An Industrial Training report

On

"Artificial Intelligence and Machine Learning"

In

"Philips Innovation Campus Bangalore"

Submitted in partial fulfillment of the requirement for the award of Degree of **Bachelor of Engineering in Electronics and Communication Engineering** BE VII Sem

Submitted to

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Session: 2019-20

IPS ACADEMY INDORE

INSTITUTE OF ENGINEERING & SCIENCE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

DECLARATION

I **Aaditya Muleva** Enrollment Number **0808EC161001** the student of **Bachelor of Engineering** in **Electronics and Communication Engineering**, **Session: 2019-20, IPS Academy Institute of Engineering & Science Indore (M.P.)**, hereby declare that the work presented in this report entitled **"Artificial Intelligence And Machine Learning"** in **Philips Innovation Campus, Bangalore** is the outcome of my own work, is bonafide and correct to the best of my knowledge and this work has been carried out taking care of Engineering Ethics and does not contain plagiarism.

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CERTIFICATE

This is to certify that Industrial training report titled "**Artificial Intelligence And Machine Learning**", in the "**Philips Innovation Campus, Bangalore**", is submitted to Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.), by **AADITYA MULEVA,** 0808EC161001**,** in partial fulfillment of the requirement of the award of the Degree of **Bachelor of Engineering in Electronics and Communication Engineering (BE VII Sem.)**

Date:

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Date:

Internal External

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CONTENTS

CHAPTER 1: INTRODUCTION

1.1 History of Artificial Intelligence (AI)

During the Second World War, noted British computer scientist Alan Turing worked to crack the 'Enigma' code which was used by German forces to send messages securely. Alan Turing and his team created the Bombe machine that was used to decipher Enigma's messages. The Enigma and Bombe Machines laid the foundations for Machine Learning. According to Turing, a machine that could converse with humans without the humans knowing that it is a machine would win the "imitation game" and could be said to be "intelligent".

In 1951, a machine known as Ferranti Mark 1 successfully used an algorithm to master checkers. Subsequently, Newell and Simon developed General Problem Solver algorithm to solve mathematical problems. Also in the 50s John McCarthy, often known as the father of AI, developed the LISP programming language which became important in machine learning.

In 1956, American computer scientist John McCarthy organized the Dartmouth Conference, at which the term 'Artificial Intelligence' was first adopted. Research centres popped up across the United States to explore the potential of AI. Researchers Allen Newell and Herbert Simon were instrumental in promoting AI as a field of computer science that could transform the world.

In the 1960s, researchers emphasized developing algorithms to solve mathematical problems and geometrical theorems. In the late 1960s, computer scientists worked on Machine Vision Learning and developing machine learning in robots. WABOT-1, the first 'intelligent' humanoid robot, was built in Japan in 1972.

1.2 Introduction to AI

Before leading to the meaning of artificial intelligence let us understand what the meaning of the Intelligence- Intelligence is**:** The ability to learn and solve problems. The most common answer that one expects is "to make computers intelligent so that they can act intelligently!", but the question is how much intelligent? How can one judge the intelligence? as intelligent as humans. If the computers can, somehow, solve real-world problems, by improving on their own from the past experiences, they would be called "intelligent". Thus, the AI systems are more generic (rather than specific), have the ability to "think" and are more flexible.

Intelligence, as we know, is the ability to acquire and apply the knowledge. Knowledge is the information acquired through experience. Experience is the knowledge gained through exposure (training). Summing the terms up, we get artificial intelligence as the "copy of something natural (i.e., human beings) 'WHO' is capable of acquiring and applying the information it has gained through exposure."

An AI system is composed of an agent and its environment. An agent(e.g., human or robot) is anything that can perceive its environment through sensors and acts upon that environment through effectors. Intelligent agents must be able to set goals and achieve them. In classical planning problems, the agent can assume that it is the only system acting in the world, allowing the agent to be certain of the consequences of its actions. However, if the agent is not the only actor, then it requires that the agent can reason under uncertainty. This calls for an agent that cannot only assess its environment and make predictions but also evaluate its predictions and adapt based on its assessment. Natural language processing gives machines the ability to read and understand human language. Some straightforward applications of natural language processing include information retrieval, text mining, question answering and machine translation. Machine perception is the ability to use input from sensors (such as cameras, microphones, sensors etc.) to deduce aspects of the world. e.g., Computer Vision. Concepts such as game theory, decision theory, necessitate that an agent be able to detect and model human emotions.

CHAPTER 2: PROBLEM STATEMENT

The problem is to determine the bone's age using different AI and ML tools. We have to get a data set regarding X-Ray of bones and then we have to analyze the reports and we have to extract data and features from the data set. Using image recognition and deep learning and using various classification tools we have to predict the bone's age. For this first we have to gain the deep knowledge of a machine learning, deep learning and image recognition tool to overcome this problem. Due to limited time this problem is on hold and I gained the knowledge of machine learning and deep learning.

CHAPTER 3: TOOLS USED DURING TRAINING

1. **Python** - Programming Language used
2. **Jupyter Notebook** - It is an excellent interface on which the program is written and run time compilation is the feature of it.
3. **Pandas** - The Pandas library is built on NumPy and provides ease to use data structure and data analysis tools for python programming language.
4. **MatPlotLib** - It is a library of python in which we can plot different kind of graphs (Even 3rd-Dimensional and Animations).
5. **Scikit Learn -** This library provides different modules and tools for Machine Learning and even provides beginner data sets.
6. **Keras -** This is a library which provides modules and tools for deep learning.
7. **NumPy -** It is a tool which provides various mathematical functions.
8. **SciPy -** It is a tool which provides complex mathematical and scientific functions.

<u>CHAPTER 4</u>: <u>ARTIFICIAL INTELLIGENCE</u>

AI works at its best by combining large amounts of data sets with fast, iterative processing and intelligent algorithms. This allows the AI software to learn automatically from patterns or features in that vast data sets.

Then these kinds of AI news become part of our daily digests with self-driving cars, Alexa/Siri like digital assistants frenzy, real time face recognition at airports, human genome projects, Amazon/Netflix algorithms, AI composers/artists, handwriting recognition, Email marketing algorithms and the list can go on and on.

While Deep neural network, the most advanced form of AI, is at the top of the Gartner 's 2018 hype cycle that is a sign of inflated expectations, self-driving cars have already made millions of miles with relatively satisfactory safety records.

Artificial intelligence can be classified into three different types of systems:

- **<u>Analytical</u>:** Analytical AI has only characteristics consistent with cognitive intelligence; generating a cognitive representation of the world and using learning based on past experience to inform future decisions.

- **<u>Human-inspired</u>:** Human-inspired AI has elements from cognitive and emotional intelligence; understanding human emotions, in addition to cognitive elements, and considering them in their decision making.

- **<u>Humanized artificial intelligence</u>:** Humanized AI shows characteristics of all types of competencies (i.e., cognitive, emotional, and social intelligence), is able to be self-conscious and is self-aware in interactions.

AI often revolves around the use of algorithms. An algorithm is a set of unambiguous instructions that a mechanical computer can execute. A complex algorithm is often built on top of other, simpler, algorithms. A simple example of an algorithm is the following (optimal for first player) recipe for play at tic-tac-toe.

1. If someone has a "threat" (that is, two in a row), take the remaining square. Otherwise,
2. If a move "forks" to create two threads at once, play that move. Otherwise,
3. Take the center square if it is free. Otherwise,
4. If your opponent has played in a corner, take the opposite corner. Otherwise,
5. Take an empty corner if one exists. Otherwise,
6. Take any empty square.

Many AI algorithms are capable of learning from data; they can enhance themselves by learning new heuristics (strategies, or "rules of thumb", that have worked well in the past), or can themselves write other algorithms. Some of the "learners" described below, including Bayesian networks, decision trees, and nearest-neighbor, could theoretically, (given infinite data, time, and memory) learn to approximate any function, including which combination of mathematical functions would best describe the world[citation needed]. These learners could therefore, derive all possible knowledge, by considering every possible hypothesis and matching them against the data. In practice, it is almost never possible to consider every possibility, because of the phenomenon of "combinatorial explosion", where the amount of time needed to solve a problem grows exponentially. Much of AI research involves figuring out how to identify and avoid considering broad range of possibilities that are unlikely to be beneficial. For example, when viewing a map and looking for the shortest driving route from Denver to New York in the East, one can in most cases skip looking at any path through San Francisco or other areas far to the West; thus, an AI wielding a path finding algorithm like A* can avoid the combinatorial explosion that would ensue if every possible route had to be ponderously considered in turn.

CHAPTER 5: MACHINE LEARNING

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it to learn for themselves. The process of learning begins with observations or data, such as examples, direct experience, or instruction, in order to look for patterns in data and make better decisions in the future based on the examples that we provide. The primary aim is to allow the computers learn automatically without human intervention or assistance and adjust actions accordingly.

On a flat screen we can draw a picture of, at most, a three-dimensional data set, but ML problems commonly deal with data with millions of dimensions, and very complex predictor functions. ML solves problems that cannot be solved by numerical means alone.

The goal of ML is never to make “perfect” guesses, because ML deals in domains where there is no such thing. The goal is to make guesses that are good enough to be useful.

Types of learning -

1. Supervised learning.
2. Unsupervised learning.
3. Reinforcement learning.

5.1 SUPERVISED LEARNING

Supervised learning is a type of system in which both input and desired output data are provided. Input and output data are labeled for classification to provide a learning basis for future data processing. The term supervised learning comes from the idea that an algorithm is learning from a training dataset, which can be thought of as the teacher.

Supervised machine learning systems provide the learning algorithms with known quantities to support future judgments. Chat bots, self-driving cars, facial recognition programs, expert systems and robots are among the systems that may use either supervised or unsupervised learning. Supervised learning systems are mostly associated with retrieval-based AI but they may also be capable of using a generative learning model.

5.1.1 How does supervised learning work?

In general, supervised learning occurs when a system is given input and output variables with the intentions of learning how they are mapped together, or related. The goal is to produce an accurate enough mapping function that when new input is given, the algorithm can predict the output. This is an iterative process, and each time the algorithm makes a prediction, it is corrected or given feedback until it achieves an acceptable level of performance.

Training data for supervised learning includes a set of examples with paired input subjects and desired output (which is also referred to as the supervisory signal). For example, in an application of supervised learning for image processing, an AI system might be provided with labeled pictures of vehicles in categories such as cars or trucks. After a sufficient amount of observation, the system should be able to distinguish between and categorize unlabeled images, at which time the training is complete.

Applications of supervised learning are typically broken down into two categories, classification and regression. Classification is similar to the example above, when the output value is a category such as car or truck and true or false. A regression problem is when the output is a real, computed value such as the price or weight.

5.1.2 TYPES OF SUPERVISED LEARNING:

5.1.2.1 REGRESSION

This is a type of problem where we need to predict and forecast for the continuous-response values. Some examples are what is the price of a house in a specific city with 5 bedrooms and above 4,000 sqft? Predicting financial results, stock prices or how many total runs can be on board in a cricket game. You have an existing data set & outputs (supervised learning) and your algorithm predicts the outcome based on a fitting function.

- **Algorithms Used In Regression Model**

A. Linear Regression

B. Multiple Linear Regression

C. Polynomial Regression

D. SVR (Support Vector Regression)

E. Decision Tree Regression

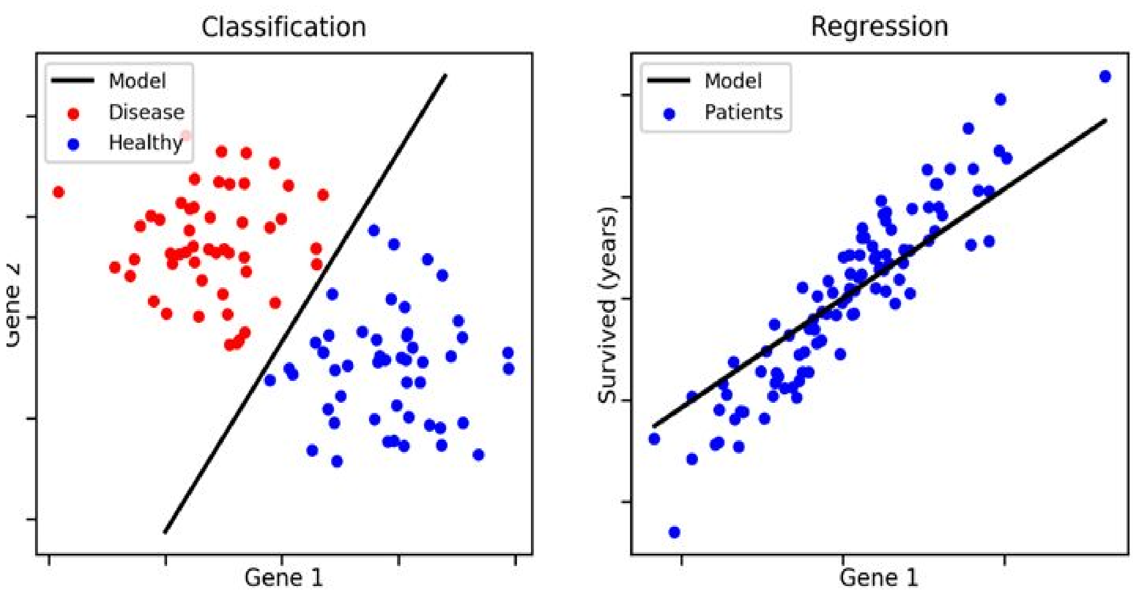
F. Random Forest Regression

5.1.2.2 CLASSIFICATION

In classification we need to categorize a certain observation into a group. In the below picture, if we are given a dot you need to classify it as either a blue dot or a red dot. Few more examples would be — to predict if a given email is spam or not spam? Is a detected particle a Higgs Boson or a normal subatomic particle? Assigning a certain news article into a group — like sports, weather, or science. Will it rain today or not? Is this picture a cat or not? Detecting fraud or evaluating risk for frauds or insurance underwriting.

- **Algorithms Used In Classification Model**

A. Logistic Regression
B. K-Nearest Neighbor
C. SVC (Support Vector Classifier)
D. Naive Bayes
E. Decision Tree Classifier
F. Random Forest Classifier



5.2 UNSUPERVISED LEARNING

Unsupervised learning is the training of machine using information that is neither classified nor labeled and allowing the algorithm to act on that information without guidance. Here the task of machine is to group unsorted information according to similarities, patterns and differences without any prior training of data.

Unlike supervised learning, no teacher is provided that means no training will be given to the machine. Therefore machine is restricted to find the hidden structure in unlabeled data by our-self.

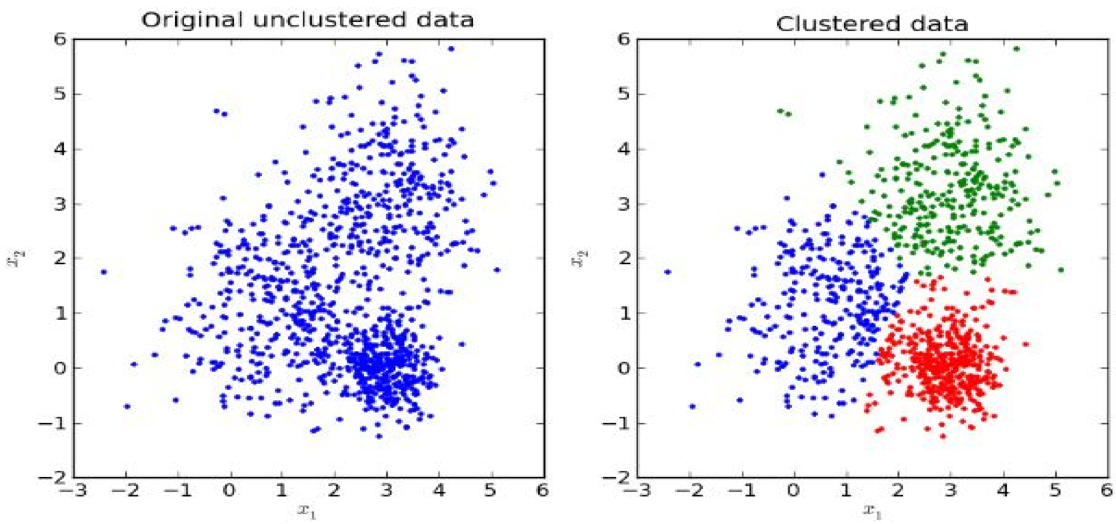
For instance, suppose it is given an image having both dogs and cats which have not seen ever. Thus the machine has no idea about the features of dogs and cats so we can't categorize it in dogs and cats. But it can categorize them according to their similarities, patterns, and differences i.e., we can easily categorize the above picture into two parts. First may contain all pics having dog**s** in it and the second part may contain all pics having cats in it.

5.2.1 CLUSTERING

This is a type of unsupervised learning problem where we group similar things together. Some examples are: Given news articles or books, cluster them into different types of themes. Given a set of tweets, cluster them based on content of tweet could also be used for politics, health care, shopping, real estate etc.

- **Algorithms Used In Clustering Model**

A. K-Means Clustering
B. Hierarchical Clustering



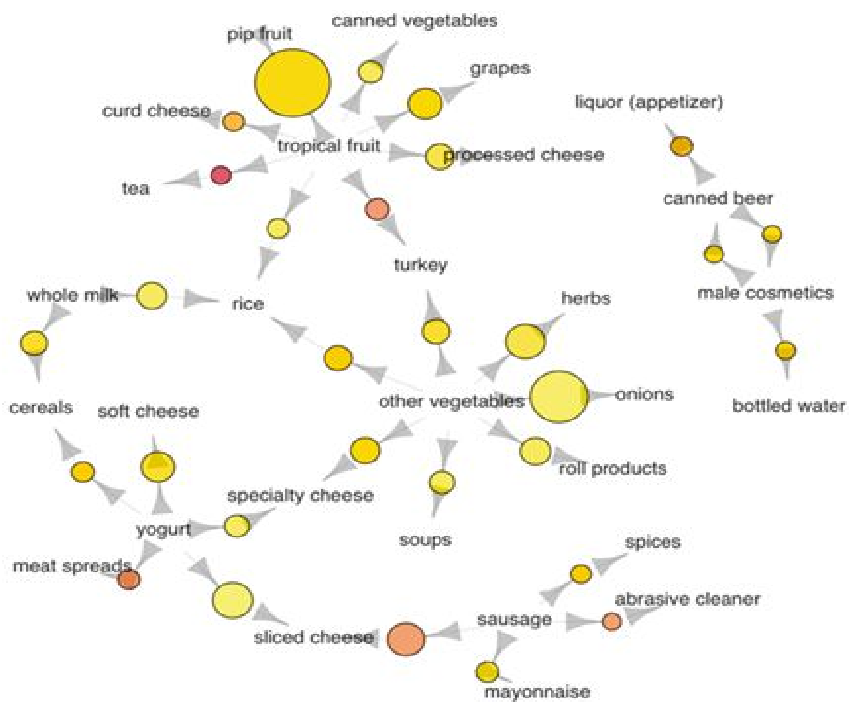
A computer-generated program showing k-means clustering [3]

5.2.2 ASSOCIATION

An association rule is where you would be discovering the exact rules that will describe the large portions of your data. Example: People who buy X are also the ones who tend to buy Y. We may encounter it when we receive a book or movie recommendation based upon previous purchases or searches. These algorithms are also used for market basket analysis using our online or offline retailers shopping (point of sales) data. Shortly given many baskets, association techniques helps us understand which items inside a basket predict another item in the same basket.

- **Algorithms Used In Association Model**

A. Apriori



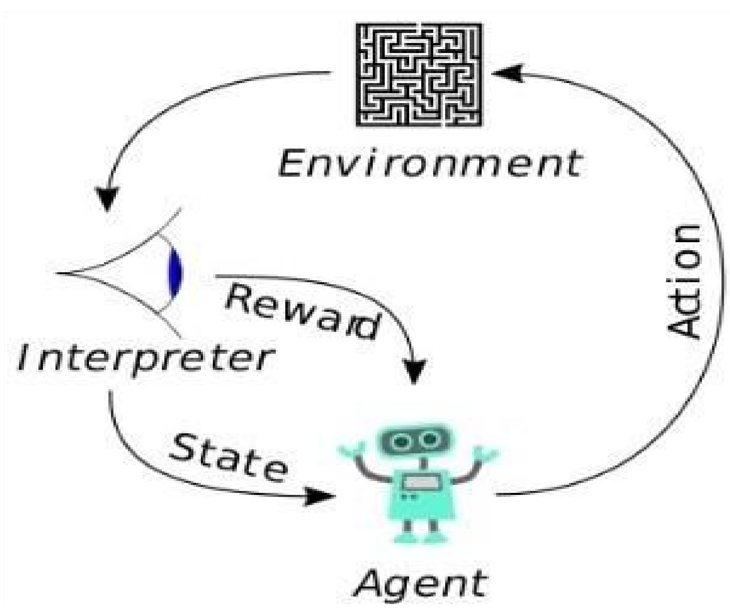
Association

5.3 REINFORCEMENT LEARNING

Now instead of telling the child which toy to put in which box, you reward the child with a 'big hug' when the child makes the right choice or you make a 'sad face' when the child makes the wrong action. Very quickly after a few iterations the child learns which toys need to go into which box — this is called Reinforcement learning.

Reinforcement learning is an area of Machine Learning. It is about taking suitable action to maximize reward in a particular situation. It is employed by various software and machines to find the best possible behavior or path it should take in a specific situation. Reinforcement learning differs from the supervised learning in a way that in supervised learning the training data has the answer key with it so the model is trained with the correct answer itself whereas in reinforcement learning, there is no answer but the reinforcement agent decides what to do to perform the given task. In the absence of training dataset, it is bound to learn from its experience.

Systems are trained by receiving virtual “rewards” or “punishments”, essentially learning by trial and error. This strategy built on observation and trial & error to achieve goals or maximize reward. The agent makes a decision by observing its environment. If the observation is negative, the algorithm adjusts its weights to be able to make a different required decision the next time. One can count Reinforcement learning as part of the Deep learning as well based on root of hidden nodes and the complexity of algorithms *(more on this later).* Reinforcement learning algorithms try to find the best ways to earn the greatest reward. Rewards can be winning a game, earning more money or beating other opponents. Google DeepMind has used reinforcement learning to develop systems that can play games, including video games and board games such as GO. AlphaGo won a game with more board states than chess at 10 to the power of 170 — is greater than the number of atoms in the universe against a den 9 GO master. A combination of reinforcement learning and human-supervised learning was used to build “value” and “policy” neural networks that also used the search tree to execute its game play strategies. The software learned from 30 million moves played in human-on-human games.



Reinforcement Learning

CHAPTER 6: DEEP LEARNING

Like ML, "Deep Learning" is also a method of statistical learning that extracts features or attributes from raw data sets. The main point of difference is DL does this by utilizing multi-layer artificial neural networks with many hidden layers stacked one after the other. DL also has somewhat more sophisticated algorithms and requires more powerful computational resources. These are specially designed computers with high performance CPUs or GPUs. They could be on premise ($$) or as workloads on Cloud. You can still use your laptop for prototyping.

Deep learning is an advanced sub-field of Artificial Intelligence (AI) and Machine Learning (ML) that stayed as a scholarly field for a long time. With the abundance of data and exponential increase of computing power, we have been seeing a proliferation of applied deep learning business cases across disciplines.

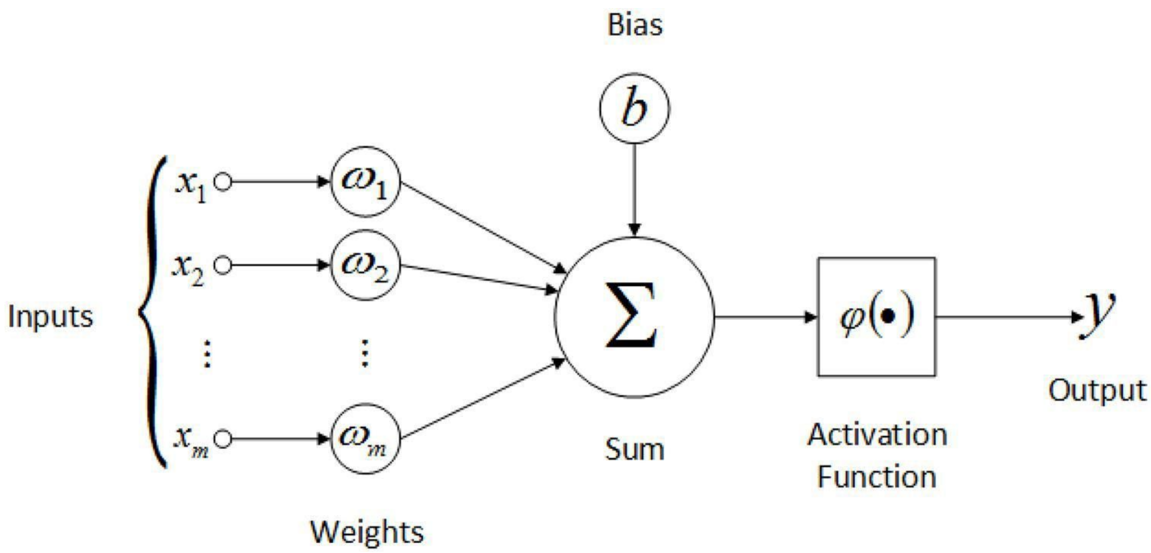
6.1 ARTIFICIAL NEURAL NETWORKS (ANN)

An artificial neural network (ANN) is a system of hardware and/or software patterned after the operation of neurons in the human brain. ANNs also called, simply, neural networks are a variety of deep learning technology, which also falls under the umbrella of artificial intelligence, or AI.

Commercial applications of these technologies generally focus on solving complex signal processing or pattern recognition problems. Examples of significant commercial applications since 2000 include handwriting recognition for check processing, speech-to-text transcription, oil-exploration data analysis, weather prediction and facial recognition.

6.1.2 BASIC STRUCTURE OF ANN

The basic structure of an ANN consists of artificial *neurons*(similar to biological neurons in the human brain) that are grouped into layers. The most common ANN structure consists of an input layer, one or more hidden layers and an output layer.



In the human brain, neurons communicate by sending signals to each other through complex connections. ANNs are based on the same principle in an attempt to simulate the learning process of the human brain by using complex algorithms. Every connection has a weight attached which may have either a positive or a negative value associated with it. Positive weights activate the neuron while negative weights inhibit it. Figure 1 shows a network structure with *inputs (x1, x2, ...xi*) being connected to neuron *j* with weights (*w1j, w2j,…wij*) on each connection. The neuron sums all the signals it receives, with each signal being multiplied by its associated weights on the connection.

This output (y) is then passed through a transfer (activation) function, *g(y),* that is normally non-linear to give the final output *Oj*. The most commonly used function is the sigmoid (logistic function) because of its easily differentiable properties, which is very convenient when the back-propagation algorithm is applied.

The back-propagation ANN is a feed-forward neural network structure that takes the input to the network and multiplies it by the weights on the connections between neurons or nodes; summing their products before passing it through a threshold function to produce an output. The back-propagation algorithm works by minimizing the error between the output and the target (actual) by propagating the error back into the network. The weights on each of the connections between the neurons are changed according to the size of the initial error. The input data are then fed forward again, producing a new output and error. The process is reiterated until an acceptable minimized error is obtained. Each of the neurons uses a transfer function and is fully connected to nodes on the next layer. Once the error reaches an acceptable value, the training is halted. The resulting model is a function that is an internal representation of the output in terms of the inputs at that point.

6.2 CONVOLUTIONAL NEURAL NETWORK (CNN)

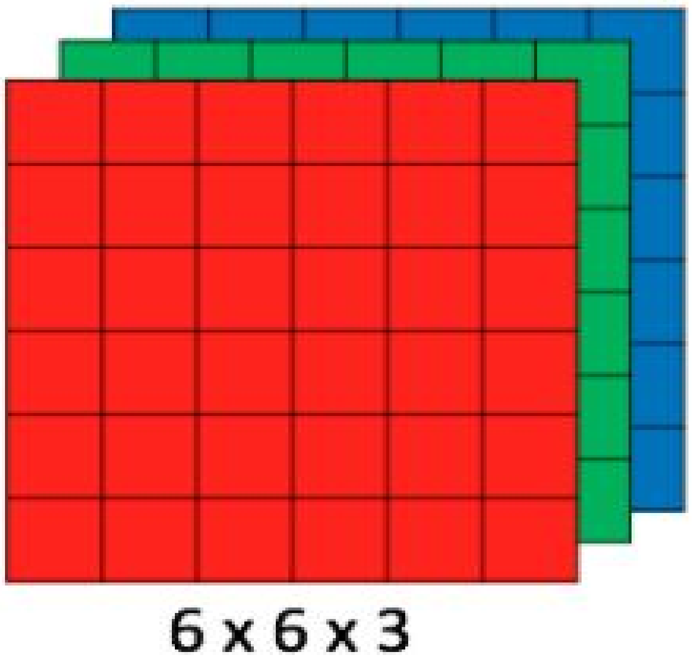
Convolution neural networks (CNN) are deep artificial neural networks that are used primarily to classify images (i.e. label what they see), cluster them by similarity (i.e. photo search), and perform object recognition within scenes. They are algorithms that can identify faces, individuals, street signs, cars, animals, anomalies, tumors and many other aspects of visual data.

Convolution layers are used to extract the features from input training samples. Each convolution layer has a set of filters that helps in feature extraction. In general, as the depth of CNN model increases, complexity of features learnt by convolution layers increases.

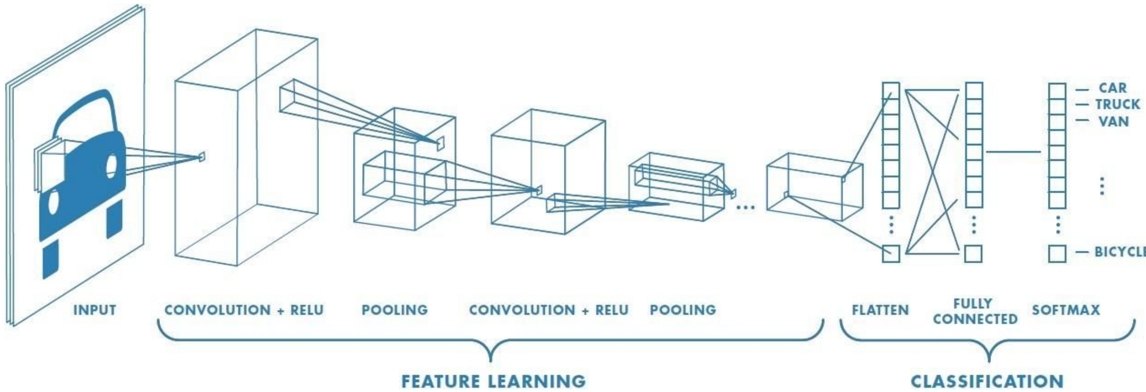
CNN is such a fascinating and disruptive domain that opened up possibilities for face recognition, self driving cars, optical character recognition, automated diagnosis of diseases, image-to-text conversions, neural art etc.

There are many further innovation opportunities out there from maybe helping millions of people with visual impairment to further advances in preventive medical diagnosis, drug discoveries, video games, omni-channel retailers' shelves/products recognition. These frameworks started working on the edges as well. Edges could be iPhones, Android gadgets, Amazon DeepLens etc.

CNN image classifications takes an input image, process it and classify it under certain categories (Eg., Dog, Cat, Tiger, Lion). Computers sees an input image as an array of pixels and it depends on the image resolution. Based on the image resolution, it will see h x w x d(h = Height, w = Width, d = Dimension). Eg., An image of 6 x 6 x 3 array of matrix of RGB (3 refers to RGB values) and an image of 4 x 4 x 1 array of matrix of grayscale image.



Technically, deep learning CNN models to train and test, each input image will pass it through a series of convolution layers with filters (Kernels), Pooling, fully connected layers (FC) and apply Softmax function to classify an object with probabilistic values between 0 and 1. The below figure is a complete flow of CNN to process an input image and classifies the objects based on values



6.2.1 Convolution Layer

Convolution is the first layer to extract features from an input image. Convolution preserves the relationship between pixels by learning image features using small squares of input data. It is a mathematical operation that takes two inputs such as image matrix and a filter or kernal.

Consider a 5 x 5 whose image pixel values are 0, 1 and filter matrix 3 x 3 as shown in below

1	1	1	0	0
0	1	1	1	0
0	0	1	1	1
0	0	1	1	0
0	1	1	0	0

5 x 5 – Image Matrix

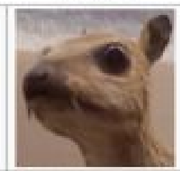
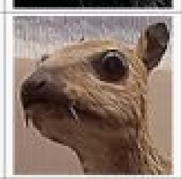
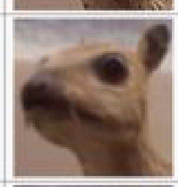
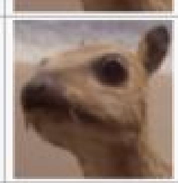
*

1	0	1
0	1	0
1	0	1

3 x 3 – Filter Matrix

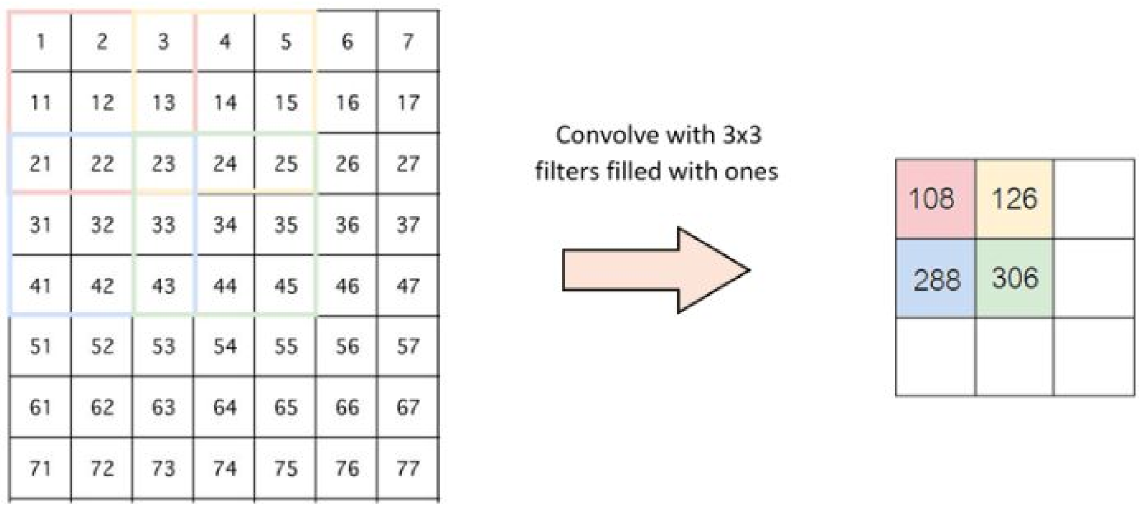
Then the convolution of 5 x 5 image matrix multiplied with 3 x 3 filter matrix which is called "Feature Map."

Convolution of an image with different filters can perform operations such as edge detection, blur and sharpen by applying filters. The below example shows various convolution image after applying different types of filters (Kernels) -

Operation	Filter	Convolved Image
Identity	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	
Edge detection	$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$	
	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	
Sharpen	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	
Box blur (normalized)	$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	
Gaussian blur (approximation)	$\frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$	

6.2.2 Strides

Stride is the number of pixel shifts over the input matrix. When the stride is 1 then we move the filters to 1 pixel at a time. When the stride is 2 then we move the filters to 2 pixels at a time and so on. The below figure shows convolution would work with a stride of 2.



6.2.3 PADDING

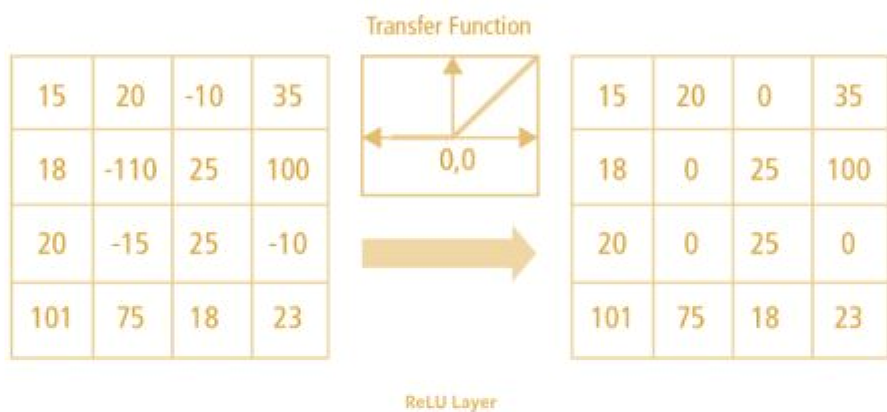
Sometimes filter does not fit perfectly fit the input image. We have two options:

- Pad the picture with zeros (zero-padding) so that it fits.
- Drop the part of the image where the filter did not fit. This is called valid padding which keeps only valid part of the image.

6.2.4 Non Linearity (ReLU)

ReLU stands for Rectified Linear Unit for a non-linear operation. The output is *f(x) = max (0, x)*.

Why ReLU is important: ReLU's purpose is to introduce non-linearity in our ConvNet. Since, the real world data would want our ConvNet to learn would be non-negative linear values.



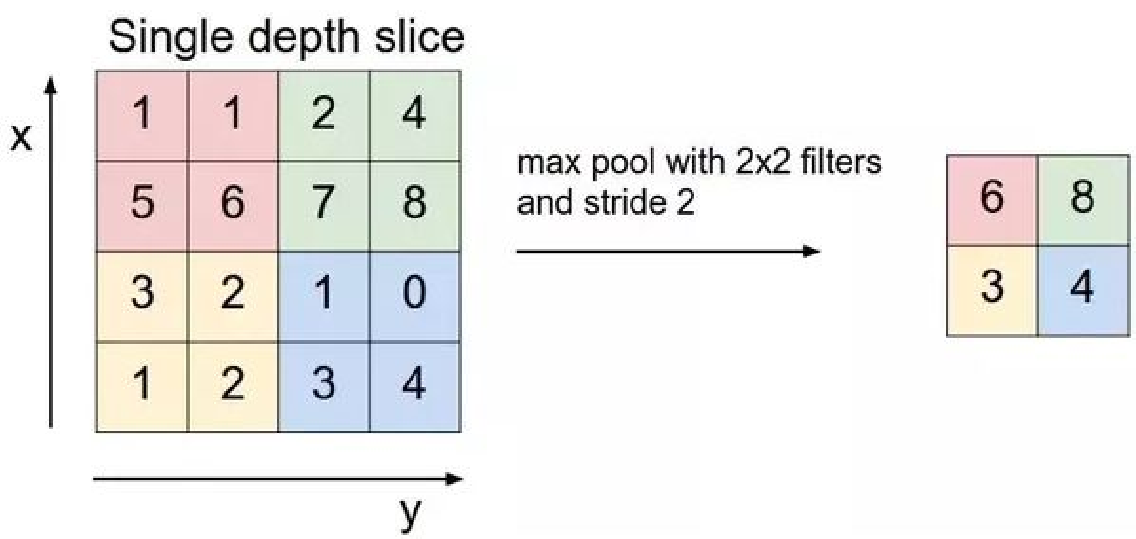
There are other nonlinear functions such as tanh or sigmoid can also be used instead of ReLU. Most of the data scientists use ReLU since performance wise ReLU is better than the other two.

6.2.5 Pooling

Pooling layers section would reduce the number of parameters when the images are too large. Spatial pooling also called sub sampling or down sampling which reduces the dimensionality of each map but retains the important information. Spatial pooling can be of different types:

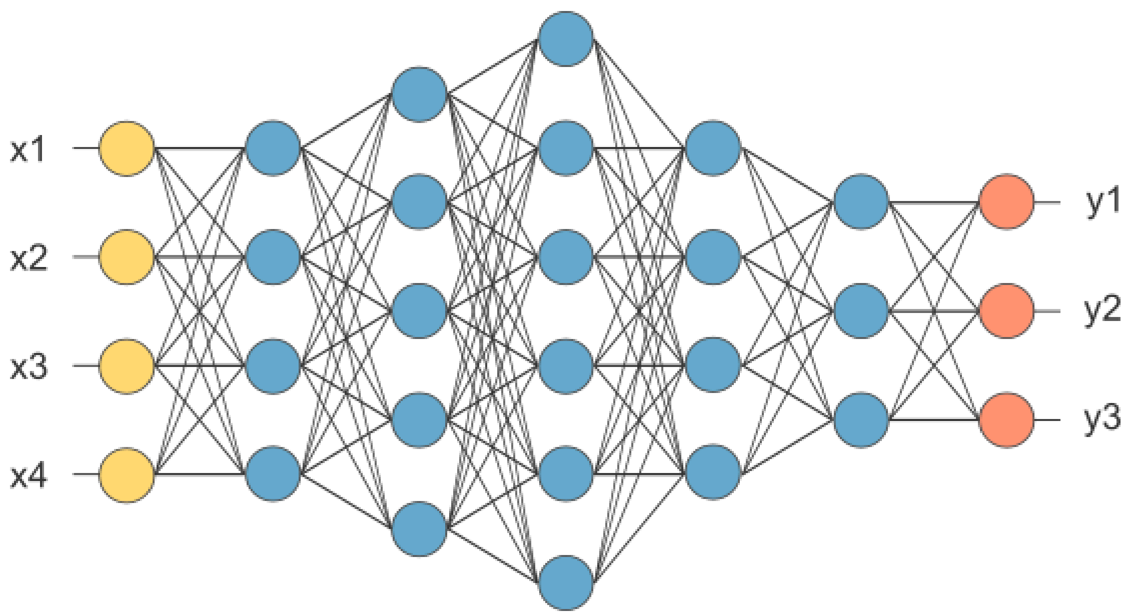
- Max Pooling
- Average Pooling
- Sum Pooling

Max pooling take the largest element from the rectified feature map. Taking the largest element could also take the average pooling. Sum of all elements in the feature map call as sum pooling.

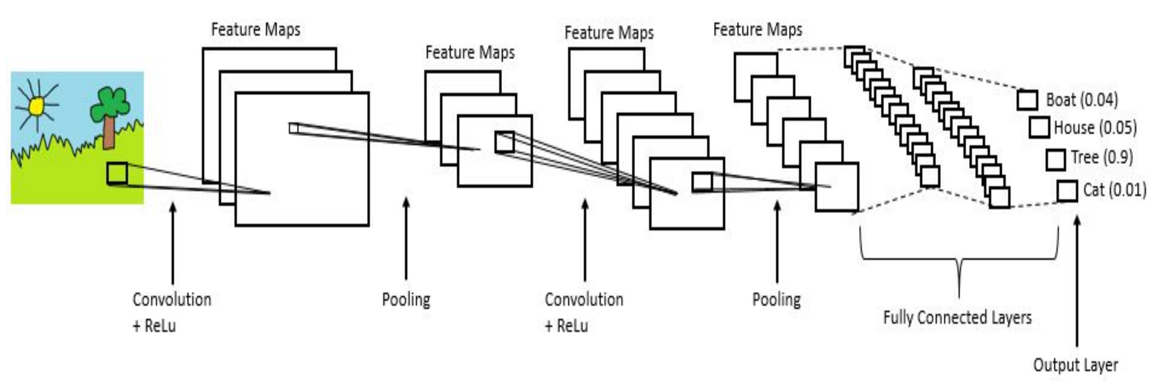


6.2.6 Fully Connected Layer

The layer we call as FC layer, we flattened our matrix into vector and feed it into a fully connected layer like neural network.

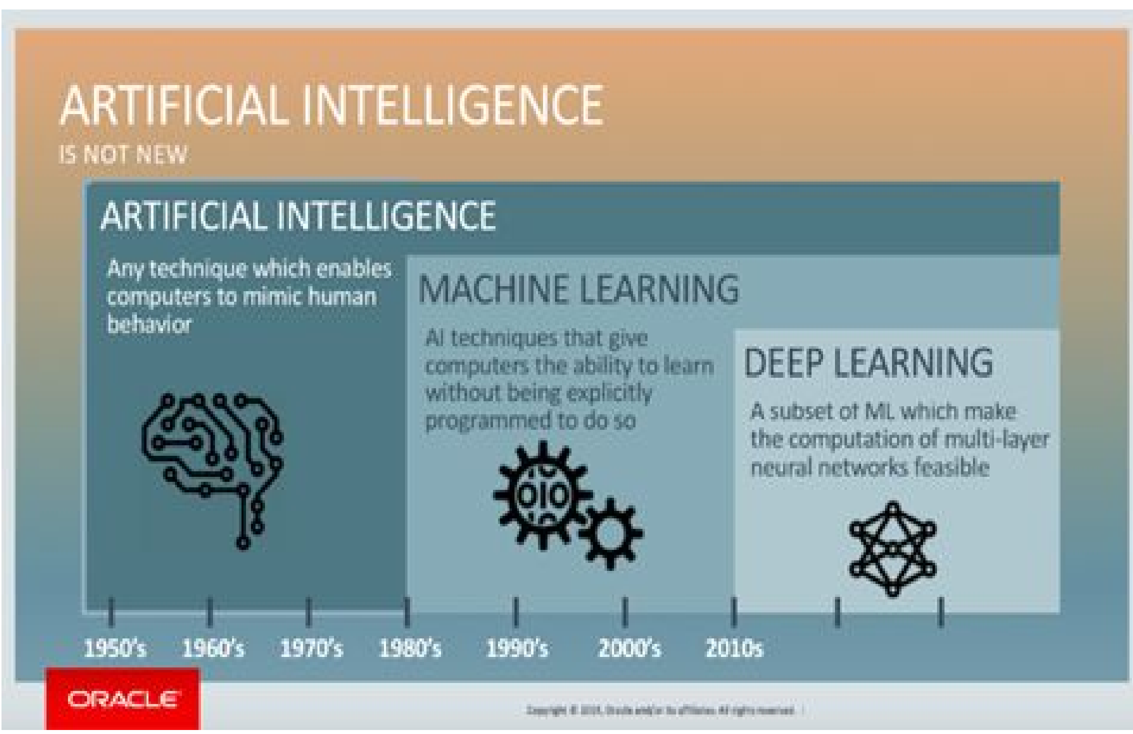


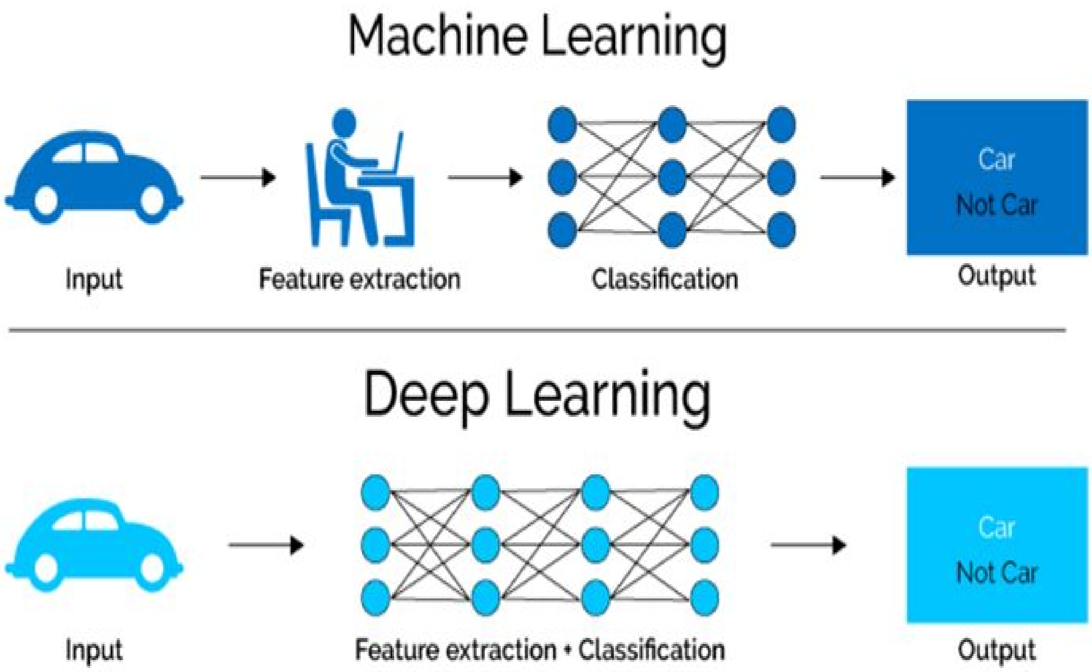
In the above diagram, feature map matrix will be converted as vector (x1, x2, x3, …). With the fully connected layers, we combined these features together to create a model. Finally, we have an activation function such as softmax or sigmoid to classify the outputs as cat, dog, car, truck etc.



CHAPTER 7: Artificial Intelligence (AI) V/S Machine Learning (ML) V/S Deep Learning (DL)

AI is really a broad term and somewhat this also causes every company to claim their product has AI these days. Then ML is a subset of AI, and consists of the more advanced techniques and models that enable computers to figure things out from the data and deliver AI applications. ML is the science of getting computers to act without being explicitly programmed. DL is a newer area of ML that that uses multi-layered artificial neural networks to deliver high accuracy in tasks such as object detection, speech recognition, language translation and other recent breakthroughs that you hear in the news. Beauty and strength of DL is they can automatically learn/extract/translate the features from data sets such as images, video or text, without introducing
traditional hand-coded code or rules.

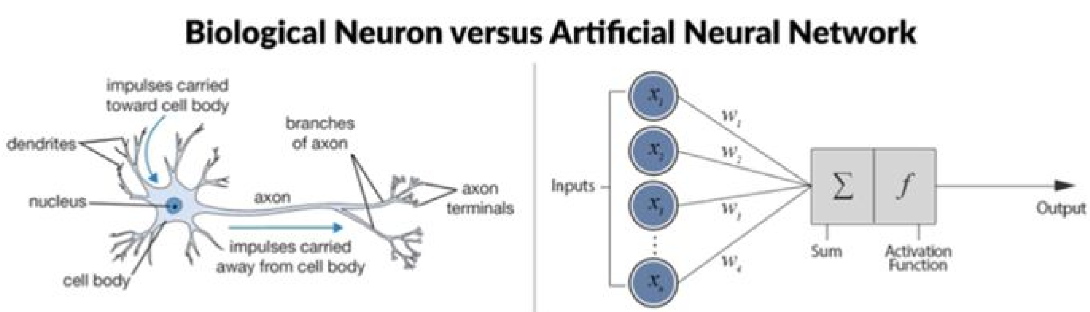



Machine Learning
Car
Not Car
Input
Feature extraction
Classification
Output
Deep Learning
Car
Not Car
Input
Feature extraction + Classification
Output

CHAPTER 8: BRAIN AND DEEP LEARNING

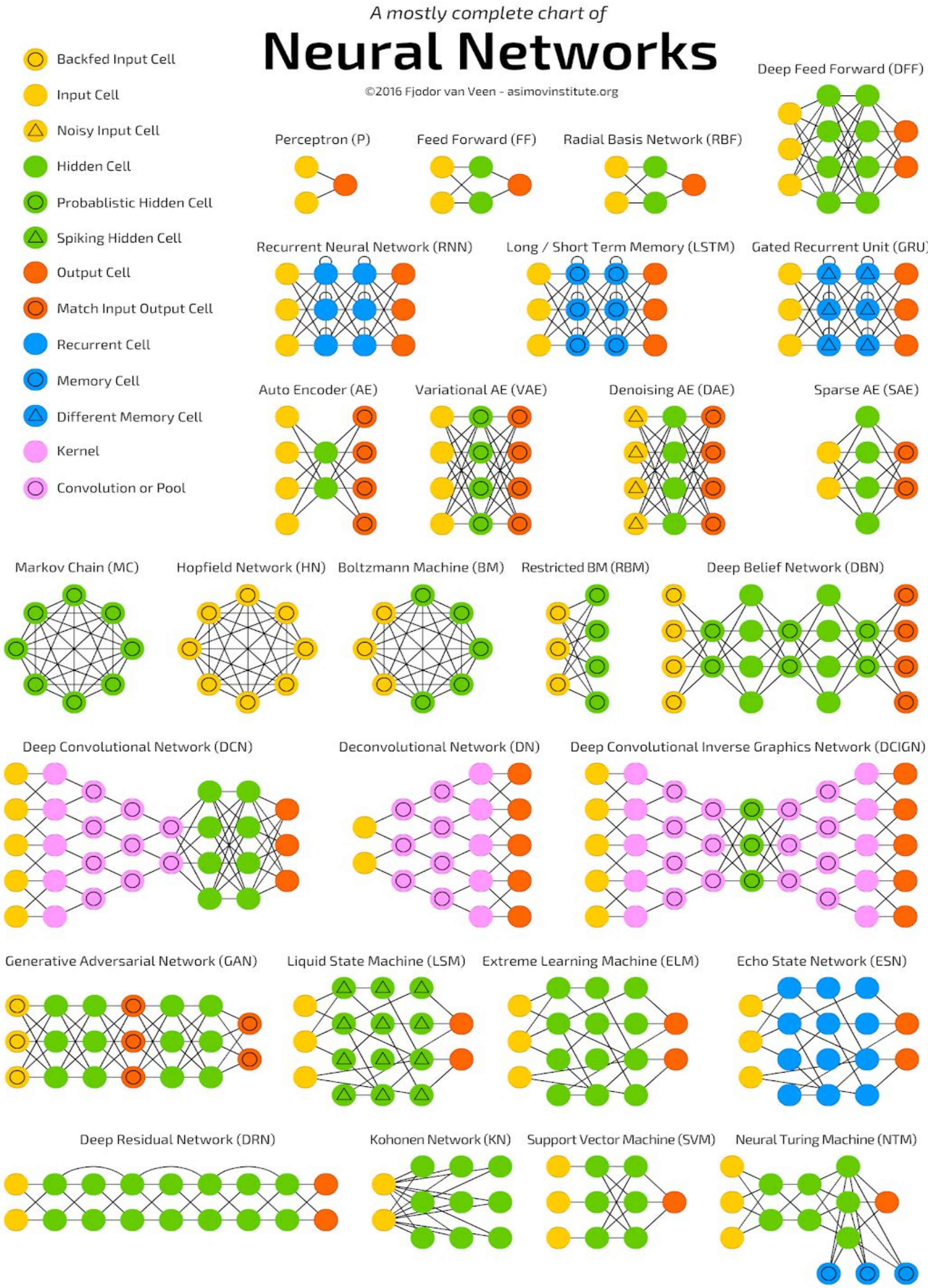
How does a small child learn to recognize the difference between a school bus and a regular transit bus? How do we subconsciously perform complex pattern recognition tasks without even noticing? The answer is we have a biological neural network that is connected to our nervous systems. Our brains are very complex networks with about 10 billion neurons each connected to 10 thousand other neurons.

Each of these neurons receives electro-chemical signals and passes these messages to other neurons. Actually, we do not even know how our brain neurons work. We do not know enough about neuroscience and the deeper functions of the brain to be able to correctly model how the brain works. DL is only inspired by the functionality of our brain cells called neurons which lead to the concept of artificial neural networks (ANN). ANN is modeled using layers of artificial neurons to receive input and apply an activation function along with a human set threshold. It may sound sci-fi to non-practitioners but DL is already in our daily lives. Deep learning has already achieved near or better than human level image classification, speech/handwriting recognition and of course the autonomous driving. Complex ad targeting or news feeds are all over when we surf the net.



In the most basic feed forward neural network there are five main components to artificial neurons these are:

1. **Input nodes:** Each input node is associated with a numerical value, which can be any real number. Example could be one pixel value of an image.
2. **Connections:** Similarly, each connection that departs from the input node has a weight (w) associated with it and this can be any real number. The ANN runs and propagates millions of times to optimize these "w" values. You need the high computational power to make this in short time.
3. Next, all the values of the input nodes and weights of the connections are brought together. They are used as inputs for a weighted sum.
4. This result will be the input for a transfer or activation function. Just like a biological neuron only fires when a certain threshold is exceeded, the artificial neuron will also only fire when the sum of the inputs exceeds a threshold. These are parameters set by us (more on ethics later).
5. As a result, you have the output node, which is associated with the function of the weighted sum of the input nodes.


A mostly complete chart of
Neural Networks
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Backfed Input Cell
Input Cell
Noisy Input Cell
Hidden Cell
Probablistic Hidden Cell
Spiking Hidden Cell
Output Cell
Match Input Output Cell
Recurrent Cell
Memory Cell
Different Memory Cell
Kernel
Convolution or Pool
Perceptron (P)
Feed Forward (FF)
Radial Basis Network (RBF)
Deep Feed Forward (DFF)
Recurrent Neural Network (RNN)
Long / Short Term Memory (LSTM)
Gated Recurrent Unit (GRU)
Auto Encoder (AE)
Variational AE (VAE)
Denoising AE (DAE)
Sparse AE (SAE)
Markov Chain (MC)
Hopfield Network (HN)
Boltzmann Machine (BM)
Restricted BM (RBM)
Deep Belief Network (DBN)
Deep Convolutional Network (DCN)
Deconvolutional Network (DN)
Deep Convolutional Inverse Graphics Network (DCIGN)
Generative Adversarial Network (GAN)
Liquid State Machine (LSM)
Extreme Learning Machine (ELM)
Echo State Network (ESN)
Deep Residual Network (DRN)
Kohonen Network (KN)
Support Vector Machine (SVM)
Neural Turing Machine (NTM)

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