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Machine Learning

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***Abstract*—** *Machine learning (ML) is about learning some properties of a data set and applying them to new data. It refers to the automated detection of meaningful patterns in a given data. It involves using the past experience to optimize the performance of a given algorithm. ML algorithms facilitate computers to learn from past experience. This paper introduces the basics of machine learning.*

***Keywords*—** *Machine learning, artificial intelligence, prediction.*

I. INTRODUCTION

Machine learning (ML) is the discipline that gives computers the ability to learn without being explicitly programmed. It is the science of facilitating computers to learn from past experience. It is a field within computer science and is closely related to artificial intelligence (AI) and computational statistics. ML is based on the idea that machines should be able to learn and adapt through experience.

Generally speaking, a learning problem considers a set of samples of data and then tries to predict properties of unknown data. ML builds heavily on statistics because when we train a machine to learn, we have to give it a statistically significant random sample as training data. Intelligent machines are increasing doing incredible things: "Facebook recognizes faces in photos, Siri understands voices, and Google translates websites" [1].

The term "machine learning" was coined in 1959 by Arthur Samuel, an American pioneer in the field of computer gaming and artificial intelligence while working at IBM. More recently, in 1997, Tom M. Mitchell at Carnegie Mellon University provided a widely quoted, more formal definition of the algorithms studied in the machine learning field: "A computer program is said to learn from experience *E* with respect to some class of tasks *T* and performance measure *P* if its performance at tasks in *T*, as measured by *P*, improves with experience *E*" [2].

Machine learning techniques are transforming many fields including computer science, engineering, mathematics, physics, neuroscience, and cognitive science. We are surrounded by ML-based technologies: search engines learn how to bring us the best results, digital cameras learn to detect faces, credit card transactions are secured by a software that detects frauds, and cars are equipped with accident prevention systems that are built using ML algorithms [3]. In ML, data plays an indispensable role, and the learning algorithm is used to learn from the data. ML algorithms are now easy to use. One can download packages in Python. Programming languages used in ML include C++, Java, Python.

II. MACHINE LEARNING METHODS

Machine learning algorithms can be supervised or unsupervised.

- *Supervised ML*: The program is "trained" on a pre-defined set of "training examples" from a "teacher," which then facilitate its ability to reach an accurate conclusion when given new data. In this case, the data comes with additional attributes that we want to predict. A common case of supervised learning is to use historical data to predict statistically likely future events. Under supervised ML, we have regression ML and classification ML.
- *Unsupervised ML:* This is used against data that has no historical labels and the system is not told the "right answer." Unsupervised algorithms do not need to be trained with desired outcome data. The program is given a bunch of data and must find patterns and relationships therein. A typical goal of unsupervised learning may be as straightforward as discovering hidden patterns within a dataset. Without being told a "correct" answer, unsupervised learning methods can look at complex data and organize it in potentially meaningful ways. Unsupervised learning algorithms are used for more complex processing tasks than supervised learning systems.
- *Classification ML*: This involves seeking a yes-or-no prediction, such as "Does this product meet our quality standard. We want to learn from already labeled data how to predict the class of unlabeled data. An example of classification problem would be the handwritten digit recognition example.
- *Regression ML*: If the desired output consists of one or more continuous variables, then the task is called regression. In this case, the value being predicted falls somewhere on a spectrum. An example of a regression problem would be the prediction of the length of a salmon as a function of its age and weight.

In addition, we also have "reinforcement" ML, which is often used for robotics, gaming, navigation, and network routing. Reinforcement learning is a technique that allows an agent to modify its behavior by interacting with its environment. A typical structuring of these ML techniques is shown in Figure 1 [4].

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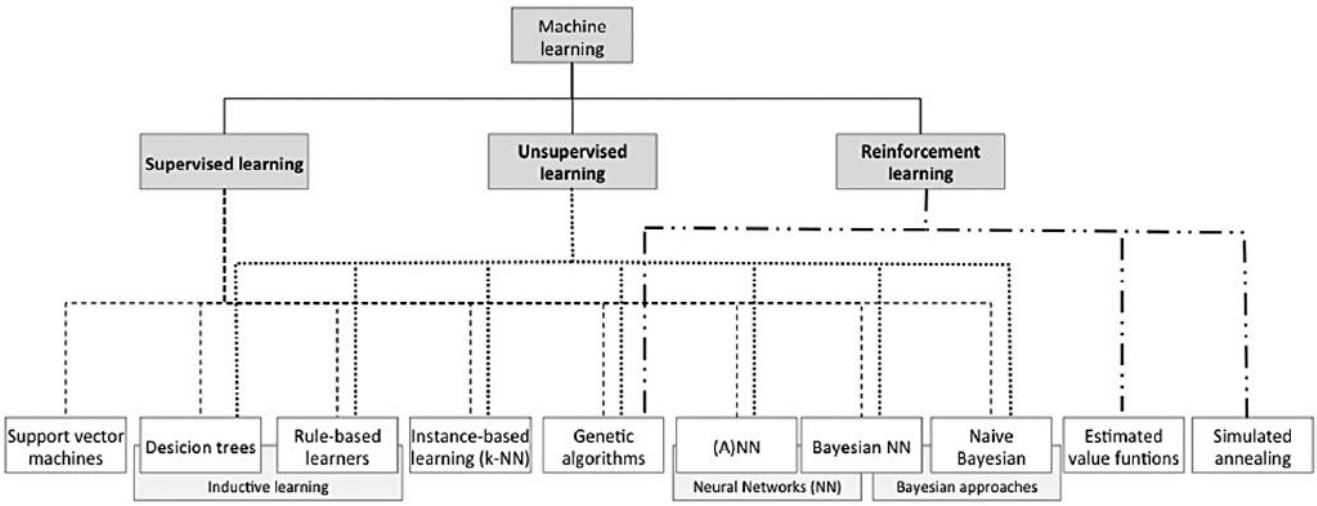

Fig. 1. A typical structuring of ML techniques [4].

III. Applications

There is a growing recognition that ML can play a key role in a wide range of critical applications such as data mining, natural language processing, image recognition, expert systems, simulation, and manufacturing. ML has been applied to each of these with great success. A sample of ML applications are provided next [5].

- *Health care*: Using ML algorithms is a fast-growing trend in the health care industry. Wearable devices and sensors can be used to assess a patient's health in real time. The medical experts can analyze data to identify trends or red flags. ML algorithms can process more information and spot more patterns than their human counterparts. ML algorithms have immense potential to enhance diagnostic and intervention research in smoking, depression, asthma, and chronic obstructive pulmonary disease (COPD) [6]. They can also be used to predict diabetes complications. ML has been applied to pharmacology for improved therapy.
- *Financial services*: ML models have been successful in finance applications. Businesses in the financial industry use ML technology for two key purposes: to prevent fraud and identify investment opportunities, or help investors know when to trade. Banks use it for credit-card fraud detection. ML is getting better and better at spotting potential cases of fraud. It can also be used to predict bankruptcy and credit risk management.
- *Transportation*: The transportation industry relies on making routes more efficient and predicting potential problems. The data analysis and modeling aspects of ML are important tools for public transportation and other transportation organizations.
- *Image recognition:* This is one of the most common uses of ML. There are also speech recognition, facial detection/recognition, object recognition, and character recognition. In speech recognition (also known as "computer speech recognition), a software application recognizes spoken words.
- *Manufacturing*: This is an area where the application of machine learning is very fruitful. The manufacturing industry today is facing an increasing volume of data which compromise a variety of different formats, semantics, and quality. ML techniques have been successfully utilized in various process optimization, monitoring and control applications in manufacturing [4].

Other potential applications include simulation, face recognition, object recognition, speech recognition, self-driving cars, natural language processing (NLP), optical character recognition, affective computing, Internet fraud, medical diagnosis, IoT, marketing, stock market prediction, economics, automotive, defense and security, government, insurance, utilities, oil and gas, advertisement, email spam detection, drug recognition, robotics, education, social science, linguistics, management, computer vision, materials science, smart city, and remote sensing, and communication networks such wireless sensor networks and mobile ad-hoc networks (MANETs).

IV. Challenges

A good machine learning model is crucial to ML applications. A major challenge of increasing importance is the question what ML technique and model to choose. Even among ML experts, selecting a good model can be a challenging task. Most ML algorithms are time-intensive and energy-inefficient since they require several days or months to train a good model. The algorithms can be accelerated with graphic processing units (GPUs) and field-programmable gate arrays (FPGAs).

Another challenge is the interpretation of the results. Although the complexity of ML has restricted its use, the supply of competent ML designers has yet to catch up to this demand.

V. Conclusion

Machine learning is the process of teaching computers to automatically recognize patterns of interest in data. It is an incredibly powerful tool that is used in a wide range of

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compelling application domains because it is applicable to many real-life problems. The extreme learning machine (ELM) is an emerging learning technique due to its faster learning speed, ease of implementation, least human intervention, and simplicity [7].

Machine learning is set to be a pillar of our future civilization. Additional information on machine learning is available in several books in Amazon.com.

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