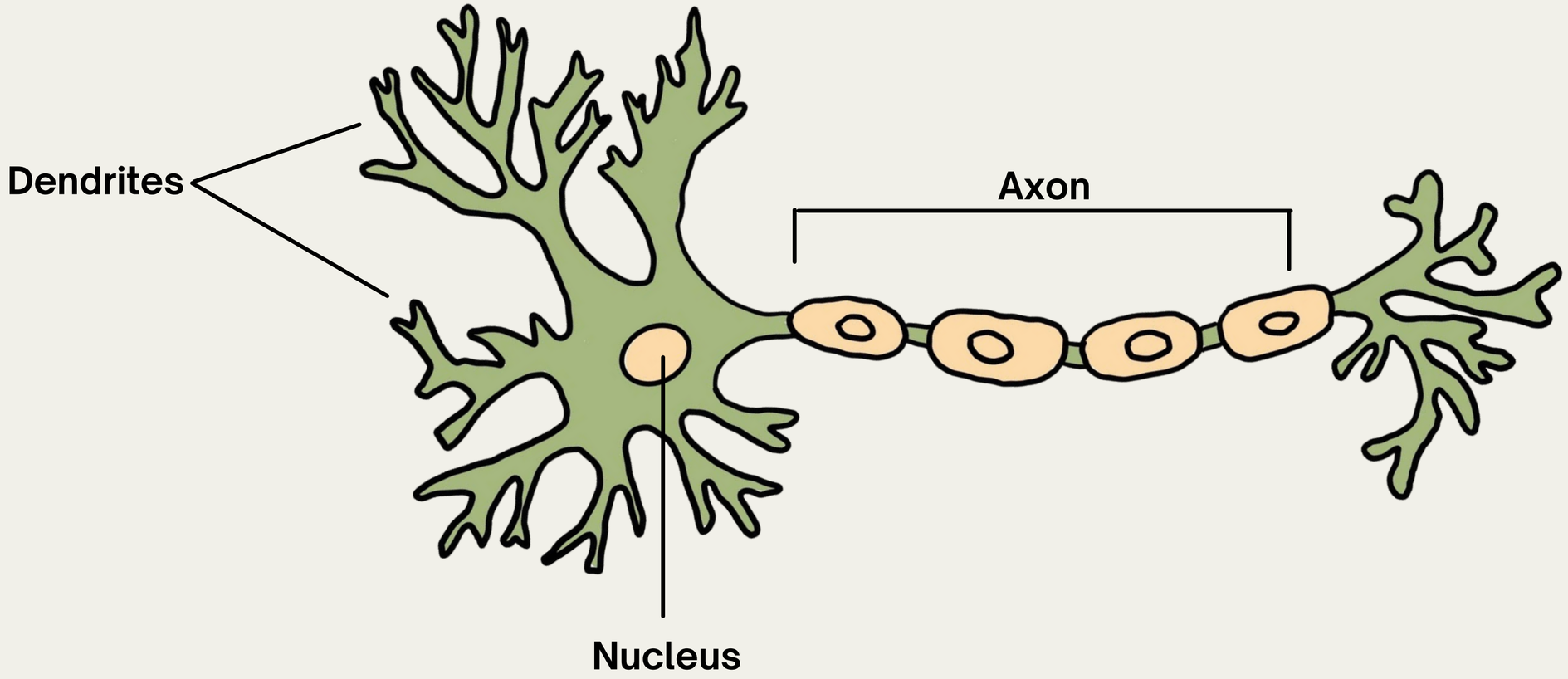
What we'll discuss this afternoon

- How the brain works
- Building block of DNN
- How models learn
- DNNs in action
- Blossoming areas
- As a student ...

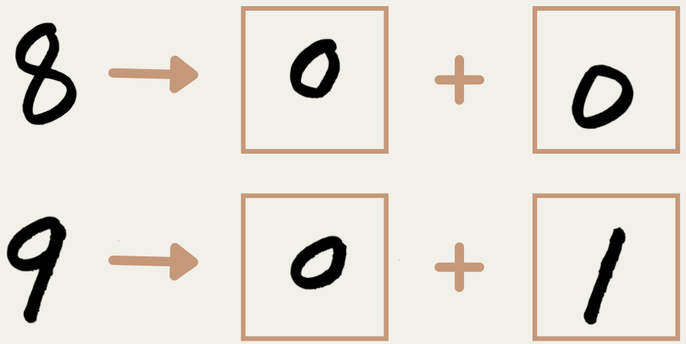
How human brain works

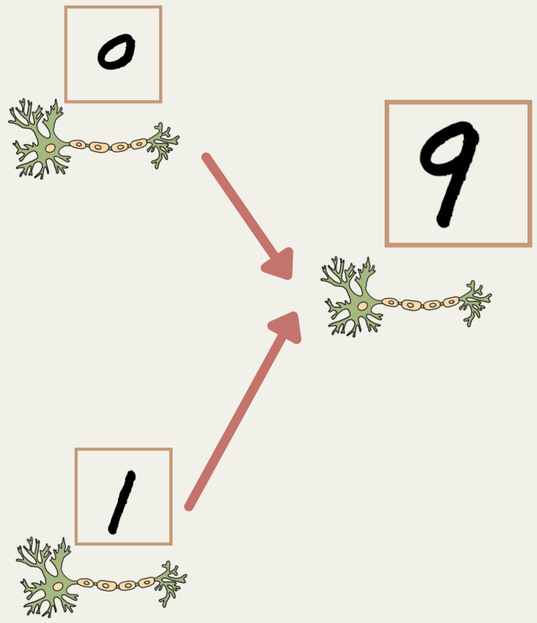


Biological Neuron

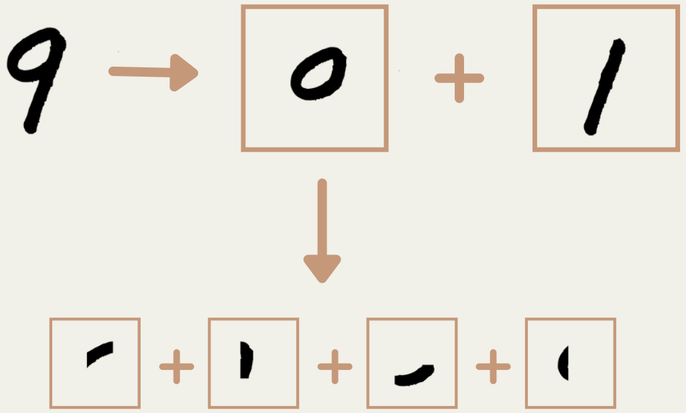


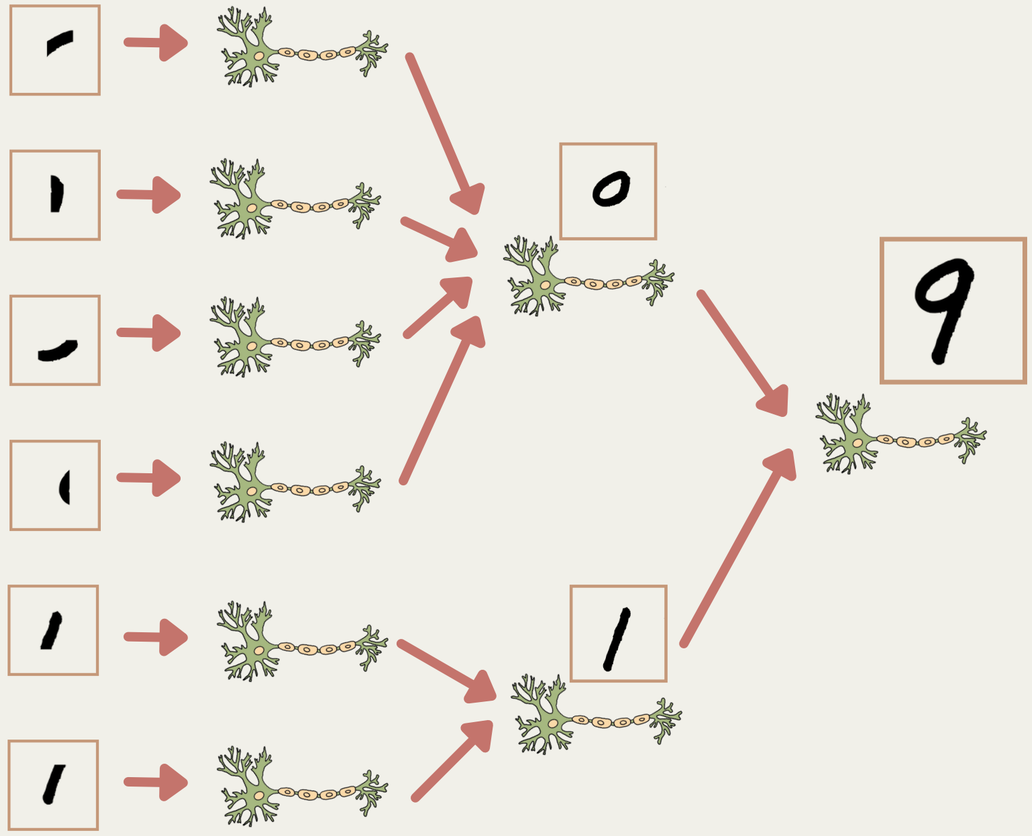
How information flows





How information flows

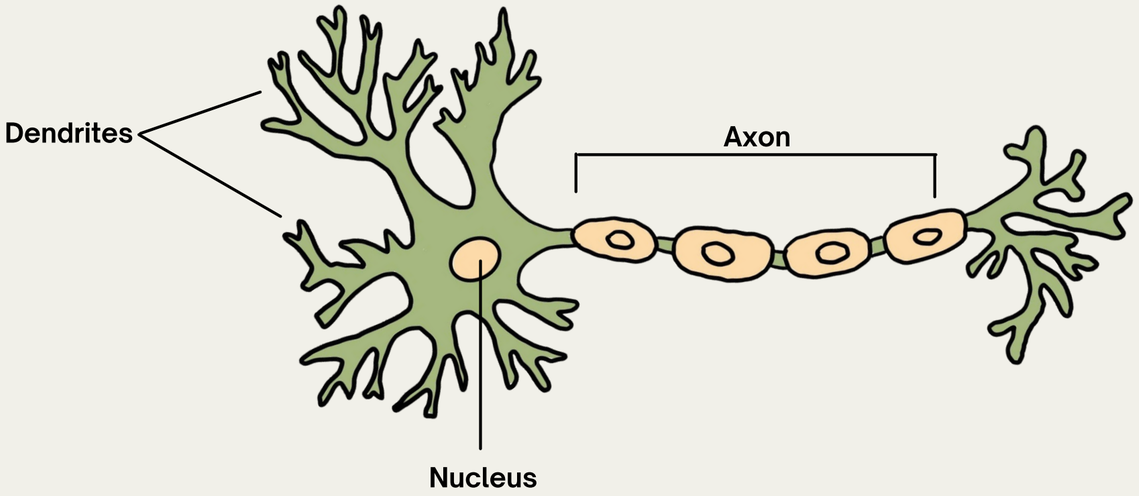


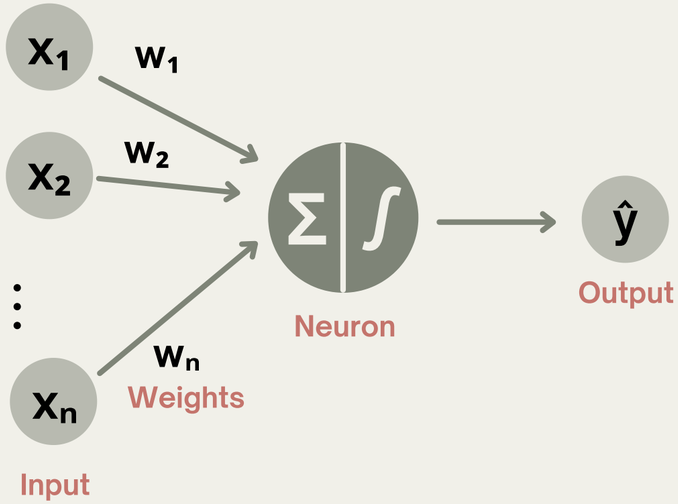


How can we use this to our advantage ?

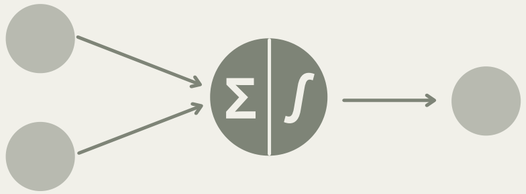
Perceptron

Building Block of Deep Neural Networks

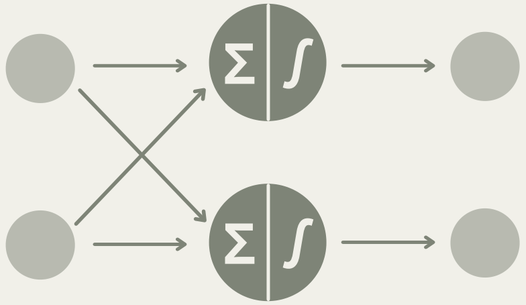




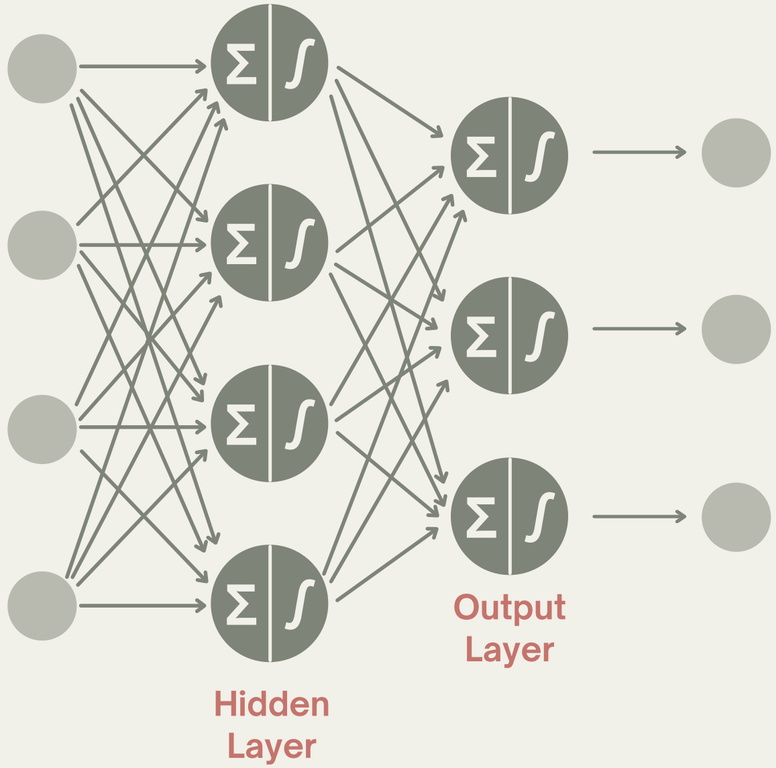
Small steps towards DNN



Perceptron



Multi-output Perceptron



Single Layer Neural Network

Why the progress was slow from Perceptron to DNN ? &

Why now ?

01

Availability of Data

- Sensors
- Social media & Access to technology

02

Availability of advance & specialized hardware

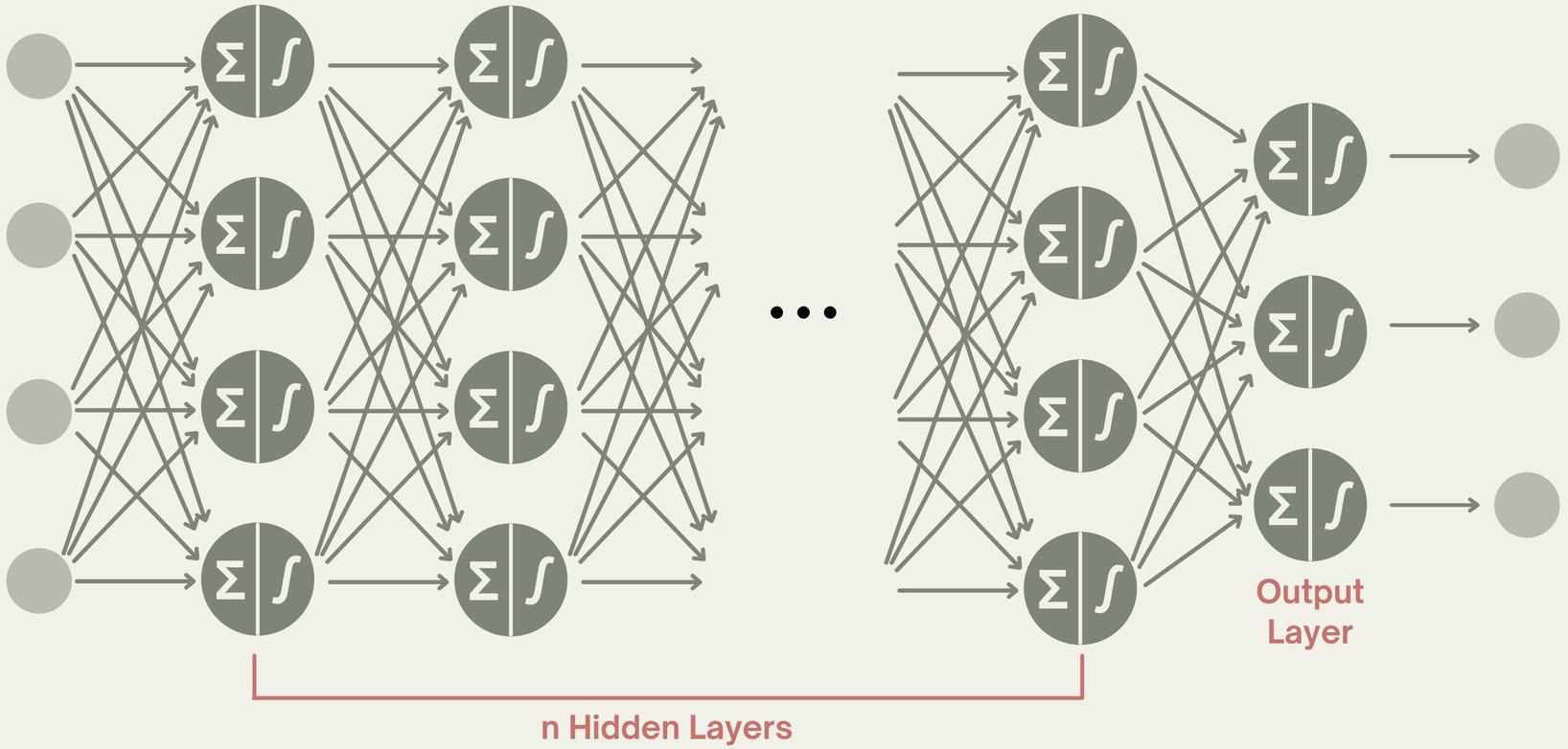
- GPU & TPU
- Cloud

03

Availability of advance software and programming concepts

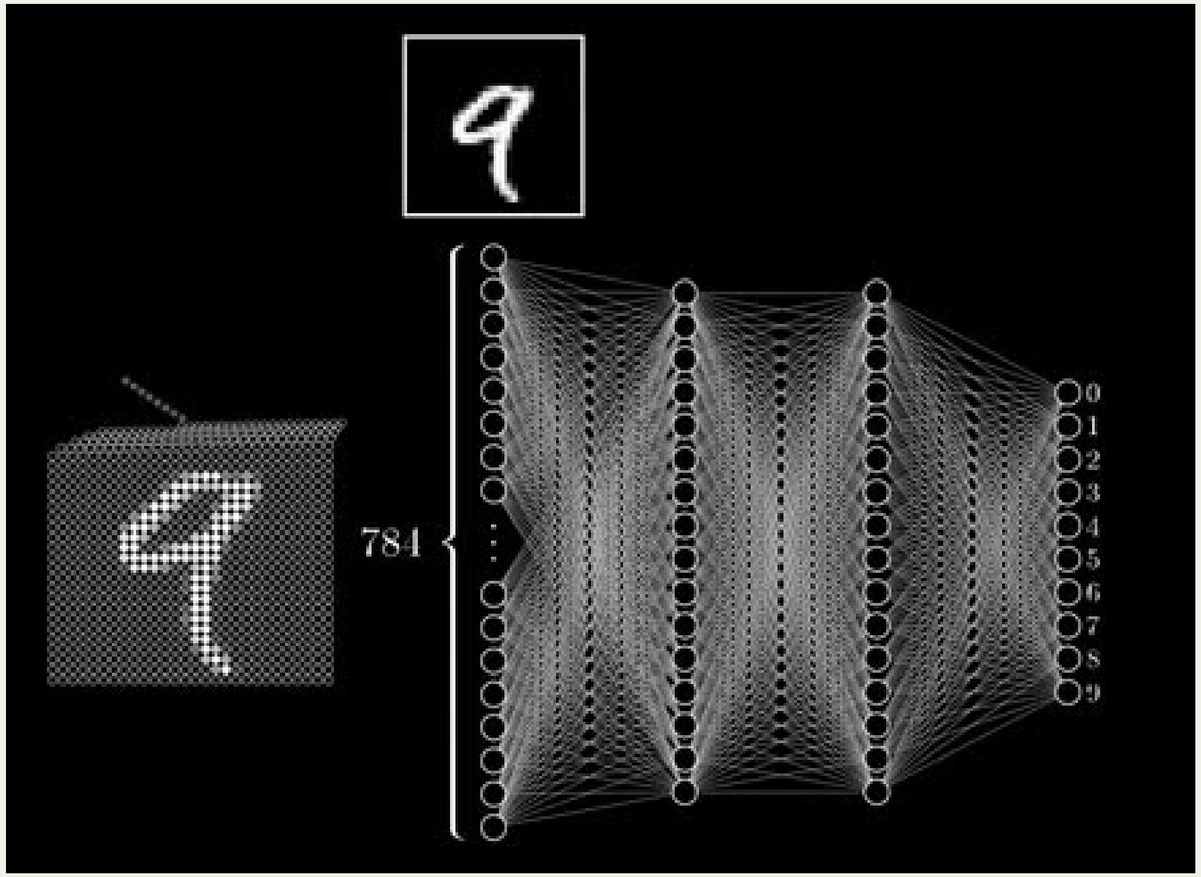
- High level APIs & libraries

Deep Neural Network



Deep Neural Network

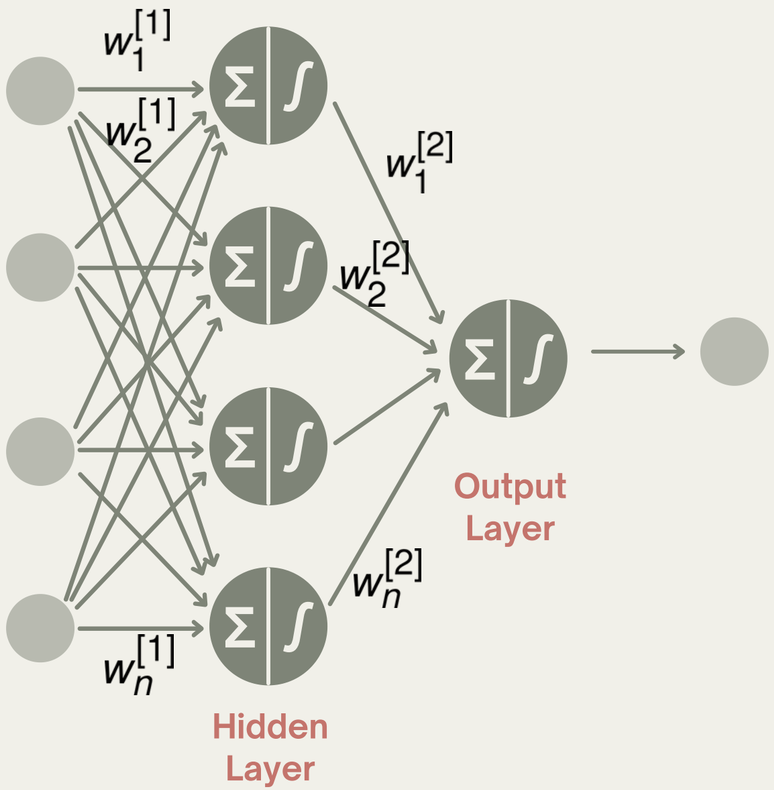
Modeling it with Maths



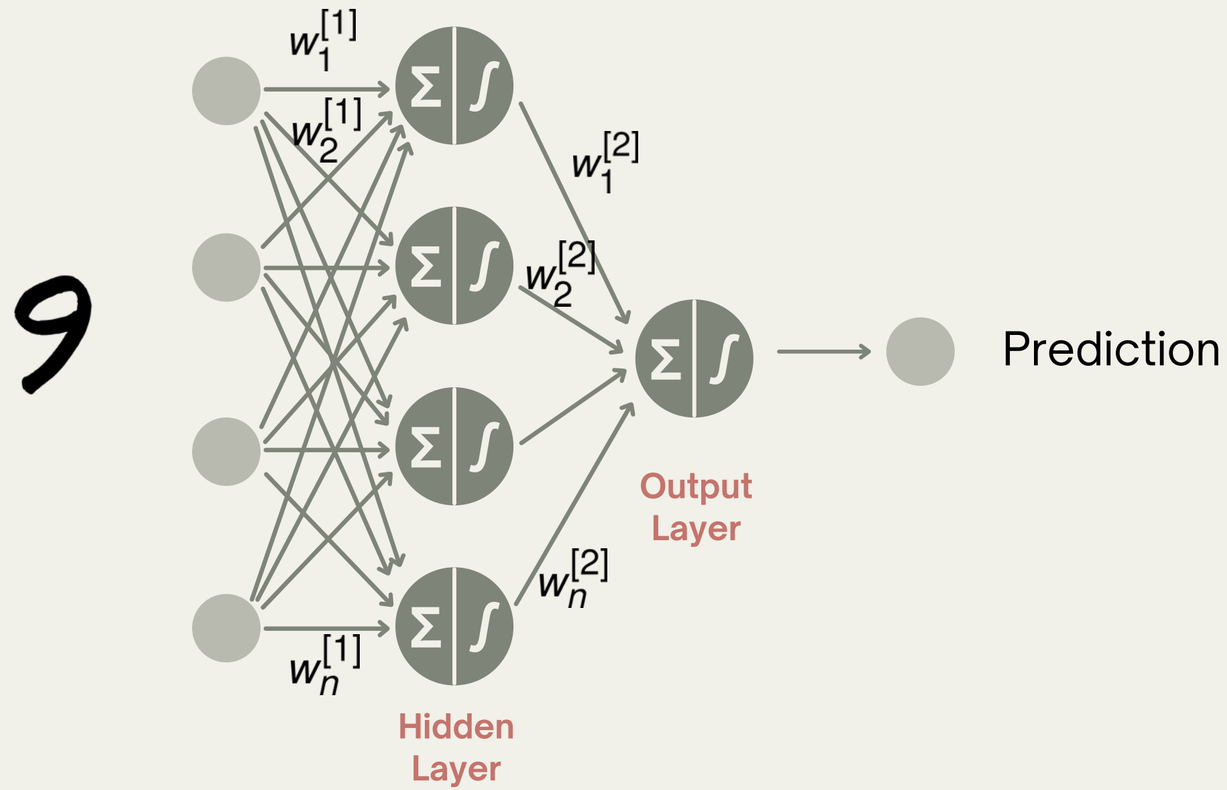
Source: 3Blue1Brown

How can we get the model to do what we want ?

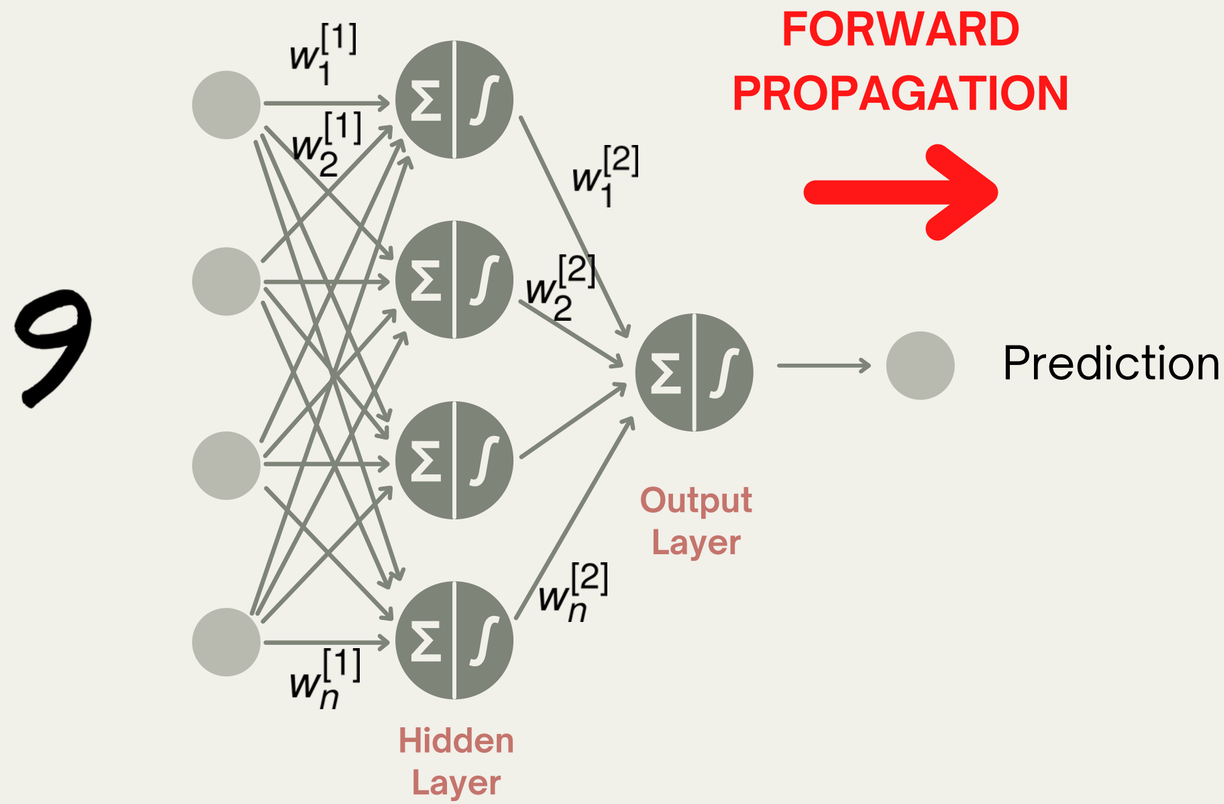
How models learn



How models learn



How models learn



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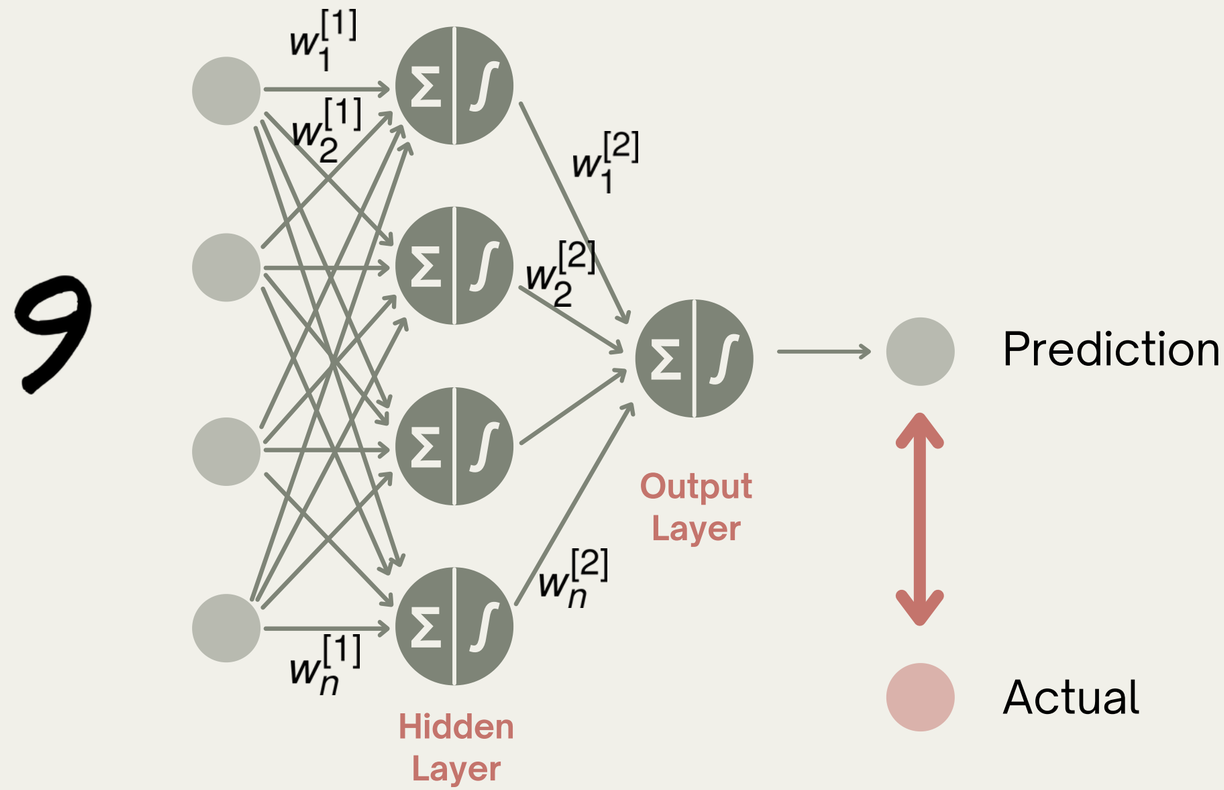
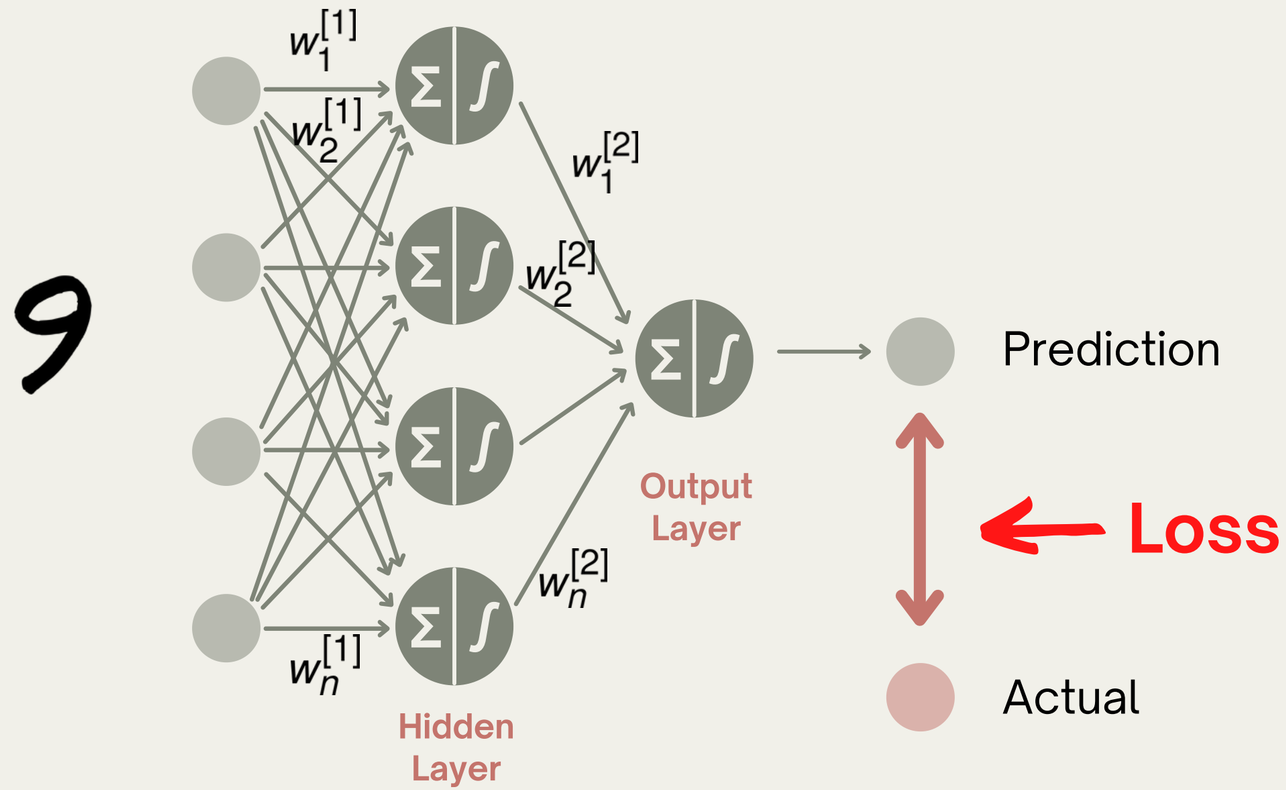
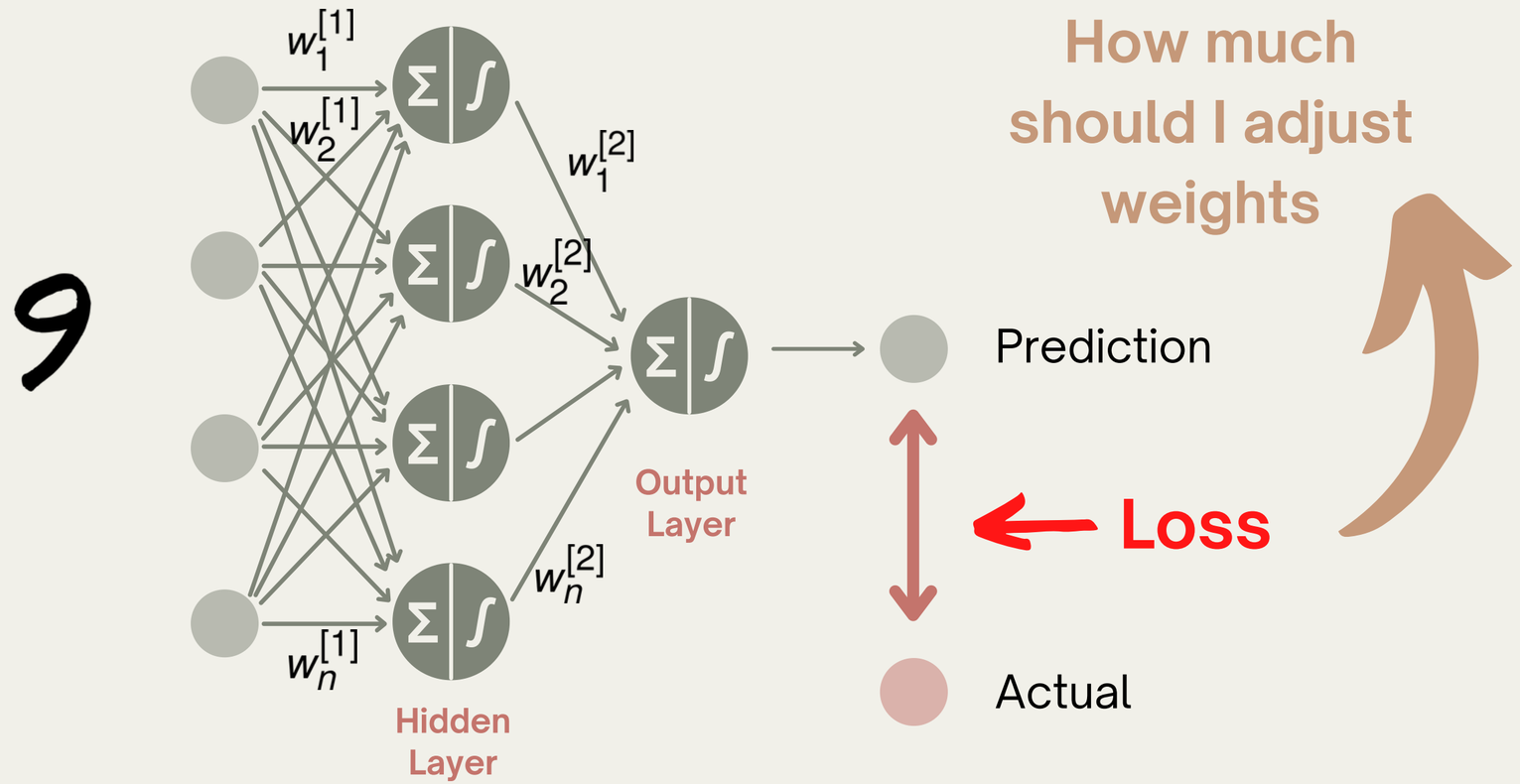


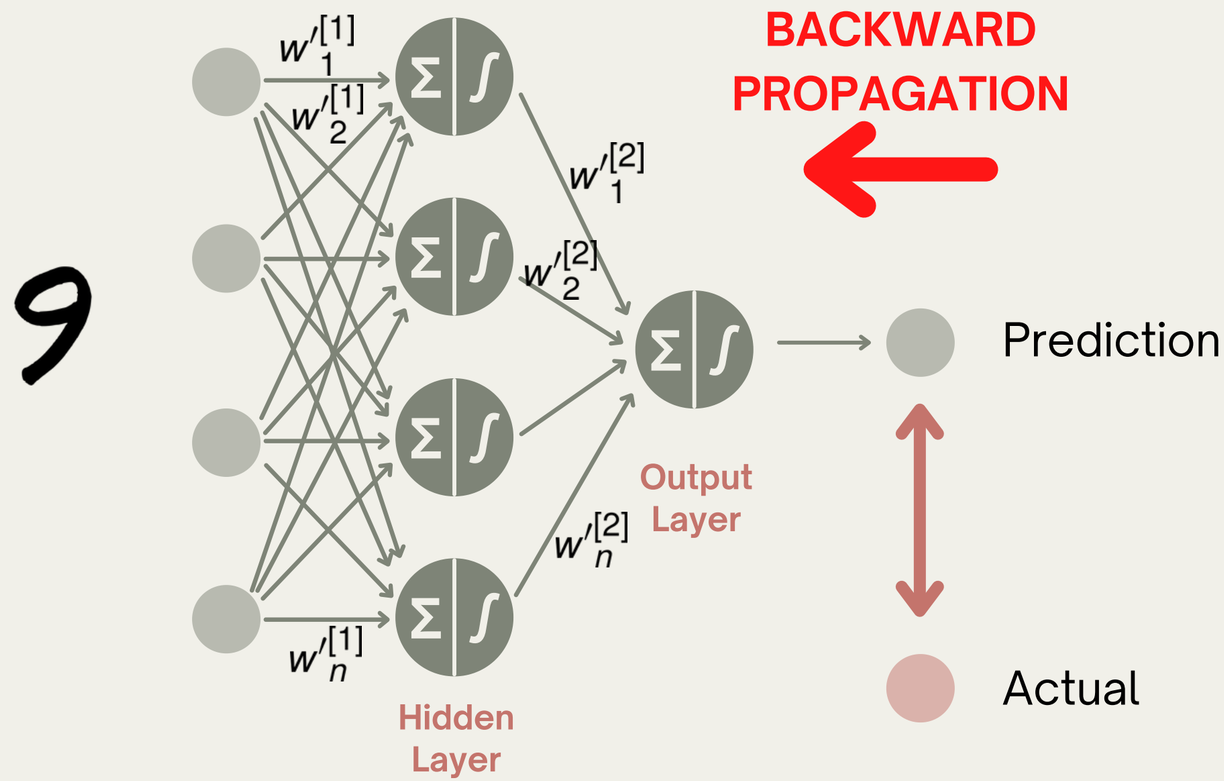
How models learn



How models learn



How models learn



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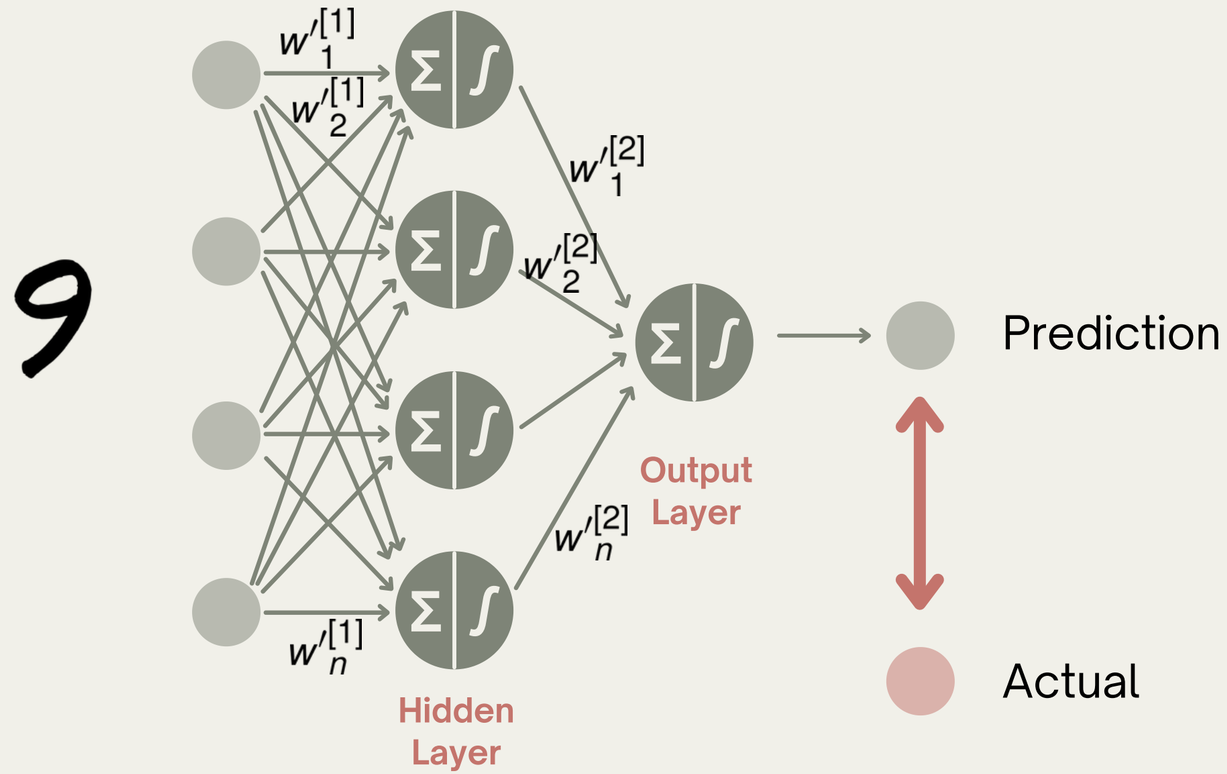

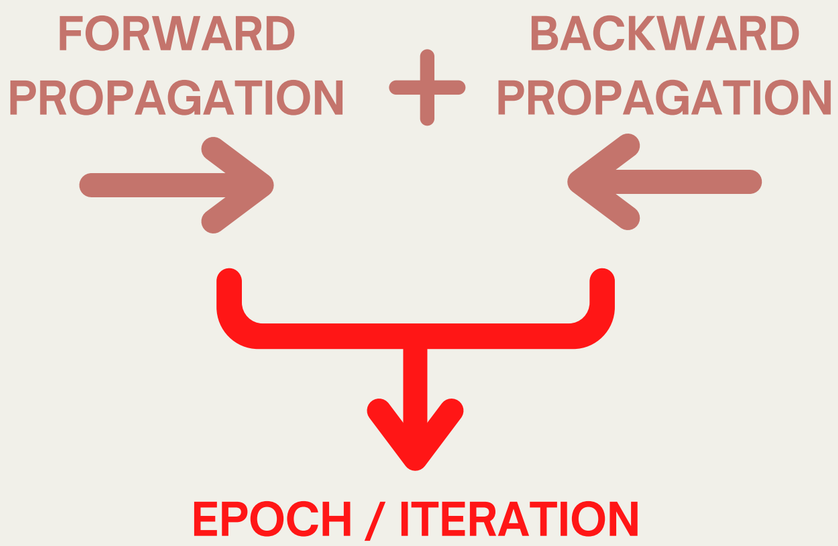

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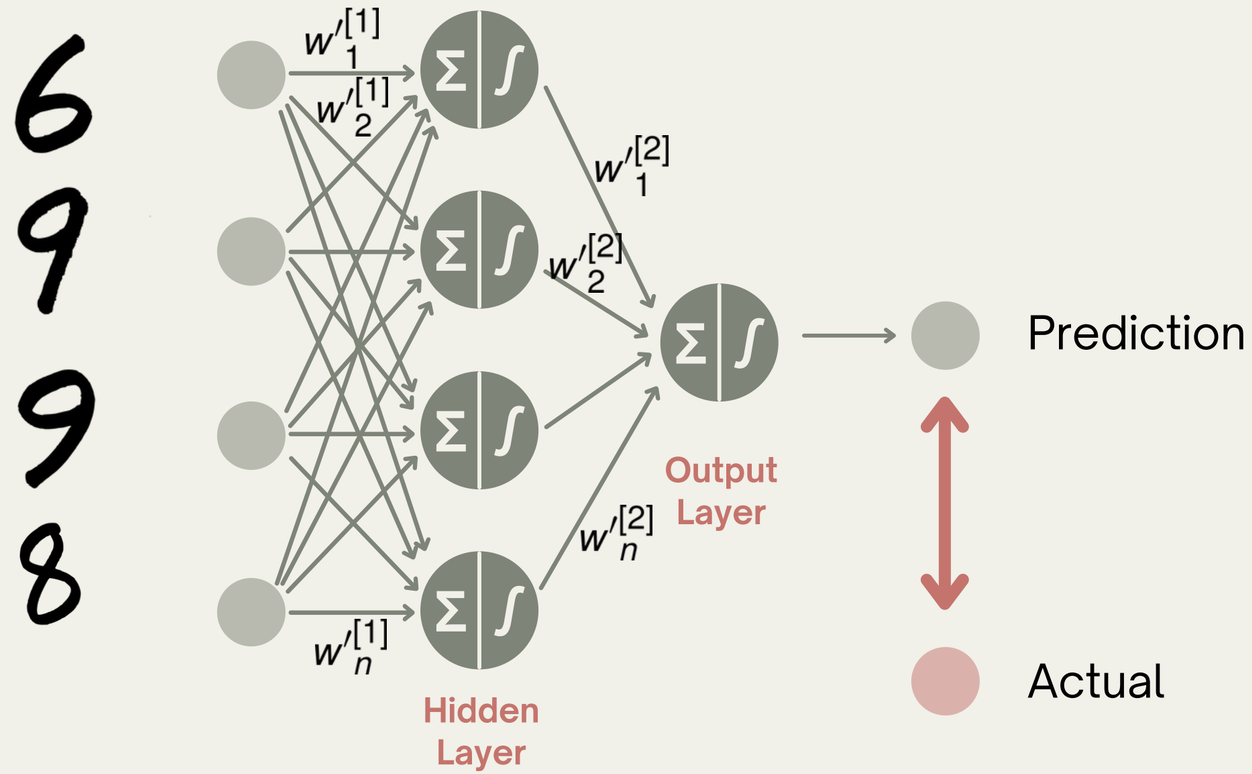
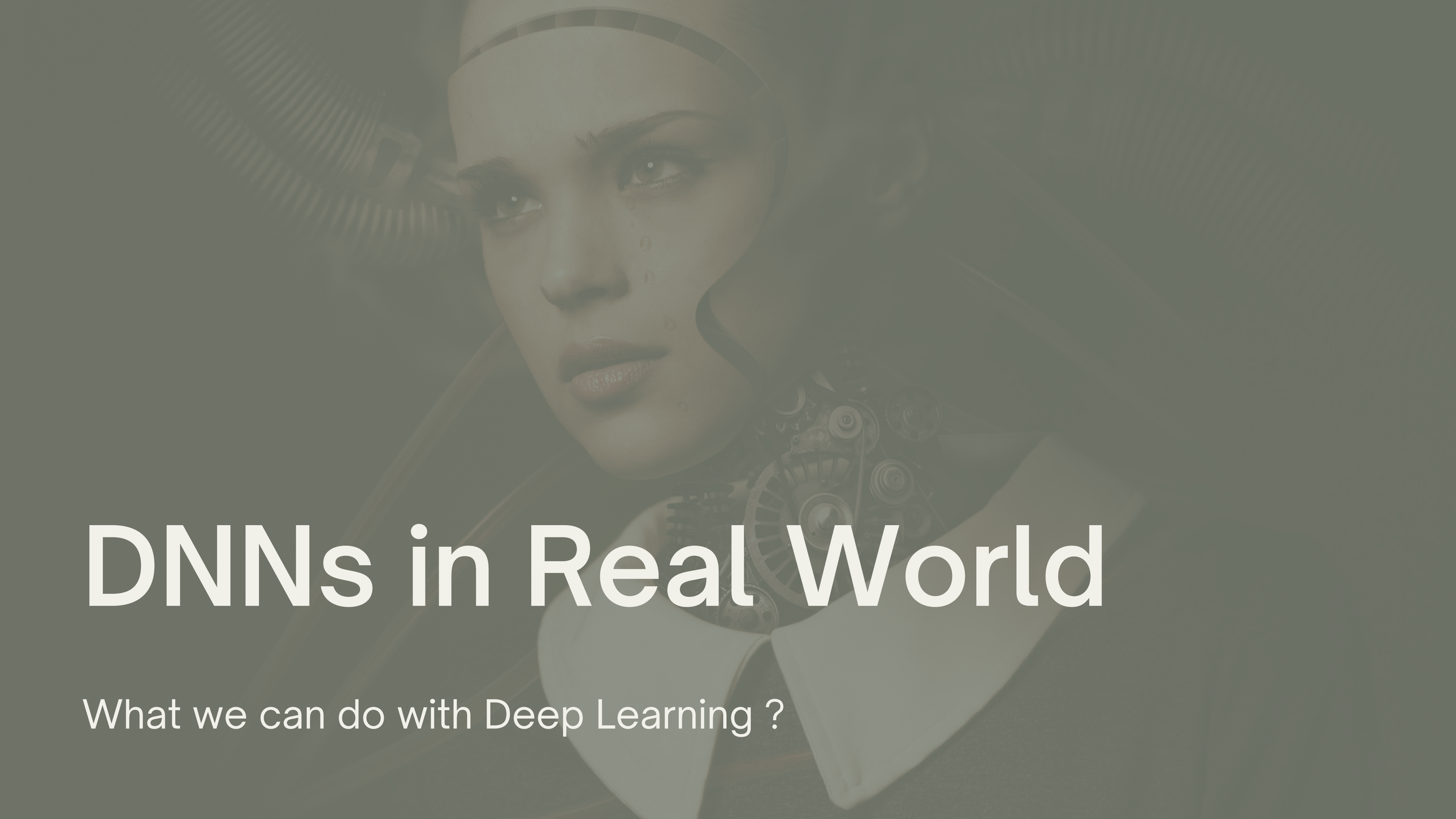




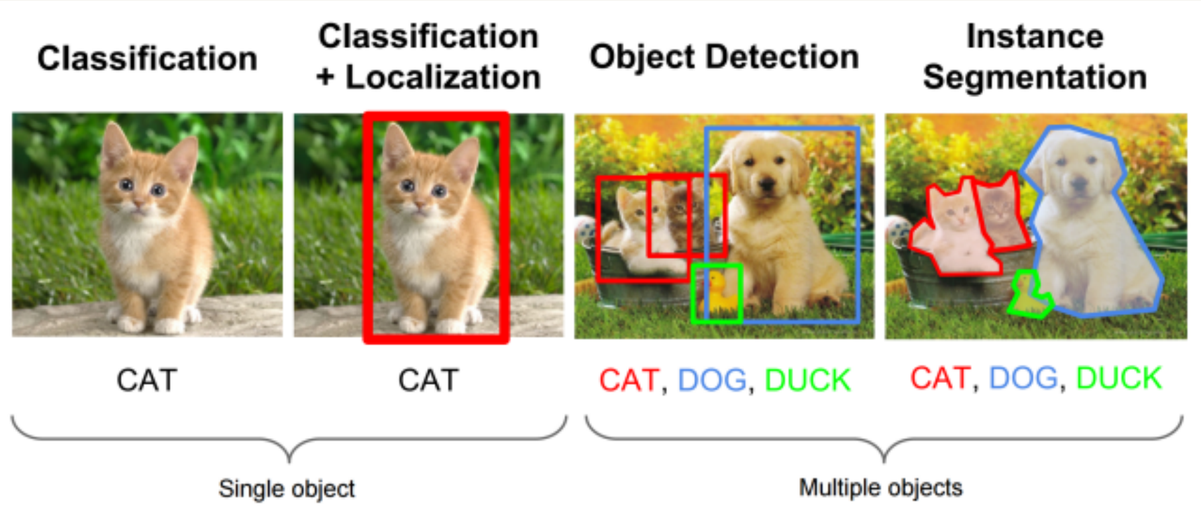
DNNs in Real World

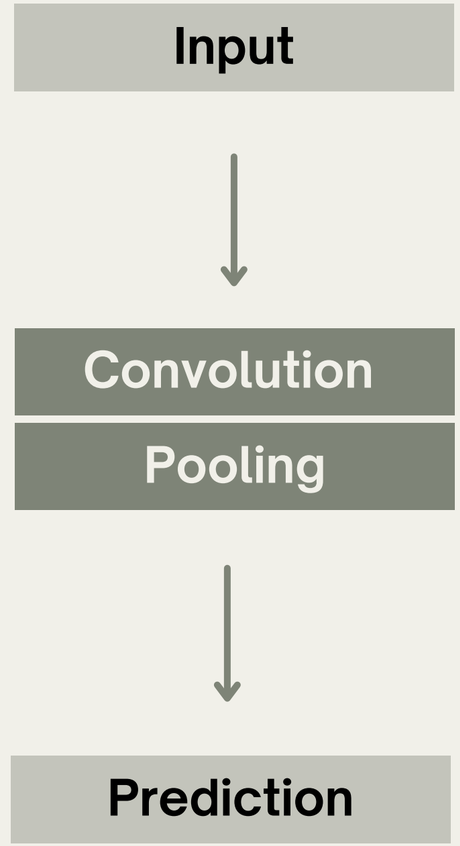
What we can do with Deep Learning ?

CNN

Convolutional Neural Network

Main tasks





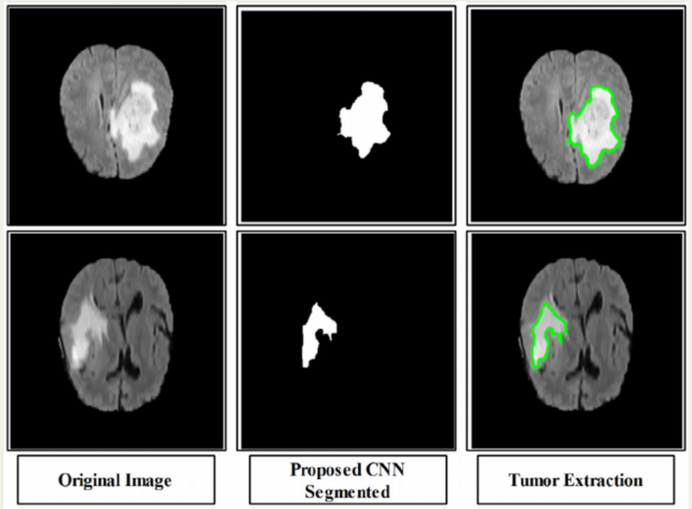
CNN

Convolutional Neural Network

CNNs in action:

- Computer vision
  - Face recognition
  - Medical imaging
  - Self driving cars
  - Colorizing historic images
  - Emotion detection
- Audio and Signal Processing
  - Music Genre Recognition

source: tesla.com



source: [1]

Colorized image

Grey scale image

Ground truth

source: [2]

[1] Rehman A, Khan MA, Saba T, Mehmood Z, Tariq U, Ayesha N. Microscopic brain tumor detection and classification using 3D CNN and feature selection architecture. Microsc Res Tech. 2021;84:133–149. https://doi.org/10.1002/jemt.23597 REHMAN ET AL. 149

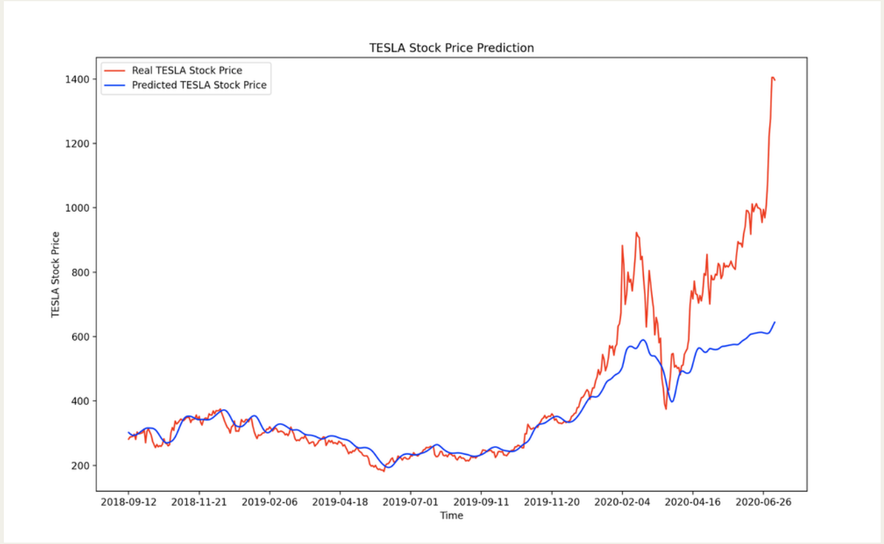
[2] D. Varga and T. Szirányi, "Fully automatic image colorization based on Convolutional Neural Network," 2016 23rd International Conference on Pattern Recognition (ICPR), 2016, pp. 3691-3696, doi: 10.1109/ICPR.2016.7900208.

RNN

Recurrent Neural Network

RNNs in action:

- Natural Language Processing
- Time series analysis
- Music Generation
- Drawing Generation



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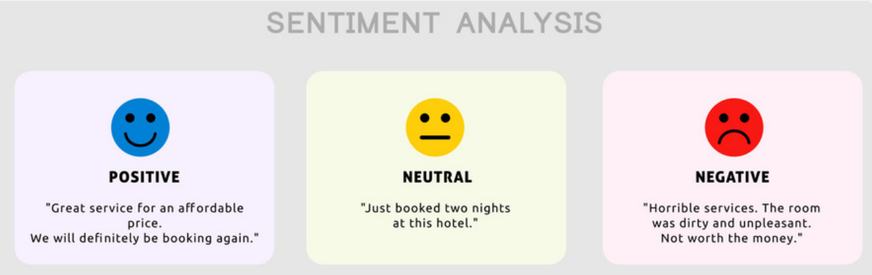

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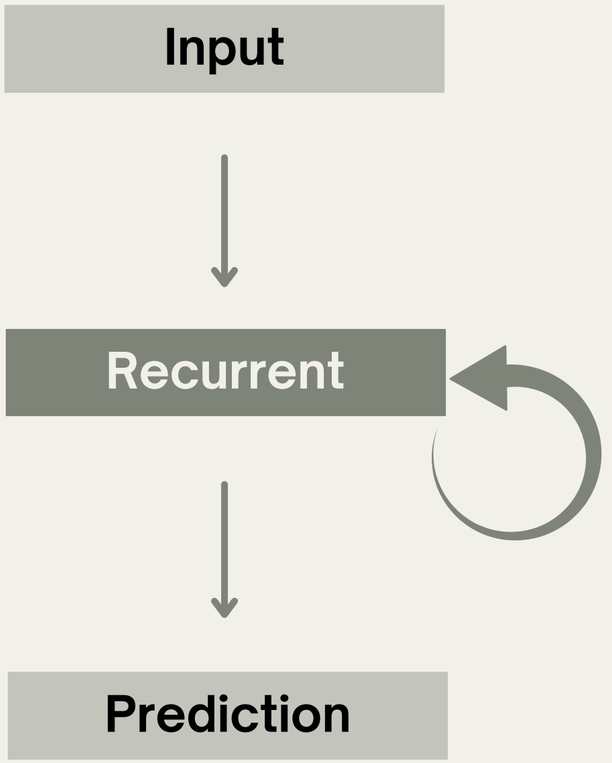
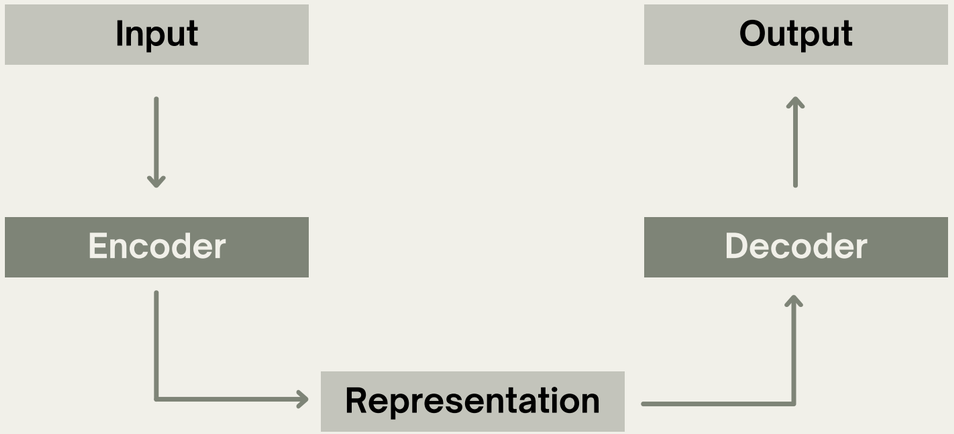


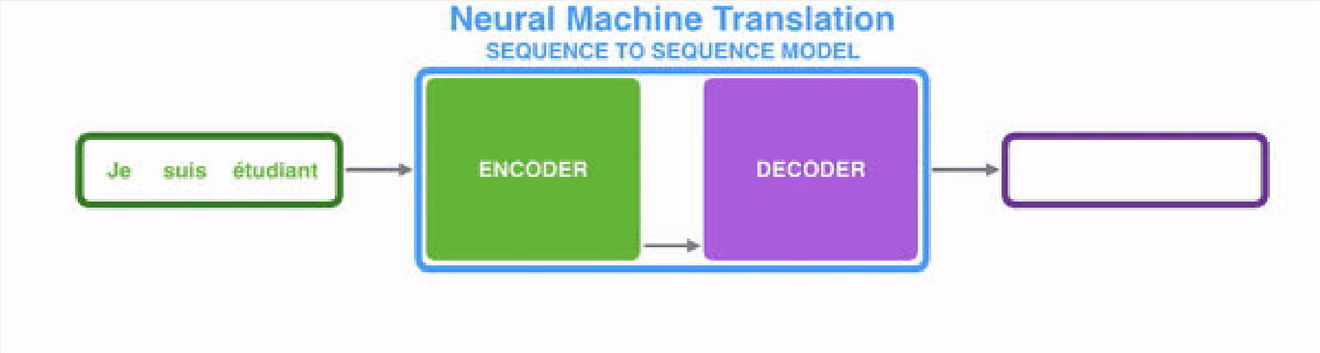
[1] Loukas, S., 2020. LSTM Time-Series Forecasting: Predicting Stock Prices Using An LSTM Model. [online] Medium.
[2] Dabhade, V., 2021. Conducting Social Media Sentiment Analysis: A Working Example. [online] Express Analytics.
[3] magenta.tensorflow.org/assets/sketch_rnn_demo

Encoder - Decoder



Applications:

- Machine Translation
- Image captioning
- Anomaly detection

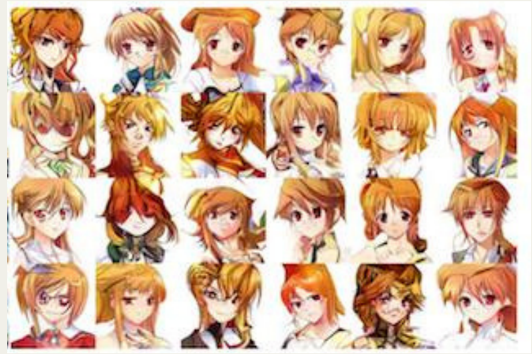


[1] Alammar, J., 2018. Visualizing A Neural Machine Translation Model (Mechanics of Seq2seq Models With Attention). [online] Jalammar.github.io.

GAN

Generative Adversarial Network

Input → **Generator** → **Generated Data** → **Discriminator** → **Fake or Real ?**



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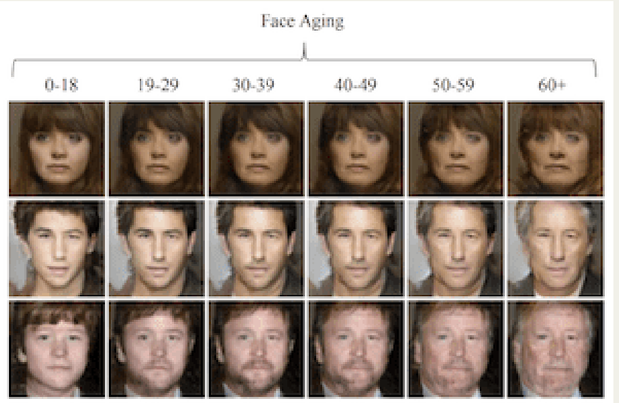

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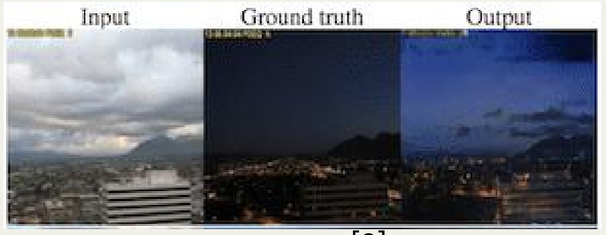
GANs in action:

- Anomaly Detection
- Music Generation
- Cartoon Character Generation
- Text-to-Image Translation
- Image-to-Image Translation
- Face Aging



source: [2]

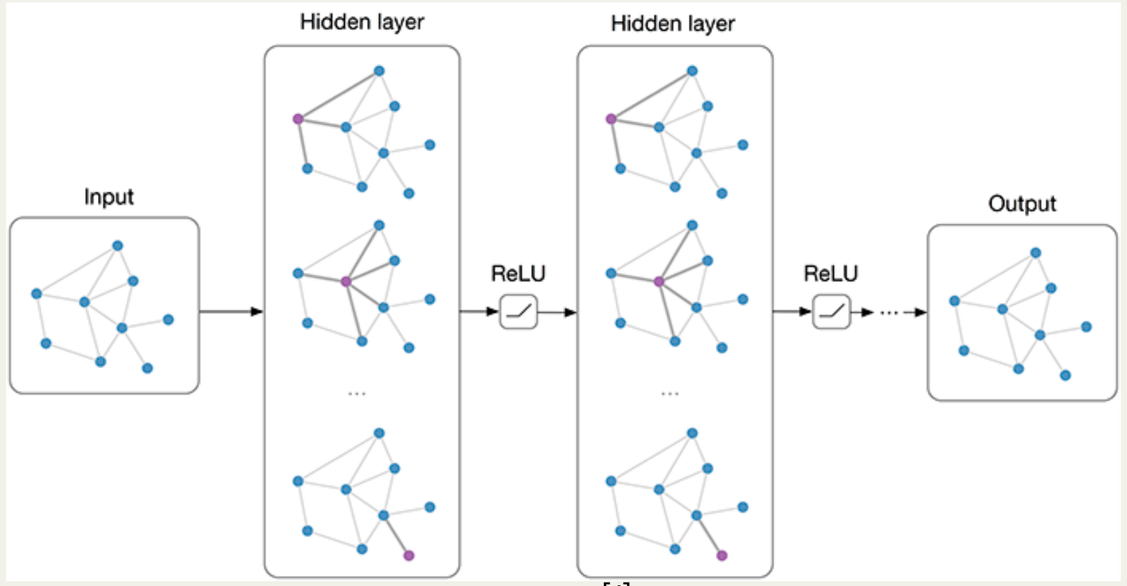
[1] Jin, Y., Zhang, J., Li, M., Tian, Y., Zhu, H. and Fang, Z., 2017. Towards the Automatic Anime Characters Creation with Generative Adversarial Networks.
[2] Isola, P., Zhu, J., Zhou, T. and Efros, A., 2016. Image-to-Image Translation with Conditional Adversarial Networks.
[3] G. Antipov, M. Baccouche and J. Dugelay, "Face aging with conditional generative adversarial networks," 2017 IEEE International Conference on Image Processing (ICIP)

GNN

Graph Neural Network

GNNs in action:

- Natural Language processing: semantic understanding
- Link prediction: Recommendations
- Molecular Fingerprints: predict the properties of a new molecule
- Drug discovery: Protein Interface Prediction
- Healthcare: clinical decision support
- ETA prediction of Google Maps



source: [1]

[1] Kipf, T., 2016. How powerful are Graph Convolutional Networks?. [online] Tkipf.github.io.

Blossoming areas

Unbiased AI

AI for healthcare

Federated learning

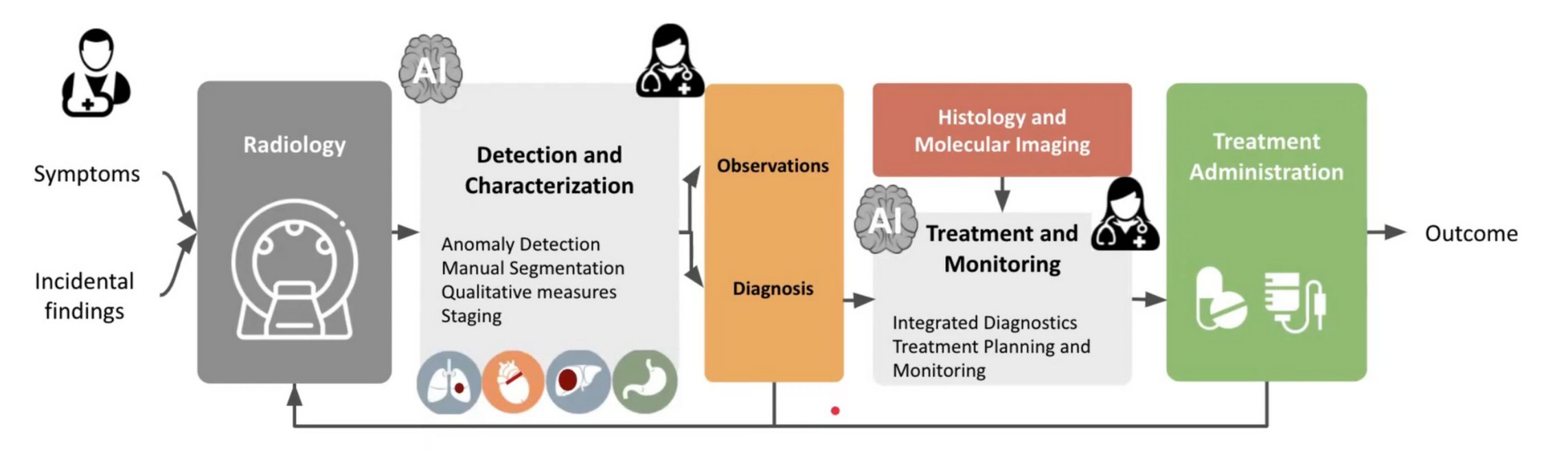
Explainable AI

Self supervised Computer Vision

Ethics in AI

Unbiased AI

AI for Healthcare



[1] Bi WL, Hosny A, Schabath MB, Giger ML, Birkbak NJ, Mehrtash A, Allison T, Arnaout O, Abbosh C, Dunn IF, Mak RH, Tamimi RM, Tempany CM, Swanton C, Hoffmann U, Schwartz LH, Gillies RJ, Huang RY, Aerts HJWL. Artificial intelligence in cancer imaging: Clinical challenges and applications. CA Cancer J Clin. 2019 Mar;69(2):127-157. doi: 10.3322/caac.21552. Epub 2019 Feb 5. PMID: 30720861; PMCID: PMC6403009.

Federated Learning

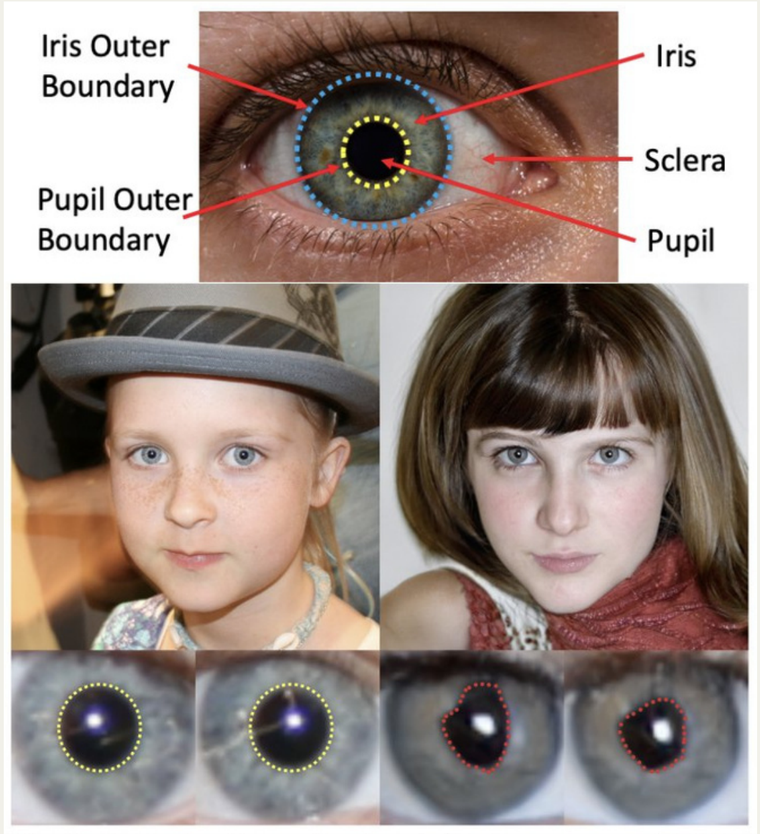
Explainable AI

Self-supervised Computer vision

Ethics in AI

Ethics in AI

source: [1]



source: [2]

[1] Brundage, M., Avin, S., Clark, J., Toner, H., Eckersley, P., Garfinkel, B., Dafoe, A., Scharre, P., Zeitzoff, T., Filar, B., Anderson, H., Roff, H., Allen, G., Steinhardt, J., Flynn, C., hÉigeartaigh, S., Beard, S., Belfield, H., Farquhar, S., Lyle, C., Crootof, R., Evans, O., Page, M., Bryson, J., Yampolskiy, R. and Amodei, D., 2018. The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation. [online] arXiv.org.

[2]Guo, H., Hu, S., Wang, X., Chang, M. and Lyu, S., 2021. Eyes Tell All: Irregular Pupil Shapes Reveal GAN-generated Faces. [online] arXiv.org.

As a student...

- Start; you don't have to know everything
- Explore and find your interest
- Applied research is EQUALLY important
- Keep up with the latest news
- Blogging, tweeting & sharing what you learn

Resource Page

MIT 6.S191

CS109 Data Science - University of Harvard

Data Science Specialization - John Hopkins University

Machine Learning and Deep Learning Specialization by Andrew Ng

Blogs: Jay Alammar Blog

Some youtube channels: 3Blue1Brown, KhanAcademy, Yannic Kilcher, Intuitive Machine Learning, 2 minute papers

For more resources ...

Thank you!

Questions are welcome!

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