1-Neural Network and Deep Learning
2-Deep Convolution Neural Network

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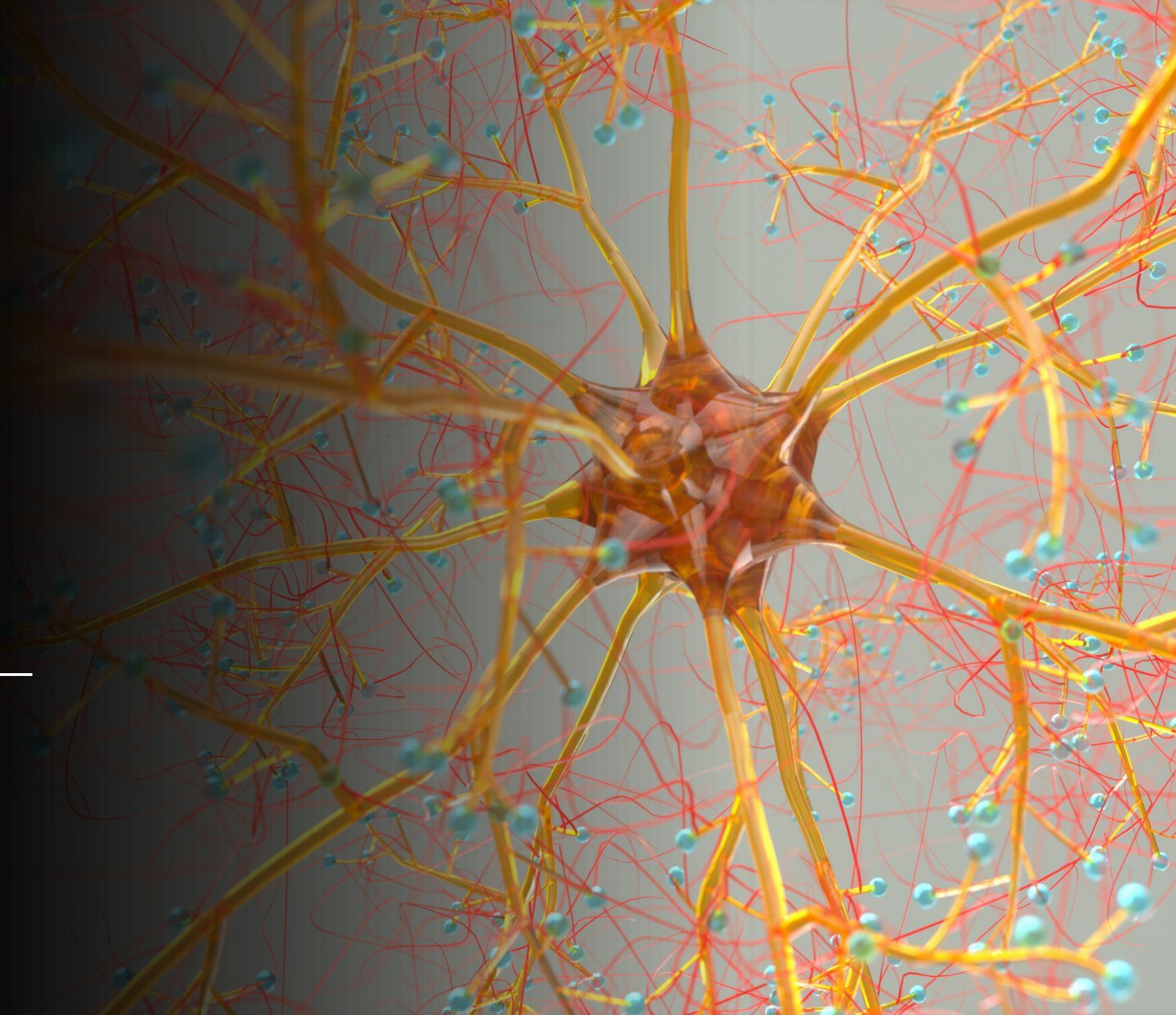


Brief

- Since their inception in the late 1950s, Artificial Intelligence and Machine Learning have come a long way. These technologies have gotten quite complex and advanced in recent years. While technological advancements in the Data Science domain are commendable, they have resulted in a flood of terminologies that are beyond the understanding of the average person.
- There are so many companies of all sizes out there that use these technologies viz. AI and ML in their day-to-day applications. Yet many have trouble distinguishing between their vast terminologies. Most people even use the terms “Machine Learning”, “Deep Learning” and “Artificial Intelligence” interchangeably.
- The reason behind this confusion is that although they have so many different names for different concepts – most of them are deeply entwined with one another and share similarities. Even so, each of these terminologies is quite unique and useful in its own way.

Architecture of Neural Network and Deep Learning

Neural Network

- **Feedforward Neural Networks** – This is the most common type of neural network architecture, with the first layer being the input layer and the last layer being the output layer. All middle layers are hidden layers.
- **Recurrent Neural Network** – This network architecture is a series of ANNs in which connections between nodes form a directed graph along a temporal sequence. Therefore, this type of network exhibits dynamic behavior over time.
- **Symmetrically Connected Neural Networks** – These are like recurrent neural networks, with the only difference being that the connections between units are symmetric in symmetrically connected neural networks (i.e., same weight n both directions).

Deep Learning

- **Unsupervised Pre-Trained Network** – As the name implies, this architecture is pre-trained based on past experiences and does not require formal training. These include A*utoencoders* and *Deep Belief networks*
- **Convolutional Neural Network** – This is a deep learning algorithm that can take an input image, assign meaning to various objects in the image (learnable weights and biases) and distinguish between these objects.
- **Recursive Neural Network** – This is created by recursively applying the same set of weights to a structured input and passing a topological structure to generate a structured prediction over a scalar prediction on a variable-size input structure.

Differences between Neural Network and Deep Learning System

NEURAL NETWORKS

- A neural network is a model of neurons inspired by the human brain. It is made up of many neurons that at inter-connected with each other.
- Neurons
- Connection and weights
- Propagation function
- Learning rate
- It generally takes less time to train them.
- They have a lower accuracy than Deep Learning Systems

Deep Learning

- Deep learning neural networks are distinguished from neural networks based on their depth or number of hidden layers.
- Motherboards
- PSU
- RAM
- Processors
- It generally takes more time to train them.
- They have a higher accuracy than Deep Learning Systems

Introduction to Deep Learning

- Deep Learning is a subset of Artificial Intelligence – a machine learning technique that teaches computers and devices logical functioning. Deep learning gets its name from the fact that it involves going deep into several layers of network, which also includes a hidden layer. The deeper you dive; you more complex information you extract.
- Deep learning methods rely on various complex programs to imitate human intelligence. This particular method teaches machines to recognise motifs so that they can be classified into distinct categories. Pattern recognition is an essential part of deep learning and thanks to machine learning, If appropriately trained computers can successfully imitate human performance and at times, deliver accurate results – the key here is exposure to data. Deep learning focuses on iterative learning methods that expose machines to huge data sets. By doing so, it helps computers pick up identifying traits and adapt to change. Repeated exposure to data sets help machines understand differences, logics and reach a reliable data conclusion. Deep learning has evolved in recent times to become more reliable with complex functions.

Advantages and Disadvantages of Deep Learning

Advantages of Deep Learning

- Ability to generate new features from the limited available training data sets.
- Can work on unsupervised learning techniques helps in generating actionable and reliable task outcomes.
- It reduces the time required for feature engineering, one of the tasks that requires major time in practicing machine learning.
- With continuous training, its architecture has become adaptive to change and is able to work on diverse problems.

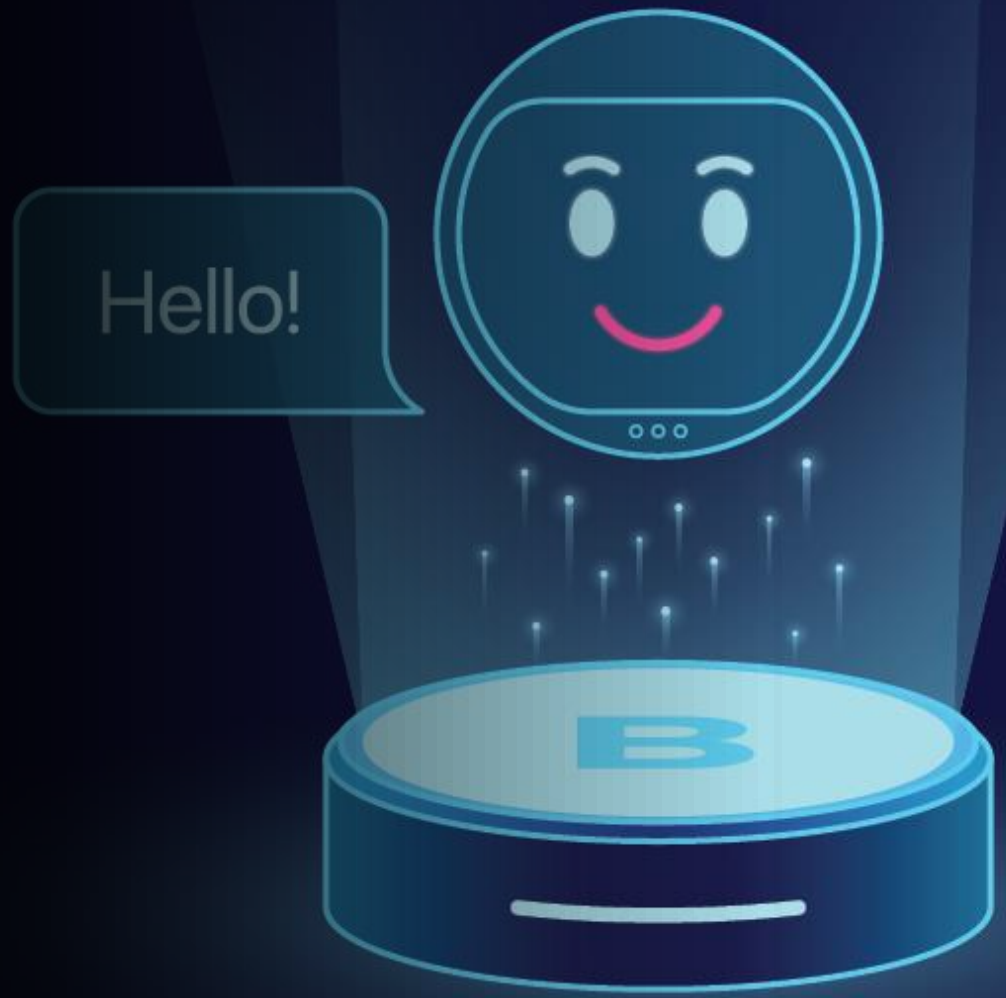
Disadvantages of Deep Learning

- With the increasing popularity, deep learning also has a handful of threats that needs to be addressed:
- The complete training process relies on the continuous flow of the data, which decreases the scope for improvement in the training process.
- The cost of computational training significantly increases with an increase in the number of datasets.
- Lack of transparency in fault revision. No intermediate steps to provide the arguments for a certain fault. In order to resolve the issue, a complete algorithm gets revised.
- Need for expensive resources, high-speed processing units and powerful GPU’s for training the data sets.

Applications of Deep Learning Across Industries

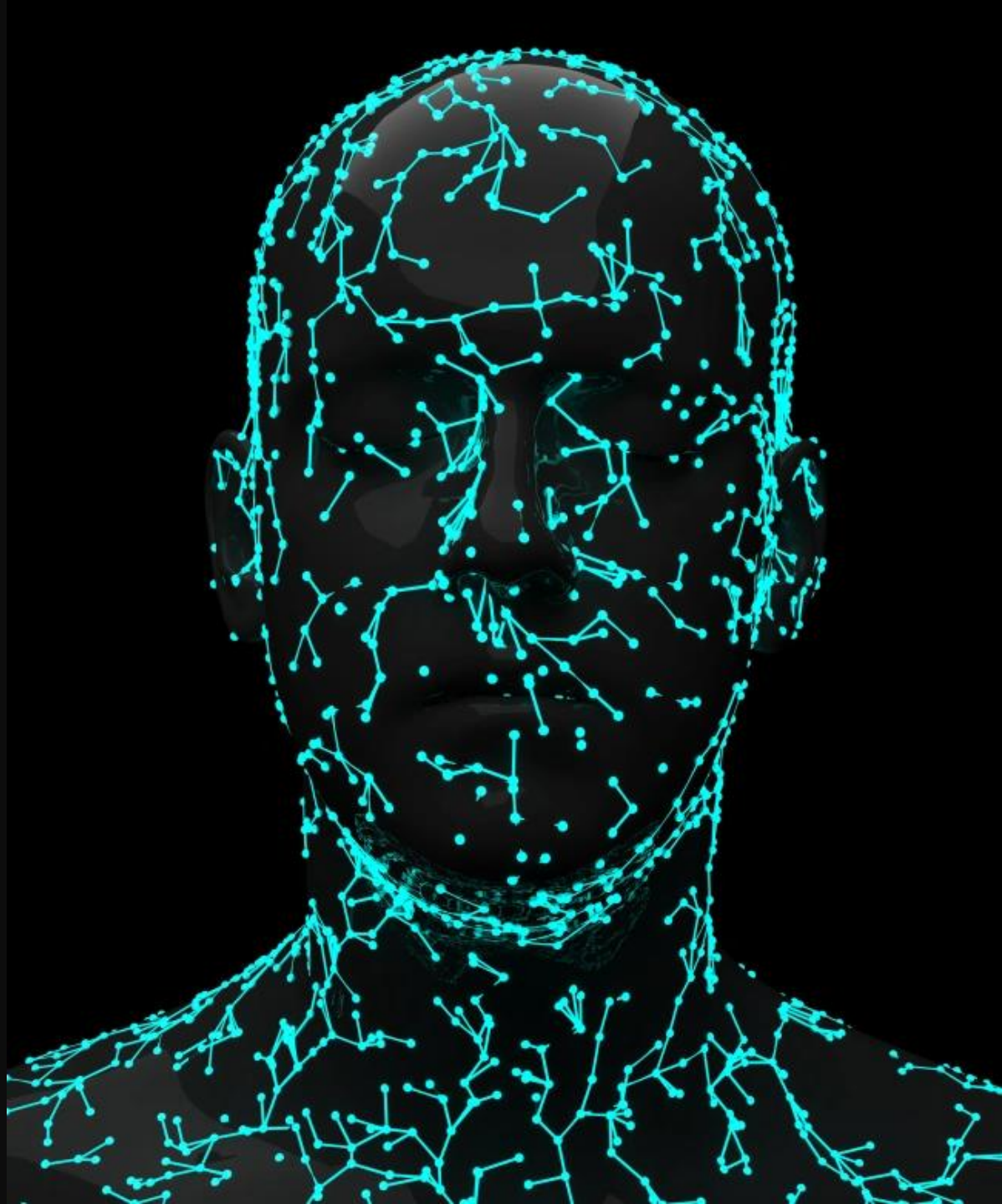
Virtual Assistants

The core functionality that requires translating the speech and language of the human’s speech, is deep learning. The common examples of virtual assistants are Cortana, Siri, and Alexa.



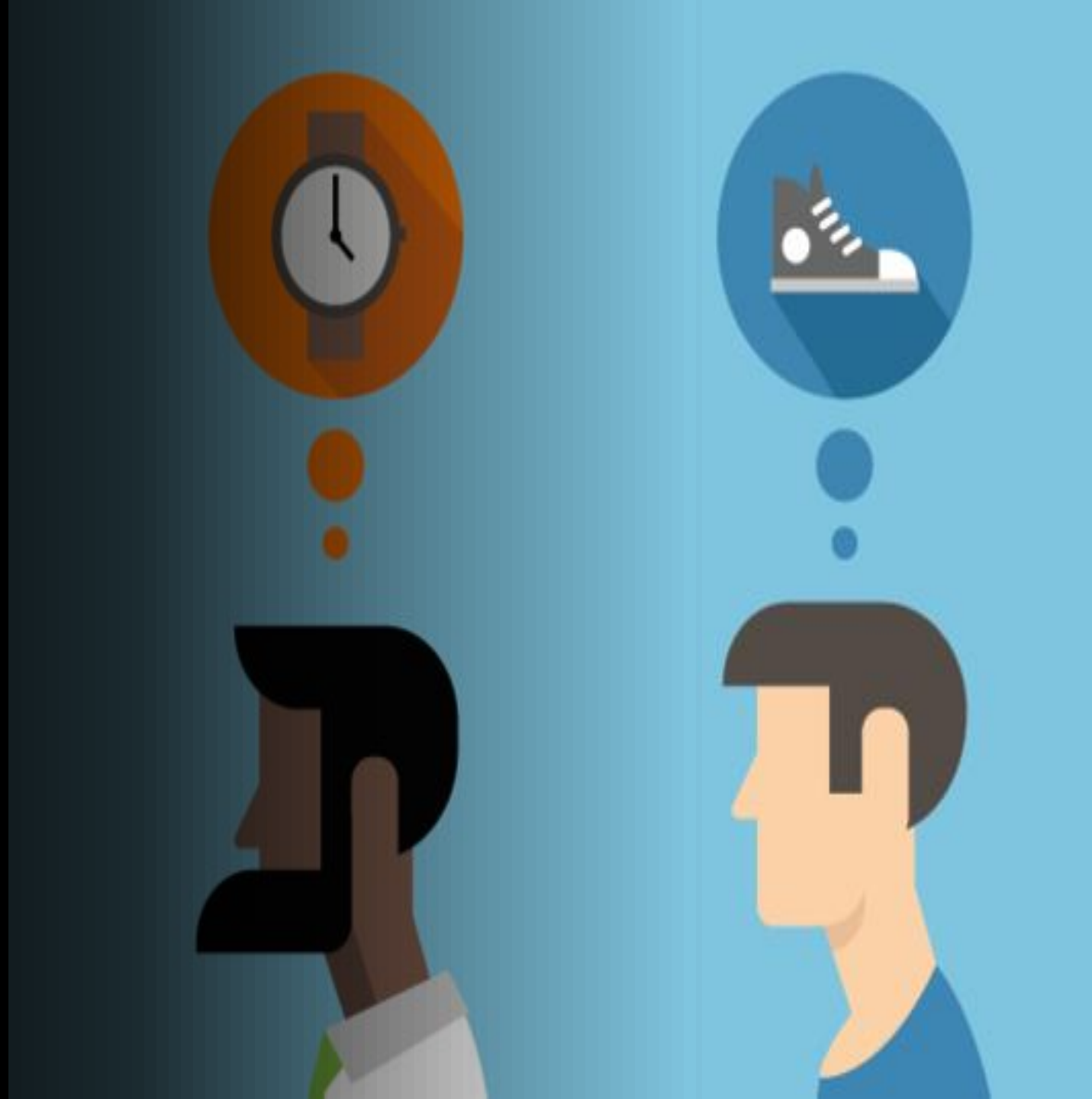
Facial Recognition

The iPhone’s Facial Recognition uses deep learning to identify data points from your face to unlock your phone or spot you in images. Deep Learning helps them protect the phone from unwanted unlocks and making your experience hassle-free even when you have changed your hairstyle, lost weight, or in poor lighting. Every time you unlock your phone, deep learning uses thousands of data points to create a depth map of your face and the inbuilt algorithm uses those to identify if it is really you or not.



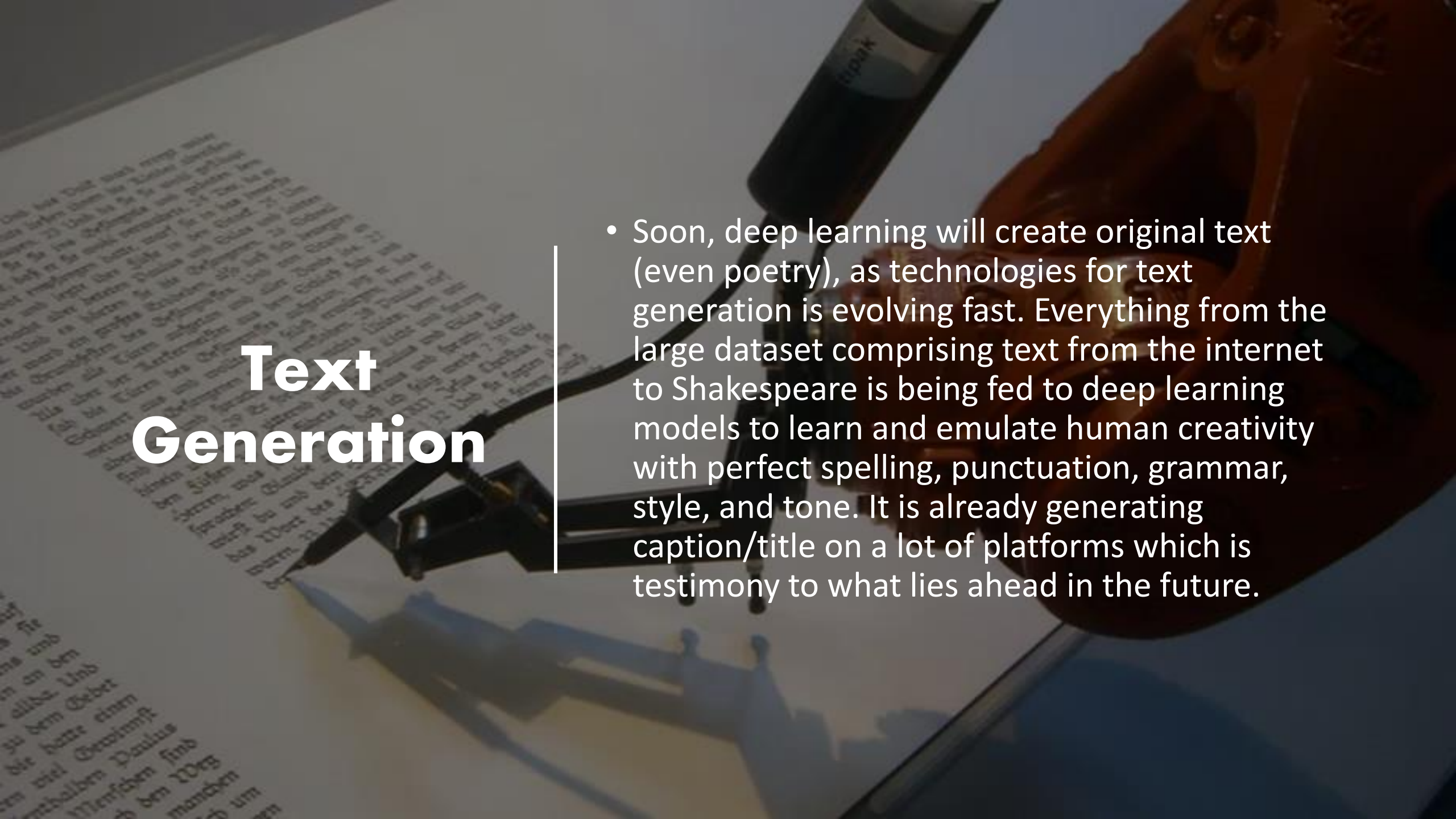
Personalization

E-Commerce and Entertainment giants like Amazon and Netflix, etc. are building their deep learning capacities further to provide you with a personalized shopping or entertainment system. Recommended items/series/movies based on your ‘pattern’ are all based on deep learning. Their businesses thrive on pushing out options in your subconscious based on your preferences, recently visited items, affinity to brands/actors/artists, and overall browsing history on their platforms.



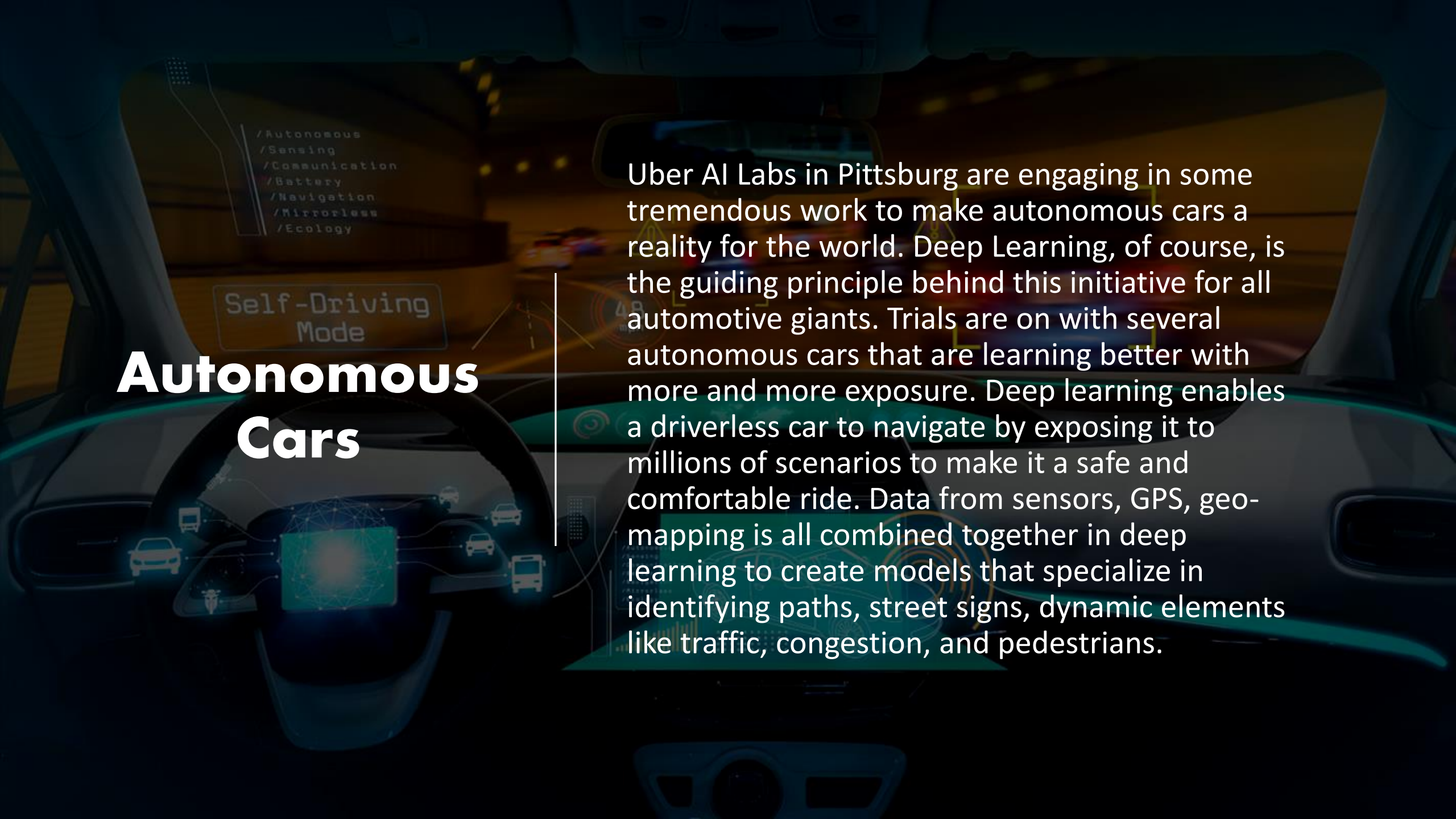
Healthcare

Another sector to have seen tremendous growth and transformation is the healthcare sector. From personal virtual assistants to fitness bands and gears, computers are recording a lot of data about a person’s physiological and mental condition every second. Early detection of diseases and conditions, quantitative imaging, robotic surgeries, and availability of decision-support tools for professionals are turning out to be game-changers in the life sciences, healthcare, and medicine domain.



Text Generation

- Soon, deep learning will create original text (even poetry), as technologies for text generation is evolving fast. Everything from the large dataset comprising text from the internet to Shakespeare is being fed to deep learning models to learn and emulate human creativity with perfect spelling, punctuation, grammar, style, and tone. It is already generating caption/title on a lot of platforms which is testimony to what lies ahead in the future.



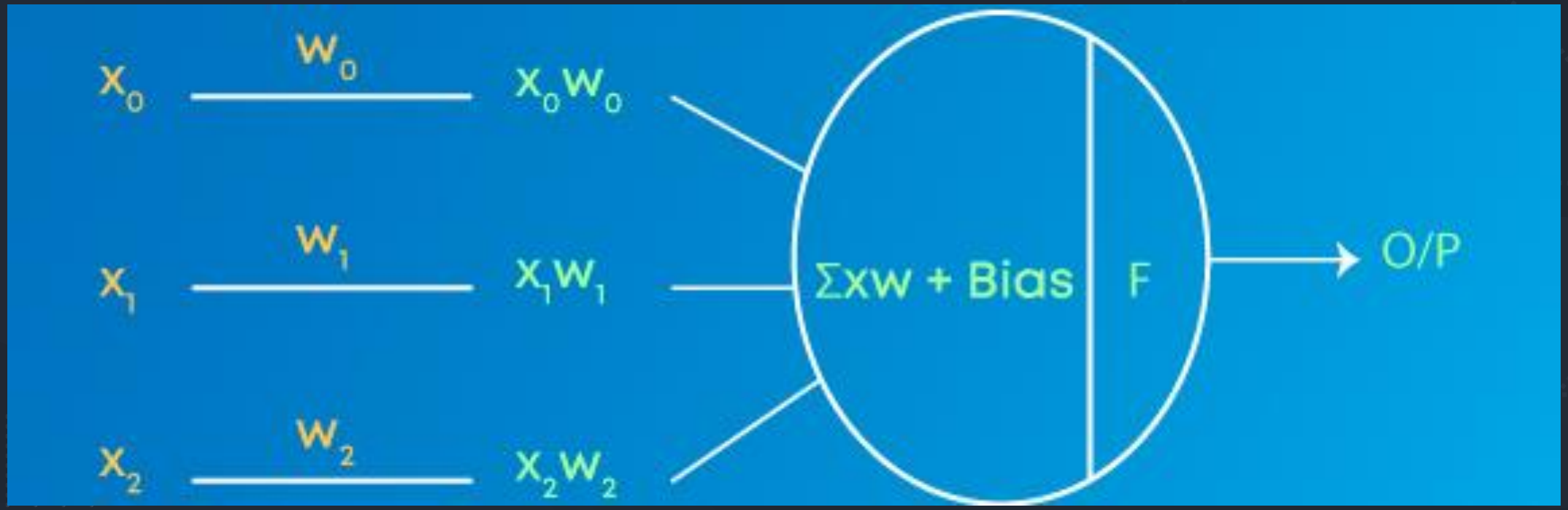
Autonomous Cars

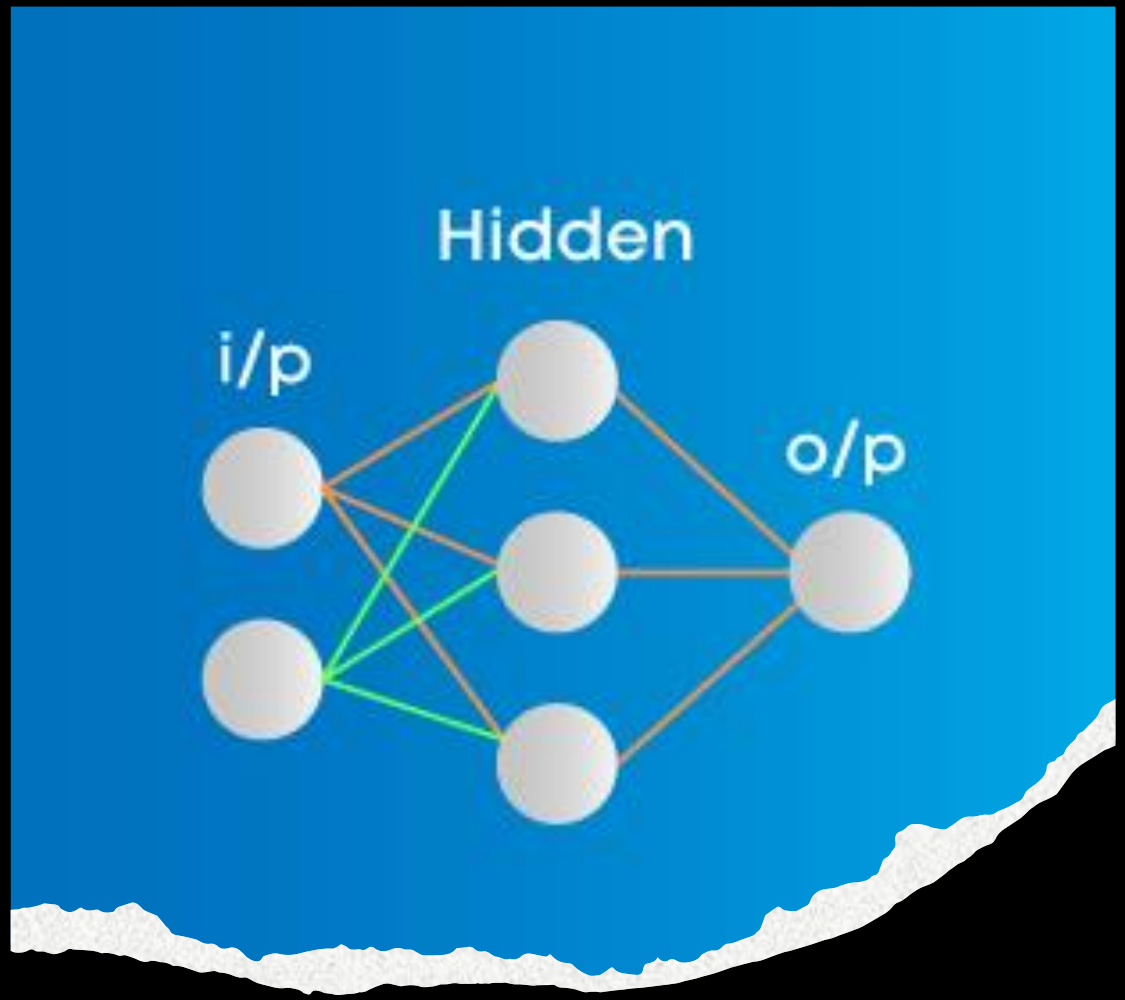
Uber AI Labs in Pittsburg are engaging in some tremendous work to make autonomous cars a reality for the world. Deep Learning, of course, is the guiding principle behind this initiative for all automotive giants. Trials are on with several autonomous cars that are learning better with more and more exposure. Deep learning enables a driverless car to navigate by exposing it to millions of scenarios to make it a safe and comfortable ride. Data from sensors, GPS, geo-mapping is all combined together in deep learning to create models that specialize in identifying paths, street signs, dynamic elements like traffic, congestion, and pedestrians.

Introduction to Artificial Neural Network

Neural networks represent deep learning using artificial intelligence. Artificial neural networks are inspired from the biological neurons within the human body which activate under certain circumstances resulting in a related action performed by the body in response. each neuron receives a multiplied version of inputs and random weights which is then added with static bias value (unique to each neuron layer), this is then passed to an appropriate activation function which decides the final value to be given out of the neuron. There are various activation functions available as per the nature of input values. Once the output is generated from the final neural net layer, loss function (input vs output)is calculated, and backpropagation is performed where the weights are adjusted to make the loss minimum. Finding optimal values of weights is what the overall operation is focusing around.

- **Weights** are numeric values which are multiplied with inputs. In backpropagation, they are modified to reduce the loss. In simple words, weights are machine learnt values from Neural Networks. They self-adjust depending on the difference between predicted outputs vs training inputs.
- **Activation** Function is a mathematical formula which helps the neuron to switch ON/OFF.

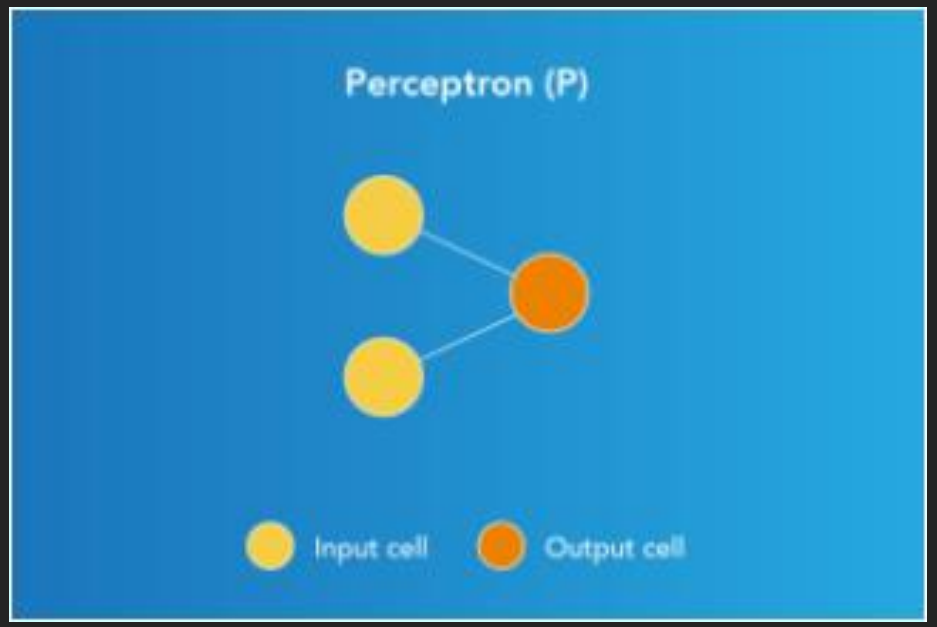


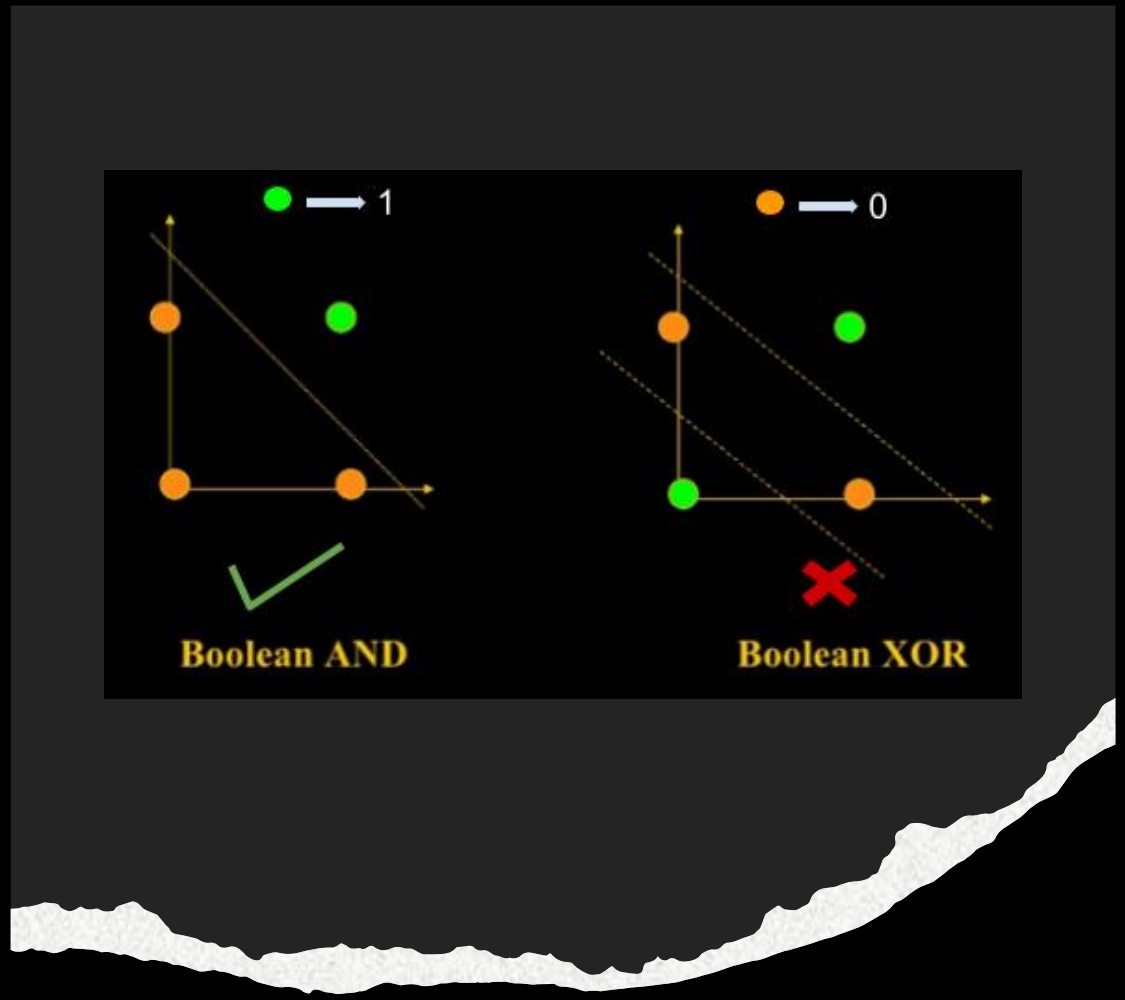


- **Input layer** represents dimensions of the input vector.
- **Hidden layer** represents the intermediary nodes that divide the input space into regions with (soft) boundaries. It takes in a set of weighted input and produces output through an activation function.
- **Output layer** represents the output of the neural network.

Some Types of Neural Networks

- **A. Perceptron:** is one of the simplest and oldest models of Neuron. It is the smallest unit of neural network that does certain computations to detect features or business intelligence in the input data. It accepts weighted inputs and apply the activation function to obtain the output as the result. Perceptron is also known as TLU(threshold logic unit)Perceptron is a supervised learning algorithm. that classifies the data into two categories, thus it is a binary classifier. A perceptron separates the input space into two categories by a hyperplane represented by the following equation $w^T x + b_i = 0$





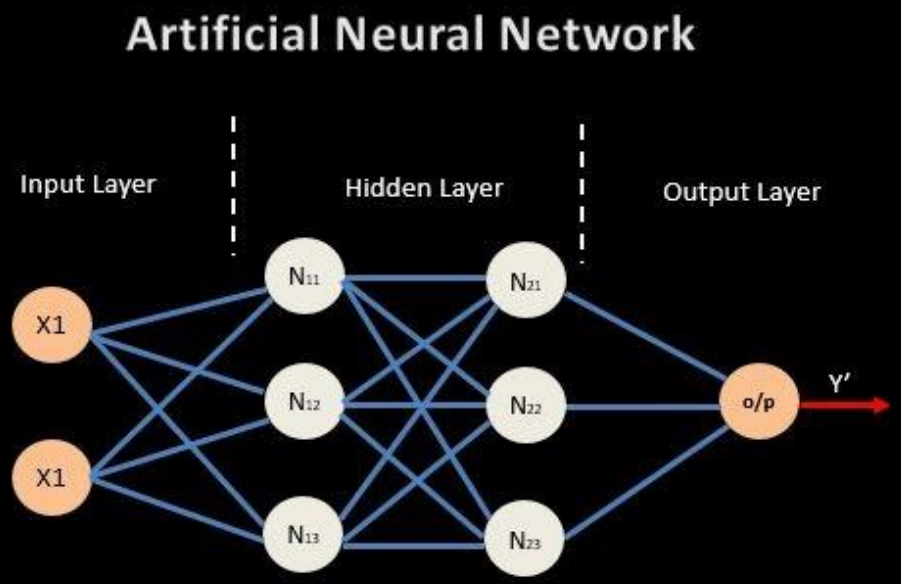
Advantages and Disadvantages

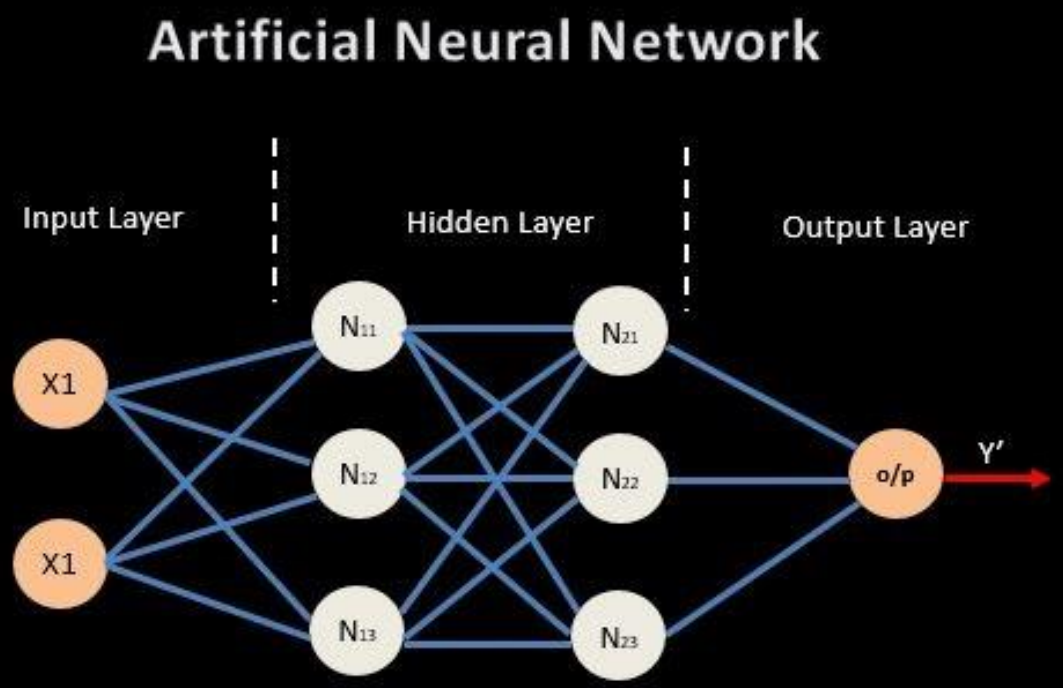
- **Advantages of Perceptron**
Perceptrons can implement Logic Gates like AND, OR, or NAND.
- **Disadvantages of Perceptron**
Perceptrons can only learn linearly separable problems such as boolean AND problem. For non-linear problems such as the boolean XOR problem, it does not work.

Feed Forward Neural Networks

Applications on Feed Forward Neural Networks:

- Simple classification (where traditional Machine-learning based classification algorithms have limitations)
- Face recognition [Simple straight forward image processing]
- Computer vision [Where target classes are difficult to classify]
- Speech Recognition





- The simplest form of neural networks where input data travels in one direction only, passing through artificial neural nodes and exiting through output nodes. Where hidden layers may or may not be present, input and output layers are present there. Based on this, they can be further classified as a single-layered or multi-layered feed-forward neural network.
- Number of layers depends on the complexity of the function. It has uni-directional forward propagation but no backward propagation. Weights are static here. An activation function is fed by inputs which are multiplied by weights. To do so, classifying activation function or step activation function is used. For example: The neuron is activated if it is above threshold (usually 0) and the neuron produces 1 as an output. The neuron is not activated if it is below threshold (usually 0) which is considered as -1. They are fairly simple to maintain and are equipped with to deal with data which contains a lot of noise.

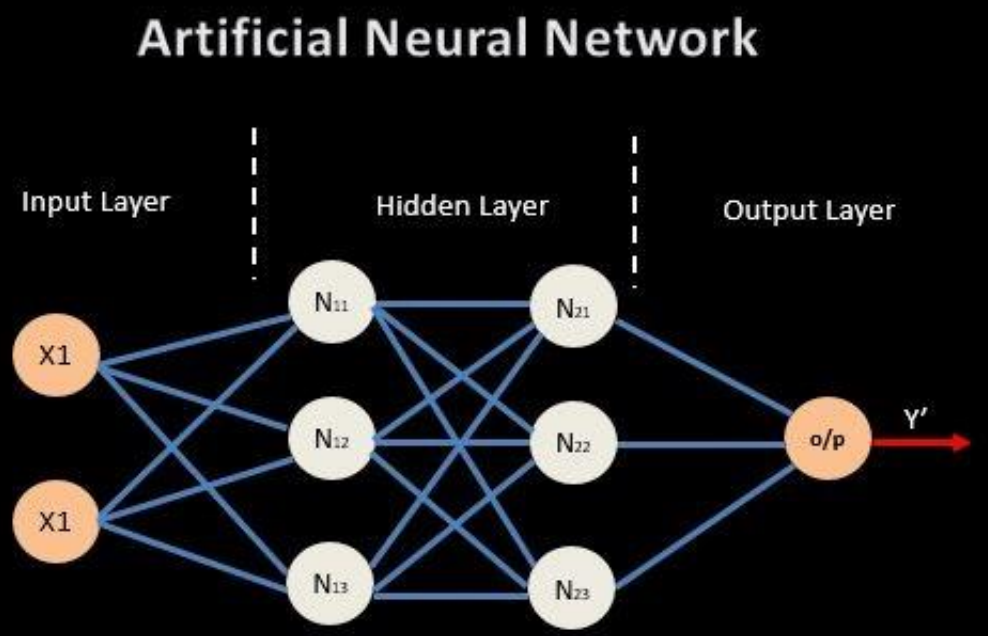
Advantages and Disadvantages of Feed Forward Neural Networks

Advantages of Feed Forward Neural Networks

- Less complex, easy to design & maintain
- Fast and speedy [One-way propagation]
- Highly responsive to noisy data

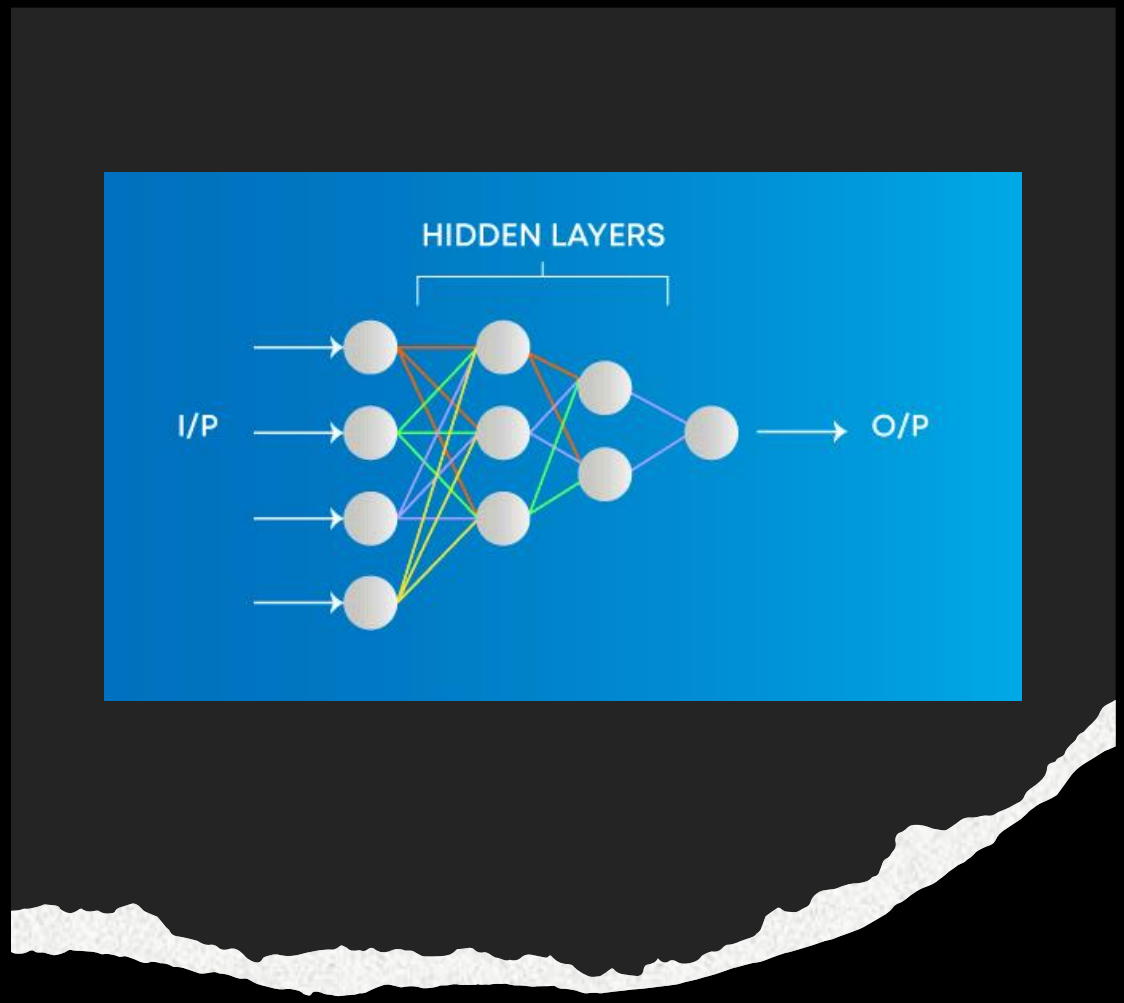
Disadvantages of Feed Forward Neural Networks:

- Cannot be used for deep learning [due to absence of dense layers and back propagation]



Multilayer Perceptron

An entry point towards complex neural nets were input data travels through various layers of artificial neurons. Every single node is connected to all neurons in the next layer which makes it a fully connected neural network. Input and output layers are present having multiple hidden Layers i.e., at least three or more layers in total. It has a bi-directional propagation i.e., forward propagation and backward propagation. Inputs are multiplied with weights and fed to the activation function and in backpropagation, they are modified to reduce the loss. In simple words, weights are machine learnt values from Neural Networks. They self-adjust depending on the difference between predicted outputs vs training inputs. Nonlinear activation functions are used followed by SoftMax as an output layer activation function.



Applications on Multi-Layer Perceptron

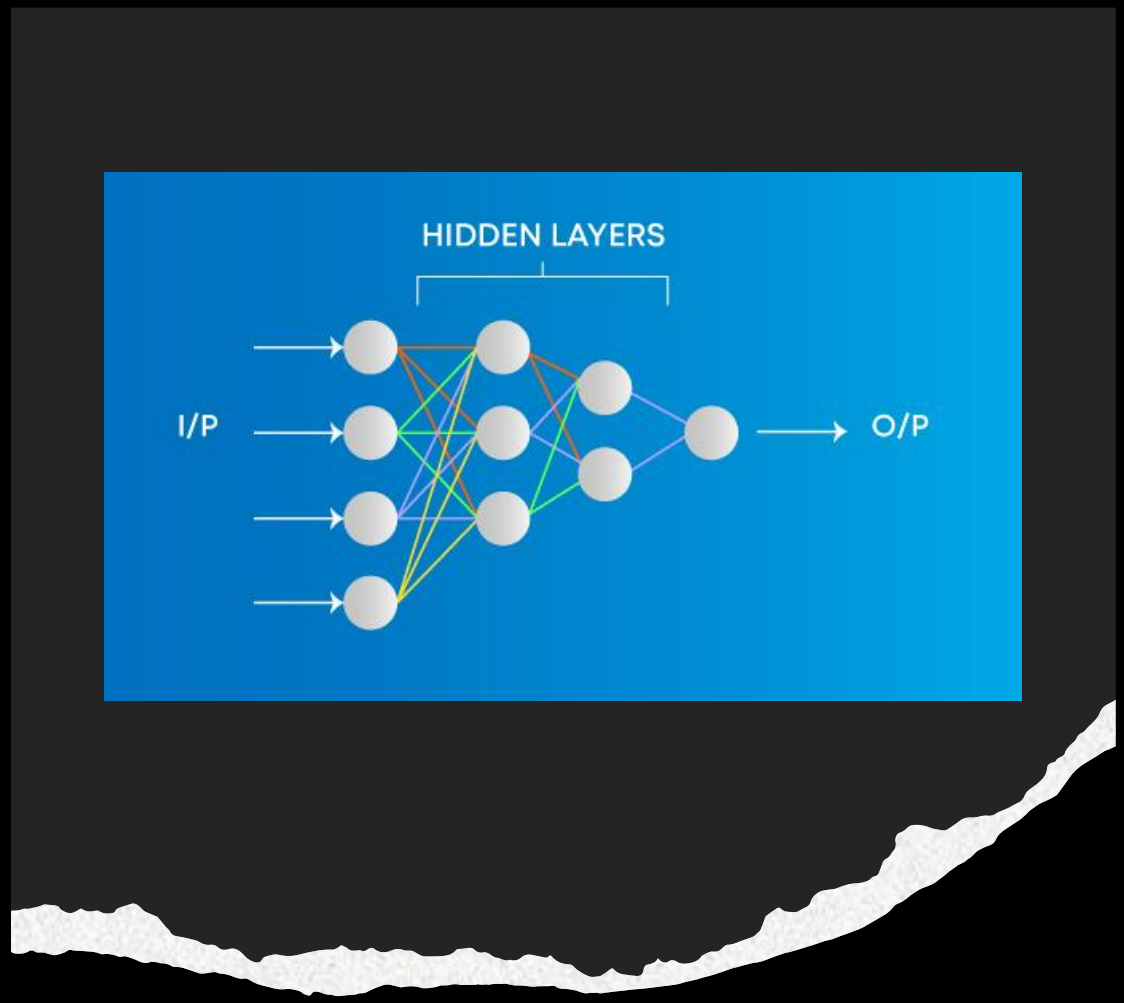
-Speech Recognition
-Machine Translation
-Complex Classification

Advantages on Multi-Layer Perceptron

- Used for deep learning [due to the presence of dense fully connected layers and back propagation]

Disadvantages on Multi-Layer Perceptron:

- Comparatively complex to design and maintain
- Comparatively slow (depends on number of hidden layers)



What are Deep Convolutional Neural Networks?

Deep learning is a machine learning technique used to build artificial intelligence (AI) systems. It is based on the idea of artificial neural networks (ANN), designed to perform complex analysis of large amounts of data by passing it through multiple layers of neurons.

There is a wide variety of deep neural networks (DNN). Deep convolutional neural networks (CNN or DCNN) are the type most commonly used to identify patterns in images and video. DCNNs have evolved from traditional artificial neural networks, using a three-dimensional neural pattern inspired by the visual cortex of animals.

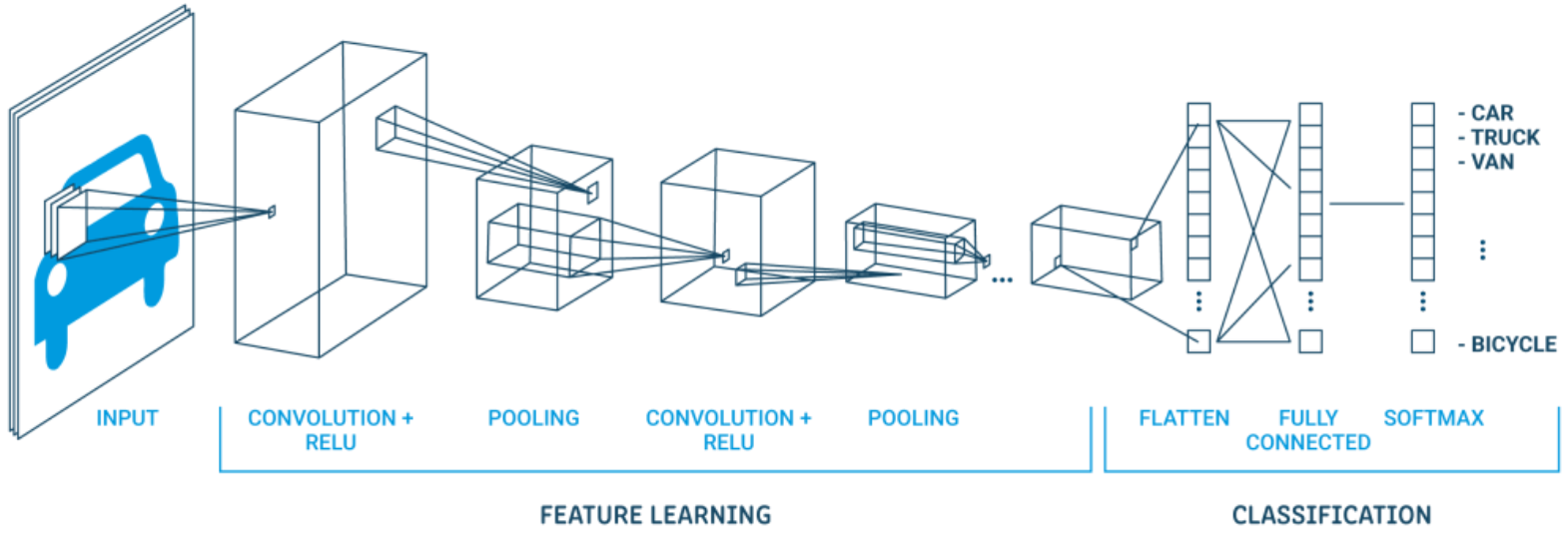
Deep convolutional neural networks are mainly focused on applications like object detection, image classification, recommendation systems, and are also sometimes used for natural language processing.

Deep Convolutional Neural Networks Explained

The strength of DCNNs is in their layering. A DCNN uses a three-dimensional neural network to process the Red, Green, and Blue elements of the image at the same time. This considerably reduces the number of artificial neurons required to process an image, compared to traditional feed forward neural networks.

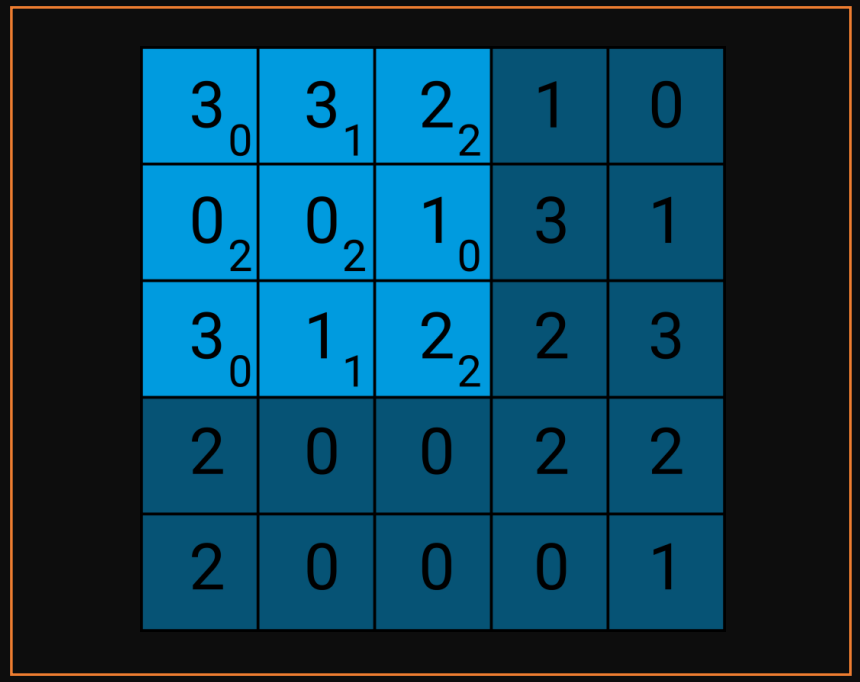
Deep convolutional neural networks receive images as an input and use them to train a classifier. The network employs a special mathematical operation called a “convolution” instead of matrix multiplication.

The architecture of a convolutional network typically consists of four types of layers: **convolution**, **pooling**, **activation**, and **fully connected**.



Convolutional Layer

- Applies a convolution filter to the image to detect features of the image. Here is how this process works:
- **A convolution**—takes a set of weights and multiplies them with inputs from the neural network.
- **Kernels or filters**—during the multiplication process, a kernel (applied for 2D arrays of weights) or a filter (applied for 3D structures) passes over an image multiple times. To cover the entire image, the filter is applied from right to left and from top to bottom.
- **Dot or scalar product**—a mathematical process performed during the convolution. Each filter multiplies the weights with different input values. The total inputs are summed, providing a unique value for each filter position.



ReLU Activation Layer

- The convolution maps are passed through a nonlinear activation layer, such as Rectified Linear Unit (ReLu), which replaces negative numbers of the filtered images with zeros.

Fully Connected Layer

- In many CNN architectures, there are multiple fully connected layers, with activation and pooling layers in between them. Fully connected layers receive an input vector containing the flattened pixels of the image, which have been filtered, corrected and reduced by convolution and pooling layers. The softmax function is applied at the end to the outputs of the fully connected layers, giving the probability of a class the image belongs to – for example, is it a car, a boat or an airplane.

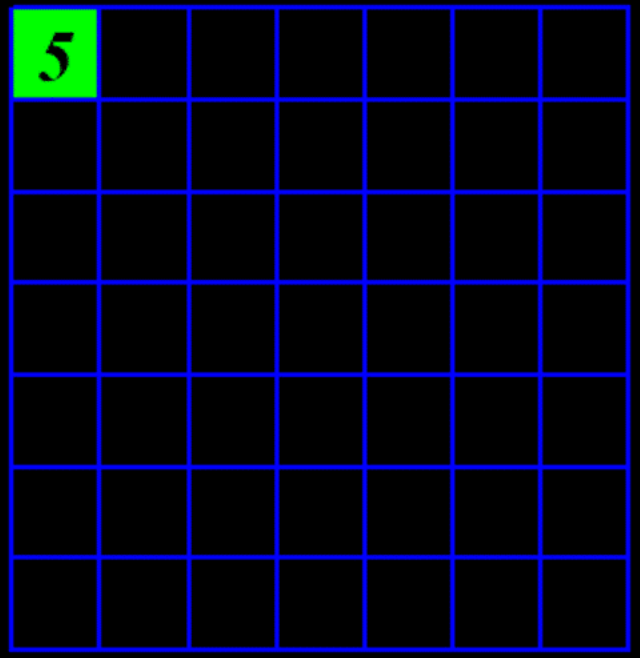
Pooling Layer

- The pooling layers gradually reduce the size of the image, keeping only the most important information. For example, for each group of 4 pixels, the pixel having the maximum value is retained (this is called max pooling), or only the average is retained (average pooling).
- Pooling layers help control overfitting by reducing the number of calculations and parameters in the network.
- After several iterations of convolution and pooling layers (in some deep convolutional neural network architectures this may happen thousands of times), at the end of the network there is a traditional multi layer perceptron or “fully connected” neural network.

Feature Map

5	7	3	10	5	6	5
10	5	7	10	8	15	5
5	6	4	5	8	8	7
13	5	12	4	10	4	15
-2	13	5	5	6	8	-1
13	3	7	4	5	10	5
9	8	9	12	4	9	8

RELU activation



What are the Types of Deep Convolutional Neural Networks?

R-CNN

- Region-based Convolutional Neural Network (R-CNN), is a network capable of accurately extracting objects to be identified in the image. However, it is very slow in the scanning phase and in the identification of regions.
- The poor performance of this architecture is due to its use of the selective search algorithm, which extracts approximately 2000 regions of the starting image. Afterwards it executes N CNNs on top of each region, whose outputs are fed to a support vector machine (SVM) to classify the region.

Fast R-CNN

- Fast R-CNN is a simplified R-CNN architecture, which can also identify regions of interest in an image but runs a lot faster. It improves performance by extracting features before it identifies regions of interest. It uses only one CNN for the entire image, instead of 2000 CNN networks on each superimposed region. Instead of the SVM which is computationally intensive, a softmax function returns the identification probability. The downside is that Fast R-CNN has lower accuracy than R-CNN in terms recognition of the bounding boxes of objects in the image.

What are the Types of Deep Convolutional Neural Networks?

GoogleNet (2014)

- GoogleNet, also called Inception v1, is a large-scale CNN architecture which won the ImageNet Challenge in 2014. It achieved an error rate of less than 7%, close to the level of human performance. The architecture consists of a 22-layer deep CNN based on small convolutions, called “inceptions”, batch normalization, and other techniques to decrease the number of parameters from tens of millions in previous architectures to four million.

VGGNet (2014)

- A deep convolutional neural network architecture with 16 convolutional layers. It uses 3x3 convolutions and trained on 4 GPUs for more than two weeks to achieve its performance. The downside of VGGNet is that unlike GoogleNet, it has 138 million parameters, making it difficult to run in the inference stage.

ResNet (2015)

- The Residual Neural Network (ResNet) is a CNN with up to 152 layers. ResNet uses “gated units”, to skip some convolutional layers. Like GoogleNet, it uses heavy batch normalization. ResNet uses an innovative design which lets it run many more convolutional layers without increasing complexity. It participated in the ImageNet Challenge 2015, achieving an impressive error rate of 3.57%, while beating human-level performance on the trained dataset.

Business Applications of Convolutional Neural Networks

1-Image Classification

- Deep convolutional neural networks are the state-of-the-art mechanism for classifying images. For example, they are used to:

Tag images—an image tag is a word or combination of words that describes an image and makes it easier to find. Google, Facebook and Amazon use this technology. Labeling includes identifying objects and even analyzing the sentiment of the image.

Visual search—matching the input image with an available database. Visual search analyzes the image and searches for an existing image with the identified information. For example, Google search uses this technique to find different sizes or colors of the same product.

Recommendation engines—using CNN image recognition to provide product recommendations, for example in websites like Amazon. The engine analyzes user preferences and returns products whose images match previous products they viewed or bought, for example, a red dress or red shoes with red lipstick.

2-Medical Image Analysis

- CNN classification on medical images is more accurate than the human eye and can detect abnormalities in X-ray or MRI images. Such systems can analyze sequences of images (for examples, tests taken over a long period of time) and identify subtle differences that human analysts might miss. This also makes it possible to perform predictive analysis.
- Classification models for medical images are trained on large public health databases. The resulting models can be used on patient test results, to identify medical conditions and automatically generate a prognosis.

3-Optical Character Recognition

- Optical character recognition (OCR) is used to identify symbols such as text or numbers in images. Traditionally OCR was performed using statistical or early machine learning techniques, but today many OCR engines use deep convolutional neural networks.
- OCR powered by CNNs can be used to improve search within rich media content, and identify text in written documents, even those with poor quality or hard to recognize handwriting. This is especially important in the banking and insurance industries. Another application of deep learning OCR is for automated signature recognition.

Thank You