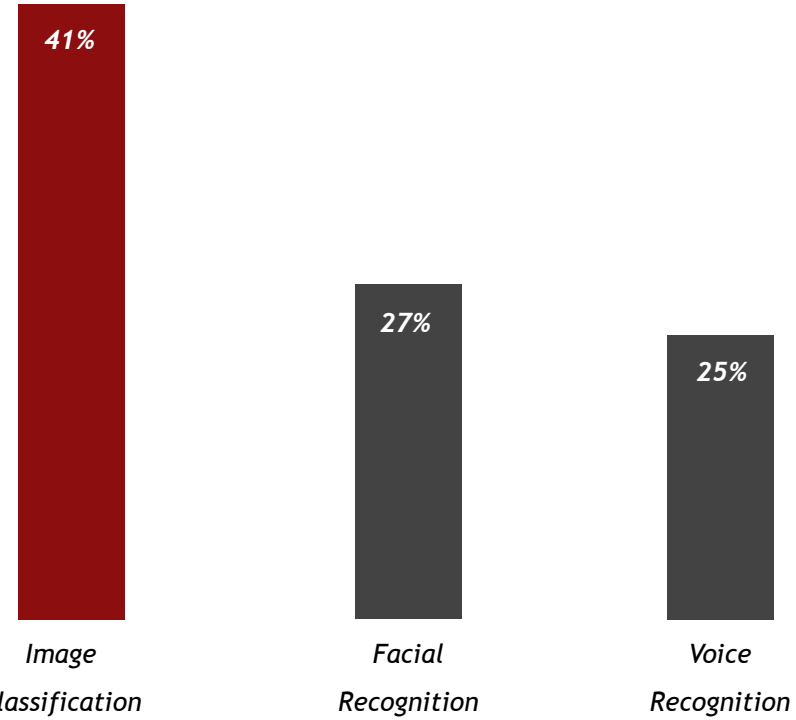
Deep Learning

Just enough AI Fundamentals for Generative AI

Deep Learning

Deep Learning often outperforms traditional ML methods

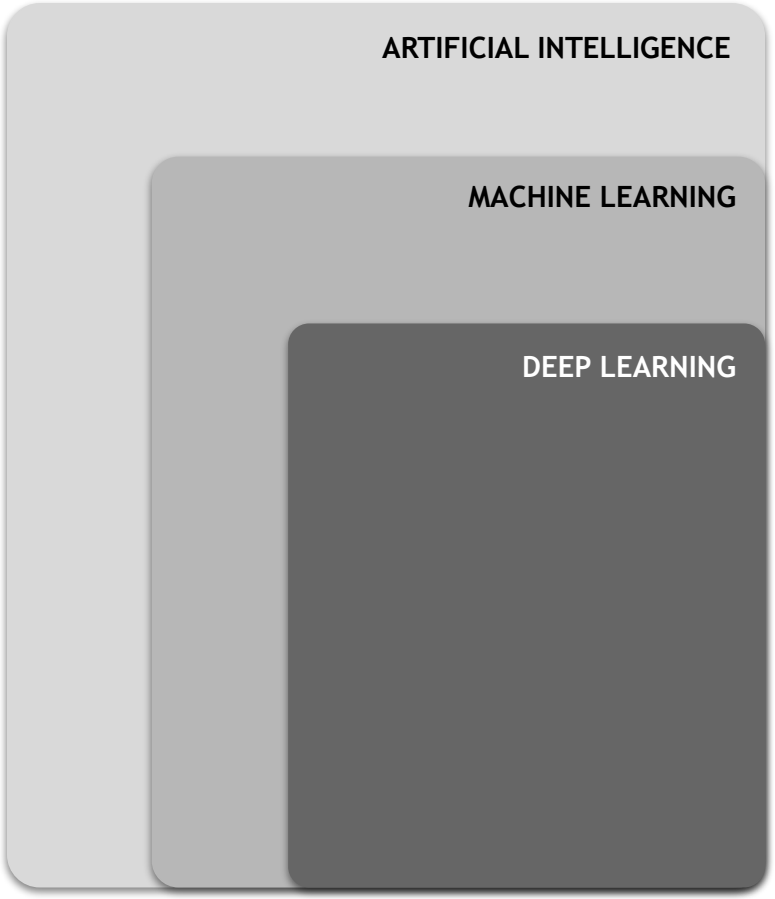
% reduction in error rate achieved by deep learning vs. traditional ML methods



Source: Mckinsey

Deep Learning can find complex patterns from the data and produce more accurate results than traditional ML approaches

Deep Learning

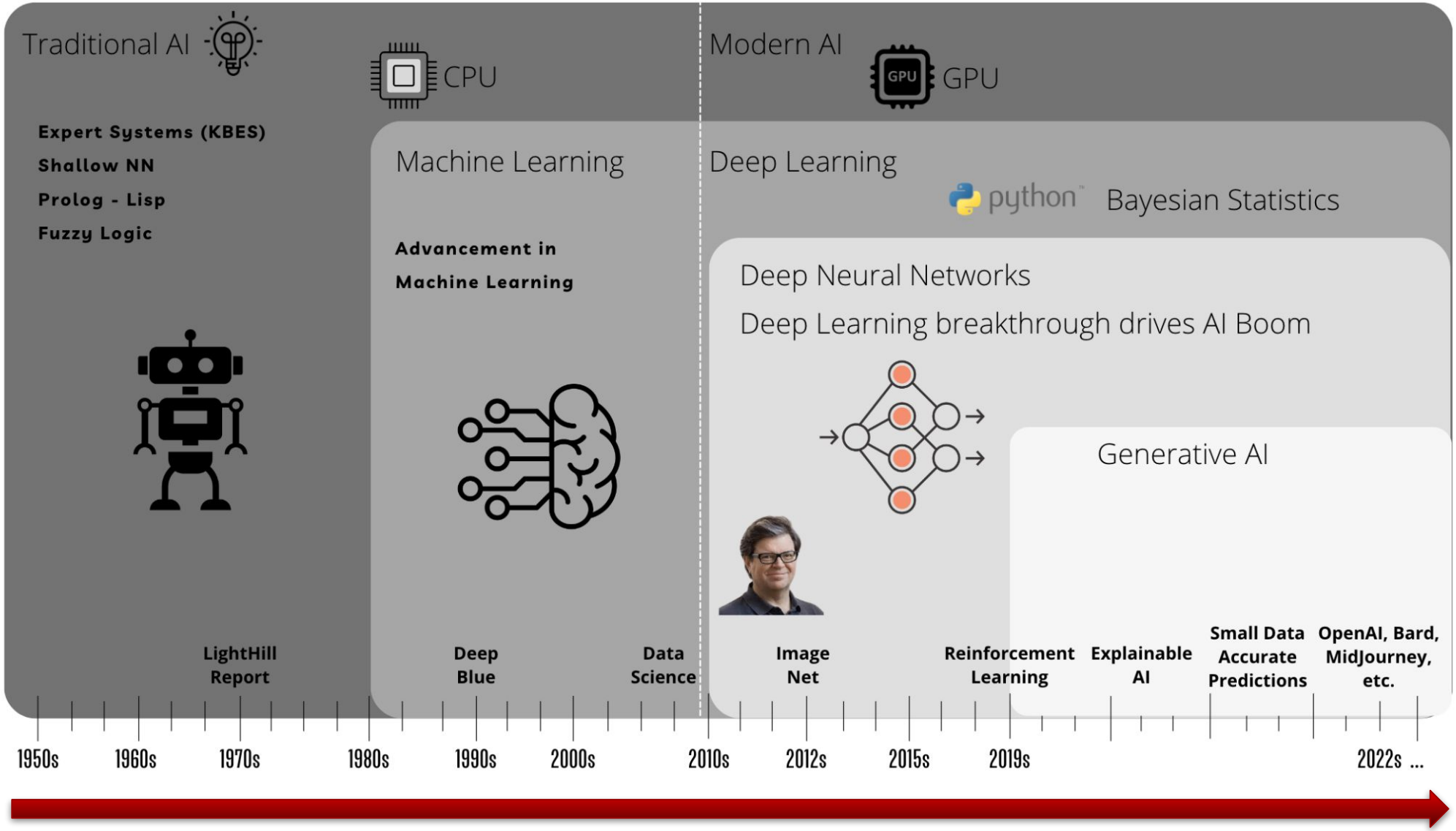


1956 Class of problems we can solve when ***computers think/act like humans***

1997 ***Make predictions*** based on relationships inferred from historical data

2012 A ML Technique in which a layer of ***neural networks are used to process data***

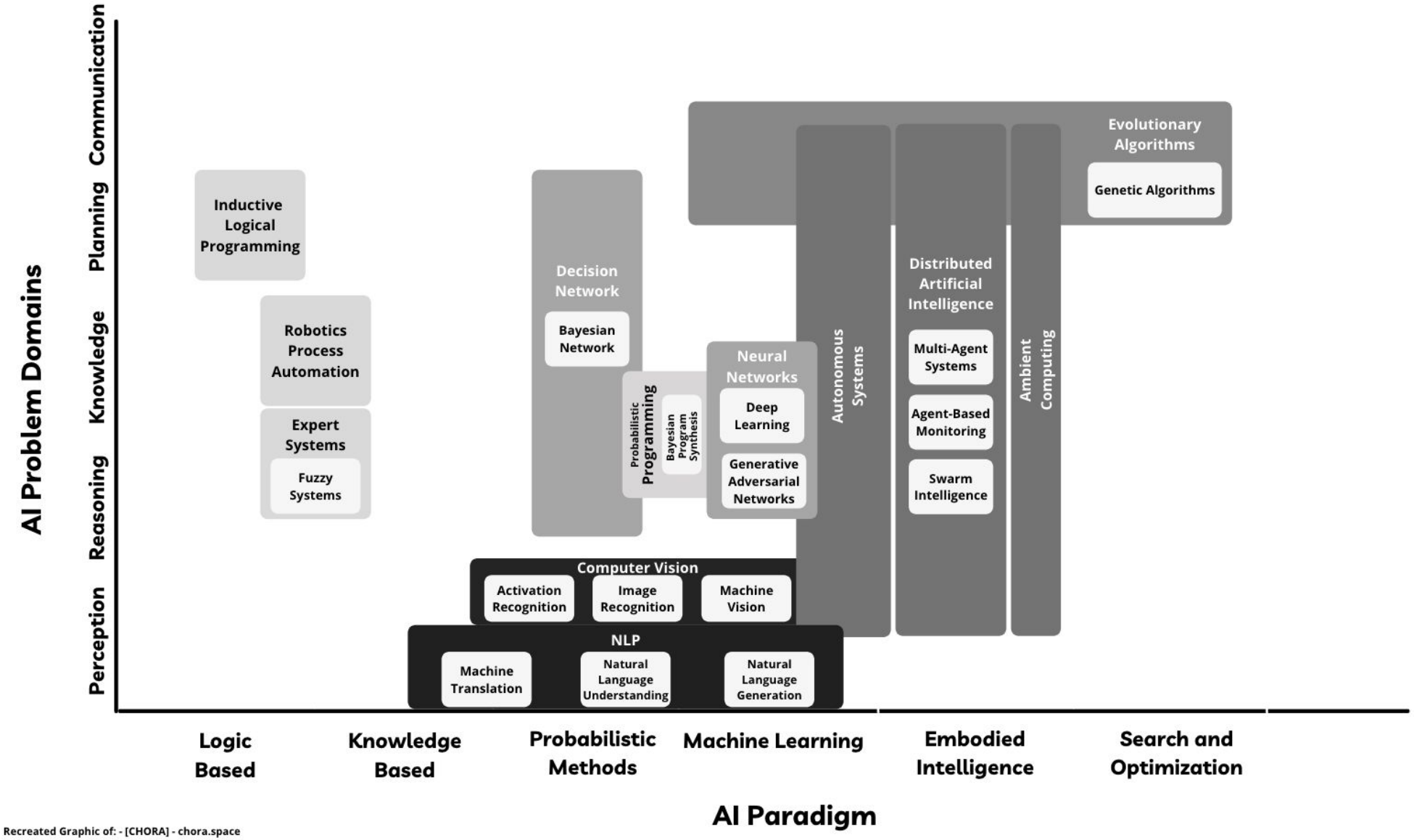
History of Deep Learning



Source: awaisbajwa.medium.com

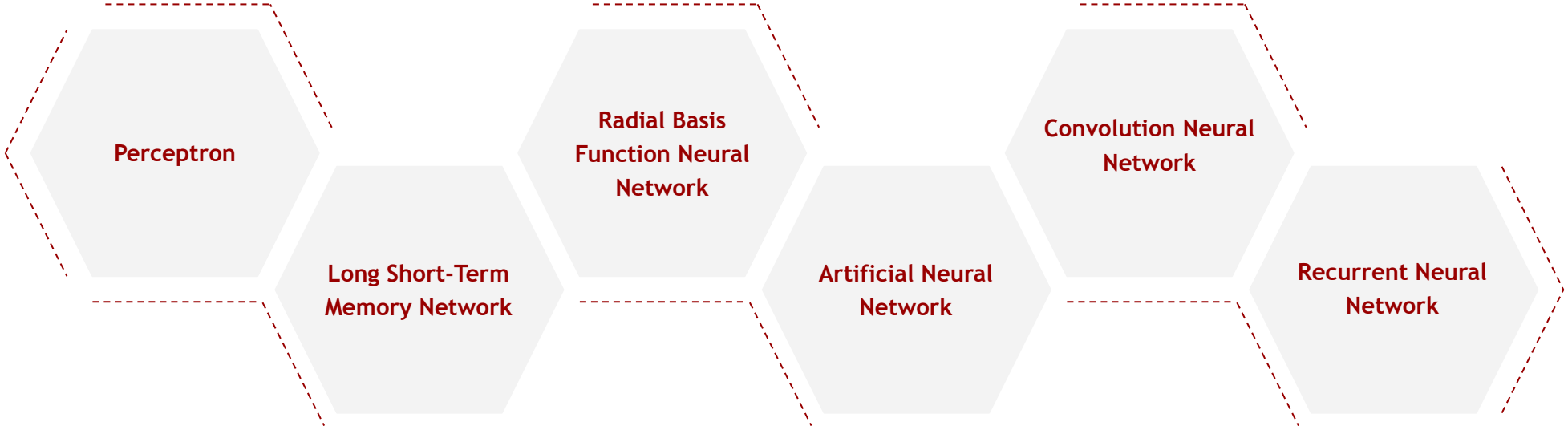
Taxonomy of AIML

Scope of Artificial Intelligence is vast & Machine Learning is not the only way of achieving Artificial Intelligence



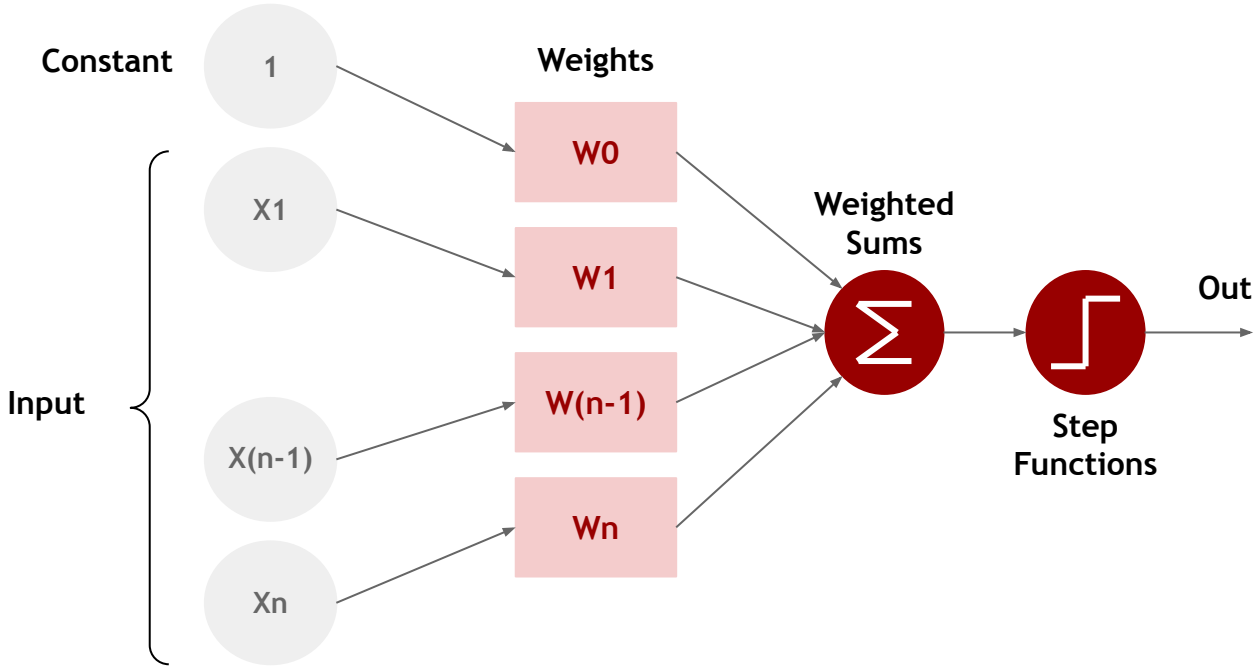
Recreated Graphic of: - [CHORA] - chora.space

Types of Deep Learning Algorithms



Perceptron

- The perceptron is a fundamental type of neural network used for binary classification tasks
- It consists of a single layer of artificial neurons that take input values, apply weights, and generate an output
- It finds applications in pattern recognition, image classification, and linear regression
- However, the perceptron has limitations in handling complex data that is not linearly separable



Applications of Perceptron

Image Classification

Perceptrons can be used for binary image classification tasks, such as identifying whether an image contains a specific object

Linear Regression

Perceptrons can be employed for solving linear regression problems, where the goal is to predict a continuous output based on input features.

Challenges with Perceptron

Limited to Linear Separability

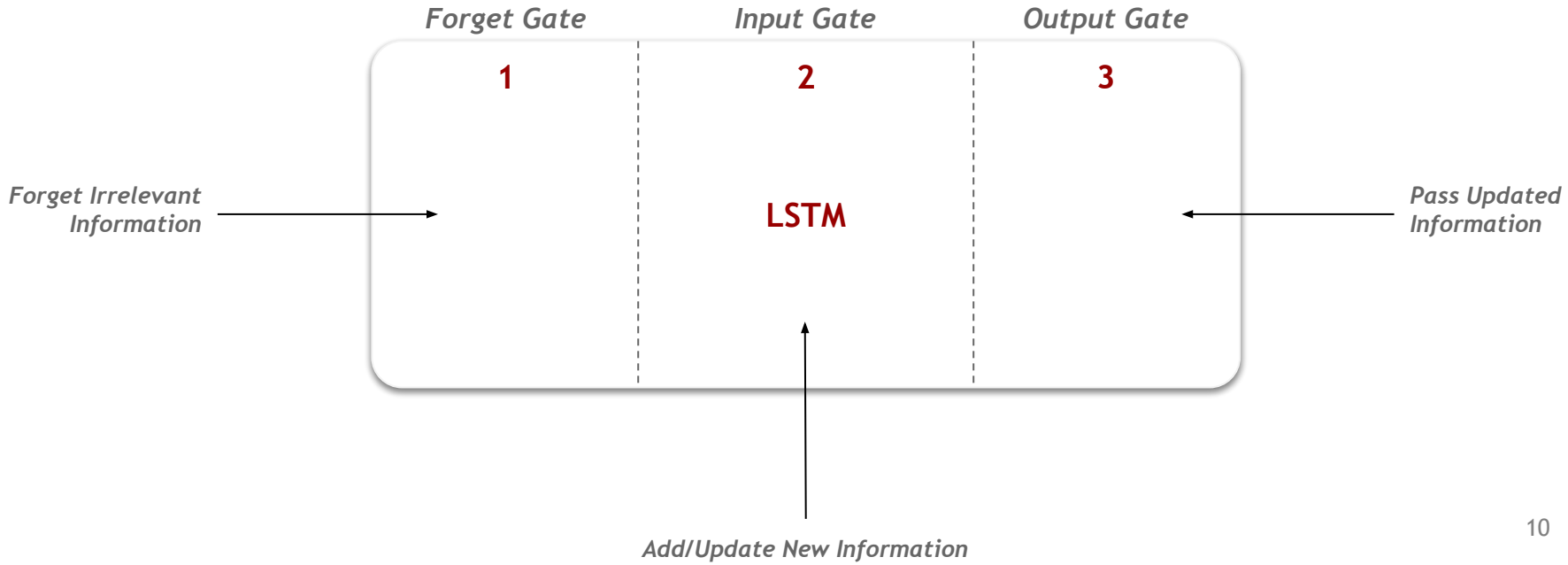
Perceptrons struggle with handling data that is not linearly separable, as they can only learn linear decision boundaries

Lack of Depth

Perceptrons are a single layer and cannot learn complex hierarchical representations

Long Short-Term Memory (LSTM) Network

- LSTM networks are a type of recurrent neural network (RNN) designed to capture long-term dependencies in sequential data
- Unlike traditional feedforward networks, LSTM networks have memory cells and gates that allow them to retain or forget information over time selectively
- This makes LSTMs effective in speech recognition, natural language processing, time series analysis, and translation
- The challenge with LSTM networks lies in selecting the appropriate architecture and parameters and dealing with vanishing or exploding gradients during training



Applications of Long Short-Term Memory (LSTM) Network

Natural Language Processing

LSTMs excel at modeling sequential data, making them highly effective in tasks like language translation, sentiment analysis, and text generation

Speech Recognition

LSTMs are used to process audio data, enabling accurate speech recognition systems

Time Series Analysis

LSTMs can capture long-term dependencies in time series data, making them suitable for tasks like stock market prediction and weather forecasting

Challenges of Long Short-Term Memory (LSTM) Network

Gradient vanishing/exploding

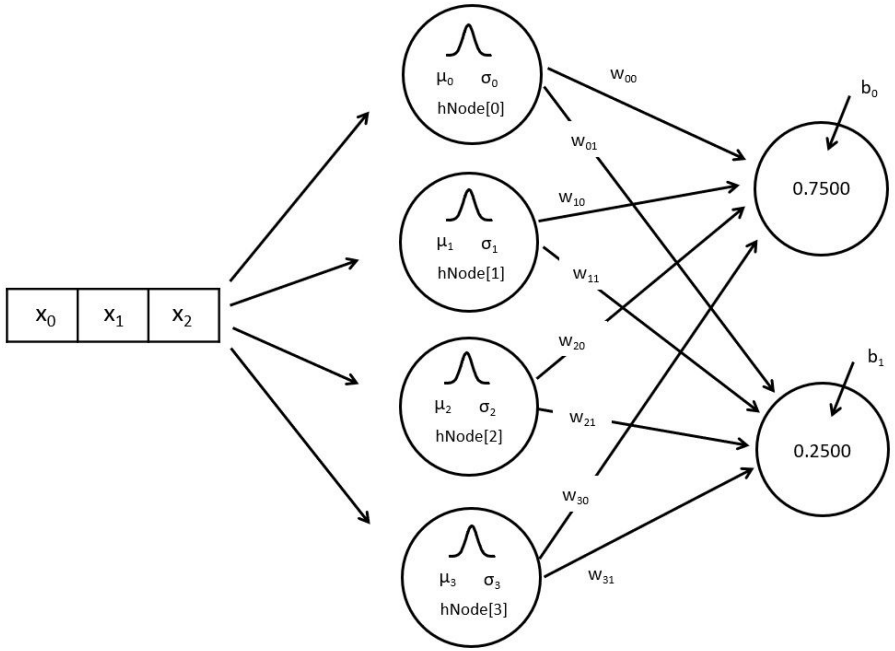
LSTMs can suffer from vanishing or exploding gradients, making it difficult to train them effectively over long sequences

Proper architecture design

Selecting appropriate LSTM architecture, such as the number of layers and hidden units, is crucial for achieving optimal performance

Radial Basis Function (RBF) Neural Network

- The RBF neural network is a feedforward neural network that uses radial basis functions as activation functions
- RBF networks consist of multiple layers, including an input layer, one or more hidden layers with radial basis activation functions, and an output layer
- RBF networks excel in pattern recognition, function approximation, and time series prediction
- However, challenges in training RBF networks include selecting appropriate basis functions, determining the number of basis functions, and handling overfitting



Applications of Radial Basis Function (RBF) Neural Network

Function Approximation

RBF networks are effective in approximating complex mathematical functions

Pattern Recognition

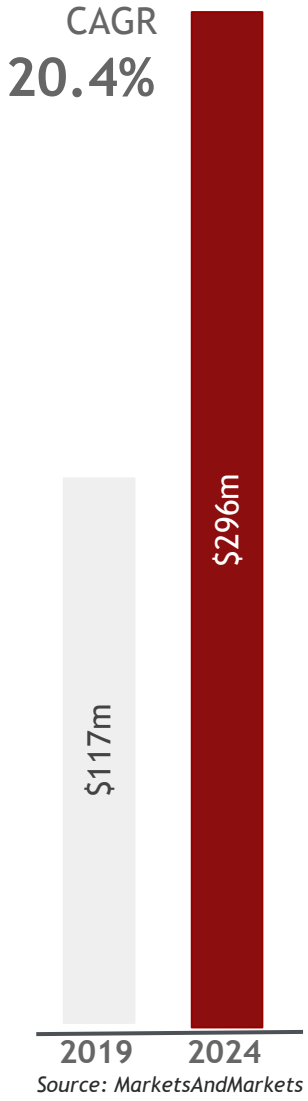
RBF networks can be used for face, fingerprint, and character recognition

Time Series Prediction

RBF networks can capture temporal dependencies and make predictions in time series data

Artificial Neural Network

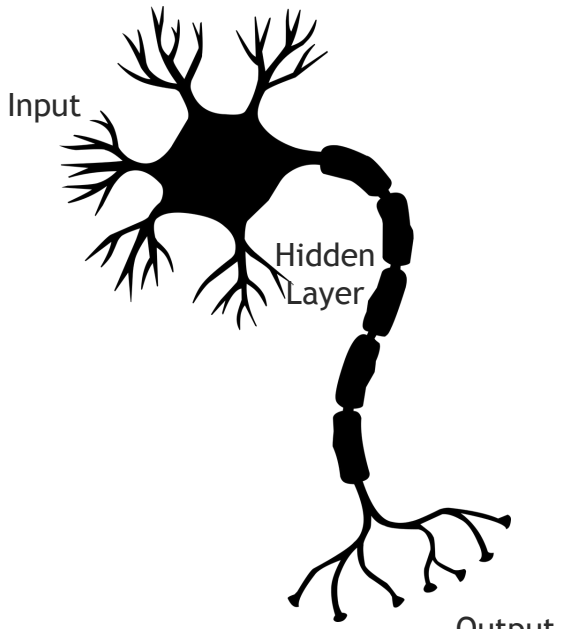
The Global market for ANN applications is projected to grow from $177m to $296m by 2024, at a CAGR of 20.4%.



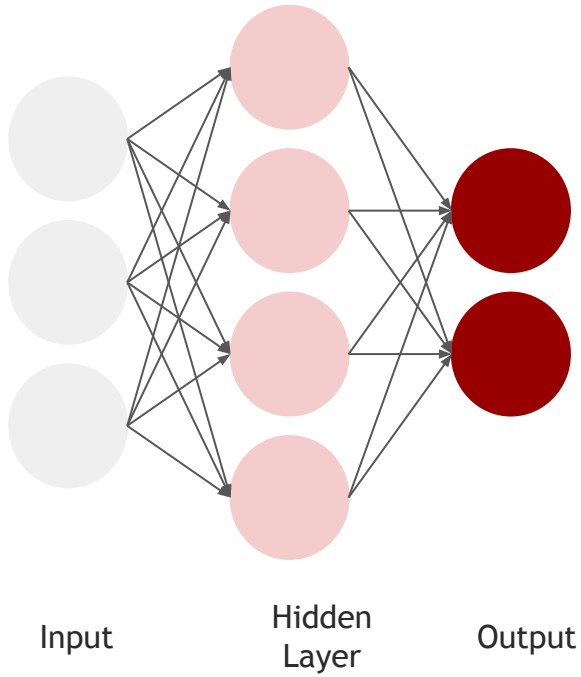
Source: MarketsAndMarkets

Artificial Neural Networks are a very rough imitation of the brain's structure

Human Brain Neuron

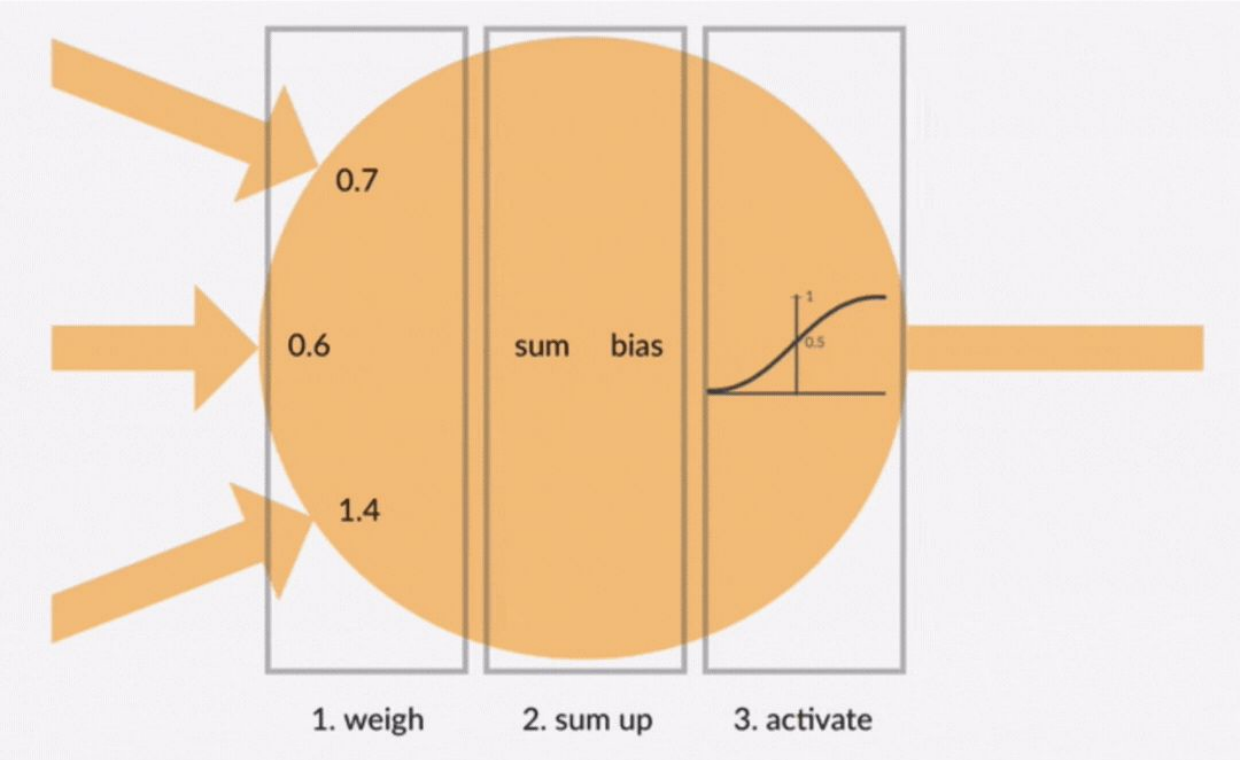


Artificial Neural Network



Artificial Neural Network

"Profound Learning and Artificial Neural Networks (ANN) have fueled the adoption of AI in several industries, such as aerospace, healthcare, manufacturing, and automotive. ANN is substituting conventional machine learning systems to evolve precise and accurate versions" - Grand View Research



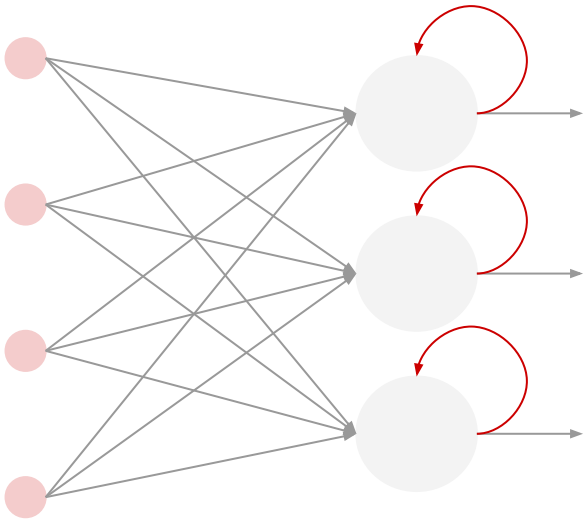
Source: Analytics Vidhya

Advantages of Artificial Neural Network

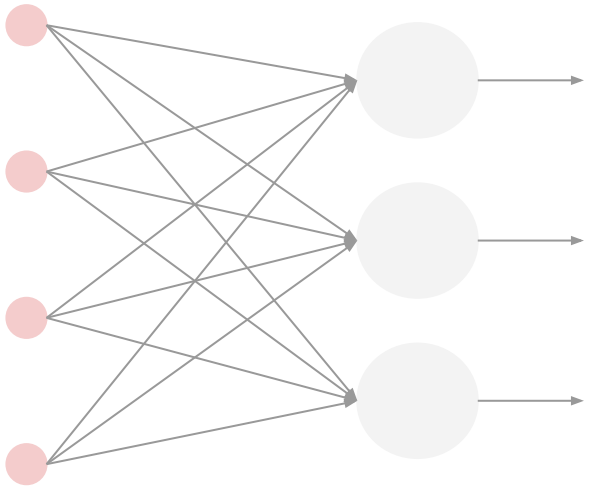
- *Artificial Neural Network is capable of learning any nonlinear function. Hence, these networks are popularly known as Universal Function Approximators*
- *ANNs have the capacity to learn weights that map any input to the output*
- *One of the main reasons behind universal approximation is the activation function*
- *Activation functions introduce nonlinear properties to the network*
- *This helps the network learn any complex relationship between input and output*

Recurrent Neural Network

- A looping constraint on the hidden layer of ANN turns to RNN
- RNN has a recurrent connection on the hidden state
- This looping constraint ensures that sequential information is captured in the input data
- Recurrent Neural Networks can be used t to solve the problems related to Time Series data, Text data, Audio data, etc.



Recurrent Neural Network



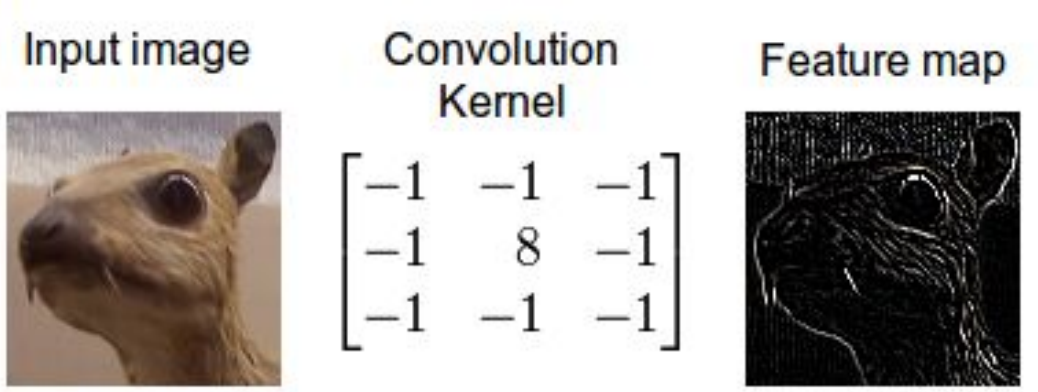
Feed-Forward Neural Network

Advantages of Recurrent Neural Network

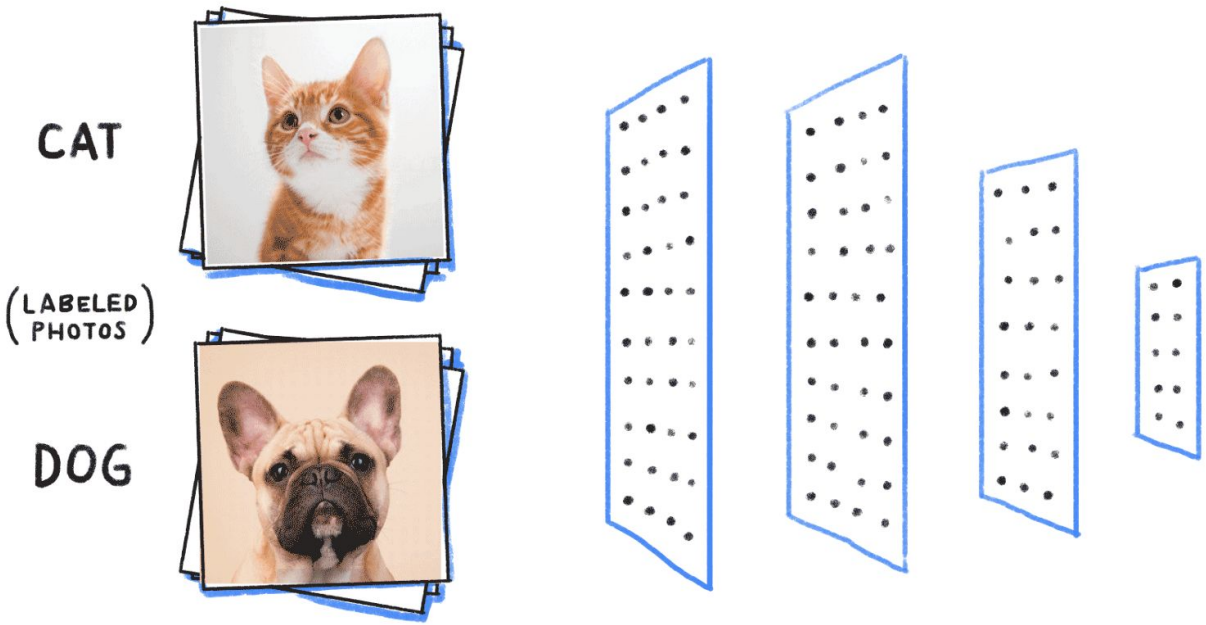
- *RNN captures the sequential information present in the input data, i.e., dependency between the words in the text while making predictions*
- *RNNs share the parameters across different time steps. This is popularly known as Parameter Sharing and results in fewer parameters to train and decreases the computational cost*

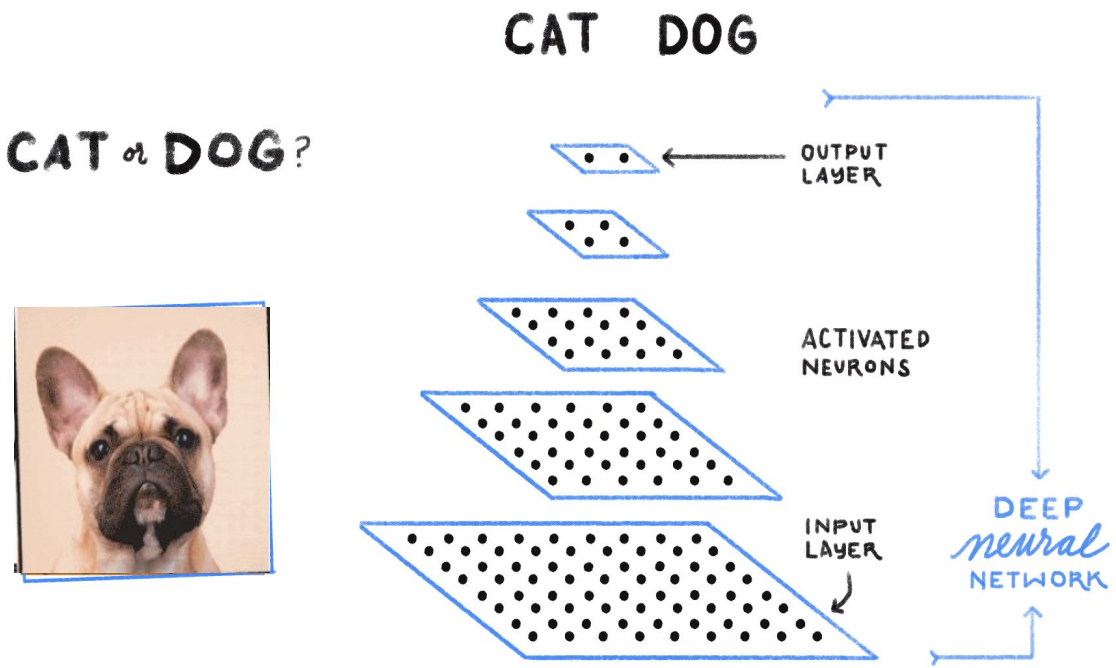
Convolution Neural Network

- Convolutional neural networks (CNN) are all the rage in the deep learning community right now
- These CNN models are being used across different applications and domains, and they're especially prevalent in image and video processing projects
- The building blocks of CNNs are filters a.k.a. kernels. Kernels are used to extract the relevant features from the input using the convolution operation
- Let's try to grasp the importance of filters using images as input data



Convolution Neural Network





Advantages of Convolution Neural Network

- *CNN learns the filters automatically without mentioning it explicitly. These filters help in extracting the right and relevant features from the input data*
- *CNN captures the spatial features from an image. Spatial features refer to the arrangement of pixels and the relationship between them in an image. They help us in identifying the object accurately, the location of an object, as well as its relation with other objects in an image*
- *CNN also follows the concept of parameter sharing. A single filter is applied across different parts of an input to produce a feature map*

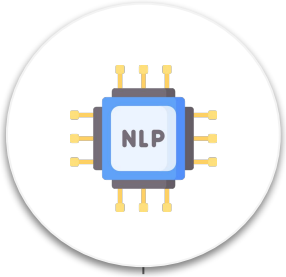
ANN vs RNN vs CNN

	ANN	RNN	CNN
Data	Tabular Data	Sequence Data such as Time Series, Text, Audio, etc	Image Data
Recurrent Connections	*No*	*Yes*	*No*
Parameter Sharing	*No*	*Yes*	*Yes*
Spatial Relationship	*No*	*No*	*Yes*
Vanish & Exploding Gradient	*Yes*	*Yes*	*Yes*

Applications of Deep Learning

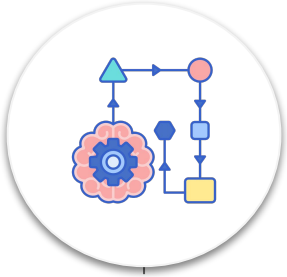
COMPUTER VISION

- *Image classification*
- *Image segmentation*
- *Object detection & recognition*



NATURAL LANGUAGE PROCESSING

- *Speech recognition*
- *Sentiment analysis*
- *Language translation*
- *Automatic Text Generation*



REINFORCEMENT LEARNING

- *Robotics*
- *Game playing*
- *Control Systems*


THANK YOU