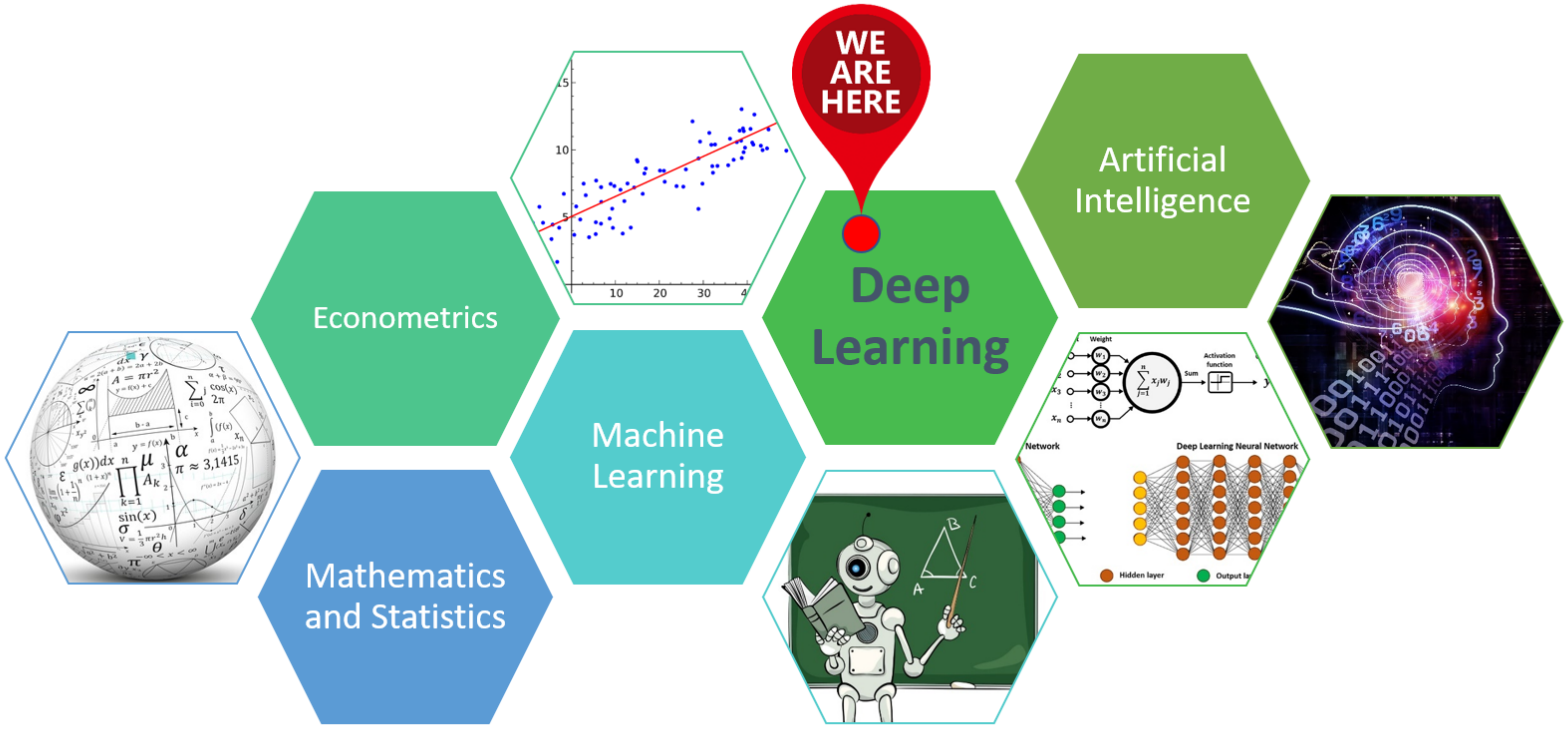
Module 1 – Part I
Welcome to the magic world of
DEEP LEARNING



Big picture: Econometrics vs Machine Learning and Deep Learning

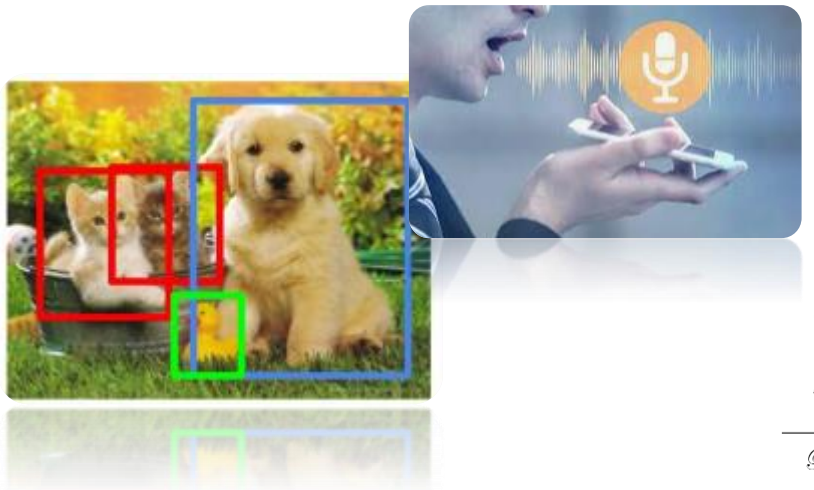
What are we trying to do as researchers? Solve real world problems, right?

Is there a theory?

1- What is the relationship between

- Quantity demanded and price / income / technology / price of competitors / … ?
- Wage and education/ age/ gender/ experience/ …?

2- How about these problems? Object detection, Image Captioning, voice recognition, machine translation, and …



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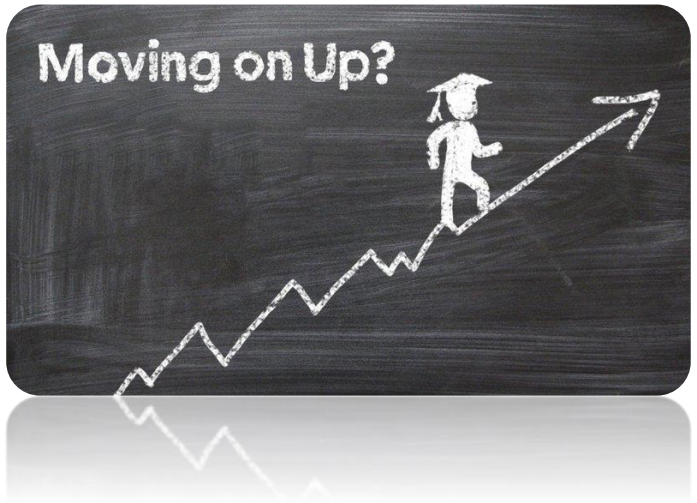
A simple example



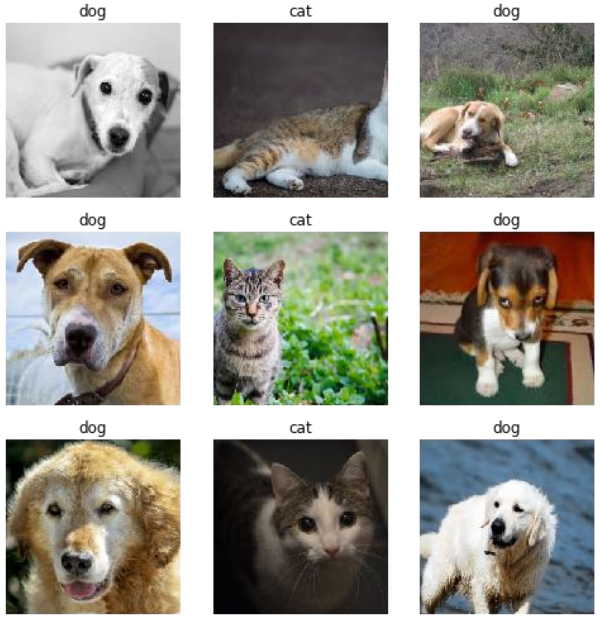
- Quantifying wage components! (is there a theory?)
- What are the drivers:
  - Demographic variables: Education, age, experience, IQ, …
  - Social and cultural variables: Ethnicity, race, gender, …
  - Job characteristic variables: Industry, location, working hours, …
- Let's build a model (assuming a linear functional form!)

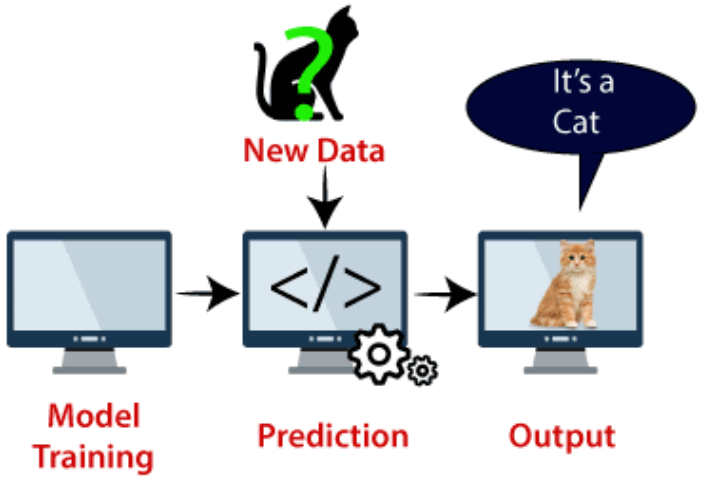
$$wage = \beta_0 + \beta_1 educ + \beta_2 age + \beta_3 exper + \beta_4 IQ + \cdots + \beta_k hours + u$$

- Can you **interpret** this model? Do you care about the interpretability?
- Can you make **predictions** using your model?
- Can you make this functional form more flexible? What are the caveats?

A different example

- Cat vs dog classification problem (image recognition)





- Do you really care about interpretability of the model here?
- What about accuracy of your predictions?

Statistical learning vs machine learning

	Statistical Learning	Machine Learning / Deep Learning
Focus	Hypothesis testing & interpretability	Predictive accuracy and extracting complex patterns
Driver	Math, theory, hypothesis	Fitting data
Data size	Any reasonable set	Big data
Data type	Structured	Structured, unstructured, semi-structured
Dimensions / scalability	Mostly low dimensional data	High dimensional data
Strength	Understand **causal** relationship & behavior	Prediction (forecasting and nowcasting)
Interpretability	High	Medium to Low

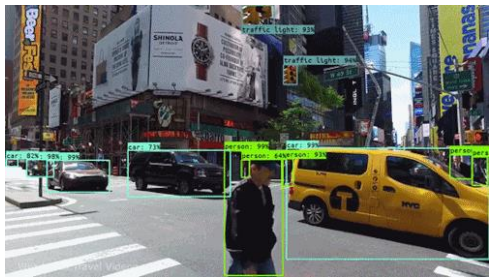
Limitations of Econometrics/Structured ML

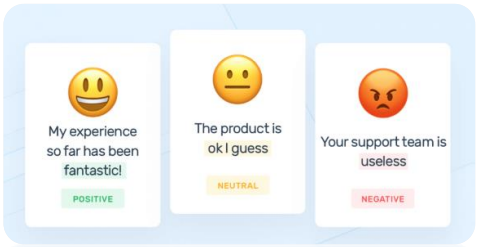
Econometrics/structured ML can only handle structured data (tabular data)!

Structured Data

	A	B	C	D
1	Date	Account	Transaction Type	Amount
2	2017-01-12	123	Credit	6089.78
3	2017-01-12	123	Fee	9.99
4	2017-01-12	456	Debit	1997
5	2017-01-12	123	Debit	20996.12
6	2017-01-13	123	Debit	17
7	2017-01-13	123	Debit	914.36
8	2017-01-14	789	Credit	11314
9	2017-01-14	789	Fee	9.99
10	2017-01-14	456	Debit	15247.89
11	2017-01-14	123	Debit	671.28
12	2017-01-15	456	Credit	5072.1
13	2017-01-15	456	Fee	9.99
14	2017-01-16	456	Debit	5109.07
15	2017-01-19	123	Credit	482.01

Unstructured Data
(everything else!!)





A more complex example

Stock price prediction $$$

- What are the classical drivers:
  - Company's fundamentals (balance sheet, income statement, cash flow statement)
  - Competitors (comparing multiples)
  - Technical analysis!
  - Seasonality (holidays, months, days, …)

What else?

- Market sentiment (news, tweets, blogger opinions, conference calls, …)
- Satellite images from parking lots!

Why should I learn it?

- It’s a bid deal, deep learning is everywhere!
- Better career opportunities
- Hedge against next recession

Road map!

- Module 1- Introduction to Machine Learning
- Module 2- Setting up Deep Learning Environment
- Module 3- Machine Learning review (ML fundamentals + models)
- Module 4- Deep Neural Networks (NN and DNN)
- Module 5- Deep Computer Vision (CNN, R-CNN, YOLO, FCN)
- Module 6- Deep Sequence Modeling (RNN, LSTM)
- Module 7- Transformers (Attention is all you need!)
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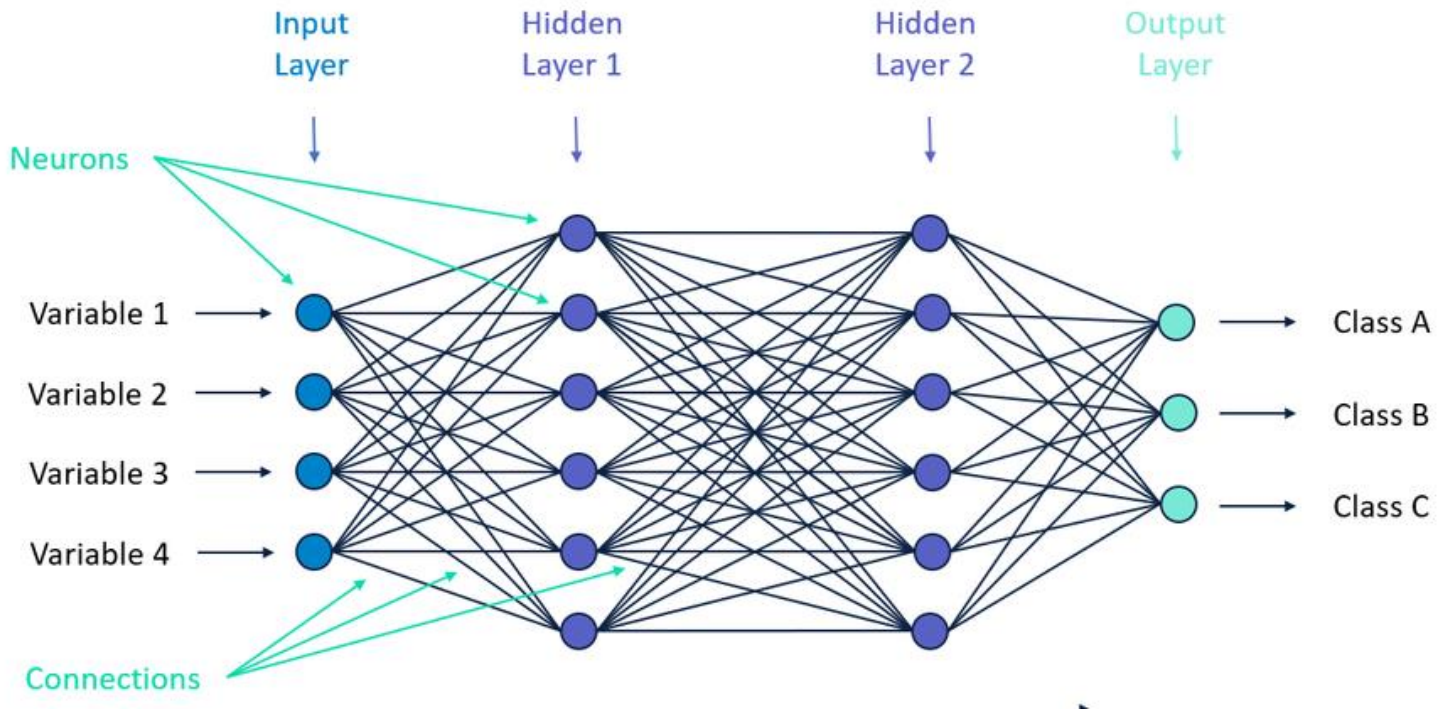
- Module 9- Deep Reinforcement Learning (DQN, PG)

Module 1 – Part II
What is Deep Learning?



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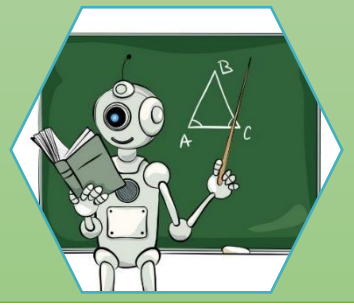
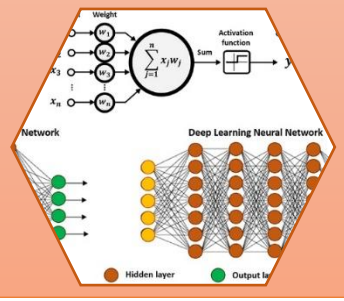
Artificial intelligence vs Machine learning vs Deep learning

Artificial intelligence: Any technique which enables machines to mimic human behavior

Machine Learning: Subset of AI that enables computers to learn from data. the model is trained with a set of algorithms

Deep Learning: Subset of ML that extract patterns from data using neural networks.

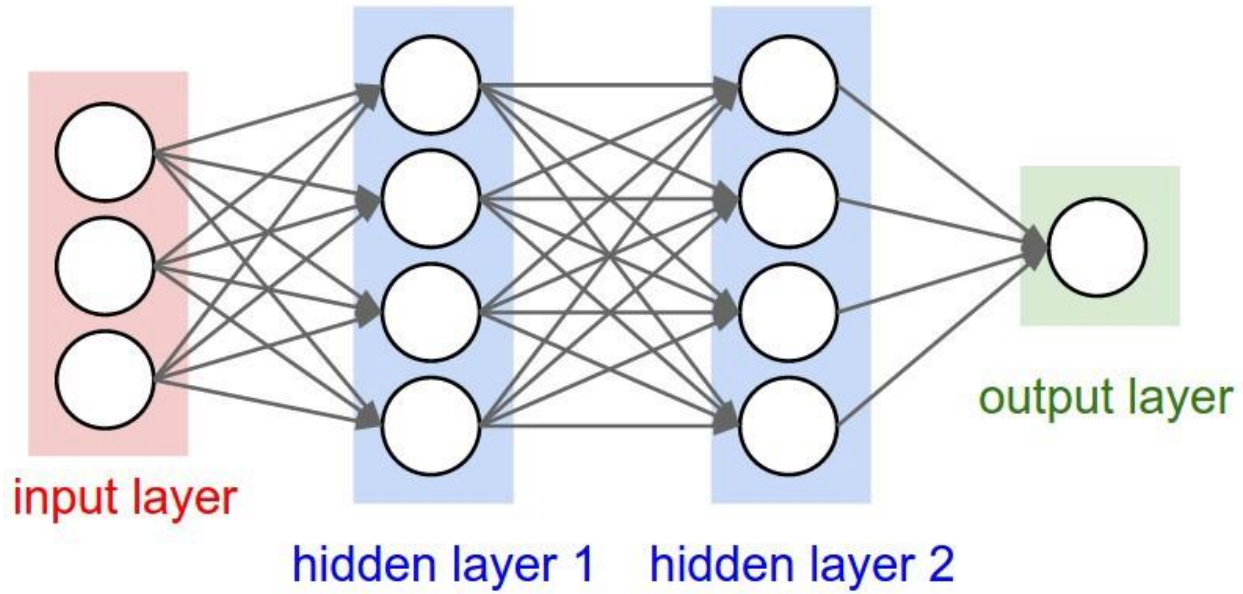




1950's 1980's 2010's

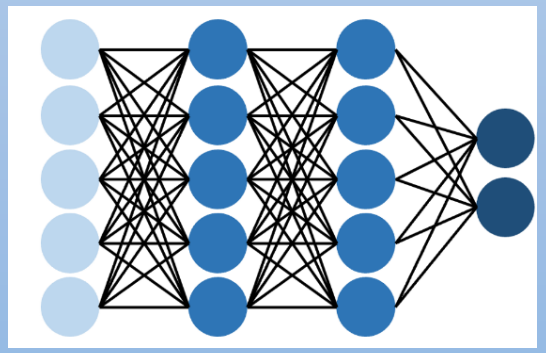
What is Deep Learning?

- Deep learning is a type of machine learning that uses multiple layers of neurons to process data
- The goal of deep learning is to build a model that can automatically learn complex patterns from the data and make accurate predictions or decisions

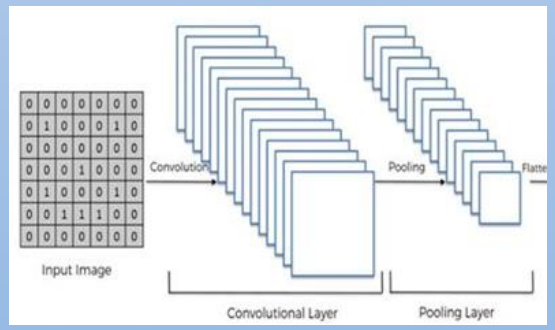


Network examples

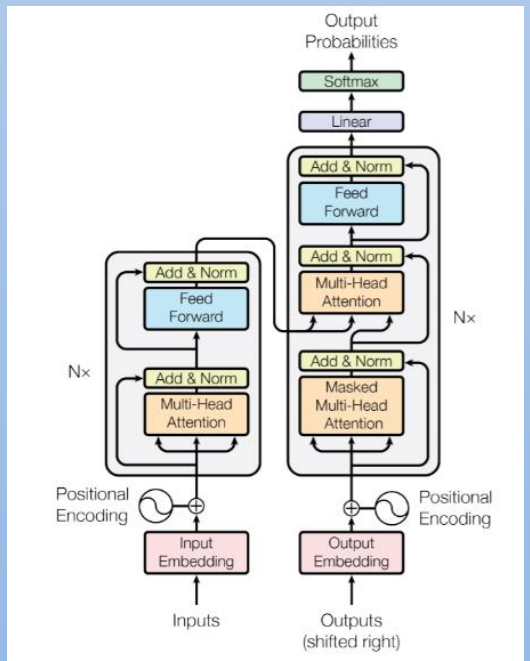
Standard NN



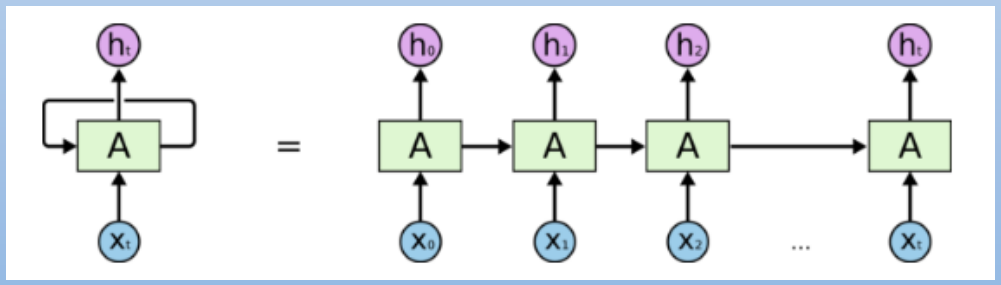
Convolutional NN



Transformers

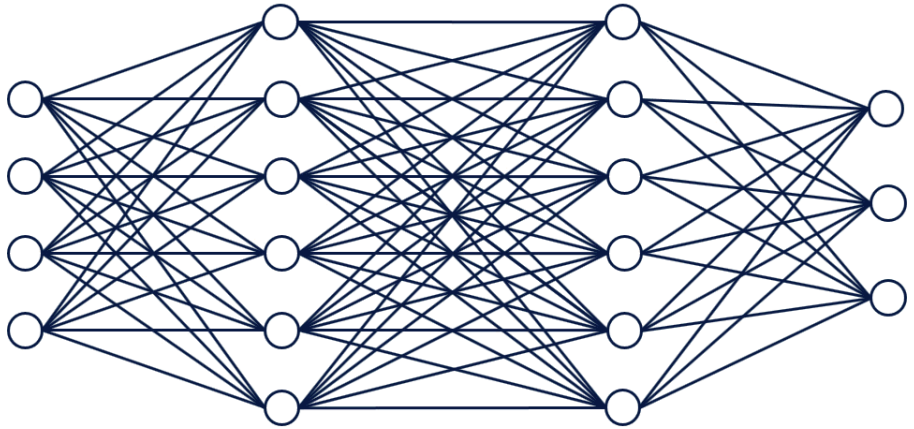


Recurrent NN

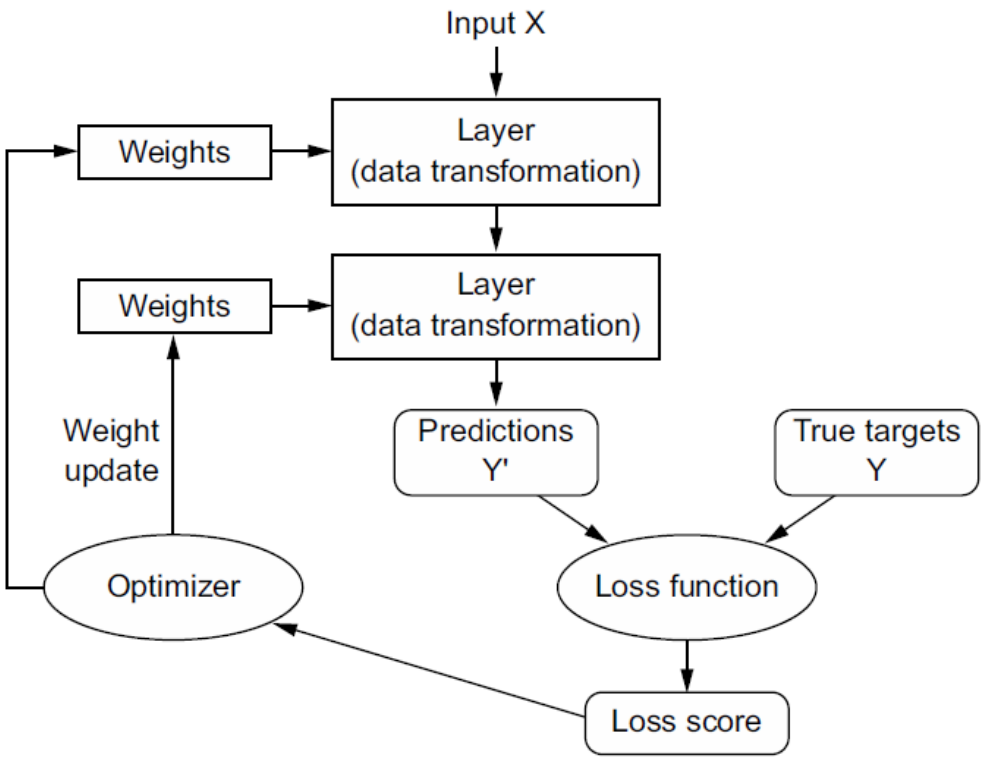


How Deep Learning Works?

- The network uses a series of interconnected layers, with each layer transforming the input and passing it on to the next layer
- The final layer of the network produces the output, which is compared to the true output label to evaluate the performance of the network
- The network is then adjusted to minimize the difference between the predicted and true output labels, and the process is repeated until the network has learned to make accurate predictions on new, unseen data

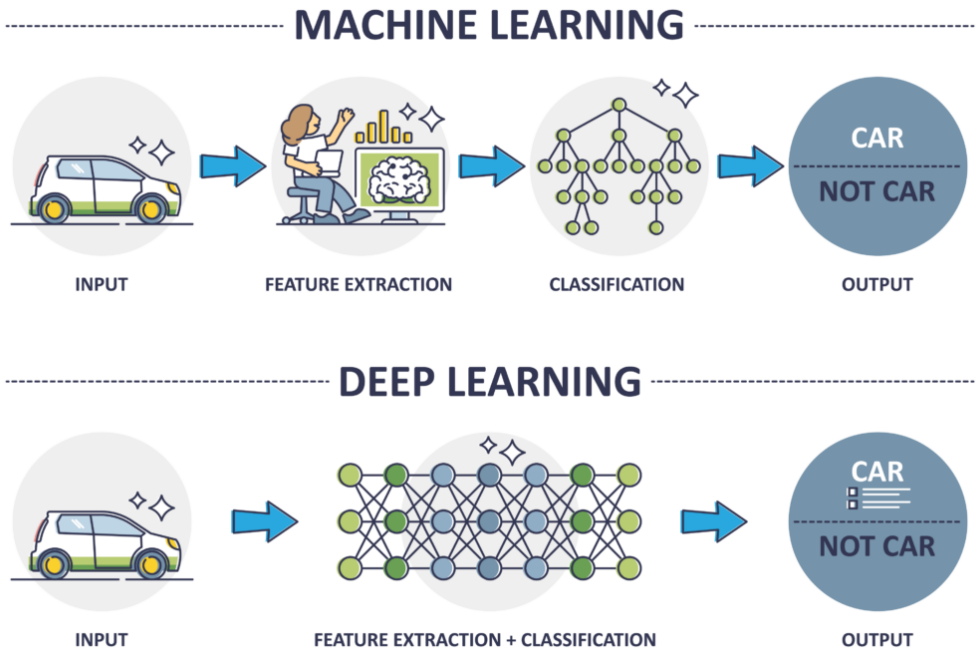


How Deep Learning Works?



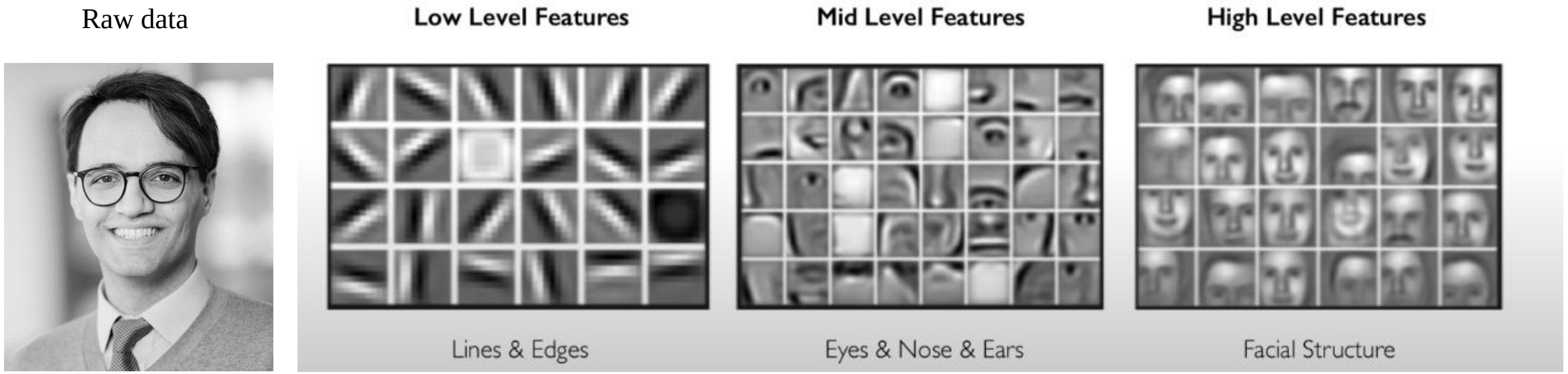
Why Deep Learning?

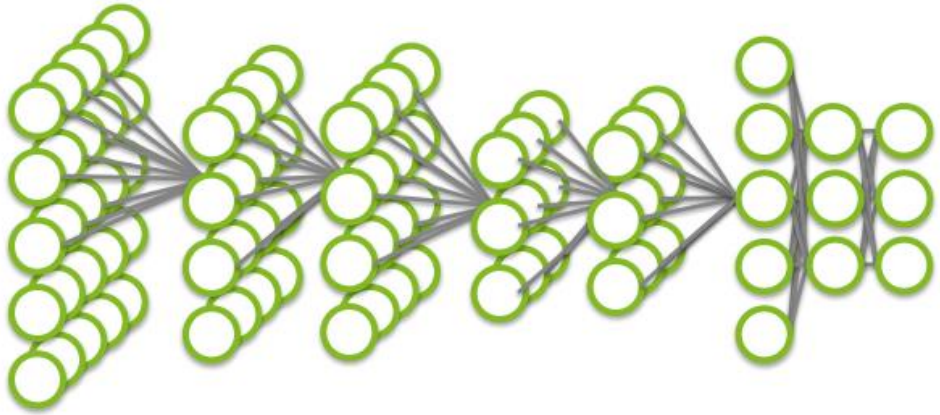
- In deep learning, the model is not explicitly programmed with a set of rules or algorithms, but instead learns to recognize patterns and make predictions by adjusting the connections between the neurons in the network!
- Can learn the underlying features directly from data and in a hierarchical manner. No feature extraction/engineering required!



Why Deep Learning?

- Hand engineering features for unstructured data is almost impossible!



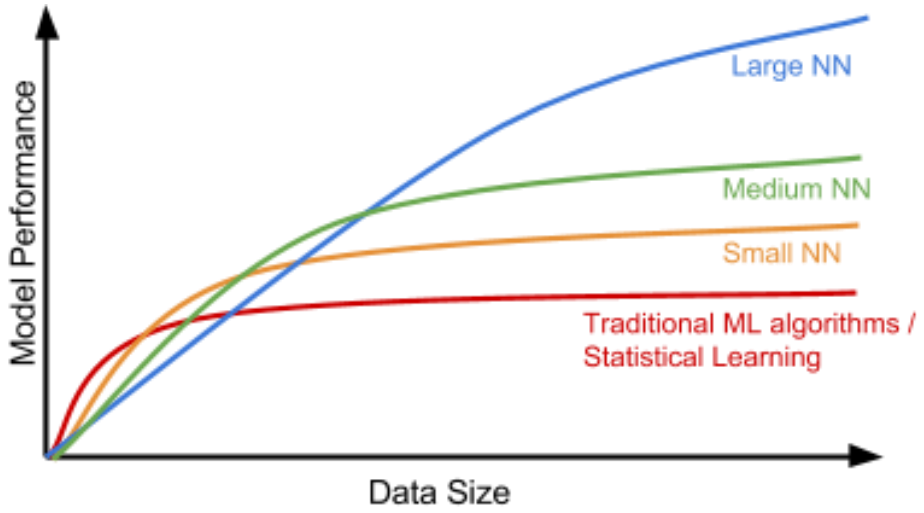


Summary

	Machine Learning	Deep Learning
Focus	General-purpose predictions	Extracting high-level features from data
Level of **Abstraction**	Explicitly programmed (rules/algos)	Learn by adjusting neurons
Examples	KNN, SVM, DT, RF, XGBoost, …	CNN, RNN, LSTM, GAN, Transformers
Requires Feature extraction	Yes	No
Requires high processing power	Not necessarily	Yes
Interpretability	Medium to low	Very low to none
Execution Time on training	Less (compared to DL)	A lot
Execution Time on testing	More (compared to DL)	Little

Why Now?

- Data, Hardware and Algorithms
- In small data sets, perhaps traditional machine learning is more effective!
- The performance of deep learning is better when the data is large.
- Training large NN is computationally expensive (Hardware)
- Algorithms are playing important role in speeding up the training process.



Will it last?

- Deep learning is here to stay!

1. Simplicity: DL removes the need for feature engineering
2. Scalability: DL is highly amenable to parallelization on GPUs and TPUs. Trained by iterating over small batches of data.
3. Versatility and reusability: DL models can be trained on additional data without restarting from scratch, suitable for continuous online learning.

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