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A Practical Guide of Machine Learning Algorithms And Applications

Hassan Kassim Albahadily, PhD
Al - Mustansiriyah University
Iraq – Baghdad

Malik Qasim Mohammed
Ministry of Education
Iraq – Baghdad

Ali Kassim Mohammed
Central Technical University
College of Applied Arts

ABSTRACT
This article examines the primary subcategories of machine learning: supervised learning, unsupervised learning, and reinforcement learning. Along with decision trees, random forests, artificial neural networks, SVMs, boosting and bagging algorithms, and BP algorithms, it also examines other well-known machine learning techniques. Through the development of theoretical systems, furthering the development of autonomous learning capacities, integrating multiple digital technologies, and promoting customized, bespoke services, the objective is to increase public awareness of machine learning and hasten its rate of adoption.

Keywords
Artificial Intelligence, Machine Learning Algorithms, Machine Learning Applications.

1. INTRODUCTION
The concept that robots may learn on their own how to tackle a particular issue by being given access to the proper data is advanced by the field of artificial intelligence known as machine learning (ML). ML enables machines to execute autonomously intellectual tasks that have historically been addressed by humans by utilizing sophisticated mathematical and statistical methods. The assumption that many activities involved in the design and management of communication networks can be offloaded to machines has sparked significant interest in the networking area in the concept of automating complicated jobs. These expectations have already been met by certain ML applications in various networking domains, including intrusion detection, traffic categorization, and cognitive radios. In this article, an overview is presented by the usage of ML, a basic tutorial on its application in various fields, a study of the literature that has already been written on the subject, and a classification of the numerous use cases that have been discussed. A machine learning techniques are discussed as well as some of its most prevalent uses. In reality, ML applications may be particularly helpful in cross-layer contexts, where changes in routing, spectrum, and modulation format assignments can result from data analysis at the physical layer, such as monitoring Bit Error Rate (BER). The goal of the literature review in this study is to provide an introduction to researchers and practitioners interested in learning more about current ML applications as well as new research directions since the application of ML to optical communication and networking is still in its infancy. [1]

A variety of security applications, such as spam detection and intrusion network detection, using learning-based systems, has been suggested by machine learning proponents. In accordance with this vision, machine A system that has learned will be able to respond to shifting external inputs from the actual world, both hostile and benign, and learn to reject undesirable behavior. The possibility exists that an attacker will attempt to compromise a machine learning system by exploiting its adaptability. Errors made by the learning system constitute failure. allowing hostile input to pass through the security barrier when it should have rejected it when it should have recognized innocuous information as hostile. An effective tool in the hostile opponent's toolbox is the ability to offer training data that will cause the learning system to create rules that erroneously identify inputs. If users see the failure, they can lose trust in the system and cease using it. If customers are unable to recognize the failure, the repercussions might be quite severe.[2]

2. BRIEF REVIEW OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING TECHNIQUES
Artificial intelligence is a word without a clear definition; instead, it has taken on several interpretations over time. As of now, it can be said that it is a technology that combines various branches of computer science by solving issues through what are known as intelligent behaviors. Examples of such behaviors include logic-based techniques, statistical techniques, techniques for analyzing natural language, and computer vision. Machine learning is now one of the fields of AI that is most broadly defined. This word covers a wide range of methods and strategies, but they are all united by a single, unmistakable characteristic they include solving issues with the aid of computer programs that can pick up knowledge from the data that is supplied. Therefore, knowledge is no longer transmitted from humans to machines instead, the machines themselves learn new information on their own. Man's job is reduced to defining how machines must learn through examples and information so they may obtain the knowledge necessary to automate tasks or transmit knowledge on their own. A decision tree and a learning set of rules are two examples of logical (symbolic) approaches. A distinct rule may be created for each path from the root to the leaf in the decision tree, which is a tree that categorizes instances and ranks them according to the values of the attributes. However, a number of rule-based algorithms allow for the direct generation of rules from training data. Techniques focused on perception make up the second group. An example of a binary classifier is the perception, which converts its inputs (a real vector) into an output value (a scalar of real type). The most well-known method is the neural network, a mathematical representation of biological brain networks that is also used to attempt to address engineering issues that span several disciplines (electronics, computer science, simulation, and other disciplines). The third category consists of statistical approaches, which differ from classification alone by providing an explicit probability model that gives the likelihood that a given occurrence belongs to each class. It is a memory-based approach in which the computer compares newly encountered issues with previously encountered ones that have been memorized during training.

The most recent method of supervised machine learning is known as (SVMs), uses learning algorithms for regression and classification. Given a set of training series, where each training series is labeled with the class to which it belongs among the two possible classes, A non-probabilistic binary linear classifier is created by the method by placing the new instances in one of the two classes. [3]

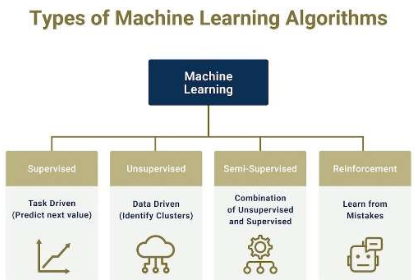

Fig 1: Types of Machine Learning Techniques

3. LEARNING TYPES

The four primary categories of machine learning algorithms are reinforcement learning, supervised learning, unsupervised learning, and semi-supervised learning, as depicted in Fig. 1 Each sort of learning strategy is briefly covered in the sections that follow (see Fig 1).[4][9]

3.1 Reinforcement

Reinforcement learning is a type of machine learning technology that enables software agents and computers to automatically choose the appropriate behavior in a specific context or environment. It does this by using an environment-driven strategy. The ultimate goal of this kind of learning, which is focused on benefits or costs, is to use the information learned from environmental activists to take actions that will either increase benefits or reduce costs. However, it is not advised to utilize it to solve straightforward or easy problems. It is an effective technique for developing AI models that can boost automation or improve the operational effectiveness of intricate systems like robots, autonomous driving, production, and logistics in the supply chain.

3.2 Supervised

Supervised learning is the process by which a computer learns a function that converts an input to an output using examples of input-output pairs. It uses a range of training samples and labeled training data to infer a function. Supervised learning is carried out when certain objectives are found to be accomplished from a particular set of inputs, i.e., a task driven technique. The two most common supervised tasks are classification, which separates the data, and regression, which fits the data. For instance, supervised learning may be used to predict the class name or sentiment of a text fragment, such a tweet or a product review.

3.3 Unsupervised

Unsupervised learning, often known as a data-driven method, analyzes unlabeled data without the assistance of a person. This is commonly used for experimental purposes, result groupings, relevant trend and structure detection, and generative feature extraction. Some of the most common unsupervised learning tasks include clustering, density estimation, feature learning, dimensionality reduction, association rule development, anomaly detection, etc.

3.4 Semi-Supervised

Semi-supervised learning may be viewed as a combination of the supervised and unsupervised methods mentioned above because it employs both labeled and unlabeled data. As a result, it falls in between learning "under supervision" and learning under supervision. Since unlabeled data are frequently available and labeled data may be in short supply in some circumstances, semi-supervised learning is useful in the real world. The primary goal of a semi-supervised learning model is to provide predictions that are better than those produced using only the labeled data from the model. Applications for semi-supervised learning include fraud detection, text classification and machine translation .

4. EXAMINATION OF TYPICAL MACHINE LEARNING ALGORITHMS

[5][6][7][8][9]

4.1 Decision Tree Algorithm

One of the often used machine learning algorithms is the decision tree method, which is a classic approach. Its basic operating premise is that, in order to process the information completely, it must first go from the collection instance's root node to the point where the nodes meet. Segmentation of real-world instances using science. The decision number approach will keep the branches separated to make data analysis easier while also trimming the branches to improve the correctness of the content of data. This algorithm is a top-down method from a mathematical perspective. The node is enlarged to more than two depending on the node after the content of the node is examined for the best features throughout the content analysis process. By doing so, you may get comprehensive information on the split, and the tree-like branching method may increase the number of samples that can be assessed. both at once, you can figure out which content in the classification has the most samples, based on sample number statistics. When evaluating data, For instance, you may decide on the maximum amount of branch splitting and identify the decision tree with the most data as the huge tree A. When the bigger tree A hits the upper limit of 5, it will cease splitting and instead examine the larger tree model using the pruning procedure. The data will be cleaned up as a result, and the results of the data analysis will be more objective.

4.2 Random Forest Algorithm

For additional processing, the random forest approach might be utilized in datacalculation process, much as the decision tree algorithm. The random forest technique will be helpful in limiting irrational data during practical application. hence significantly enhancing the data split findings' scientific rigor and the data analysis results precision. During the data analysis process, multiple sets of classification trees will be created simultaneously. The regression data will then be processed using the unified technique. Assuming the decision tree is an independent set ai I = 1, 2, 3..., n, the random forest is the total set A, where A = a1, a2, a3,..., an. The distribution is in a state of unpredictability, and each set remains independent. Voting will be used to determine how well the classification data information is evaluated. The classification that received The vector value xi that receives the most votes during voting will be output, and the vector's content will then be classified to discover the average value of the different score states and serve as a source of information for decision making.

4.3 Artificial Neural Network Algorithm

A term "artificial neural network" describes a system that replicates the way humans transmit information by categorizing various pieces of information into separate neurons and linking those neurons through the Internet to perform complicated memory functions. However, this developing data analysis process is the foundation of the artificial neural network algorithm. Among the distinct neurons, each digital unit has a high level of authenticity, and the data may complete the process of external output. the way the human body moves forward, stops, and then sprints The artificial neural network algorithm's data information has a variety of application properties, and the associated analysis process may be completed in line with actual requirements. Self-organizing neural networks (SOM), artificial generalized neurons, and multilayer forward neural networks (MLFN) (ART)are now the most widely utilized artificial neural networks. It is possible to pre-set the output threshold first, then the weighting coefficient. to make the data analysis and computation easier. The output of a specific number to the outside when the calculated total surpasses The orderliness of the entire numerical analysis process is improved by this criterion.

4.4 SVM Algorithm

SVM algorithm is one of the often employed algorithmic components in machine learning. The algorithm mostly rely on the vector machine technique to complete the specified application procedure's stated data analysis task. The SVM algorithm will simultaneously evaluate the data information that needs to be processed in order to improve the data information with the automated assistance of the SVM. To strengthen the final data analysis results' scientific validity, the sample data for the boundary value must be selected from many sets of study samples. For instance, if the data information to be processed is H (d), complete dispersion is made possible by first processing the data information centrally using SVM technology. The greatest distance of the whole plane is used to calculate the H (d) plane's border. The output vector is then generated by scrutinizing the H (d) plane's vector content, which improves the precision of the data processing.

4.5 Boosting and Bagging Algorithms

The primary application benefit of boosting algorithm, a novel type of machine algorithm content, is that it can efficiently process input data and improve the output data's correctness. By using Boosting algorithm to build the function prediction system and the reinforcement learning mode to constantly improve the system's content, the processing of data and information is accelerated. AdaBoost is one of the Boosting algorithm's more straightforward applications. AdaBoost is a critical safeguard for the simultaneous extension of the boosting algorithm. The Bagging algorithm and other data processing methods are quite similar. The distinction is that the Bagging algorithm really picks the training set at random. Additionally, since the Bagging method does not analyze the weight content while creating the function model, it must be continuously build the data model with the help of training in order to improve the accuracy of the outcomes of the data analysis.

4.6 Back Propagation (BP) Algorithm

The supervised learning field includes the BP algorithm. Figure 2 displays the algorithm's fundamental idea. a computational paradigm for shallow forward neural networks with input, hidden, and output layers is shown in the figure below . As network nodes, several neurons are linked to one another. Each neuron uses an excitation function to analyze the network weights that indicate link strength. By altering these connection strengths, the output layer receives the pattern information included in the input data.

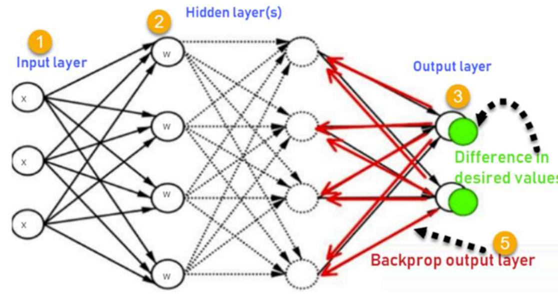

Fig 2: Working Principle of Backpropagation Algorithm

5. APPLICATIONS OF MACHINE LEARNING [9]

The Fourth Industrial Revolution (4IR) period has seen a rise in the use of machine learning due to its ability to learn from the past and make sensible decisions. The sections that follow provide an overview and discussion of the machine learning technology's top 7 application area:

5.1 Predictive Analytics & Intelligent Decision Making

A key use of machine learning is intelligent decision making utilizing data driven predictive analytics. The core of predictive analytics is the identification and use of relationships between explanatory variables and predicted variables from past events in order to predict the future.

5.2 Cybersecurity and threat intelligence

Cybersecurity, which is frequently the process of protecting networks, systems, hardware, and data against cyberattacks, is one of the most crucial elements of Industry 4.0. ML has become a crucial cybersecurity technique that may be used to better detect malware in encrypted communications, identify internal dangers, foresee dangerous web regions, protect people while they are browsing, or protect cloud data by revealing questionable activity.

5.3 IoT and smart cities

The Internet of Things (IoT), which enables everyday devices to communicate data and automate operations without requiring human interaction, is another essential element of Industry 4.0 . The Internet of Things (IoT) is therefore seen as having untapped potential that might enhance nearly every area of our lives, including smart home technologies, smart governance, education, communication, and transportation. The smart city, which uses technology to enhance both city services and resident quality of life, is one of the key applications for IoT. Since machine learning uses experience to identify trends and create models that help with the prediction of future behavior and events, it has become a crucial technology for IoT applications.

5.4 Traffic prediction and transportation:

The development of any nation's transportation networks has proven essential to its economic growth. However, there are many cities throughout the globe that are seeing an excessive increase in traffic, which is leading to serious problems like Modern civilization is plagued by delays, gridlock, rising fuel costs, increased CO_2 emissions, accidents, crises, and a deterioration in the standard of living. A smart transportation system that can predict future traffic is therefore necessary for the existence of a smart city. Accurate traffic forecasts based on machine learning and deep learning models help lessen the issues. Machine learning, for instance, may help transportation businesses identify potential challenges that may arise on specific routes and advise their clients to choose a particular route based on travel patterns and history.

5.5 Healthcare and COVID-19 pandemic

In a variety of medical disciplines, such as disease prognosis, information extraction from the medical literature, data regularity detection, patient management, etc., machine learning can assist in the resolution of diagnostic and prognostic issues.

5.6 E-commerce and product recommendations

Product recommendation, which is one of the most well-known and often used applications of machine learning today, is also one of the most obvious elements of almost any e-commerce website. Businesses may employ machine learning technology to assess the past purchases of their clients and offer tailored product suggestions for their next purchases based on their preferences and behaviors. For instance, by examining browsing habits and click through rates of certain items, e-commerce companies may swiftly make product recommendations and offers.

5.7 Image, speech and pattern recognition

Utilizing machine learning in the actual world is a well-known and frequent practice is the ability to recognize an object as a digital picture. Examples of picture recognition include Character recognition, picture face detection, and tag suggestions on social networking sites like Facebook are examples of tasks that fall under this category. Another widely used technology is speech recognition, which generally makes use of linguistic and acoustic models such are : Alexa , Cortana and google assistant, etc.

6. COMMON TECHNOLOGIES OF MICROSOFT MACHINE LEARNING [10]

6.1 Image, Text, and Voice Analytics

There are several tools for photo, text, and audio analytics in the Microsoft stack. Cognitive Services is one of the well-known technologies for text, audio, and image analytics that provides APIs for use in other applications. The CNTK platform, however, may also be utilized for image and audio processing. These Microsoft packages and libraries can be used by developers to implement deep learning-based machine learning.

6.2 Machine Learning on ETL

Applying ML to data that has been fed and modified with intention of producing reports is another potential necessity. Before displaying data to end users, descriptive or predictive analytics must always be used. As a consequence, users of Power BI self-service BI may take advantage of machine learning by employing R and Python scripts to enhance the understanding of their reports. Using Python and SQL Server 2016 / 2017 is an alternative strategy. Additionally, Databricks may be used for both machine learning and ETL simultaneously provided the data is on the cloud. ETL stands for Extract Transform Load which is involves transferring data from several sources to a consolidated single database.

6.3 IoT Scenario

Event Hub, Stream Analytics, Databricks, and other Microsoft products have all addressed the demand for real-time data analysis. With Power BI, a live stream report can be produced using the actual data flowing from sensors, apps, and other sources. For the majority of this situation, it is necessary to spot data anomalies or divide future data into several categories. It should apply machine learning to IoT settings with the use of Databricks or Azure ML by use of Stream Analytics.

6.4 Machine Learning Prototype

For organizations who want to use machine learning on their data for the first time, Azure Machine Learning Studio is an excellent tool that demonstrates the entire machine learning process, from obtaining data to training and testing models. The machine learning process may also be accelerated by managers and other stakeholders, who can then examine how it might be used as an API in other applications or as a simple Excel file. As a result, the architecture being used, the amount of programming effort being done, and the scenario being used all influence the machine learning tools that are used. The tools are based on both pre-built and custom AI for the first criterion. The second one depends on the current architecture, which may be cloud-based or on-premises. The final consideration is the appropriate technologies to be employed, such as IoT, ETL, or the development of a prototype.

7. RESULTS

Depending on the nature of the data described earlier and the desired result, various machine learning approaches can play a key role in the development of effective models in a variety of application areas. Table 1 provides an overview of several machine learning approaches and provides examples. The intelligence and capacities of a data-driven application may be improved by using machine learning methods, which are fully described in the section that follows.

Table 1. Machine Learning Techniques with Examples

Learning Types	Model building	Examples
Unsupervised	Algorithms learn from unlabeled data (Data-Driven Approach)	Clustering, associations, dimensionality reduction
Supervised	Algorithms learn from labeled data (task-driven approach)	Classification, regression
Reinforcement	Models are based on reward or penalty (environment-driven approach)	Classification, control
Semi-supervised	Models are built using combined data (labeled + unlabeled)	Classification, clustering

Additionally, machine learning techniques (such as regression, classification, clustering, anomaly detection, etc.) are used to build the training data or a mathematical model using specific algorithms based upon computations statistics to make predictions without the need for programming. These techniques are important in promoting automation of processes with lower costs and labor requirements.

A few techniques have a significant impact on encouraging systems to automatically learn from experience and advance. Nevertheless, they may be classified into other sorts or categories, such as supervised learning, unsupervised learning, reinforcement learning, representation learning, etc. The methods listed below come within machine learning, as indicated in Table 2. Discourse on Different ML Methods.

With the aid of computer systems that can learn to solve a problem instead of being explicitly programmed, a range of real-world issues may be solved using a set of methods known as machine learning. We can distinguish between supervised and unsupervised machine learning in general. Although the most popular approaches are supervised, we concentrate on the latter for the purposes of this paper. When it comes to supervised machine learning, learning is defined as the process of using a set of examples to develop expertise about a certain activity.

According to the prediction in Table 1, the calculated model could be different. Therefore, the different result could be derived based on the desire and the purpose of use, while Table 2 includes number of machine learning approches and a short discription of each benefits and it is limitations as mentioned below

Table 2. Various ML Techniques Discussion

Technique	Application Areas	Potential Benefits	Limitations
Neural Networks (NN)	Testing Effort Estimation Function Point Analysis Risk Management Reliability Metrics Sales Forecasting	Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time. Real Time Operation: ANN computations may be acarried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability. Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.	Minimizing over fitting requires a great deal of computational effort. The individual relations between the input variables and the output variables are not developed by engineering judgment so that the model tends to be a black box or input/output table without nalytical basis. The sample size has to be large.
Case Based Reasoning	Help-Desk Systems Software Effort Estimation Classification and Prediction Knowledge Based Decision systems.	No Expert is Required The CBR Process is more kin to human thinking. CBR can handle failed cases (i.e. those cases for which accurate prediction cannot be made(No extensive maintenance is required.	Case data can be hard to gather. Predictions are limited to the cases that have been observed.
Classification and Regression Trees (CART)	Financial applications like Customer Relationship Management (CRM) Effort Prediction (used in models like COCOMO)	It is inherently non-parametric in other words no assumptions are made regarding the underlying distribution of values of the predictor variables. CART identifies splitting variables based on an exhaustive search of all possibilities. It has methods for dealing with missing variables. It is a relatively automatic machine learning technique. CART trees are easy to interpret even for non- statisticians.	Relatively new and somewhat unknown. Since CART is a new technique it is difficult to find satatisticians with significant expertise in this technique. CART amay have unstable adecision trees. CART splits only by one variable
Rule Induction	Making Credit Decisions (in various loan companies) Diagnosis of Mechanical Devices Classification of Celestial Objects Preventing breakdowns in Transformers	Simplicity of input variables. The representation in rule-based technique is easier to depict and understand.	No sufficient background knowledge is available. It is deduced from examples. Hard to maintain a complex rulebase.
Genetic Algorithms (GA) and Genetic Programming (GP)	Optimization Simulation of economic processes Scientific research purposes (Biological Evolution) Computer Gaes	GA and GP techniques can be applied to a variety of problems. GP is abased on the 'Survival of the Fittest Scheme' allowing fitter individuals to develop and discarding unfit ones. GA is easy to grasp and can be easily applied without much difficulty	Resource requirements are large. It can be a time consuming process. GA practitioners often run many copies of the same code with the same inputs to get statistically reliable results.

8. CONCLUSIONS

In this Paper , a full overview of machine learning techniques presented for applications that call for sophisticated data analysis. a briefly discussed how different machine learning approaches may be applied to provide solutions to a variety of real-world situations that are consistent with our goal. For a machine learning model to be successful, both high-quality data and effective learning algorithms are required. In conclusion, machine learning is still in its infancy, heavily depends on supervised learning, and cannot totally replace inadequate artificial intelligence.

The theoretical underpinnings and practical application of machine learning need to be continually improved by the appropriate individuals. The future of machine learning is quite promising, it is necessary to create a favorable environment for it in the relevant scientific field and in the development of computer technology. Furthermore, it's critical to actively learn from the mistakes and experiences of developed nations, design computer algorithms that are appropriate for the expansion of local enterprises, and provide technical support for the economic development of the sector.

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