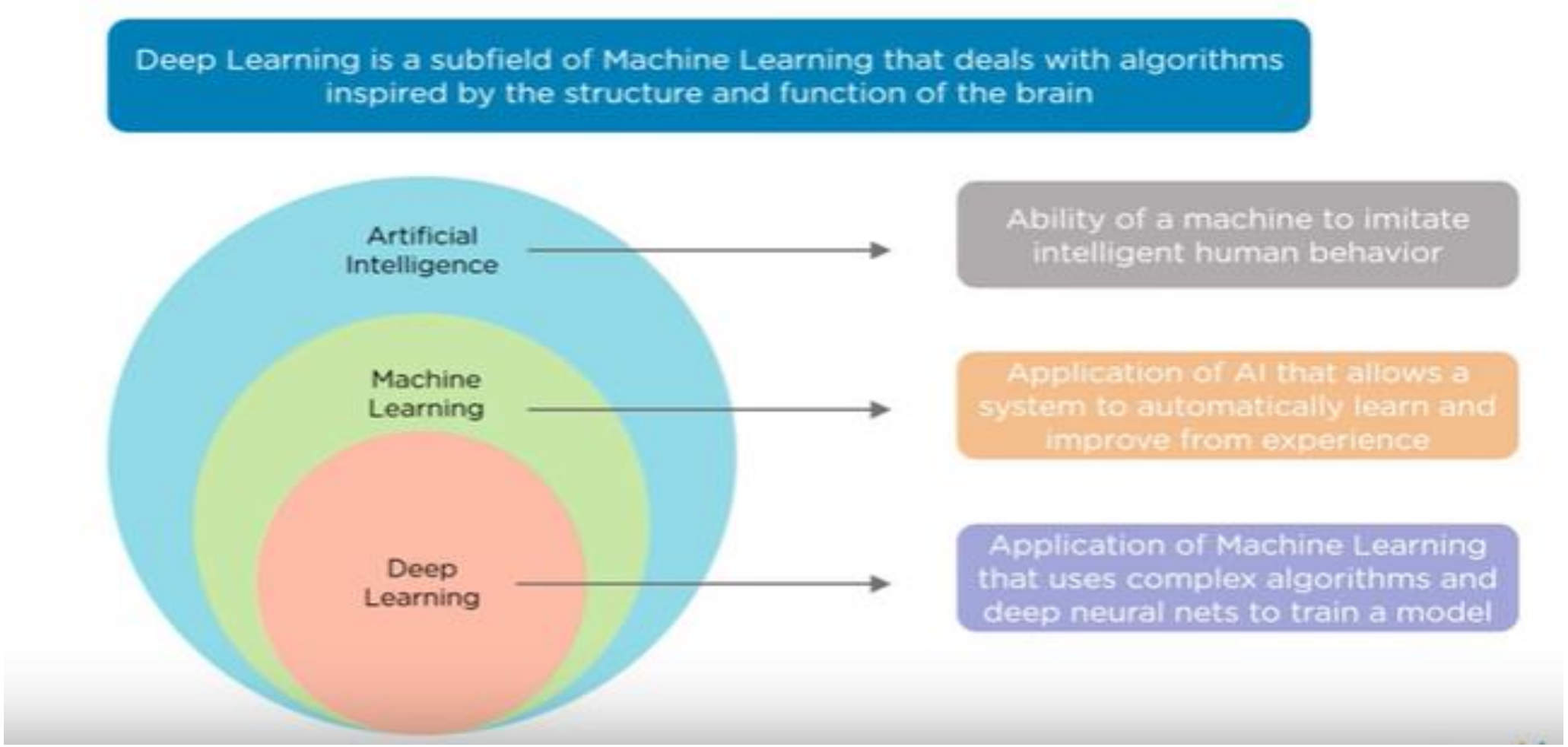
Deep Learning

"Deep learning is a particular kind of machine learning that is inspired by the functionality of our brain cells called neurons which led to the concept of artificial neural network"

Deep Learning is a Type of Machine Learning



Deep Learning is a Type of Machine Learning

- In deep learning, a computer model learns to perform classification tasks directly from images, text, or sound.
- Deep learning models can achieve state-of-the-art accuracy, sometimes exceeding human-level performance. Models are trained by using a large set of labeled data and neural network architectures that contain many layers.

Why we need Deep Learning

Process huge amount of data

Machine Learning algorithms work with huge amount of structured data but Deep Learning algorithms can work with enormous amount of structured and unstructured data

Perform complex algorithms

Machine Learning algorithms cannot perform complex operations, to do that we need Deep Learning algorithms

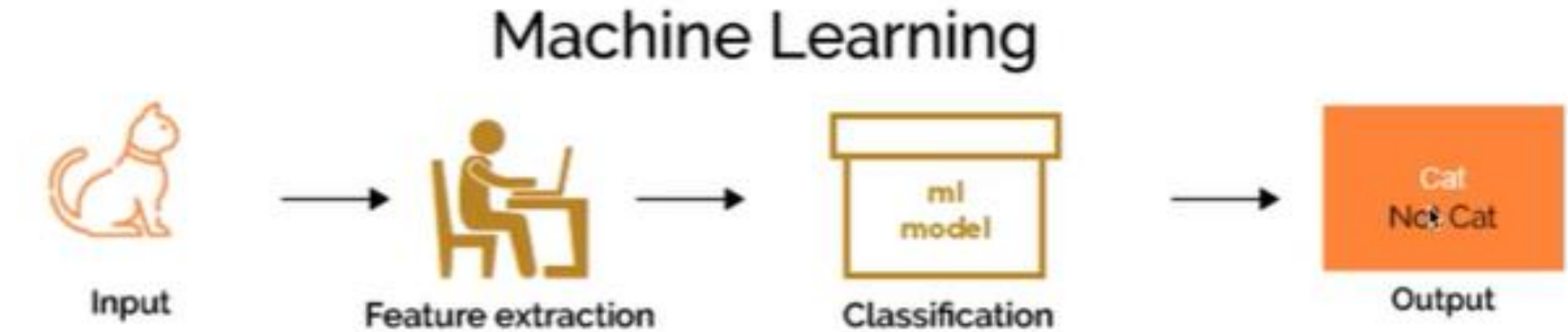
To achieve the best performance with large amount of data

As the amount of data increases, the performance of Machine Learning algorithms decreases, to make sure the performance of a model is good, we need Deep Learning

Feature Extraction

Machine Learning algorithms extract patterns based on labelled sample data, while Deep Learning algorithms take large volumes of data as input, analyze the input to extract features out of an object and identifies similar objects

Machine Learning vs. Deep Learning



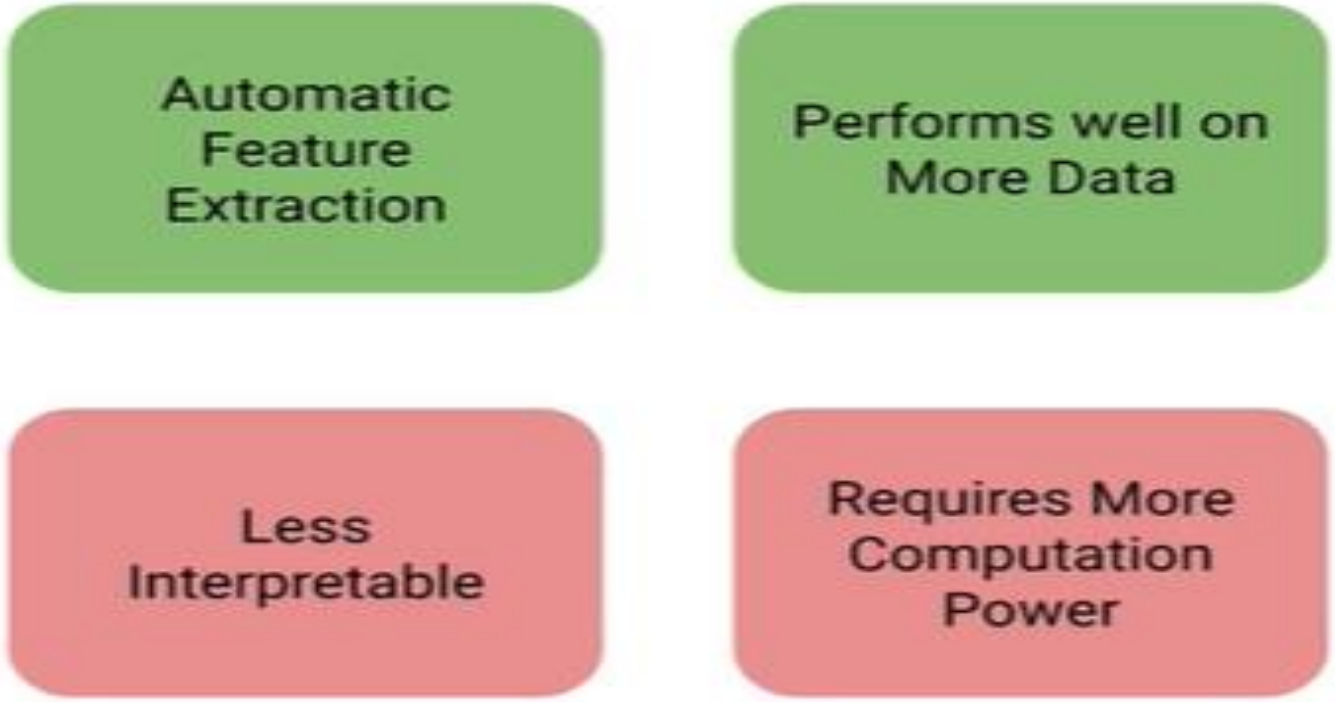
Deep Learning has fewer steps than traditional Machine Learning

Traditional Machine Learning Flow

Deep Learning Flow

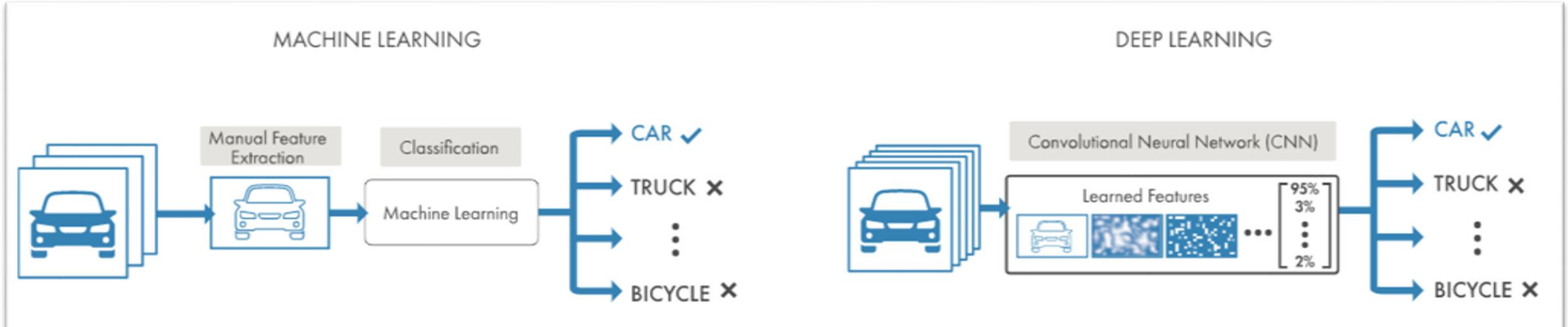
Machine Learning Vs Deep Learning

- ML uses algorithms to parse data, learn from the data and make informed decision based on what it has learnt.
- DL structures algorithms in layers to create artificial neural networks that can learn and make intelligent decisions on their own.
- DL is a subfield of ML while both fall under broad category of AI.



Machine Learning vs Deep Learning

- Another key difference is deep learning algorithms scale with data, whereas shallow learning converges.
- Shallow learning refers to machine learning methods that plateau at a certain level of performance when you add more examples and training data to the network.
- A key advantage of deep learning networks is that they often continue to improve as the size of your data increases.
- In machine learning, you manually choose features and a classifier to sort images. With deep learning, feature extraction and modeling steps are automatic.



Machine Learning Vs Deep Learning
1. Difference based on Volume of Data

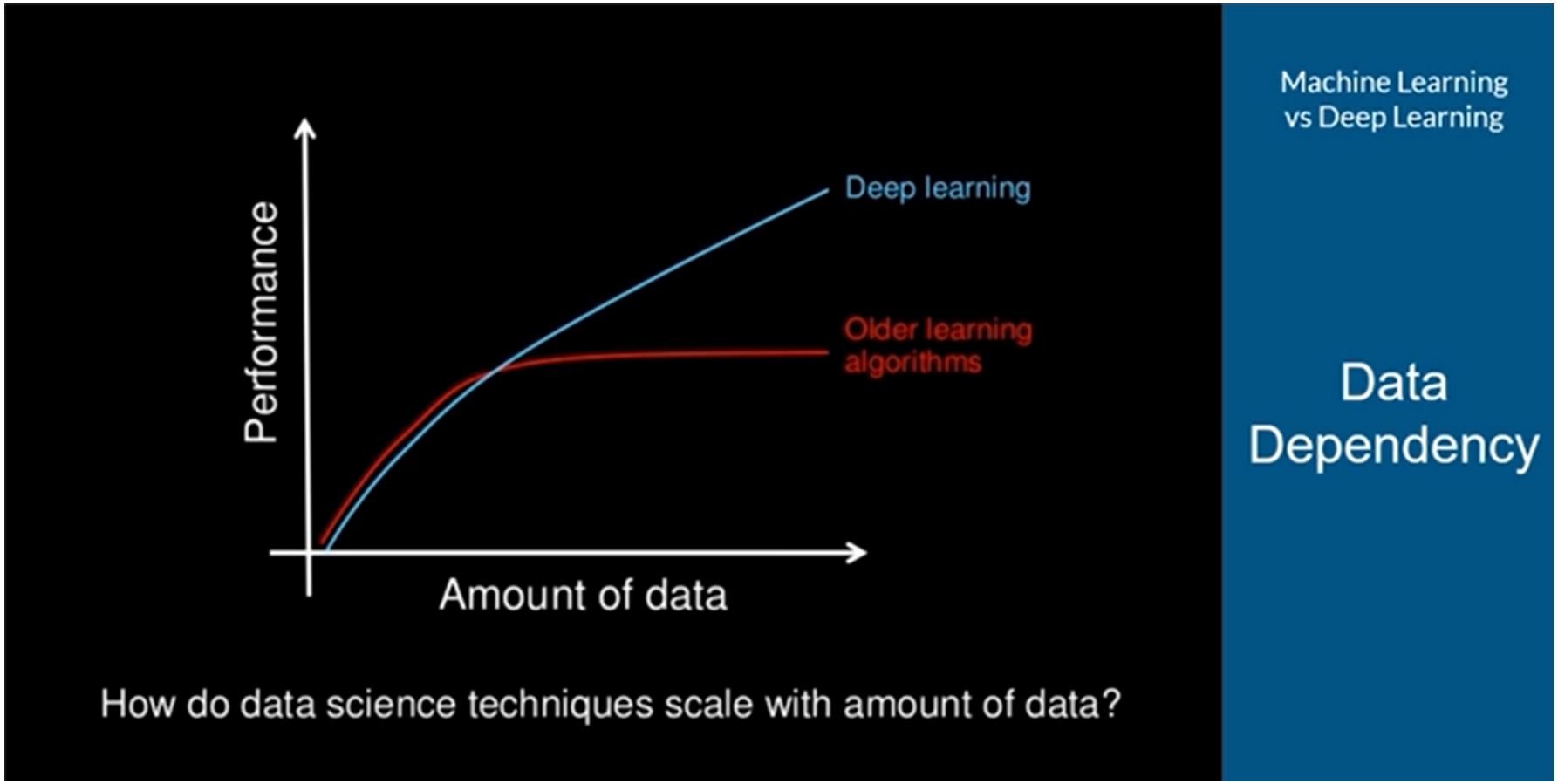


Image : Edureka

2. Difference based on Hardware Dependency

- DL models work on lots of Matrix Multiplication and optimization of multiplication possible only with GPU which are especially engineered for DL.
- Whereas ML models can work on low end machines

CPU

GPU

TPU

Difference Between CPU and GPU

CPU	GPU
Few complex cores	Hundreds of simpler cores
Focuses on doing one task as efficiently as possible	Focuses on doing various tasks parallely
Used for general purpose tasks	Used for graphics processing or matrix multiplication

CPU	GPU
Intel® Core™ i7-10510U Processor	NVIDIA GTX 1080 Ti
4 cores	3584 cores
	

Massive parallel operations possible in GPU

TPU is extremely specific, especially for mathematical applications using DL, as they do computational tasks and better than CPU or GPU.
Not general purpose.

Dataset vs. computer memory and computational power

Decade	Dataset	Memory	Floating Point Calculations per Second
1970	100 (Iris)	1 KB	100 KF (Intel 8080)
1980	1 K (House prices in Boston)	100 KB	1 MF (Intel 80186)
1990	10 K (optical character recognition)	10 MB	10 MF (Intel 80486)
2000	10 M (web pages)	100 MB	1 GF (Intel Core)
2010	10 G (advertising)	1 GB	1 TF (Nvidia C2050)
2020	1 T (social network)	100 GB	1 PF (Nvidia DGX-2)

Power of GPU (Video)

- https://www.youtube.com/watch?v=-P28LKWTzrI

3. Difference based on Feature Engineering

In ML we will define the features like whiskers, ears etc, But in DL, model automatically finds the features which are importantfor classificatian

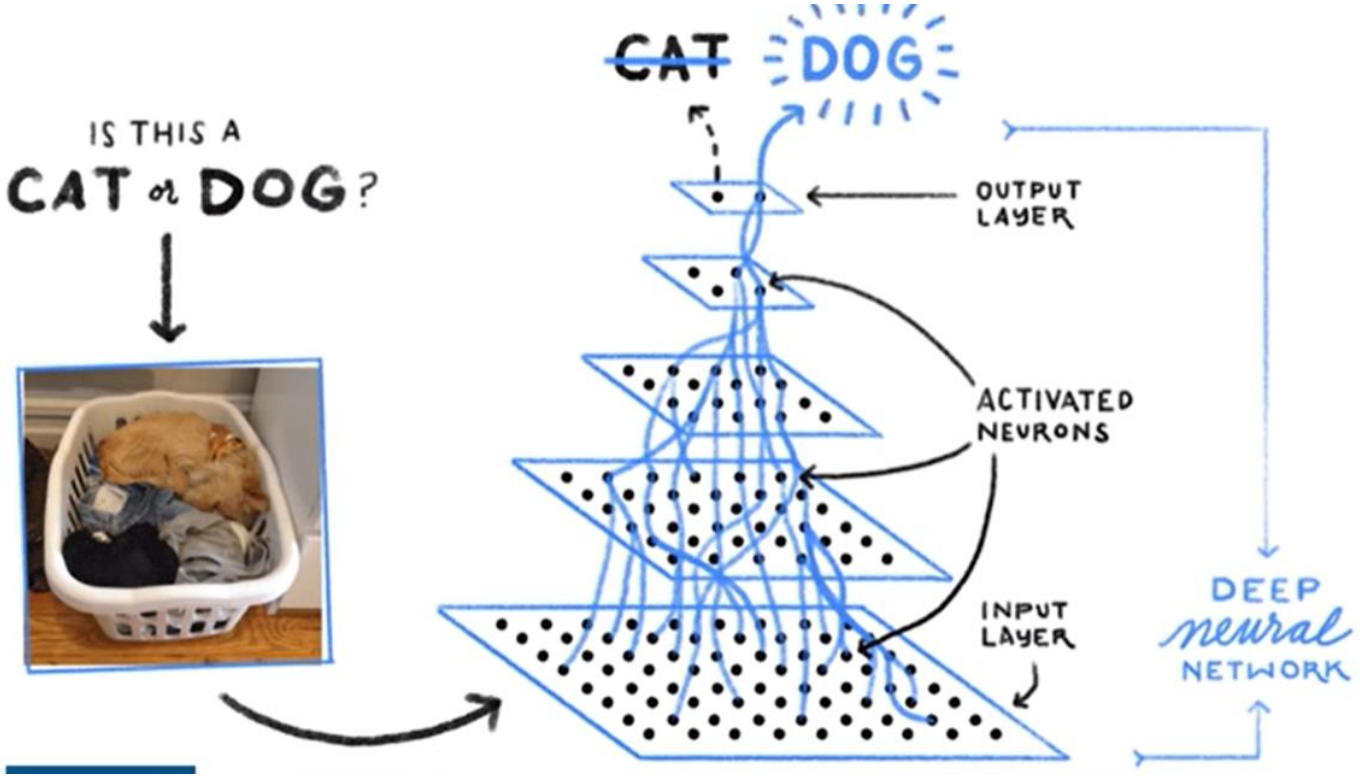


Image : Edureka

Difference based on Feature Engineering

- It is the process of putting the domain knowledge to reduce the complexity of the data and make patters more visible to learning algorithms.
- This process is difficult and expensive in terms of time and expertise.
- In ML, most of the features need to be identified by expert and hand coded as per the domain and data type like pixel value , shape, texture, orientation etc
- Performance of ML algos depends on how accurately the features are identified and extracted.
- But in DL high level features are identified from data. So way ahead of ML. It reduces the task of developing new feature extractor for every problem.
- Eg in CNN algo, first learns low level features of image like edges and lines, then it proceeds to parts of faces and finally high level representation of the face.

Automatic Feature Engineering

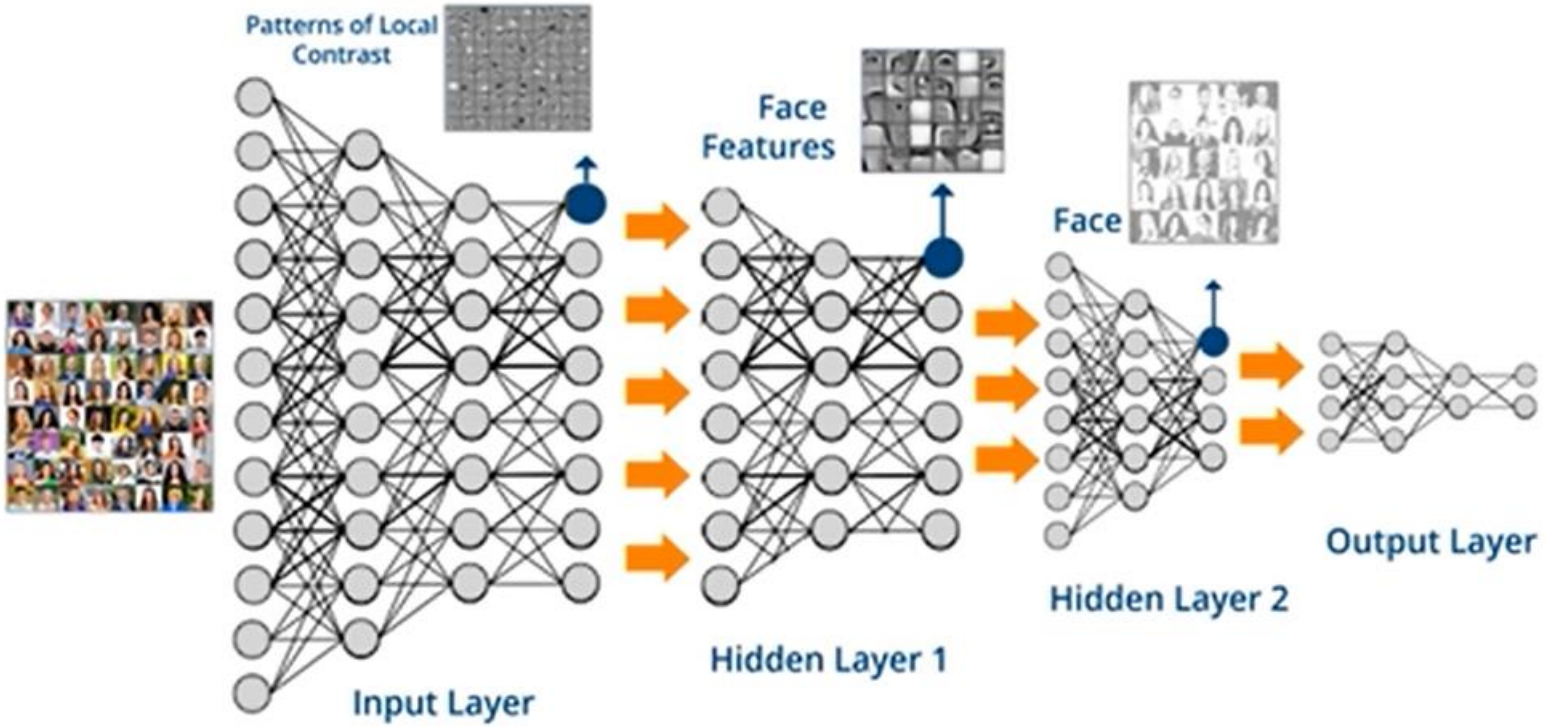


Image : Edureka

4. Difference based on Problem Solving Approach

- In ML:
  - Breaking the problems into subparts, solving and then combining results.
  - Eg : To detect multiple object detection, object detection and object recognition, like Bounding box detection algorithms ie scanning through the image and find all possible objects and then object recognition algorithms like SVM to recognize relevant objects.
  - Then combine the result to get image and its name.
  - As data increases, testing time increases eg KNN

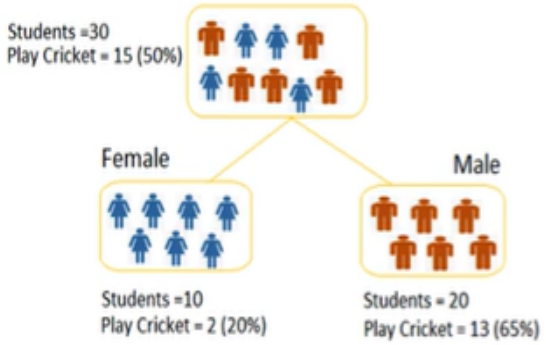
- IN DL:
  - Process solved end to end, pass an image and it would give location along with name of object.
  - Though it takes long time to train, because there are normally many parameters.
  - But testing takes less time.

5. Difference based on Interpretability

- DL lacks interpretability.
- Eg DL model gives automated scores to essays in an excellent way.
- But how and why?
- Mathematically you can find out which node of deep neural network was activated but we do not know what the neurons were supposed to model and what these layers of neurons were doing collectively.

DL performs better than ML but less interpretable

ML



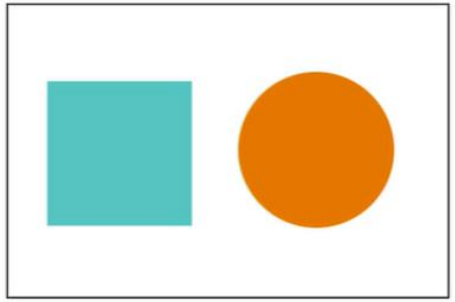
DL

So we fail to interpret the result in DL.
But ML algorithms like decision tress gives us a crisp rule why it chose and what it chose so easy to interpret the reasoning.

That is why the algorithms like Decision tree, linear regression and logistic regression are used in industry for interpretability.

How Deep Learning Works?

- DL breaks a complex concept into a hierarchy of simpler concepts.
  Eg. A complex concept of identifying a square from an image. DL makes it simple by determining whether it has 4 lines, it is closed, perpendicular, all lines are equal.



- There are multiple ways to do it. But how model knows what is the right representation?

- This is the beauty of DL. It finds this representation by itself using the training data

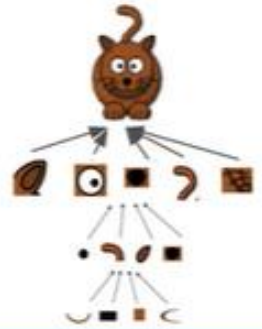
How Deep Learning Works?

- Images stored as matrix of pixels.
- DL model builds hierarchy by identifying the edges in the image by looking at the changes in values of the colors and learns them.
- Further it looks at the combination of edges to build simple features like end of tail or ears, it then adds these features to build more complex features like eye, tail or ears.

How Deep Learning Works?

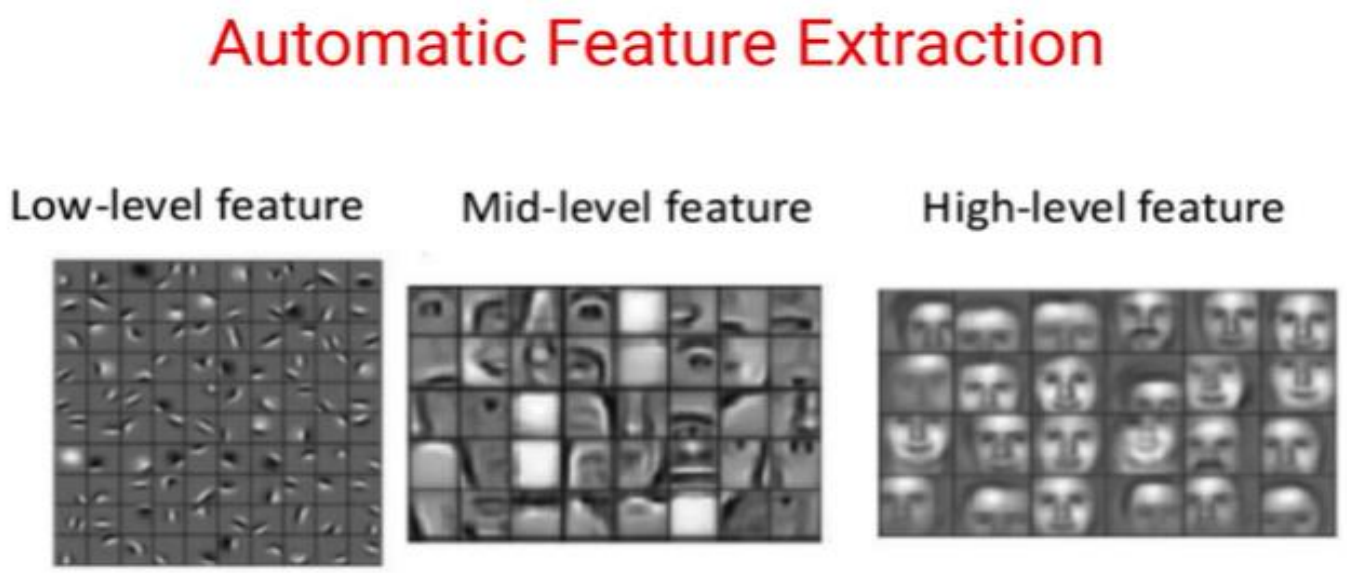
- Finally from these complex features, models tries to learn whether the image is of cat and dog depending whether these features are available in the given image.
- DL models build these representations by itself from huge data.

1. Identifies what are the edges
2. Builds on this hierarchically to find combination of shapes and edges
3. Identifies which of these features are responsible for Cat Vs. Dog classification



How Deep Learning Works?

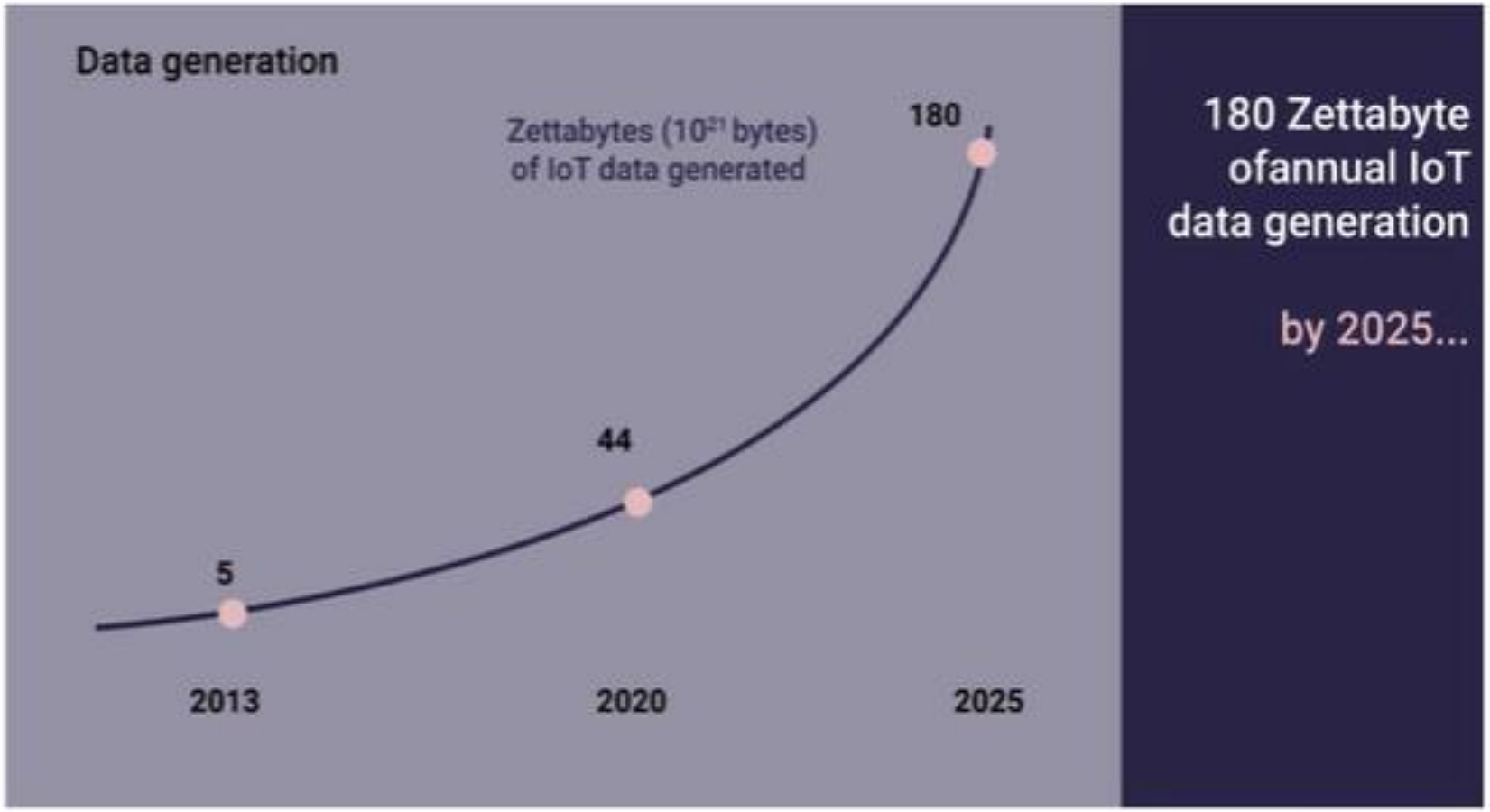
- DL model extracts low level features like boundaries of eyes, nose etc given images of various faces. Then features are combined to build mid level features and finally combined to form high level features



Source : Deep Learning in a Nutshell: Core Concepts, Nvidia
https://devblogs.nvidia.com/parallelforall/deep-learning-nutshell-core-concepts/

Popularity of Deep Learning?
1. Exponential Growth in Data

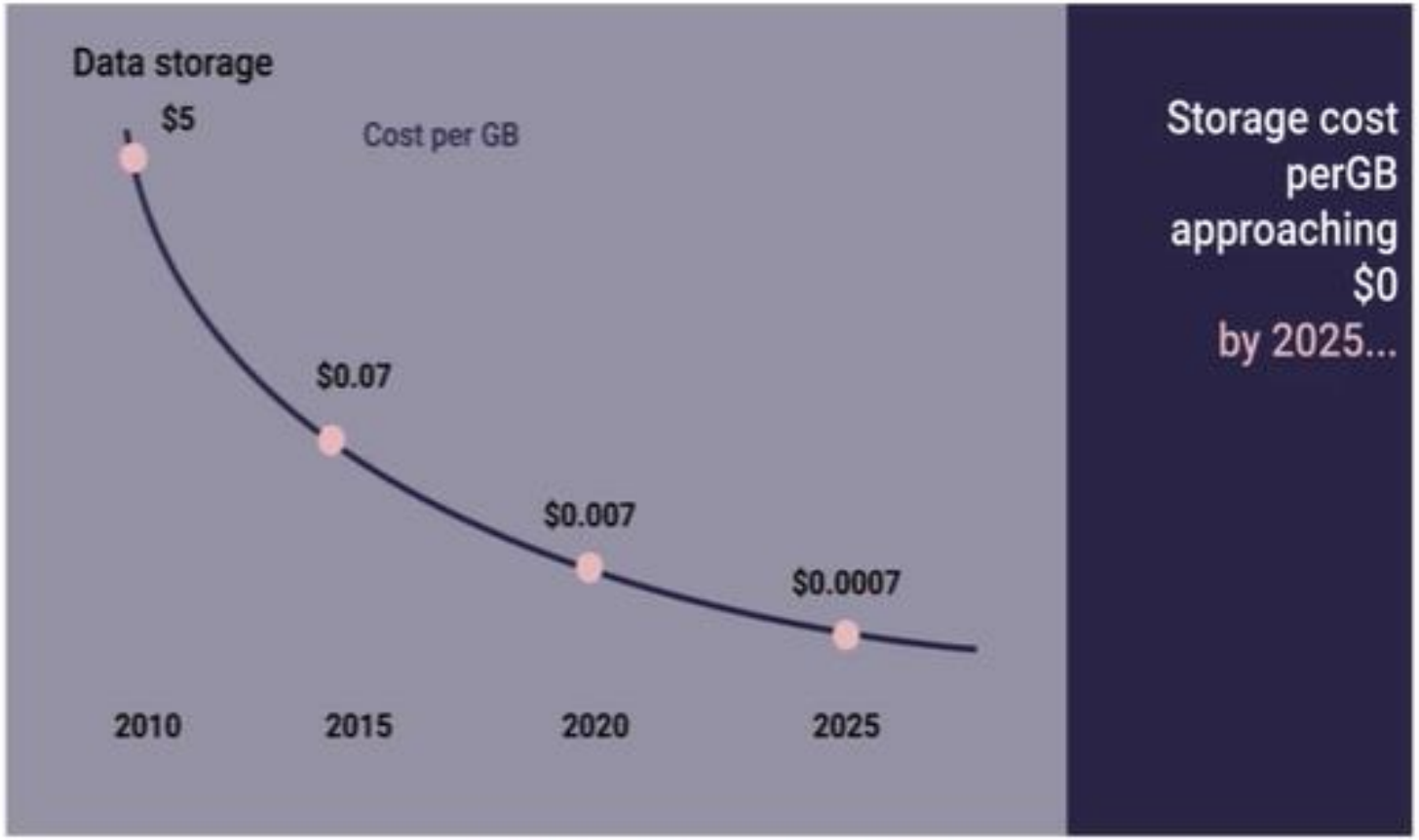
Data



Source: https://fortune.com/2018/09/24/business-strategy-technology-mckinsey/

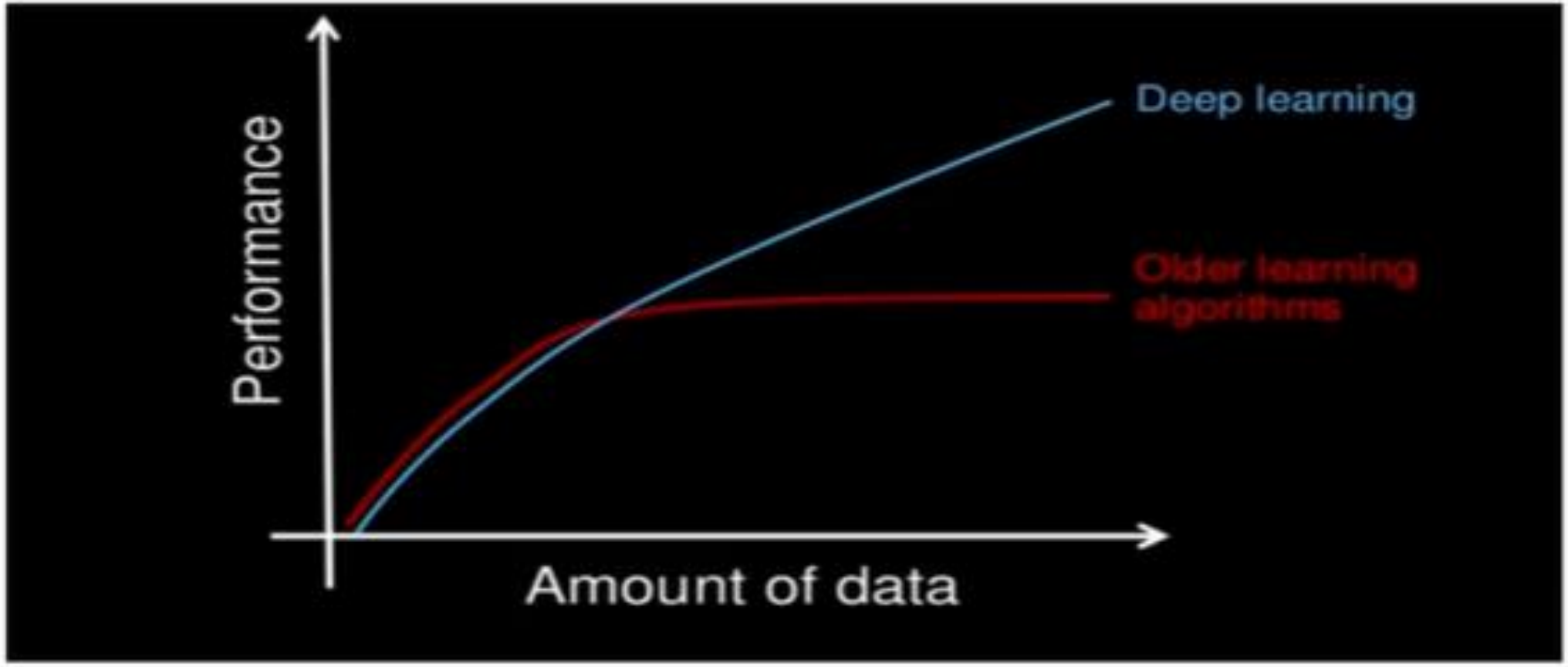
Popularity of Deep Learning?
2. Reduction in Storage Cost

Data

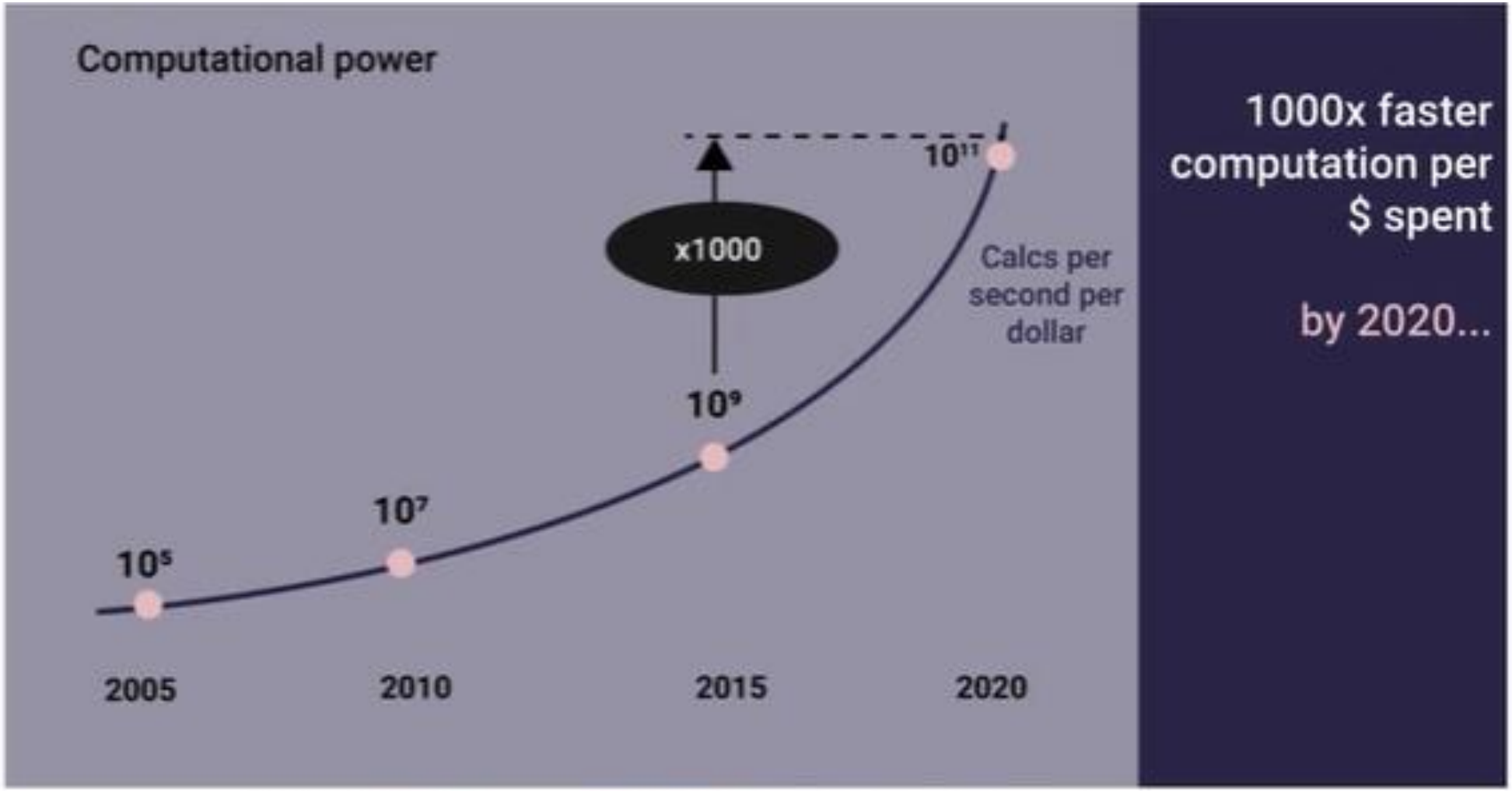


Source: https://fortune.com/2018/09/24/business-strategy-technology-mckinsey/

Popularity of Deep Learning?
3. Works Well with Huge Amount of Data



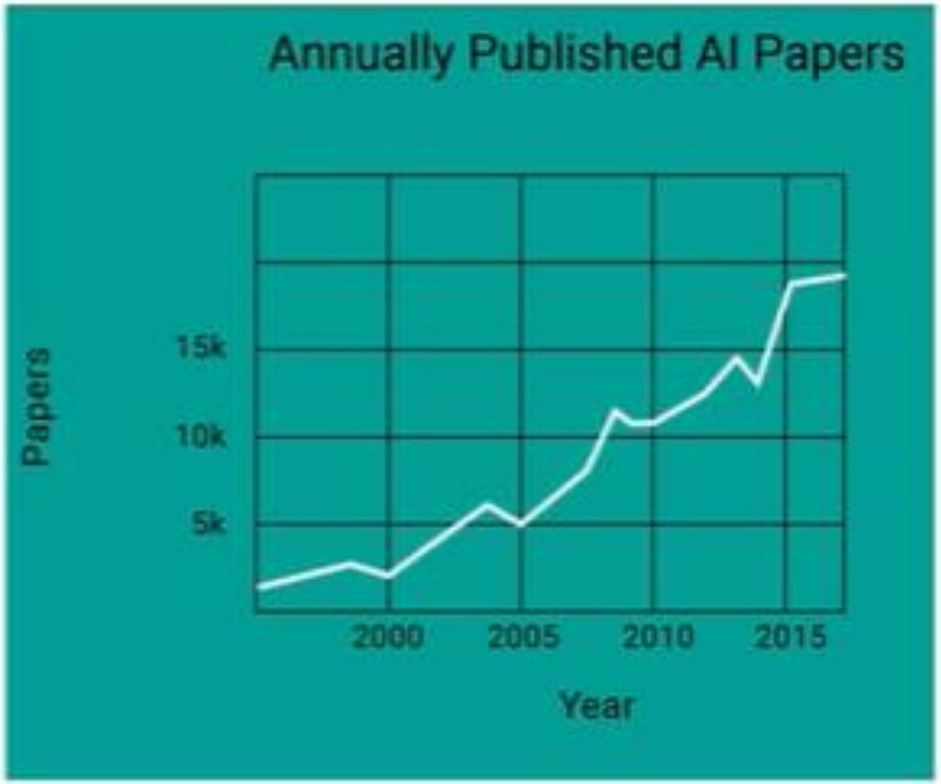
Popularity of Deep Learning?
4. Computational Power : Increased by 1000 times



Source: https://fortune.com/2018/09/24/business-strategy-technology-mckinsey/

Popularity of Deep Learning?
5. More Research

Research

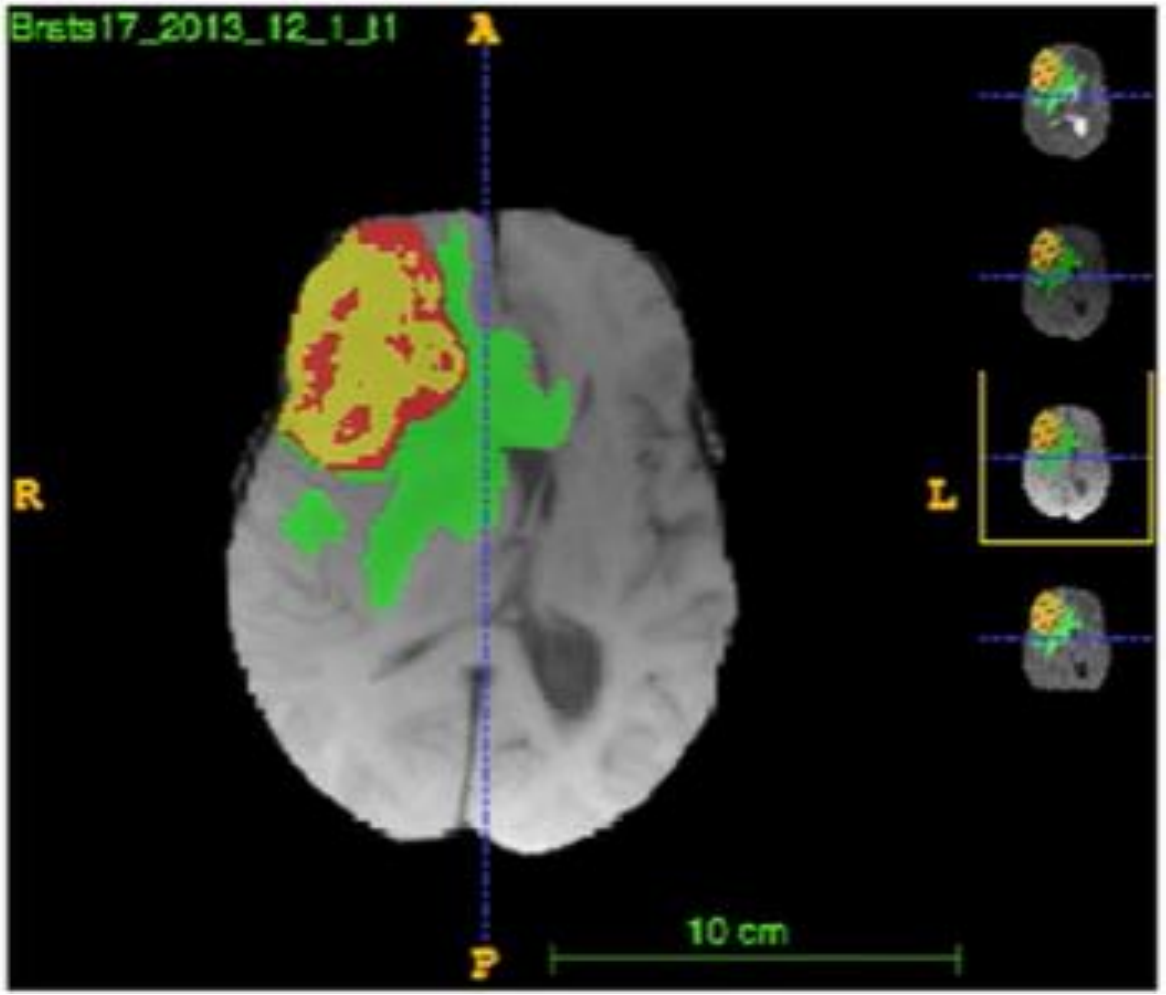


DL Framework

Each of these libraries provide standard ways to build DL models. They come with prebuilt packages to build models faster and quicker.

Applications of Deep Learning : Driver-less Cars

Applications of Deep Learning : Healthcare



Applications of Deep Learning : AI Assistant

Applications of DL

Hardware Requirements for Deep Learning

- A system with the following requirements:
  - I7
  - 8 GB Ram
  - 1 TB of storage
  - 4 GB Nvidia Graphics Card

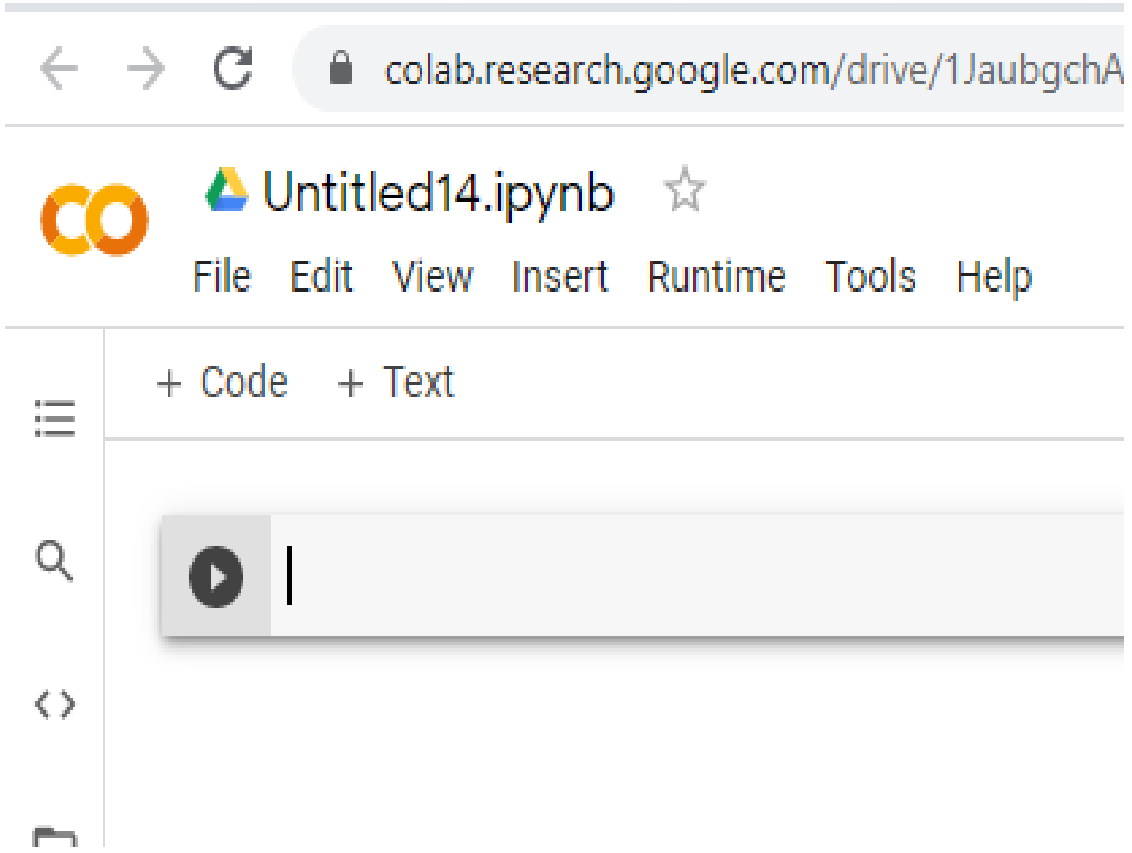
- Other Ways
  - Use Cloud System

Cloud Providers for Deep Learning

- Google Colaboratory (GPU and TPU)
- Kaggle Kernels
- Paperspace
- Vast.AI
- Oracle Cloud
- Amazon Web Services (AWS)
- Microsoft Azure
- Google Cloud Platform (GCP)

Google Colaboratory

- It is a free online cloud based jupyter notebook environment that allows us to train our machine learning and deep learning models and gives flexibility to use CPUs, TPUs and GPUs for free.
- Use this tool to build Deep Learning models
- One can access files / data sets from Google Drive directly by mounting.
- Data Sets can also be accessed from local machines.
- Session restarts after every 12 hours.



Deep Learning models usage

Deep Learning models can be used for a variety of complex tasks:

- Artificial Neural Networks(ANN) for Regression and classification
- Convolutional Neural Networks(CNN) for Computer Vision
- Recurrent Neural Networks(RNN) for Time Series analysis
- Self-organizing maps for Feature extraction
- Deep Boltzmann machines for Recommendation systems
- Auto Encoders for Recommendation systems

References

- Towardsdatascience.com
- Edureka.co
- analyticsvidhya.com
- Medium.com
- Wikipedia