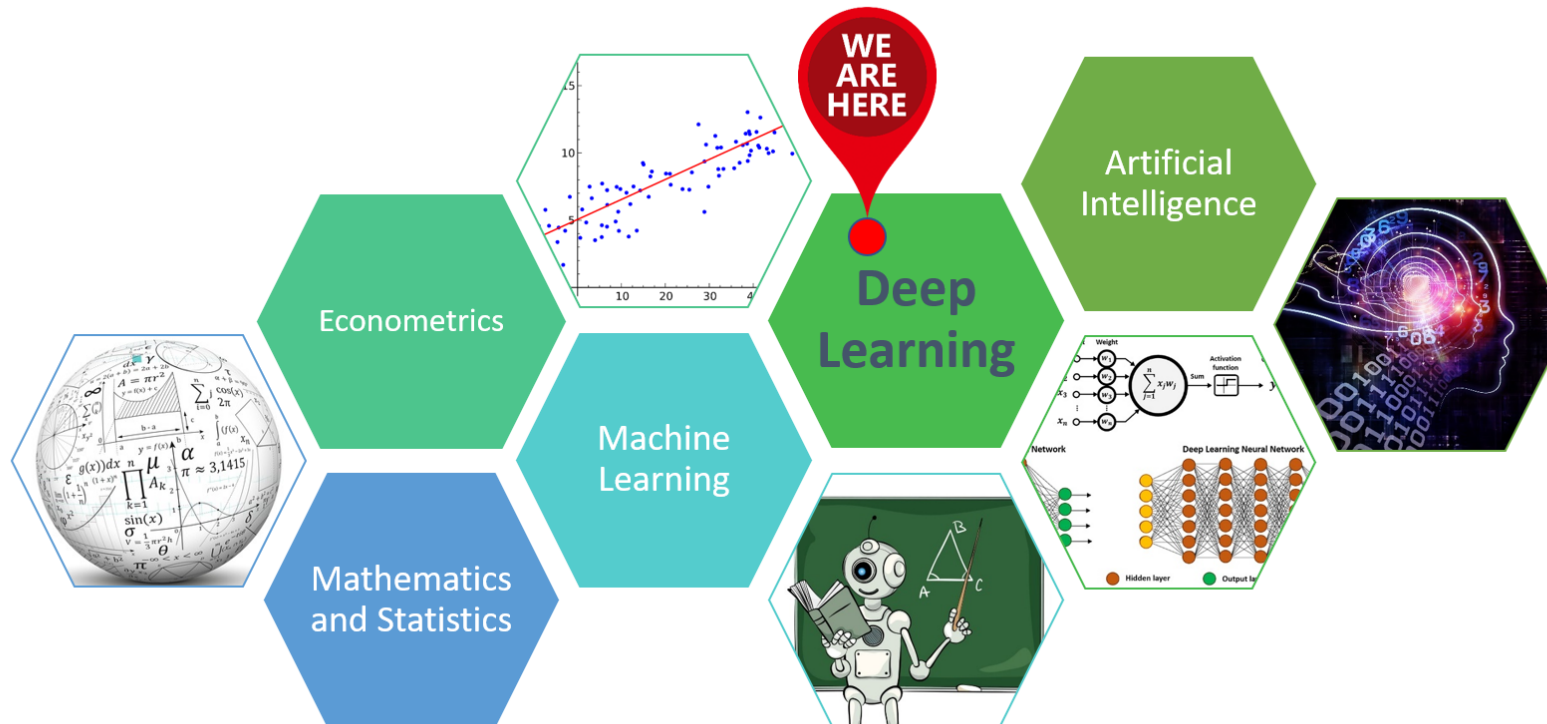


Module 1 – Part I

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?

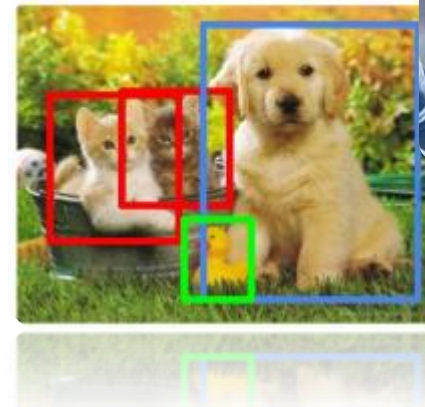


Is there a theory?

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 ...



➔ 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!)

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

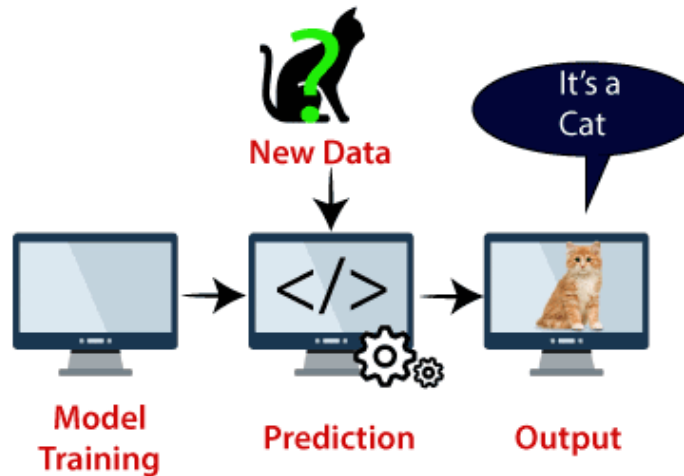
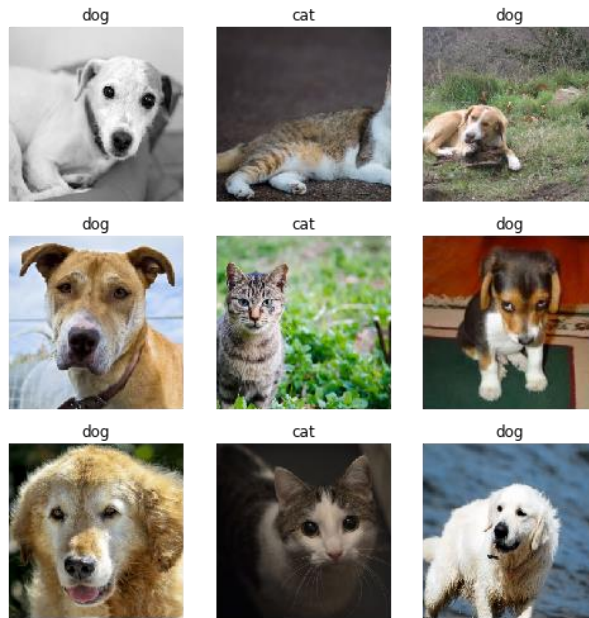
- Can you **interpret** this model? Do you care about the interpretability?
- Can you make **predictions** using your model?
- Can you make this functional form more flexible? What are the caveats?





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

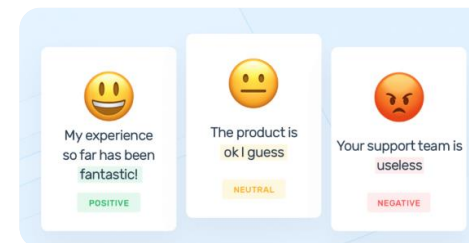
Econometrics/structured ML can **only** handle structured data (tabular data)!

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?

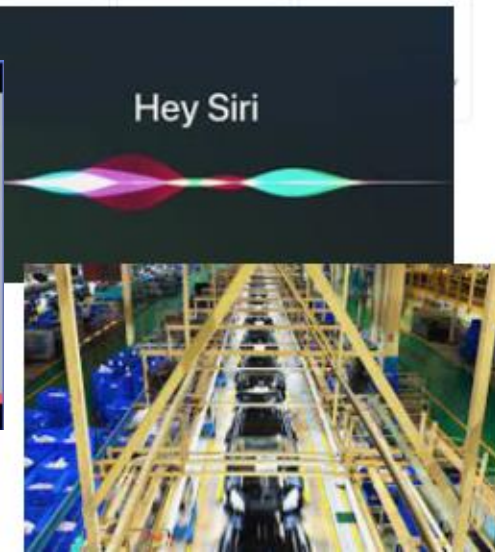
- Market sentiment (news, tweets, blogger opinions, conference calls, ...)
- Satellite images from parking lots!

Why should I learn it?

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



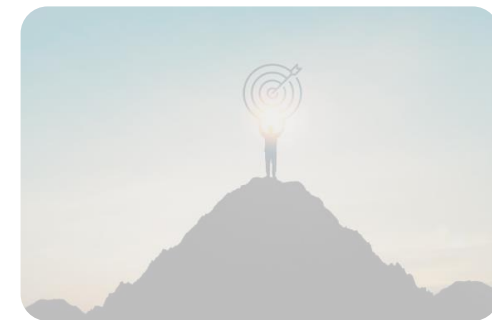
OpenAI





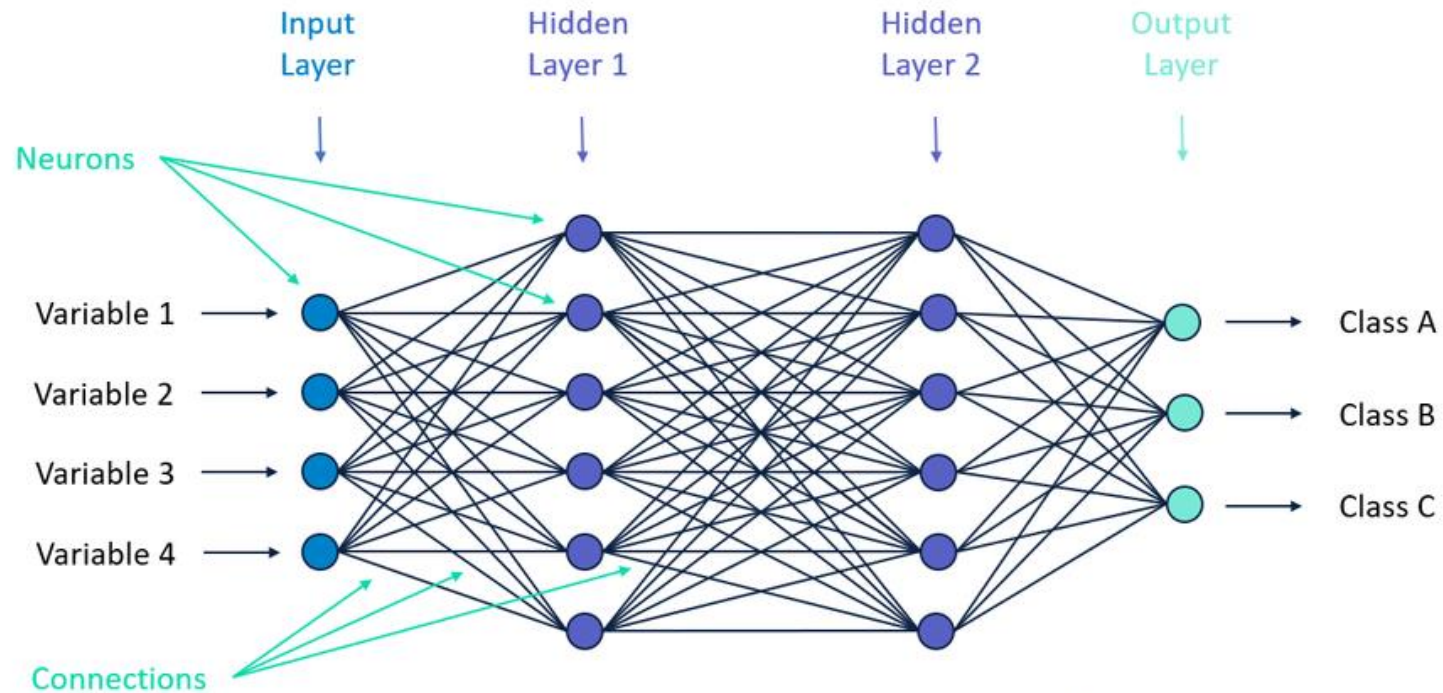
Road map!

- Module 1- Introduction to Deep 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!)
- Module 8- Deep Generative Modeling (AE, VAE, GAN)
- Module 9- Deep Reinforcement Learning (DQN, PG)



Module 1 – Part II

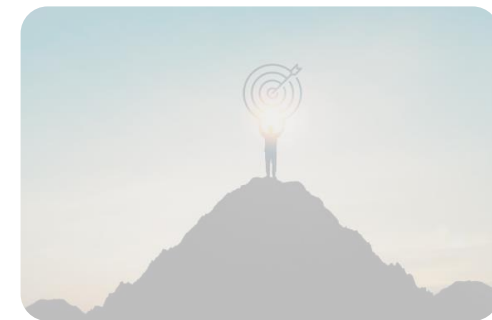
What is Deep Learning?





Road map!

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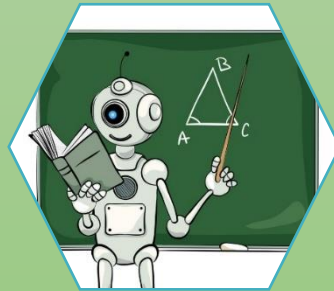
Artificial intelligence vs Machine learning vs Deep learning

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



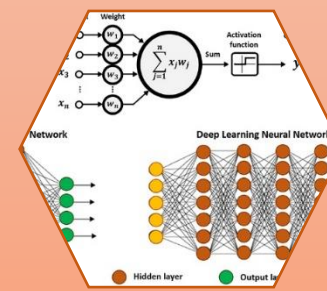
1950's

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



1980's

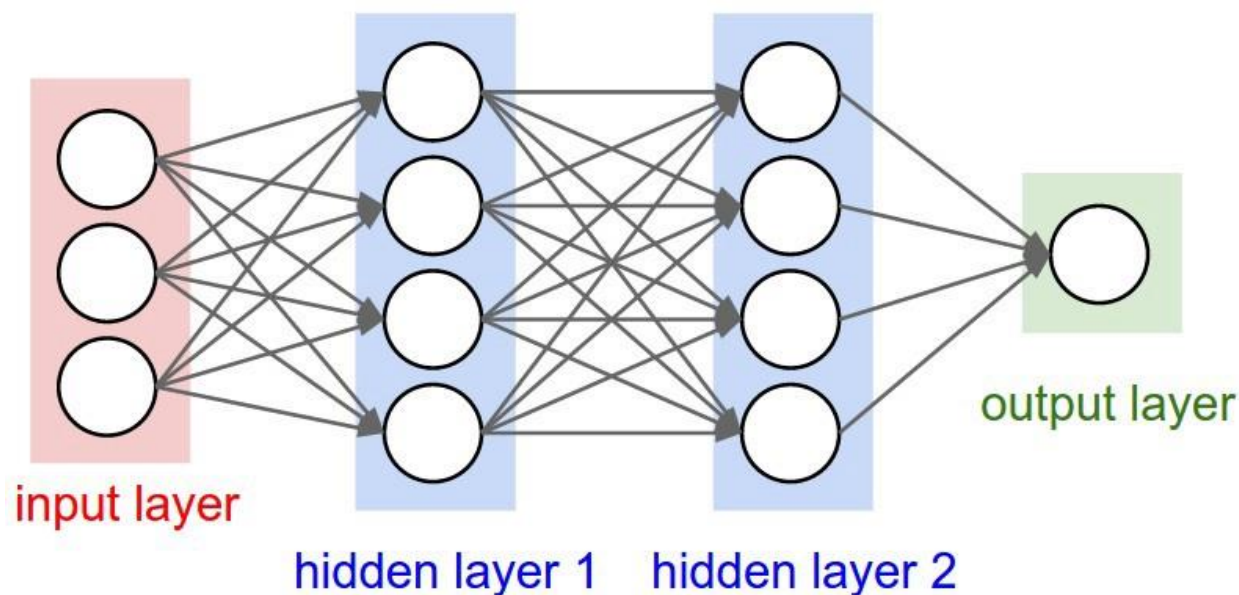
Deep Learning: Subset of ML that extract patterns from data using neural networks.



2010's

➔ What is Deep Learning?

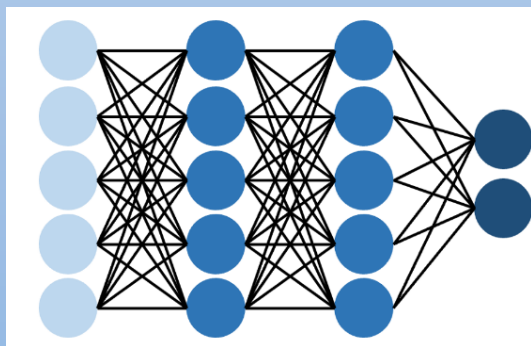
- Deep learning is a type of machine learning that uses **multiple layers of neurons** to process data
- The goal of deep learning is to build a model that can **automatically learn complex patterns** from the data and make **accurate predictions** or decisions



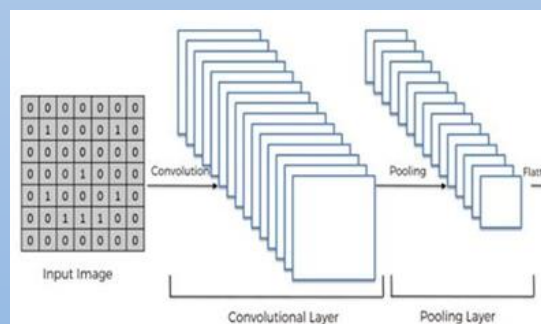


Network examples

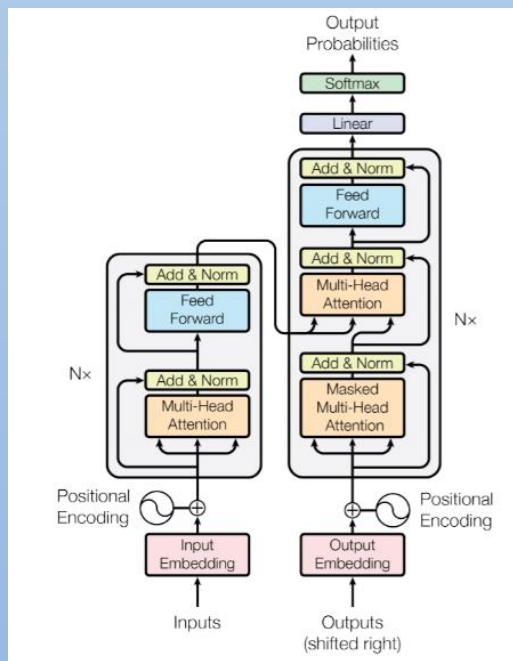
Standard NN



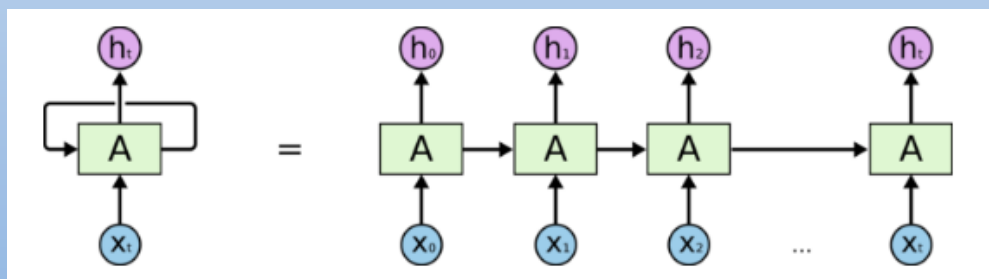
Convolutional NN



Transformers

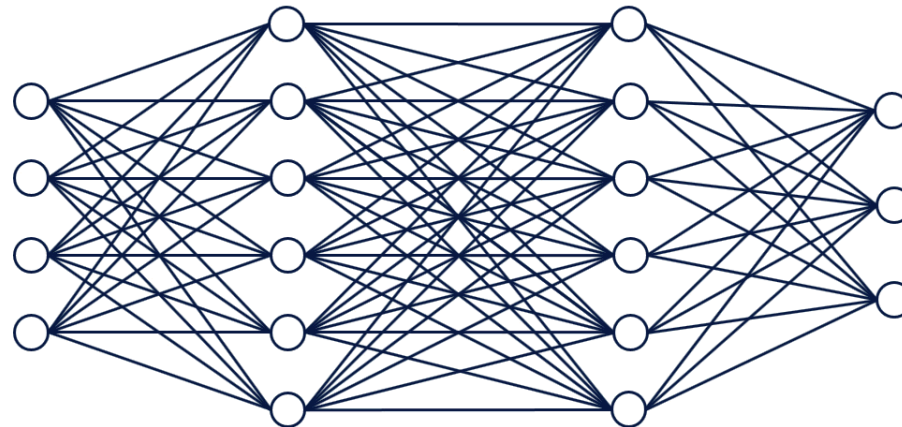


Recurrent NN



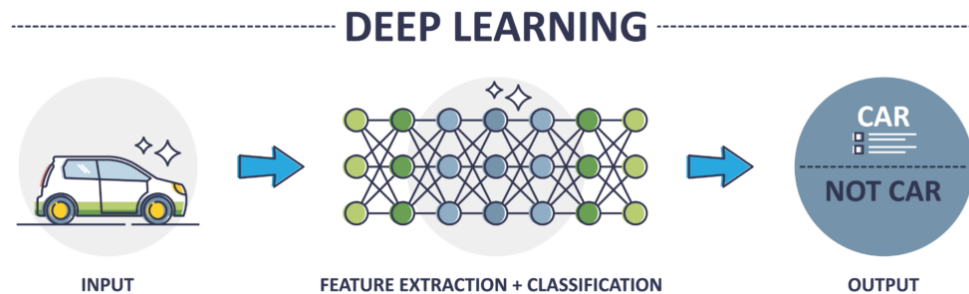
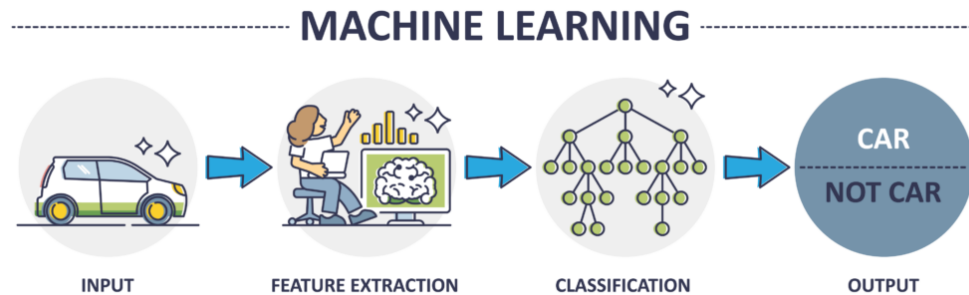
➔ How Deep Learning Works?

- 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



➔ 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!**



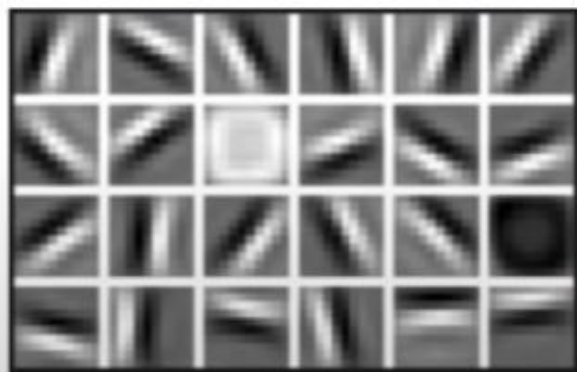
➔ Why Deep Learning?

- Hand engineering features for unstructured data is **almost impossible!**

Raw data



Low Level Features



Lines & Edges

Mid Level Features

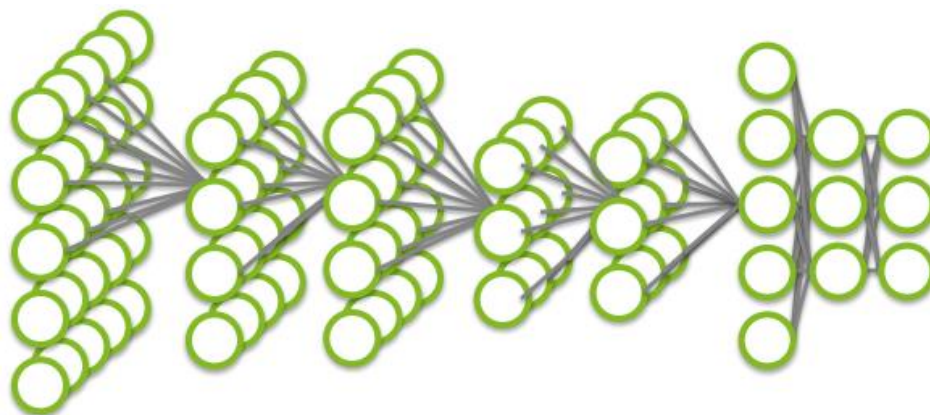


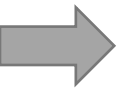
Eyes & Nose & Ears

High Level Features



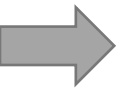
Facial Structure





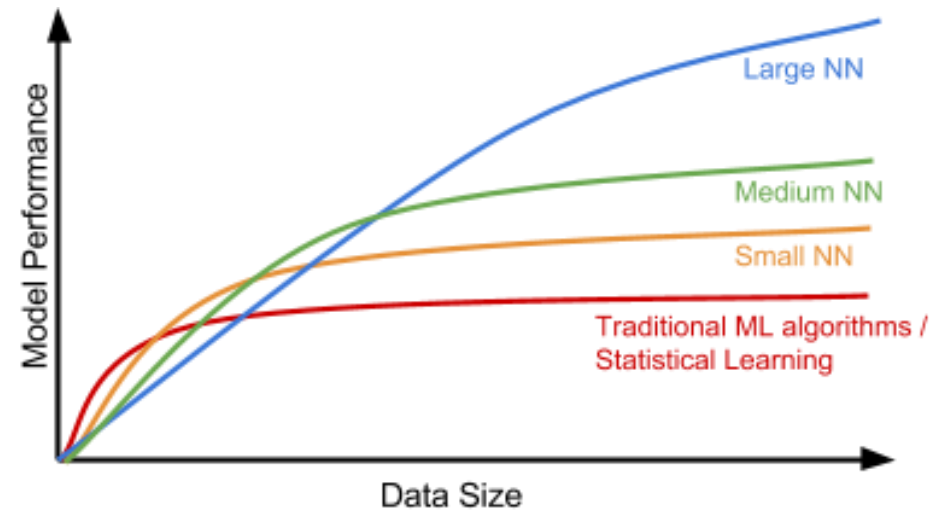
Summary

| | 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?

- 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**.
- **Algorithms** are playing important role in speeding up the training process.



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