REVIEW

Machine Learning: A Review

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1. Introduction

Questions have been asked with regards to computers if they are capable of learning on their own. Human beings have over the years created different tools to enable them solve various tasks which led to the invention and production of different machines [57]. With the rapid developments, the difference between humans and machines has remained intelligence. A human brain analyses information and makes decision accordingly but machines are not able to analyse and take decisions [1]. Automating tasks has generated high interest in the information technology field where some designs and operations can be handed over to machines [13]. Recently, with the introduction of artificial intelligence, machines have been created to have the same level of intelligence as the human brains. Artificial intelligence started in 1943 when the first Neural Network Model was introduced [12].

A machine is expected to learn whenever there is changes in the structure, program or data, this is based on the input or response to the external environment which improves its expected results [51], therefore, machine learning can be defined as a part of artificial intelligence that explains that fact that machines can learn on their own when given the right data thereby solving a specific problem [80]. With the help of mathematics and statistics, machine learning can
perform intellectual tasks independently that are always generally performed by human beings. Machine learning is a part of computer science that emanated from the study of pattern recognition and computational learning theory all in artificial intelligence. Algorithms are used to make predictions on data. Before now the field of machine learning was mainly algorithms and theory of optimization but recently machine learning covers several other disciplines which includes statistics, information theory, theory of algorithms, probability and functional analysis. Machine learning and computational statistics are always closely related because of their specialty in prediction making and mathematical optimization which brings about methods, theories and application to the field. In machine learning, strictly static program instructions are not followed, rather, algorithms are used to build a model from input which are used to make data-driven prediction or decisions.

Currently, research on machine learning focuses on areas like pattern recognition, natural language processing, computer imaging, computer tracking, knowledge representation, traffic classification, cognitive radio and intrusion detection, optical networks and so on. Machine learning problems and tasks are mostly classified into three broad categories because of the signal and feedback that is being fed into the learning system. These categories are explained below:

1. Supervised Learning where the computer is being supplied with example input and their desired output which learns a rule that is able to map inputs to outputs.

2. Unsupervised Learning where no label is given to the learning algorithm and its allowed to determine the structure of its input.

3. Semi-Supervised Learning lies between supervised and unsupervised learning where the teacher gives an incomplete input or signal where some of the target outputs are missing, it can also be regarded as Transduction.

4. Reinforcement Learning where an environment interacts with the computer to be able to perform a certain goal without any input or interference of a teacher telling it what to do.

There are various reasons why machine learning is important:

1. Machine learning is important in adjusting its structure to produce desired outputs due to the heavy amount of data input into the system.

2. Machine learning is also suitable for data mining because of the little amount of important data hidden in the heavy chunk of data that can be important for processing of output.

3. Machine learning is important for jobs that are on the go thereby improving the existing machine designs because some designers produce non-workable machines that are not desired in the environment.

Knowledge computation is being carried out by machines easily which will be a bit difficult for humans due to the large amount of knowledge available for certain tasks. Redesigning of systems due to change in environment is reduced with the introduction of machine learning because environments change overtime. New knowledge, new tasks, new data is being gotten and discovered by humans on every day, with machine learning, tracking of new knowledge is made easy.

In this paper, a general overview of the application of machine learning is carried out. An introductory highlight on the use of machine learning, its methods, techniques and applications in various fields is considered. We also carry out a survey on the existing work with machine learning so far. This paper is organized as follows: Section 2 describes machine learning, its applications and current work being carried out. It also highlights the number of journals and their sources being used for this paper. Section 3 introduces and highlights the techniques and methods used in machine learning while section 4 presents the conclusion of the paper.

2. Review of Literature

Machine learning is a fast growing field and one of the latest technologies being used recently in the information technology field. Machine learning has been deployed to solve different problems in different aspects of life like medical, engineering, agricultural etc. This section discusses various applications of machine learning in different aspects of life.

Machine learning is recently deployed in National Innovation Performance data analysis where the impact of government decisions and policies are still not clear. A machine learning approach is proposed which includes clustering, correlation analysis, Bayesian Neural network and breakdown for decomposing innovation output prediction. This approach has shown improvement for benchmarking national innovation profiles.

Machine learning is combined with satellite imaging to predict poverty. A study carried out from five African countries which are Nigeria, Tanzania, Uganda, Malawi and Rwanda. Here a neural network is used and trained to capture and identify image features that explains local economic outcomes.

Scientist are now called upon and required to use advanced machine learning and many other artificial intelligence technologies to help find new scientific discoveries in the analysis of their data. This is important for applica-
Machine learning is applied in databases that are compiled using symmetry-based calculations which contains thousands of topological insulators and semimetals. Using the gradient boosted trees approach of machine learning. The model predicts the topology of a given existent material. Although the model has errors which can be overcome.

In the field of chemistry, a machine learning approach known as graph neural networks is proposed for solving problem of quantitative structure-odor relationship which relationship between molecules structure and its odor remains difficult.

Based on widely analysed classification model, patient data is being analysed for the predictability of the patient to have liver disease. There are five phases highlighted. The first is the min-max algorithm application followed by the use of PSO feature selection for demarcation of attributes, then classification algorithm is used for comparative analysis and categorization. The fourth phase is the accuracy calculation and finally evaluation phase.

Decision Tree based algorithm is used to evaluate individual and ensemble model performance for predicting secondary progressive multiple sclerosis disability progression.

Machine learning is a branch of artificial intelligence that is deployed and most suited for medical applications especially in the detection and prediction of cancer and prognosis. A number of publications have shown that machine learning methods can be used to improve the accuracy of predicting cancer susceptibility, reoccurrence and mortality.

The use of Bayesian deep learning method as machine learning technique to address the analysis challenges of future surveys. This technique will enable multibendpass, multi-instrument processing of individual images, targeting science objectives.

In order to manage and control the operational environment while also predicting future actions, IoT application developers tend to buy data from IoT owners in order to train machine learning models by combining edge computing resources with data sources.

Machine learning is used in the multimedia world for conversion assignment. The audio/video data is recorded from a location and converted to text data. The text data is then analysed and tagged to each individual based on attributes. Self learning software designed using machine learning algorithm is generated based on the tagging.

Machine learning approach has also been deployed in the discovery of drugs. The use of virtual screening evolving from traditional similarity searching to an advanced application domain for data mining and machine learning approaches. The advanced approach requires large training set compounds to learn robust decision rules.

Wireless sensor networks work dynamically due to the external factors or initiated by the system designers. Therefore, machine learning is used to adapt to these conditions and eliminate the need for unnecessary and also prolong the lifespan of the network.

Quantum systems are said to be faster and produce patterns that classical systems cannot which means quantum computers may outperform classical computers in terms of machine learning. Although hardware and software challenges still exist, quantum algorithms could act as a building block for machine learning programs.

In project management, project delay is one of the pressing challenges faced by the construction sector due to complexity and delay risk sources. Machine learning algorithms identified and developed in order to facilitate accurate delay risk analysis and prediction using objective data sources. Two machine learning algorithms which are decision tree and naive Bayesian classification were trained using the data set for predicting project delay events.

In order to minimize investment risks while evaluating the potential business impact, machine learning systems is used to leverage business transformation.

Retrieval of patients data rightly and at the right time is vital, therefore, a learning electronic medical record (LEMR) is developed that learns statistical models of clinician information seeking behaviour and applies it to the direct display of data for future patients.

3. Machine Learning Techniques

Machine learning is simply about designing algorithm that will allow a computer to be able to learn. This is based on the input and desired outcome of the algorithm. Some of the machine learning techniques will define how humans can approach a task. Several mathematicians and programmers have come up with solutions on the approaches and techniques for machine learning which is narrowed down as shown in the diagram below.

Figure 1. Machine Learning Techniques
The various techniques of machine learning is discussed below and the different applications that follow the techniques are also highlighted:

(1) SUPERVISED LEARNING: In supervised learning, a correct classification is already assigned to train a data sample from the data source [22]. It can also be seen as a formalization of a certain idea of learning from examples where there is an input and desired output [25]. Here, the learner which could be a computer program is provided with a training set and test set of data. The trainer is required to learn from the training set with examples of labelled set which will be used to identify the unlabelled examples in the test set with highest possible accuracy [15]. The supervised learning technique requires external assistance. The work flow of the supervised learning technique is shown below.

![Figure 2. Workflow of supervised machine learning technique [25]](image)

There are three major types or algorithm of supervised learning technique as discussed below:

(a) Decision Tree: Decision trees group attributes thereby sorting them based on their different values [62]. Each of this decision trees consist of nodes and branches and are mainly used for classification. A node represents attributes in a group while the branch represents a value that the node can take. An example of a decision tree is shown below.

![Figure 3. Decision Tree [25]](image)

(b) Naive Bayes: This algorithm is mostly used and is a target of the text classification industry [83]. It is also used for clustering and classification purposes. Conditional probability is the backbone of Naive bayes algorithm where it creates trees based on the probability of occurring. These trees can also be regarded as Bayesian Network. An example is shown below.

![Figure 4. Bayesian Network [25]](image)

(c) Support Vector Machine: This algorithm is a commonly and widely used machine learning technique and mostly used for classification [90]. Support Vector Machine uses margin calculations where it draws margins between the classes. The distance between margins and classes is always big so as to reduce the error in classification [7]. The diagram below shows a working support vector machine.

![Figure 5. A working Support Vector Machine [25]](image)

An application of the supervised learning technique is where a supervised data of the Stanford Natural Language Inference datasets is used to train and show how universal sentence representations can consistently outperform unsupervised methods [22].

(2) UNSUPERVISED LEARNING: This technique is a
bit harder than the supervised learning. This is so because we tell the computer to learn to do something that we don’t tell it how to do [85]. This learning technique does not produce classification but make decisions that maximize rewards. Some self-organized neural networks learn using the unsupervised learning technique to uncover hidden patterns in unlabelled data input [89]. The advantage of this lack of direction is that it lets the algorithm to look back for patterns that were not previously considered. The unsupervised learning technique learns few features from a set of data and then when a new data is being introduced, then it uses the learned features to recognize the class of the data [70]. Unsupervised learning technique is mainly used for clustering and feature reduction. And example is shown below.

**Figure 6. Example of Unsupervised Learning** [25]

There are two main algorithms for supervised learning technique which are discussed below:

(a) K-Means Clustering: Clustering is also known as grouping which is a type of unsupervised learning technique that creates group which initiated automatically [87]. It is known as K-means because it creates k-distance clusters where items with similar characteristics are put in the same cluster. The centre of the cluster is gotten from the mean of the values in the cluster.

(b) Principal Component Analysis: Here, to make the computation faster and a bit easier, the dimension of the data is reduced. For example, when principal component analysis is being applied on a 2D data, the data will then be reduced to 1D [87].

Unsupervised learning techniques can be applied to sentences to improve embeddings [72]. Unsupervised learning technique can be used to identify phases and its transitions in systems, principal component analysis is used to extract the original data while clustering is used to identify the phases [71].

(3) SEMI SUPERVISED LEARNING: This technique is a technique that combines both supervised and unsupervised learning techniques [46]. The unlabelled data is already present while discovering the labelled data is very tasking and tedious. This technique is common in data mining field [73]. Some of the algorithms for semi-supervised learning technique are discussed below.

(a) Generative Models: This is one of the oldest semi-supervised learning technique where models like gaussian mixture models is used as a mixed distribution to assume a structure [48]. The mixed component can be identified within the unlabelled data.

(b) Self-Training: Here, the classified is trained to learn by itself by providing it with portion of labelled data where the labelled points and the predicted labels are added together in the training set, and then the process is repeated [65].

(c) Transductive Support Vector Machine: This algorithm is an extension of the Support Vector Machine algorithm where both the labelled and unlabelled data is considered [86]. This algorithm is used to label the unlabelled data such that the margin is large between the labelled and unlabelled data.

Odena Augustus in 2015 extended Generative adversarial networks to the semi-supervised learning technique of machine learning to show it can be used to create a more data-efficient classifier and higher quality samples can be generated. Semi-supervised learning is applied on graph-structured data which learns hidden layer representation that encode the graph structure and feature of nodes [46].

(4) REINFORCEMENT LEARNING: In this type of technique, the positive outcome of the decisions is determinant or dependent on the actions to take [95]. The learner has no idea of the action to take until it is given a particular situation. Depending on the actions taken by the learner, the future is affected in terms of the situations. Below shows a model for reinforcement learning.

**Figure 7. Reinforcement Learning Model** [25]

In the above model, the input i, is being received by the agent. The agent also receives current state, s, state transition r, and input function I from the environment. With these inputs, the agent generates a behaviour B and takes an action a which generates an outcome [25]. Rein-
Artificial Neural Network is being applied to natural language processing for dialogue creation where a model simulates dialogues between virtual agents using policy gradients for reward to conversational properties [54].

(5) MULTITASK LEARNING: The algorithm remembers the process and procedure how a particular problem was solved and how it arrived at a certain conclusion [54]. The process and procedure is being used to proffer solution to other tasks or problem. It can also be known as transfer mechanism [73]. Sharing experience between learners helps them to learn concurrently rather than individually which is much faster. Four clinical predictions benchmark is proposed using data derived from publicly available medical information database where multitask learning, deep supervision and data specific modifications is applied on the performance of neural models [56].

(6) ENSEMBLE LEARNING: This technique refers to the combination of individual learners to form one learner [49]. For example, a decision tree, naive baye and neural network can be combined to form an ensemble learning. Combination of learners performs better work than individual learner. There are two algorithms under ensemble learning:

(a) Boosting: This technique collects weak learners and converts them to one strong learner [92]. It decreases bias and variance.

(b) Bagging: This technique is also known as bootstrap aggregating, whenever the machine learning algorithm needs to increase accuracy and stability, bagging technique is required [92].

Machine learning models are built and proposed using ensemble learning technique where large repository of malware samples and applications are gotten from an anti-virus vendor. This is in vie to reduce that malware attack on the android platform [92].

(7) NEURAL NETWORK LEARNING: This technique is gotten from the concept of neurons which has four parts, dendrites, nucleus, Soma and Axon [58]. Interconnection of the neurons is known as neural network. The artificial neural network behaves in the same pattern. A diagram of artificial neural network is shown below.

The input layer takes input while the hidden layer processes the input and then the output layer sends the calculated output. Artificial Neural Network can be divided into three types which are supervised, unsupervised and reinforcement neural network. Neural networks are powerful and works well for difficult learning task like in image, speech and natural language processing [95].

(8) INSTANCE-BASED LEARNING: In this technique, the learner is familiar with only one particular type of pattern where it tries to apply to newly fed data [16]. The technique is termed lazy because it waits for the test data to arrive and then act on it with training data. It gets complex as the data increases. An example of the instance-based learning technique is the k-nearest neighbour algorithm. In the agricultural field, the instance based learning approach is used to segment crop images whereby green texture crops are automatically discriminated from the rest of the crops [72].

4. Conclusion

This review presented a general research on machine learning, its algorithm and techniques. The paper reviews literatures on the applications of machine learning algorithm and techniques on various fields of life which include medical, agriculture, science and so on. Machine learning is one of the high rising technologies used recently for solutions to various problems. It has various algorithms which include supervised, semi-supervised, unsupervised, reinforcement algorithms and so on.

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