A Brief Review of Machine Learning and its Applications

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Abstract

Machine learning fit in to be a widespread technology now-a-day. Machine learning is preponderantly a subcomponent of Artificial Intelligence which has garnered significant eyeballs resulting in major AI-led developments in the arena of digitalization solutions with the anticipation of adoption of AR and VR technologies. There are ample of research of different kinds that are going on so that we can make the machines more and more intelligent and advanced. Humans display natural intelligence which influenced machines as well with an ensuant response in the form of technologies. The improvement in accuracy of the machine learning algorithms is a concern on which researchers and scientists are regularly working upon. This paper is an intendment of a brief review of machine learning and its various categories along with some of its applications.

1. INTRODUCTION

Let us first get familiar with the fundamentals of Artificial Intelligence (AI). AI is an act of applying human intelligence processes on machines, especially computers. According to Computer Science terminology, AI is simply, the survey of "intelligent agents" which can be thought of as any device that recognizes its environment and makes decisions in order to get the maximum possibility of success while achieving its predefined goals.

Informally, AI is defined as the ability of any device or machine to comprehend just like how humans grasp from other human brains, such as "capability to learn and solve problems". In this manner, Machine Learning is a field of AI. Since 1950s there are several advancements made in the demesne of machine learning, followed by a wave of disappointment in AI winter, followed by its resurgence with new practices and success due to enormous efforts made in last few years [1].

Now we need to understand the fundamental concepts of Machine Learning (ML). Machine Learning is the term coined for scientific cogitation of algorithms and statistical models used by computers to accomplish a particular task without even programming the device explicitly, depending upon the patterns and instructions instead. Thus, ML is a diligence of AI which provides various abilities to the system to perceive the surroundings and continuously improve from the experience with time. Machine Learning mainly emphases on the deployment of various computer algorithms that enables machines to access the provided data, utilize it in learning and gaining more and more experience along with executing its tasks. In this way, the machines take decisions and make predictions based on the available data.

Consider the example of a computer program that is taught to detect or predict cancer by analyzing the medical reports of a patient. It will obviously result as improvement in its performance as it gathers more experience by properly analyzing medical reports of wider number of patients. The number of correct predictions and detections, as validated by a professional Oncologist will determine the performance of program.

Deep Learning, simply is a subclass of Machine Learning (ML) that is primarily focused on the working of our Brain cells, called Neurons, which indirectly led to the concept of artificial intelligence. 'Deep' is the term coined to refer the layer counts of any neural network. Thus, 'deep network' has multiple layers which are hidden whereas a 'shallow network' has only one layer. Figure 1 describes the relationship between AI, ML and Deep Learning.

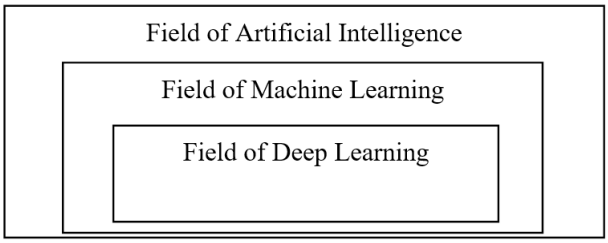

Figure 1:. Relation between AI, ML and Deep Learning

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This paper intends to present a brief review on ML and its applications. A brief literature survey on ML is listed in Section 2. Section 3 demonstrates the different kinds of Machine Learning, Section 4 gives an overview of the algorithms commonly used in Machine Learning, Section 5 tells us about the tools which are used in implementing Machine Learning, Section 6 defines the steps which are involved in building a basic Machine Learning model, Section 7 gives an overview of different fields and areas of application of Machine Learning, Section 8 describes about the challenges which are faced while adapting Machine Learning which is followed by Conclusion in Section 9.

2. LITERATURE SURVEY

In 1988, [2] tried to predict the occupancy rates in Hong Kong hotel rooms with the help of neural networks and concluded that the naïve extrapolation model is outperformed by neural networks, also they are superior than multiple regression. This research computed the feasibility of neural networks in the fields of forecasting of the occupancy rates in the Hong Kong hotels.

[3] describes a method of machine learning with the help of genetic algorithm (GA)-SVR with real value Gas. The obtained experimental outcomes investigate that SVR performs better than those models of ARIMA and BPNN.

[4] proposed a method for projecting the future demands of tourism implemented using Chaotic Genetic Algorithm (CGA), like SVRCGA, being capable of overcoming premature local optimum problem. The research suggested that SVRCGA model is able to outclass other methodologies.

Researchers in [5] propose a model to predict future stock price, ideally based on a four-layered structure of Fuzzy Multi Agent System (FMAS). Authors investigated that FMAS is a suitable tool for the purpose. This AI based model utilized the coordination among intelligent agents for this task.

An intelligent model for the purpose of estimating tourism demand i.e., a Modular Genetic-Fuzzy Forecasting System using a genetic fuzzy expert system is proposed in [6]. It also finds that the accuracy achieved in predicting power of this system is better than approaches such as Classical Time Series models, therefore declaring it more suitable for prediction problems related to tourism demands.

[7] presented Machine Learning methods in statistical time series forecasting and then made a comparison of correctness of those methods with that of conventional statistical methods and declared the former as better and more accurate.

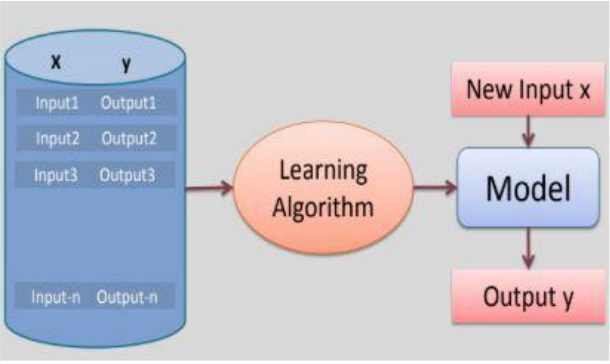

Figure 2: Supervised Learning [8]

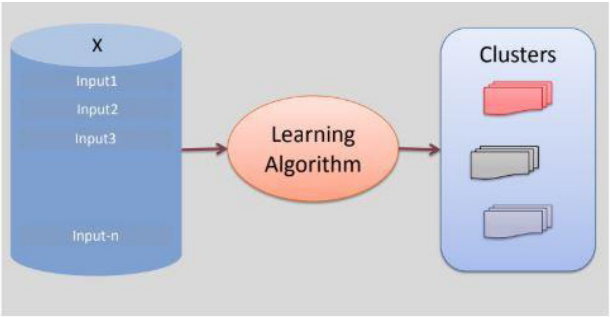

Figure 3: Unsupervised Learning [8]

3. TYPES OF MACHINE LEARNING

Machine Learning algorithms can be categorized into different types based on various possible scenarios in the availability of training data, test data and teaching methods as described below:

3.1. Supervised Learning

Supervised learning is one of the most popular learning methods in which a data set is fed as the input with the known outputs for each corresponding input. With the help of them the Machine Learning model tries to establish a relationship between the feed and result as shown in Figure 2..

Supervised learning methods are again subdivided into two types, namely “regression” and “classification” problems.

In case of regression problem, the machine learning model maps the continuous output function against the input variables. For e.g. given a picture of a person, the model has to predict the age on the basis of given picture.

While in case of classification problem, the machine learning model tries to map input variables into discrete categories. For e.g., Predicting the house prices based on the area.

3.2. Unsupervised Learning

Unsupervised learning gives us the advantage above all the other learning algorithms because in this we try to solve those problems about which we have a little or no idea of their results and the effect of variables. The structures are

traced by clustering the given data based on the relationship among the variables of data as shown in Figure 3.

Here the main task of the machine learning model is to make a cluster of unsorted information based on the similarities, Patterns and differences without having any previous knowledge about the training data. The machine is restricted to find the hidden structure in unlabeled data by itself.

Unsupervised Learning problems are also divided into two types, namely Clustering and Association.[9]

Clustering: In a clustering problem, we do the grouping of data points according to the relationships among the variables, such as grouping customers by their ways of purchasing items from the shops. It is a method generally used for statistical analysis of data in different areas.

Association: In an association problem, we discover trends which define the large portion of the dataset, such as projecting that people who bought X are highly likely to buy Y.

3.3. Semi-supervised Learning

Semi-supervised learning algorithm is a combination of both supervised and unsupervised learning. It can be highly beneficial in those fields of machine learning where we already have unlabeled data and obtaining the labeled data from this is a tedious process [10].

In Semi-Supervised Learning Problems, we have a huge quantity of input data in which only a little amount is labeled and rest of the data remain as it is. For e.g. A photo catalogue in which only a few of the pictures are labeled (e.g. elephant, car, bridge) and rest we have is a set of unlabeled images.

3.4. Reinforcement Learning

Reinforcement learning is a type of Machine learning in which the reinforcement agent takes actions in order to get more and more positive results. The learner initially has no clue about which action to take while waiting for any kind of condition given. But the decisions made by the learner may make an effect on the conditions and their impact in the future. The feedback is received by the learning algorithm from the environment after selecting an output for the particular input which basically indicates the degree to which the output fulfills the goals of the learner. Reinforcement learning algorithm applies to those problems which are sequential i.e., in which the learner interrelates with an environment by taking the actions sequentially – the outputs – on the basis of its observations – its inputs – while receiving response regarding each carefully chosen action.

Reinforcement learning completely depends upon two factors i.e., Trial & Error search and delayed outcome [11].

In the above Figure 4., the agent accepts some feed *i,* has current state denoted as *s*, makes a transition of state *r* and affected by function *a* of the environment. On the basis of them, the agent derives a behavior denoted as B and with the help of this behavior it takes action which is responsible for the outcome.

3.5. Multitask Learning

In Multi-Task Learning the main motive is to help the other learners so that they can improve and perform better. When this algorithm is practiced on a particular task, it basically remembers the procedure how that particular problem is solved and also how the learning algorithm reacts to it to reach to that inference. The algorithm then applies the same approaches for finding the solution of other similar tasks. One better way of executing and improving the learning algorithm can be done by all the learners sharing their experiences with each other and so that they all can learn simultaneously and effectively [12].

3.6. Ensemble Learning

In Ensemble Learning many individual learners are merged together to form a single learner. This individual learner may be Naïve Bayes, neural network or decision tree. Ensemble learning has been in trend since 1990s. It is always good to have a group of learners for performing a particular task as compared to any individual [13].

3.7. Neural Network Learning

The Neural Network is basically derived from the biologic realization of neurons, which are cell-like structure present inside our brain. In order to interpret neural network, one must have the knowledge about how neuron functions. A neuron has primarily four parts i.e., Dendrites, Nucleus, Soma and Axon as referred in Figure 5 given below.

The Dendrites capture electrical signals and send those signals to Soma which processes these electrical signals. The resultant from this process is drifted to dendrite terminals with the help of axon which direct the resultant to the next connected neuron. This interconnection of neurons

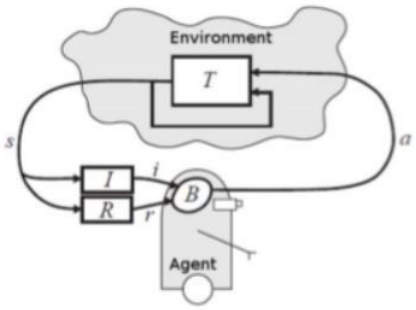

Figure 4: Reinforcement Learning [11]

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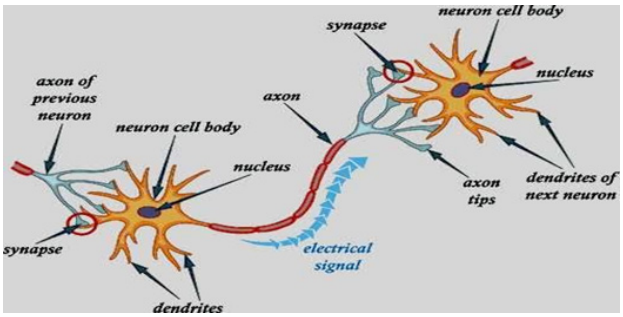

Figure 5: Neuron [14]

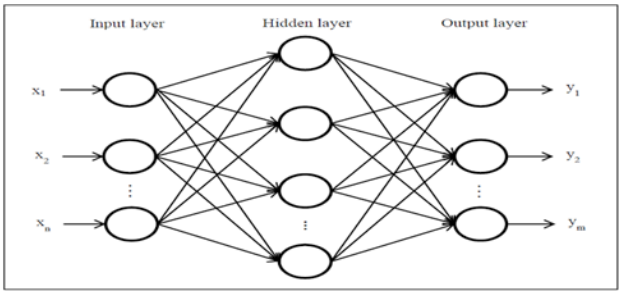

Figure 6: An Example of a Neural Network [15]

is called as neural network through which the electrical signals travel across the brain. In the exact similar manner, an artificial neural network behaves and it also three layers as shown in Figure 6. First is the input layer which accepts input (similar to dendrites), second is the hidden layer which takes action on that input (like soma or axon does) and third, the output layer used to carry the output (like dendrites do) [16]. The artificial neural network is mainly of three types: supervised, unsupervised and reinforcement [17].

3.8. Instance Based Learning

In this type of learning, the learner is prepared enough to make them able to learn specific patterns which it tries to practice on the data fed to it. Hence is known by this name. It is actually that kind of slothful learner that waits until the test set arrives and then processes them altogether with training dataset. The disadvantage is that its complexity increases with the increase in the size of data.

4. ALGORITHMS USED IN MACHINE LEARNING

Algorithms are the heart of Machine Learning. Not only do they make the whole system work but when supplied with good data, they can do the predictions which are very quick and efficient.

4.1. Supervised Machine Learning Algorithms

- Linear Regression
- Decision Trees
- Random Forest

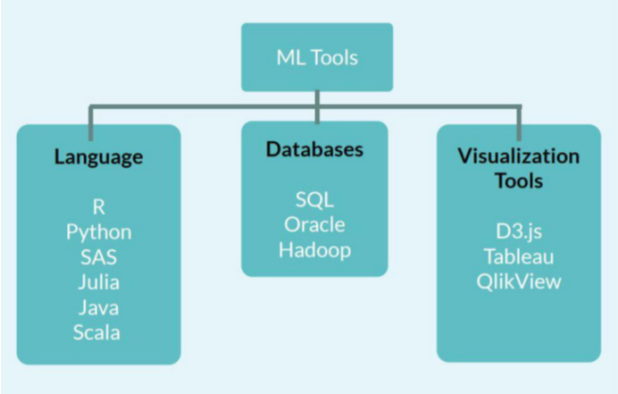

Figure 7: Common Tools used in Machine Learning[17]

- Gradient Boosting Machines
- Support Vector Machines
- K-nearest neighbour

4.2. Unsupervised Machine Learning Algorithms

- Hierarchical Clustering
- Neural Networks
- k-means Clustering

4.3. Reinforcement Learning Algorithms

- Q-Learning
- SARSA
- DQN

5. TOOLS USED IN MACHINE LEARNING

With the amount of development happening in AI & ML, there are plenty of tools coming out regularly. However, there are a few tools that are more popular than the others. The most popular tools used in machine learning applications are summarized in Figure 7.

6. STEPS INVOLVED IN BUILDING MACHINE LEARNING MODEL

To build a basic Machine Learning model mainly 5 steps are required:

- Problem definition is the first step which comprises of converting any business problem to a machine learning problem.
- Hypothesis generation is second step which consists of the procedure for the creation of a possible business hypothesis for the model.
- Data Collection is the third step which requires collection of a dataset to test our hypothesis and build that model.
- Data Exploration and cleaning is the fourth step in which all the outliers and missing values are eliminated and then data is transformed into the required format.
- Modelling which is the fifth step in which we actually

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build machine learning models. Finally, when the model is built, we deploy it.

7. APPLICATIONS TO MACHINE LEARNING

While surveying through we arrived at various application domains and sub-domains of machine learning applications which are depicted in Figure 8.

The most common applications of machine learning which one can observe in daily life are discussed below.

- Voice Assistants accept inputs as text queries, understand the meaning of those inputs with the help of ML models and after processing them, perform action. They use Natural Language Processing and have Automatic Sound Recognition (ASR) component, which converts analog voice signals into texts.
- Smartphone Cameras apply image recognition with the help of neural network trained on millions of images. With the help of machine learning the camera identifies the scene to which it is looking, adjusts light, chooses most appropriate exposure and makes color adjustments.
- Face Unlocking makes use of convolutional neural networks to perform a person's authentication by classifying and recognizing faces. A proper training of neural network is needed for automatically identifying the features in millions of images and then detecting face contours.

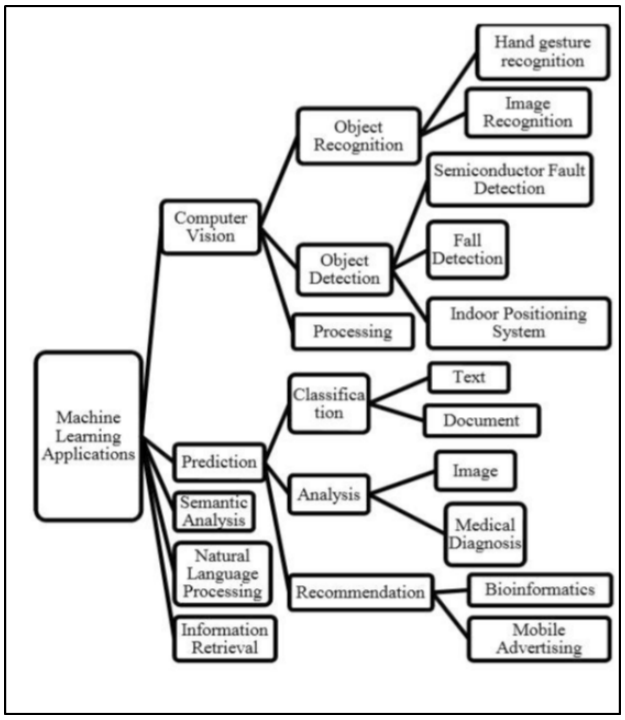

Figure 8: Common Tools used in Machine Learning[17]

- Recommendation Engine combines two approaches, namely content based and collaborative filtering, to filter data and provide most relevant items to users. It calculates similarity of attributes from previous interactions with users to predict future preferences. Some of the examples are e-commerce websites recommending us latest products based on our browsing history and food delivery partners showing us our restaurant recommendations based on our previous orders.
- Chatbots use machine learning to converse in order to answer FAQs or to guide a person in doing a task according to their intelligence. These are getting more intelligent day by day, hence smoothening user experiences.
- Google Search uses previous experiences and learn from history to make patterns for predicting and providing best possible results.

8. CHALLENGES IN MACHINE LEARNING

Machine Learning has achieved an enormous amount of progress in the recent decades, there are some big challenges that still need to be resolved.

- Large amount of dataset is required – It takes a large sum of dataset to train a particular model so that it can perform the particular task. For e.g. If we want to make an image classifier for the classification of cats and dogs then we will have to train our Machine Learning model with thousands of images so that it can predict correctly whether it is a cat or dog after seeing the image of it.
- High computation required – Machine learning and models need very large computations to achieve simpler tasks. That is the main reason for the requirement of special hardware including GPU'S and TPU'S.
- Requirement of innovative, better and efficient algorithms – Researchers are consistently trying to find out new algorithms which are more efficient and perform the task assigned to them precisely and correctly.

9. CONCLUSION

This paper gives an insight about what machine learning is and what are its various types. It tells about the different kinds of algorithms which are used along with the different kinds of tools which are available. It briefly presented the generation of machine learning models along with its applications explored in the last few decades. There is still a lot of scope in this field which motivates us to dig deep into the other possible application areas of Machine learning.

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