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Chapter

Advancements in Deep Learning Theory and Applications: Perspective in 2020 and beyond

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Abstract

The aim of this chapter is to introduce newcomers to deep learning, deep learning platforms, algorithms, applications, and open-source datasets. This chapter will give you a broad overview of the term deep learning, in context to deep learning machine learning, and Artificial Intelligence (AI) is also introduced. In Introduction, there is a brief overview of the research achievements of deep learning. After Introduction, a brief history of deep learning has been also discussed. The history started from a famous scientist called Allen Turing (1951) to 2020. In the start of a chapter after Introduction, there are some commonly used terminologies, which are used in deep learning. The main focus is on the most recent applications, the most commonly used algorithms, modern platforms, and relevant open-source databases or datasets available online. While discussing the most recent applications and platforms of deep learning, their scope in future is also discussed. Future research directions are discussed in applications and platforms. The natural language processing and auto-pilot vehicles were considered the state-of-the-art application, and these applications still need a good portion of further research. Any reader from undergraduate and postgraduate students, data scientist, and researchers would be benefitted from this.

Keywords: deep learning, machine learning, artificial intelligence, neural networks

1. Introduction

Deep learning is focusing comprehensively on video, image, text and audio recognition, autonomous driving, robotics, healthcare, etc. [1]. Deep learning is a result orientated field of study that why getting very much attention from researcher and academicians. The Rina Dechter introduced the word of deep learning in 1986, the main motivation behind the advent of field deep learning was making an intelligent machine that mimic the human brain. In humans, the brain is the most important and decision-making organ; brain takes decision based on sight, smell, touch, and sounds. The brain also can store memory and solve complex problems based on their experience.

For the last few decades, the researchers dreamed of making a machine that is as intelligent as, like our brains, they started studying the biological structure and working of the human brain. Making a robot that performs certain duties and self-driving cars is to reduce roadside incidents. Because according to the World

Health Organization (WHO), 1.35 million people die every year in road incidents [2] and approximately 90% of the incidents are due to human errors [3]. To develop state-of-the-art devices for the applications listed above, ones need to think in a different way of programming a device to make it artificially intelligent. Deep learning is one of the most innovative paradigms that make it possible up to some extent. In deep learning, the word deep indicates the number of layers through which data are converted from input to the desired output. It is difficult for a new researcher or student to recognize any project whether it is from artificial intelligence machine learning or deep learning because all these overlap each other some way or the other. Machine learning is any sort of computer program that can learn by their own without having specially programmed by the programmer. There are two types of machine learning: supervised learning and unsupervised learning. In supervised learning, you teach or train the machine with a fully labeled data, the machine learns from the labeled data and then anticipate the unforeseen data. In supervised learning, the machine can only give you correct output when the input is already experienced in training phase; it is based on experience; the more is the training dataset or experience of your machine the higher is the chances of getting the actual output. It is a time-consuming process and also required a lot of expertise in data science. On the other hand, in unsupervised learning, supervision of a model is not needed, rather the model work on its own catches new data and discovers the information inside the data. It usually deals with label-less data; compared to supervised learning, unsupervised learning is more complicated. It is usually used to find features and unknown patterns.

Deep learning models are agile and result oriented in terms of complicated abstractions. Deep learning models are mostly based on ANN, categorically CNNs, although there are deep belief networks, generative models, propositional formulas and Boltzmann machine also play their part (**Figure 1**).

Deep learning has been evaluated as a game-changer in AI and computer vision. Today, state-of-the-art object detection is possible only due to deep learning [4]; traditional methods of object detection are not enough to cater with detection so smartly. To understand the whole image of object detection, it is not necessary
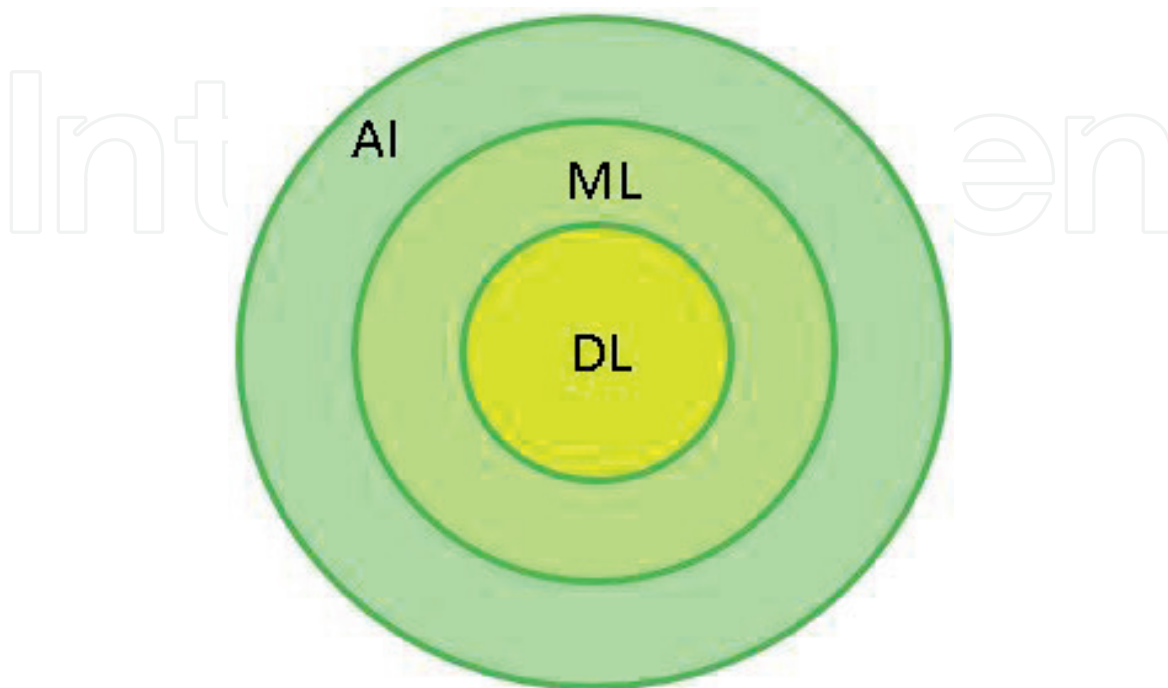

Figure 1.
Deep learning a subset of machine learning and AI.

to only focus on image classification, but to precisely calculate the concept and locations of the objects in every image, that is, object detection which is based on face detection, pedestrian detection, and skeleton detection [5]. Deep learning has cutting-edge technology and has application in every field of life ranging from computational to healthcare. It has a very deep impact on the life of the people or societies because its application is always the need of the day. The deep learning also gains significant importance due to new and flourishing field called big data analytics. Big data analytics is the number of complicated processes examining large and varied data sets, or it is also defined as techniques and methods used to identify the hidden patterns, unknown correlations market trends, and customer preference from huge dataset. Big data analytics can offer various business benefits, that is, more effective marketing strategies, better customer service, improved operational efficiency, etc.

Deep learning is an emerging area of research and modern application. The deep learning is a very widespread and demanding field now-days, it covers industry, business, and healthcare; it combines all the hot research-oriented fields, that is, IoT, e-health-care, cybersecurity, bioinformatics, optimization, and cyber-physical systems; these all are seen interdependent. Gartner has proposed top ten technology trends for 2020, some of them are, hyper-automation, human augmentation, AI Security, IoT, Autonomous things; etc.; all are related to AI, machine learning, and deep learning some way or the other. Surely, deep learning will bring a bunch of innovations to everywhere whether it is industry, health-care or business intelligence. According to Ref. [6], machine learning and AI will be used more in 2020 experts says in the survey conducted by the computer-world.

In 2019, many researchers, academicians, and teachers claimed that deep learning is over because it cannot do common-sense reasoning; Rodney Brooks a professor in MIT says that some popular press started stories that the deep learning will be over by 2020. In 2020, hybrid, interdisciplinary, collaborative, and open-minded research is expected to add more contribution. The topics that are expected to be more prevalent in 2020 are common-sense reasoning, active learning and life-long learning, multi-modal and multi-task learning, open-domain dialogue conversation, medical applications and autonomous vehicles, ethics that includes privacy, confidentiality, and biases, and finally robotics.

There are two most common deep learning platforms: TensorFlow and PyTorch; these two platforms compete; and this competition is very fruitful for the community; TensorFlow is easy to use, integrated with Keras; while on the other hand, Pytorch has TPU support, etc. In 2020, it is expected to have a platform which can easily transform a TensorFlow model to Pytorch and vice versa. There is a need to develop an actively developed stable reinforcement learning framework. The higher layers of abstractions are expected in 2020 like Keras, so that machine learning is used outside the machine learning fields.

1.1 History

Deep learning is a sub branch of machine learning, and machine learning is a sub branch of artificial intelligence. Deep learning is a set of algorithms that processes large set of data Dend imitates the thinking process. The history of deep leaning is started from 1943, when Warren McCulloch and Walter Pitts created a neural network-based computer model. There basic aim was to mimic thought process of human brain; they used algorithms and mathematics to make the threshold logic to mimic human thought process. Alan Turing called the father of AI concluded in 1951 that the machines would not take much time in started thinking of their own; at some point of time, they would be able to talk to each other; and it is

also expected that they would take the control of the universe. In context to this, the frank Rosenblatt introduced single and multi-layer artificial neural network (1957–1962). The history amazed us when the world champion of chess player called Kasparov was defeated by Deep blue computer in 1997. In 1957–62, the single layer and multi-layer perceptron's was introduced. The first deep feedforward general purpose learning algorithm multilayer perceptron's by Alexey Icakhnenko and Lapa was published in 1967. In 1971, a deep network with eight layers trained by the group method of data handling algorithm was described already. The idea of backpropagation, Recurrent Neural Network (RNN), and restricted Boltzmann machine (RBM) was introduced in 1970–1986. In 1979-1998, the Convolution Neural Network (CNN), Bidirectional RNN, and long short-term memory (LSTM) were the state of the art. The deep belief network (DBN) was introduced by Geoff Hinton in 2006. The data sets called ImageNet and AlexNet that was created in 2009. Generative Adversarial Network (GAN) is a class of machine learning system invented by Ian Goodfellow and his colleagues in 2014. Coming up in history in 2016 Google DeepMind challenge match between Alpha Go versus Lee Sedol, the AlphaGo win all the matches from a world champion Lee Sedol. AlfaGo and AlfaZero are computer programs developed by artificial intelligence research company called DeepMind in (2016–2017); it plays the board game Go. The transformer introduced in 2017–19 a deep learning model used specially used for Natural language Processing (NLP). Although there is a lot of community contributed to the deep learning but Yann LeCun, Geoffrey Hinton, and Yoshua Bengio have received Turing awards in 2018.

2. Deep network topologies

2.1 Deep neural network (DNN)

In DNN, there is multilayer perceptron or hidden layer between the input and output. All the layers are connected to previous layers; by going through each layer, the network estimates the exact output based on the weights and activation function. Through DNN, we can model any complex non-linear relation. The backbone of the DNN is the characteristic of learning about the feature that is most relevant to the targets [7]. The DNN has research gap in model selection, training dynamics, by using graph convolution neural network combination optimization, and Bayesian neural network for estimation of uncertainty. There are a lot of applications for DNN, that is, computer vision, machine translation, social network filtering, playing board, video games, and medical diagnosis (**Figure 2**).

2.2 Recurrent neural network (RNN)

RNN is a type of deep learning network that is used specifically when there is sequential data or time-series, that is, video, speech, etc. The RNN usually maintained the data from the previous state to the next state. It is called recurrent because it performs the same function for each input, while the output is different because it also depends on past calculations. The state-of-the-art topic of deep learning with RNN is Long Short-Term Memory Network (LSTM). RNN provides the solution to many problems, that is, intelligent transportation system [8], solving time-varying matrix inversion [9], and many more. The RNN is famous for sentence evaluation and linguistic data processing (**Figure 3**).
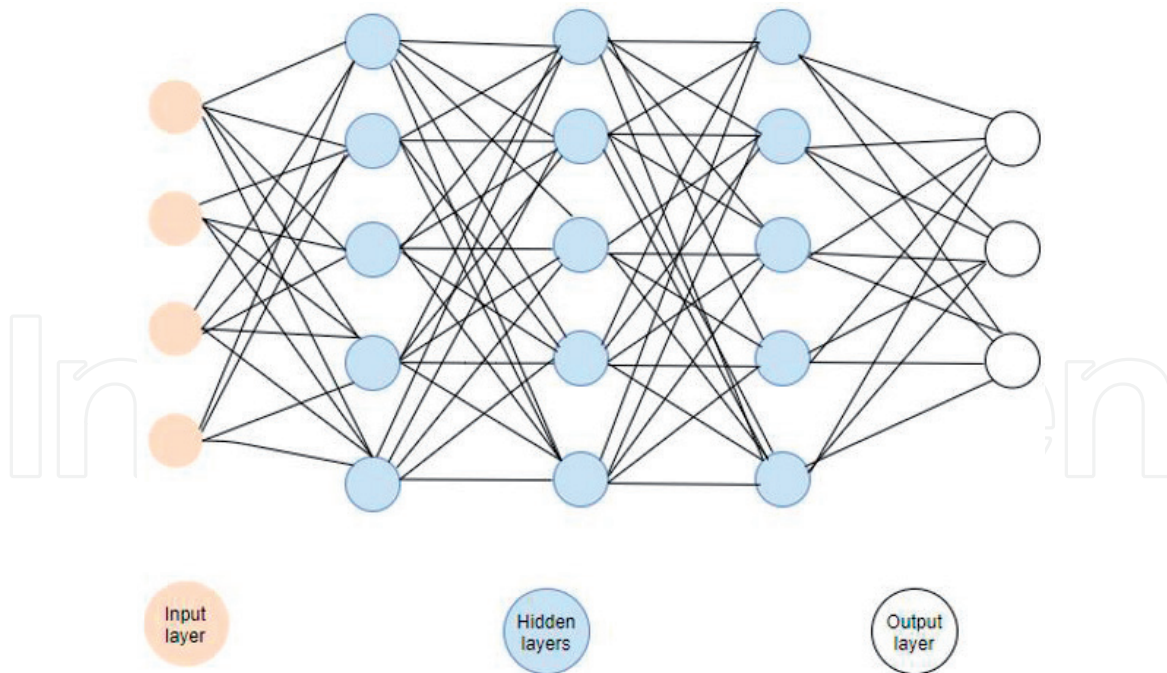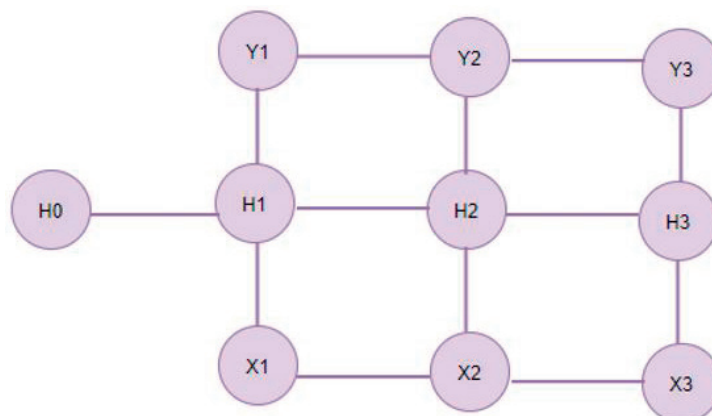
Figure 2.
Deep neural network.

Figure 3.
Recurrent neural network.

2.3 Deep belief network (DBN)

DBN is a probabilistic unsupervised deep learning algorithm. It has many layers of hidden variables. To solve the more complex problems, it needs more hidden layers; each layer is a special statistical relation with the other layer. DBN can learn probabilistically; after learning, BDN needs training under supervisor to perform classification. The DBN is used to recognize clusters and generates images, video sequences, and motion-capture data (**Figure 4**).

2.4 Boltzmann machine (BM)

The BM is a network that is a uniformly attached, neuron-like unit, which is responsible for taking decisions stochastically about whether to be off or on. Computational problems are solved through BM like search, optimization, and learning problem. Many features are uncovered in learning algorithm that shows
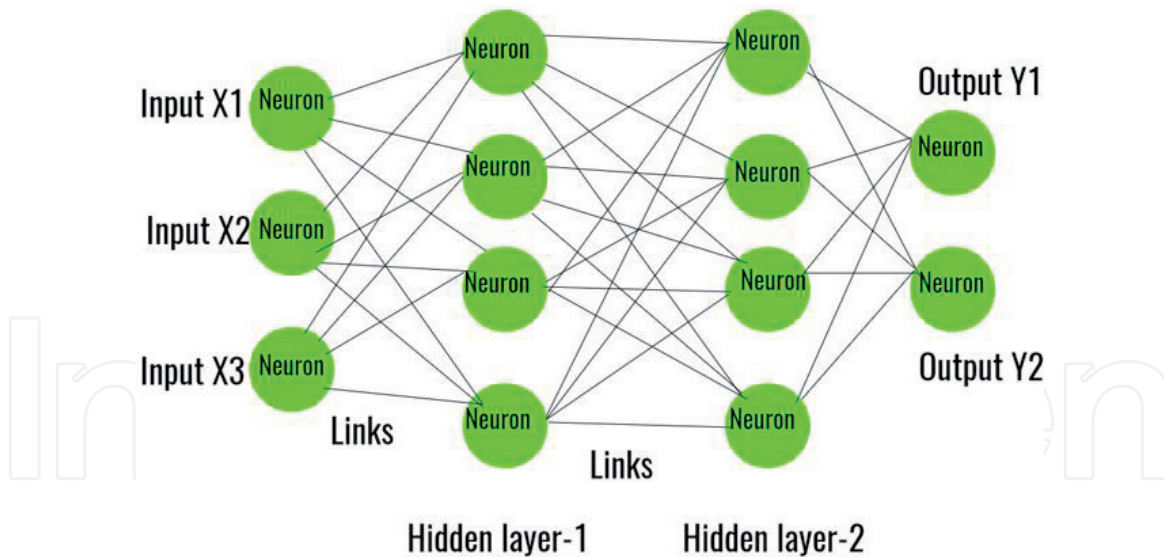
Figure 4.
Deep belief network.

very complex behavior in training dataset. Boltzmann machine is used for classification and dimensionality reduction.

2.5 Restricted Boltzmann machine (RBM)

RBM introduced in 1986 by Smolensky: two layers visible and hidden units, while there is no connection between visible-visible and hidden-hidden. It can learn a probability distribution over a collection of datasets. The applications of RBM are features learning, collaborative filtering, dimensionality reduction, and classification.

2.6 Convolutional neural network (CNN)

In CNN, the layers are delicately connected to input layer as well as each other. There is a specific function for each neuron of the subsequent layer like it is only responsible for only a part of the input. CNN is now widely used for remote sensing, computer vision, audio, and text processing [10].

2.7 Deep auto-encoder

Just like others, deep auto-encoder has also many hidden layers. The difference between a simple auto-encoder and deep-auto-encoder is the simple auto-encoder that has one hidden layer, while the deep-auto-encoder has many hidden layers. In deep-auto-encoder, the training is complex normally, you need to train one hidden layer first to reconstruct the structure of the input data, and this input data are further used to train other hidden layers and so on. Some applications of deep auto-encoder are image extraction, image generation recommendation system, and sequence to sequence prediction.

2.8 Gradient descent (GD)

GD is used to reduce the overall cost function; it is considered as an optimization algorithm and is widely used for determination of coefficient function in machine learning. When there is not possible to estimate the parameters analytically, then

GD is used to calculate the desired parameters. Using the GD weight of the model is updated for every epoch. It is used for supervised machine learning.

2.9 Stochastic gradient descent (SGD)

Just like GD, SGD is also an optimization algorithm but GD is used when the datasets are small, while SGD is usually used when the datasets are large, and SD becomes very costly if used for a large number of datasets.

3. Application of deep learning

Deep learning is new and state-of-the-art technology used for large scale applications now-days. Deep learning (also called differential programming or structure learning) is member of a large family of machine learning class. It is edge-cutting technology used for many different new research fields which are stated below.

3.1 Deep learning in automatic speech recognition

The automatic speech recognition is the convincing application of deep learning. Speech recognition means making speech as in input to a machine that can make the input process very easy and has a hundred of other advantages as well, that is, illiterate people can also use technology, speech coding, text to speech synthesis, speech recognition, speaker recognition, speech enhancement, speech segmentation, language identification, and many more [11]. The speech is the natural form of communication, hence it is considered a very convincing application.

3.2 Image recognition

Image recognition based on deep learning becomes very famous and accurate result-oriented technology based on the training and experience of machine. Deep learning plays a very important part in image recognition and image classification in underwater target recognition [12] although the images from underwater are always noisy and deteriorated. MNIST is one of the most renowned examples used for image classification, below is the simple of dataset of MNIST dataset (**Figure 5**).

3.3 Natural language processing

LSTM helps a lot in language modeling and machine translation [13]; language modeling task is to understand the language. To implement the language, models' neural networks are used. Google translate is the most famous and widely used application in this regard; Google translate is used for more than 100 languages all over the world. It also used LSTM; and it learns from millions of examples and translates the whole sentence rather than word by word translation. BERT (Google) is one of the most common technologies in this field achieved a lot of benchmarks, that is, sentence classification, sentence pair classification, sentence pair similarity, sentence tagging, create contextualized words embedding, question answering, and multiple-choice questions. There are some other transformer-based language models developed in 2019, which are XLNet (Google/CMU), RoBERTa (Facebook), Distil BERT (hugging Face), CTRL (Salesforce), GPT-2 (Open-AI), ALBERT (Google), and Magatron (NVIDIA). Magatron is the largest transformer model ever trained. It has 8.3 million parameters transformer language model. XLNet is the best transformer in terms of performance; XLNet outperforms BERT on 20 tasks
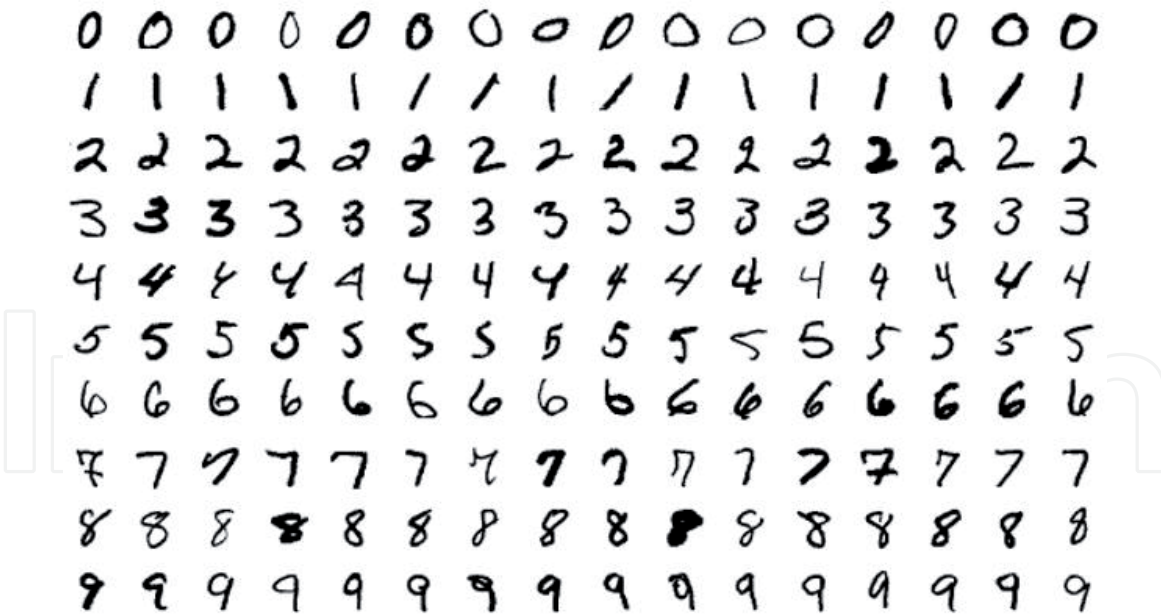
Figure 5.
Image example of handwritten digits from the MNIST dataset.

often by a large margin. ALBERT developed by Google is used to reduce the parameters via cross-layer parameters sharing. The state of the artwork in this domain is about multi-domain task-oriented dialogue system [14]. In 2020, it expected to combine common sense reasoning with language models, extending language model context to thousands of words and to have more focus on open-domain dialogue (**Figure 6**).

3.4 Games and robotics

Robots are the agents who are artificially intelligent and working in the real-world replacing humans. OpenAI and Dota 2 are popular games; in 2017, 1v1 bot beats top professional Dota 2 players; in 2018, OpenAI five lost two games against top Dota 2 player, while in 2019, OpenAI five beat OG team (the world champion in 2018). The OpenAI five win in 2019 is only because of the more training compute; the current version of OpenAI has consumed 800 petaflops/day and experiences about 45,000 years of dota self-play over 10 real-time months. The current version has 99.9%-win rate versus the 2018 version. It is one of the best experiences in deep learning that systems that learn to play with each other and incrementally
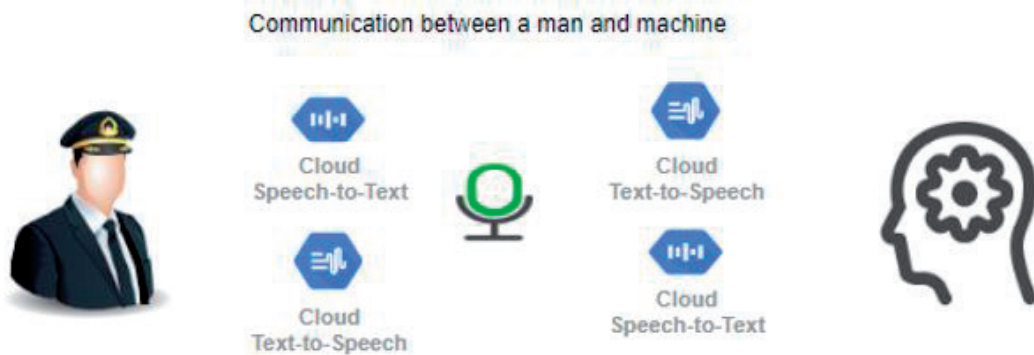

Figure 6.
NLP and deep learning.

improving. OpenAI Rubiks Cube Manipulation is another example from Robotics. The researchers are expecting in 2020 to implement reinforcement-learning methods in the manipulation of real-world interaction tasks. In games, experts are loss from different machines, using these machines to assist human experts in discovering new strategies. Waymo a company that is focusing on developing auto-pilot like Tesla in October 2018; they have 10 million miles on road and now in 2020 they have 20 million miles on road 20,000 of classes for structure test, also initiated testing without having a safety driver.

3.5 Financial fraud detection

Deep learning is playing a very important role in financial fraud detection. With the advent of technology and a significant amount of e-commerce platforms, the number of e-payments is increasing day by day chances of financial fraud, which is also a source of headache for banks and other financial institutions. Thus, focusing on fraud detection is a hot area of research. The author of [15] used auto-encoder for financial fraud detection [16]. This research uses deep learning model for fraud detection, while [17] proposed a solution to fraud detection using machine learning approach.

3.6 Deep learning in health-care

In this modern era of computing, deep learning also produced best results medical and health care, that is, deep learning is used for cancer cell coordination, organ segmentation, protein folding, lesion detection, and image enhancement in the field of medicine. There are several other issues like [18–21] and much more where deep learning is directly involved in the suggestion of the ultimate solution to the problem in healthcare.

3.7 Military

Deep learning is used for making many different military devices used in wars or other spy services. The military is also working on robots to train the robots to handle the critical situation through these robots. The militaries of some countries are making their weapons more intelligent using AI. In a war zone, AI can be embedded in the robots for remote surgical support in healthcare.

3.8 Cybersecurity

Cybersecurity is also one of the hot research areas; deep learning models are used for the cybersecurity of the Internet of Things (IoT) [22]. The IoT devices are usually low power devices having power-constrained that's why always vulnerable to external threats. Deep learning models can detect threats more accurately than any other technology. The author of [23] used deep learning and machine learning for intrusion, spam, and malware detection.

4. Modern deep learning platforms

Open-sources deep learning platforms discussed in this section. It will provide a quick review of the open-source platforms for beginners and mediocre because every platform has its pros and cons.

4.1 TensorFlow

The TensorFlow is new and open-source platform for differential programming; it was developed by Google team called Google brain and was first released in 2015 [24]. In February 2017, they released version 1.0.0; TensorFlow can work on CPU and GPU; it is available for Mac, Linux, and windows and also for mobile computing platform android and iOS. It is the most famous machine learning library in the world today. Its best-supported client language is python but there is also interface available in C++, Java, and GO. It is easy to use and have Keras integration. TensorFlow has many of its versions available like for mobiles TensorFlow lite, for industry TensorFlow Serving, etc.

4.2 Pytorch

Pytorch is also machine learning and deep learning library, based on torch library. It was initially released by Facebook's AI Research lab (FAIR) in 2016. Pytorch has two high-level features, Tensor computing with graphics processing units (GPU), and auto-diff based deep neural network. It is too easy in Pytorch to move tensors to and from GPU. Pytorch Mobile is the version of Pytorch used for mobiles. There are some key features of Pytorch; the first feature is called imperative programming; most of the python code is imperative; this type of programming is more flexible. The other feature of Pytorch is dynamic computation graphs, it run time the system generates the graph structure, dynamic graph work well for dynamic networks like RNN, dynamic graph also makes debugging very easy. The Pytorch provides maximum flexibility and speed during implementing and building deep neural network.

4.3 Theano

Theano is designed by Montreal Institute for Learning Algorithms (MILA), which is very famous after their deployment, but unfortunately, there is no support after version 1.0.0 (November 2017). It is a python library designed for code compilation optimization [25]; it is primarily used for mathematical operations like multi-dimensional arrays. Theano was far better than other python libraries like Numpy in terms of speed, computing symbolic graphs, and stability optimizations. Tensor operations, GPU computation, and parallelism are also supported by Theano.

4.4 Microsoft cognitive toolkit (CNTK)

CNTK is used for commercial-grade distributed deep learning. It can be used as a standalone tool for machine learning or also can be included as a library in C++ programs, python, and C#; its model evaluation functionality can be also used from Java programs. It supports ONNX that allows sharing model with frameworks Caffe2, MXNet, and PyTorch [26]. CNTK can be used only on Linux and Windows. The CNTK is considered as a powerful machine learning platform similar surge of performance as compared to other widely used platforms [27].

4.5 Keras

Keras is a powerful library written in python; it uses TensorFlow, Theano, and CNTK as a framework because it does not have their framework. Keras can work on GPUs and CPUs and can also support RNNs and CNNs. The beauty of Keras is it has

the ability of fast and easy prototyping; Keras is user-friendly. It has been ranged one of the most cited API in 2018 and has enough number of users on board.

4.6 Deep learning 4J

It is distributed open-source, robust deep learning framework for Java designed by Skymind [28] which is added a lot to Java ecosystem and eclipse foundation. It has compatibility with Clojure and Scala APIs just like Keras; it is also able to work with both CPUs and GPUs. It is widely used for academics and industrial applications.

4.7 Torch

It is a scientific computing open-source machine learning framework released in October 2002; it is not able to work on CPUs; it is only made to focus on GPUs accelerated computing. It is developed in programming language C and based on Lua, a contribute in a LuaJIT, a scripting language. Max OSX and Ubuntu 12+ can use this framework, although they have Platform for Windows, but their implementations are not supported officially [29].

4.8 Caffe and Caffe2

CAFFE (Convolutional Architecture for Fast Feature Embedding) created by Berkeley AI Research (BAIR) is a framework for deep learning. It is developed in C++ with a python interface. Caffe2 was introduced by the research group of Facebook in 2017, but Caffe2 was merged in PyTorch in March 2018. It supports multiple platforms, that is, Mac OS X, Windows, Linux, iOS, and Android [30].

4.9 Apache MXNet

An MXNet is a fast-scalable deep learning platform that supports many programming languages, i.e., Scala, Julia, C++, R, Python, Gluon API, and Perl APIs. Like Torch, it is also made only for GPUs, and it is very competent in multi GPUs implementations. The Apache MXNet is scalable flexible and portable, and due to these qualities, it attracts many users.

5. Training algorithms

One of the most important parts of deep learning is learning algorithms. The deep neural network can be differentiated only through the number of layers; if the number of layers increases, the network becomes deeper and more complex. Each layer has its specific function or can detect or help in the detection of the special feature.

According to the author [31], if the problem is face recognition, the first layer has the responsibility to recognize edges, the second has to detect higher features such as the nose, eye, ears, etc., the next layer can further dig out the features, and so on. Thus, each layer is developed earlier to the development of training algorithm like gradient descent; that's why these kinds of classifiers are not suitable for a dataset with huge volume or variation. This was discussed by Yann et al. [32]; they further concluded that a system with less manual and more automatic design can give better results in pattern recognition.

Backpropagation is the solution; it takes information from the data without going through classifiers and finds the representation needed for recognition. List of few famous training algorithms is listed below.

5.1 Gradient descent

In statistics, data science, and machine learning, we optimize a lot of stuffs; when we fit a line with linear regression, we optimize the intercept and slope; when we use logistic regression, we optimize a squiggle; when we use t-SNE, we optimize clusters. The gradient descent is used to optimize all these and tons of others as well.

Gradient descent algorithm is similar to Newton's roots finding algorithm of 2D function. The methodology is very simple; just pick a point randomly on a curve and move toward the right or left along x-axis depending on the positive and negative value of the slope of the function at the given point up-till the value of y-axis, that is, function or f(x) becomes zero. There is the same concept behind the gradient descent; we move or traverse along a specific path in many-dimensional space weight when the error rate is reduced to your limits than we stop. It is one of the underlying concepts for most of deep learning and machine learning algorithms.

$$C = \frac{1}{2}\left(Yexpected - Yactual\right)^2 \qquad (1)$$

5.2 Stochastic gradient descent

A method used for optimizing an objective function with the iterative method is called stochastic gradient descent. It can also be called gradient descent optimization. Stochastic gradient descent would randomly pick one sample for each step and from that, just use this one sample to calculate the derivatives, thus in super sample example, stochastic gradient descent reduced the number of terms by computed by 3.

If we had one million samples than the stochastic gradient descent would reduce the number of terms by computed by factor of one million. In stochastic gradient descent, when minibatch of the number of samples finished running than updates are applied, in here update of weights is more frequent, so we reach a global minimum in less time (**Figure 7**).
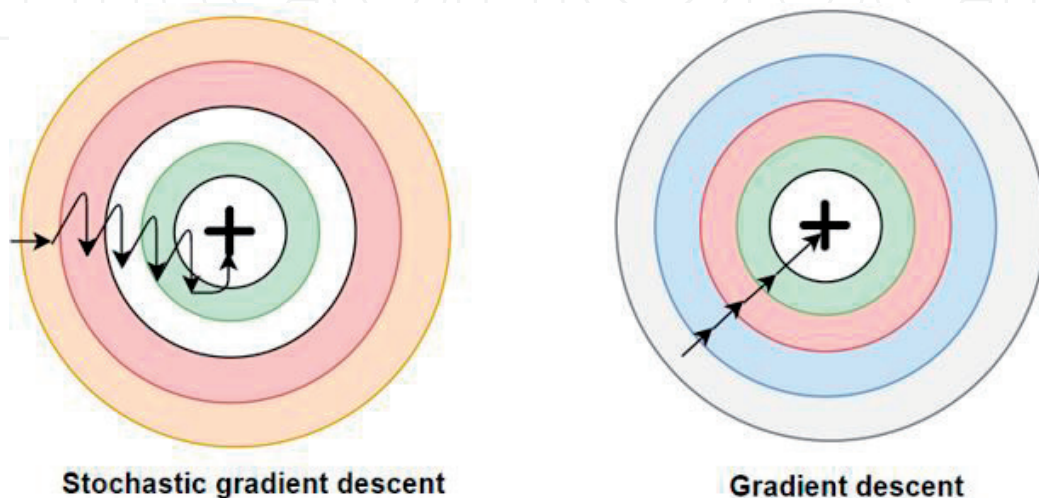

Stochastic gradient descent   Gradient descent

Figure 7.
Comparison of GD and SGD.

5.3 Momentum

In stochastic gradient descent to update the weight or to calculate step size, a fixed multiplier is used as a learning rate; this can cause the update to overshoot a potential-minima; if the gradient is too steep or delay, the convergence of the gradient is noisy. The concept of momentum used in Physics is velocity exponentially decreasing an average of gradient [33]. This prevents the descent going in the wrong direction.

5.4 Levenberg-Marquardt algorithm

This type of algorithm is used for curve fitting or non-linear least-squares problems. This algorithm is also called as deep least-square; these kinds of issues arise usually in the least-squares curve fitting. It was first introduced by Kenneth Levenberg in 1944, although it was rediscovered by statistician called Donald Marquardt in 1963.

5.5 Backpropagation through time

It is one of the famous and standard methods used to train the recurrent neural network. It was developed independently by several researchers. Unlike general-purpose optimization techniques, it is faster in training RNN. The backpropagation through time also has issues with local optima [34].

6. Routine challenges of deep learning

According to Google trends graph more and more expert and professionals have attracted toward deep learning in last five year; the percentage of profession-als increased from 12 to 100% [35, 36]. Deep learning is used everywhere, that is, bio-informatics, computer vision, IoT security, health-care, e-commerce, digital marketing, natural language processing, and many more [37, 38]. Because of the very hot research area, there must have some challenges which are enlisted below.

6.1 Non-contributing columns or inputs

When dealing with data or making a model, several inputs are not necessary for finding any feature, so it is advised to drop un-necessary attributes. There is also necessary to find one best column and make it separate from the dataset; it can be done using numpy array in Keras; but it is difficult and challenging to find best match attribute.

6.2 Number of hidden layers

The number of hidden layers is directly propositional to computational complexity and deepness of the network. To deal with a large number of layers require a high computational cost, difficult to manage a large number of neurons.

6.3 Optimization algorithms

In model optimizations, gradient descent optimizer helps to make the model cost minimum by adjusting the value; choosing an optimizer is also a challenging task to do, because sometimes it makes your cost of model high rather than decreasing the model cost.

6.4 Loss function

Is from the name indicate loss function, it estimates the loss or the difference between the expected outcome and the actual outcome the formula for loss function is listed below.

$$Floss = Expected\ outcome - actual\ outcome \qquad (2)$$

There are many different ways to calculate the loss function; choosing a loss function is also one of the essential and challenging tasks of deep learning

6.5 Activation function

There are many different activation functions; every activation function does not produce the same results; sigmoid activation function shows good results with binary classification problem. One needs to be careful about Tanh activation function because of the vanishing gradient problem. In multi-labeled classification, softmax is the best option; Relu should be used when there is much zeros in the input side because Relu is good in dead neuron generation. It is also a point to use the required activation function.

6.6 Epoch

When the dataset is passed backwards and forward through the whole neural network, it is called one epoch, as after every epoch value of weights assigned is analyzed to make model. The weights are changed, checked, and tested in every cycle for the same dataset simulation. The main memory is keeping the record of all the training data; sometimes it is not possible to keep all the record in main memory, like for larger datasets, so the epoch is brought to memory in divided or batches form, and finally the result is represented as an epoch output. Dealing with epoch is also a challenging task in deep learning.

7. Available open-source datasets

Research in machine learning and deep learning is started since last many decades hence significant improvement it brings to the society in terms of various application-based on deep learning and machine learning. There are many freely available datasets on the web which can be used by researchers for various purposes.

Image datasets (Table 1):

Pascal VOC	MS COCO
MNIST handwritten digits	NORB
CIFAR10/CIFAR100 color images data set with	COIL100
Caltech101	Google's Open Images
Caltech 256	COIL 20
The dataset of street view	LabelMe
STL-10	ImageNet

Table 1.
Open source image datasets.

Geospatial datasets available online:

1. NEXRAD

2. OpenstreetMAP

3. Landsat8

Dataset available for text (Table 2):

Google books Ngrams	Yelp open dataset	20 newsgroups	
UCI's Spambase (Older)	Prediction	UCI machine learning repository	Text classification datasets
SQuAD	Google books Ngrams	Broadcast news	WikiText
Penn Treebank	Reuters news dataset	Billion words dataset:	Common crawl

Table 2.
Text open-source datasets.

Artificial datasets:

1. Arcade Universe

2. Dataset inspired from baby-AIschool

3. All images and question datasets

4. Deep vs. shallow comparison ICML

5. Background correlation

6. Rectangles data

7. Mnist variations

Facial datasets (Table 3):

Labeled faces in the wild	UMD faces annotated dataset	CASIA WebFace facial	
MS-Celeb-1M	Olivetti	Multi-Pie	
JACFEE	FERET	mmifacedb	
Indian face database	The Yale face database	Mut1nyFace/head segmentation dataset	

Table 3.
Databases for face recognitions.

Recent additions of datasets (Table 4):

Open data monitor	Quandl data portal	Mutiny face/head segmentation dataset
Awesome public dataset	Head CT scan dataset	Open datasets
WAPo	Chess dataset	NLP datasets

Table 4.
Free databases developed recently.

The UZH-FPV drone racing dataset	**North Korean missile test database**	**Flickr-Faces-HQ Dataset (FFHQ)**
Hotels-50K	MIMIC-CXR	Google Audioset
Two new evaluation data-sets	Open-source biometric data recognition	Uber 2B trip data
Yelp Open Dataset	Core50	Data portals

Video datasets:

For video only one and big and diverse labeled dataset available is Youtube-8M [39].

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