Soft Computing

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Soft computing is the use of approximate calculations to provide imprecise but usable solutions to complex computational problems. The approach enables solutions for problems that may be either unsolvable or just too time-consuming to solve with current hardware. Soft computing is sometimes referred to as computational intelligence.

Soft computing provides an approach to problem-solving using means other than computers. With the human mind as a role model, soft computing is tolerant of partial truths, uncertainty, imprecision and approximation, unlike traditional computing models. The tolerance of soft computing allows researchers to approach some problems that traditional computing can't process.

Soft Computing became a formal area of study in Computer Science in the early 1990s. Earlier computational approaches could model and precisely analyze only relatively simple systems. More complex systems arising in biology, medicine, the humanities, management sciences, and similar fields often remained intractable to conventional mathematical and analytical methods. However, it should be pointed out that complexity of systems is relative and that many conventional mathematical models have been very productive in spite of their complexity.

Soft computing uses component fields of study in:

- Fuzzy logic
- Machine learning
- Probabilistic reasoning
- Evolutionary computation
- Perceptron
- Genetic algorithms
- Differential algorithms
- Support vector machines
- Metaheuristics
- Swarm intelligence
- Ant colony optimization
- Particle optimization

- Bayesian networks
- Artificial neural networks
- Expert systems

Artificial Intelligence vs Computational Intelligence

We have witnessed nothing sort of a revolution in the history of mankind as artificial intelligence (AI) becomes mainstream in our everyday life and augmenting human capabilities to solve some of the complex problems that troubled us for a really long time. What was once a distant dream of the future is now the future of mankind! We are at a stage where human intelligence and machine intelligence coexist at the onset of a data revolution. Artificial Intelligence aims at emulating human intelligence on machines to make them think and behave like humans. The human brain has evolved for thousands of years to its current state. However, traditional AI was not enough to serve the increasing demands of machine learning. The shortcomings of AI opened up new avenues for the non-conventional models which eventually have rise to a new discipline called computational intelligence (CI). The development of CI techniques follows a different path than that of the AI. Let's take a brief look at the new computational model called the CI and how it is compared to the classical AI approach.

What is Artificial Intelligence?

Artificial Intelligence, commonly abbreviated as AI, is the study of intelligent behavior and how to make machines do things at which humans are doing better. AI is one of the technological breakthroughs of this digital era which aims at emulating human intelligence on machines to make them think and behave like human beings. AI is based on the idea that human intelligence could be replicated in computer programs. Although, the idea of creating intelligent machines – ones that are as smart as or smarter than human beings – is not new but it became part of modern science with the rise of digital computers and proliferation of the internet. On the practical side, AI means to create computer programs that perform tasks as well as or better than humans. In simple terms, AI is human intelligence demonstrated by machines.

What is Computational Intelligence?

Computational Intelligence, also referred to as CI, refers to a computationally intelligent system that is characterized with the capability of computational adaptation, fault tolerance, and high computation speed. It is the study of adaptive mechanisms to enable or facilitate intelligent behaviour in complex and changing environments. Computational adaptation means the ability of a system to adapt to the changes in its input and output instances. The adaptive mechanisms include the following AI paradigms that exhibit an ability to learn or adapt to new environments: swarm intelligence (SI), artificial neural networks (ANN), evolutionary computation (EC), artificial immune systems (AIS), and fuzzy systems (FS). All these AI paradigms are the building blocks of computational intelligence. It is an emerging approach to computing which parallels the remarkable and intelligent ability of the human mind.

Constituents of Soft Computing:

Soft computing is a branch of computing which, unlike hard computing, can deal with uncertain, imprecise and inexact data. The three constituents of soft computing are fuzzy-logic-based computing, neurocomputing, and genetic algorithms. Fuzzy logic contributes the capability of approximate reasoning, neurocomputing offers function approximation and learning capabilities, and genetic algorithms provide a methodology for systematic random search and optimization. These three capabilities are combined in a complementary and synergetic fashion.

"Basically, soft computing is not a homogeneous body of concepts and techniques. Rather, it is a partnership of distinct methods that in one way or another conform to its guiding principle. The dominant aim of soft computing is to exploit the tolerance for imprecision and uncertainty to achieve tractability, robustness and low solutions cost. The principal constituents of soft computing are fuzzy logic, neurocomputing, and probabilistic reasoning, with the latter subsuming genetic algorithms, belief networks, chaotic systems, and parts of learning theory. In the partnership of fuzzy logic, neurocomputing, and probabilistic reasoning, fuzzy logic is mainly concerned with imprecision and approximate reasoning; neurocomputing with learning and curve-fitting; and probabilistic reasoning with uncertainty and belief propagation".

Basic Concepts in Machine Learning

Machine Learning is continuously growing in the IT world and gaining strength in different business sectors. Although Machine Learning is in the developing phase, it is popular among all technologies. It is a field of study that makes computers capable of automatically learning and improving from experience. Hence, Machine Learning focuses on the strength of computer programs with the help of collecting data from various observations. In this article, "Concepts in Machine Learning", we will discuss a few basic concepts used in Machine Learning such as what is Machine Learning, technologies and algorithms used in Machine Learning, Applications and example of Machine Learning, and much more. So, let's start with a quick introduction to machine learning.

What is Machine Learning?

Machine Learning is defined as a technology that is used to train machines to perform various actions such as predictions, recommendations, estimations, etc., based on historical data or past experience.

Machine Learning enables computers to behave like human beings by training them with the help of past experience and predicted data.

There are three key aspects of Machine Learning, which are as follows:

- **Task**: A task is defined as the main problem in which we are interested. This task/problem can be related to the predictions and recommendations and estimations, etc.
- **Experience**: It is defined as learning from historical or past data and used to estimate and resolve future tasks.
- **Performance**: It is defined as the capacity of any machine to resolve any machine learning task or problem and provide the best outcome for the same. However, performance is dependent on the type of machine learning problems.

Techniques in Machine Learning

Machine Learning techniques are divided mainly into the following 4 categories:

1. Supervised Learning

Supervised learning is applicable when a machine has sample data, i.e., input as well as output data with correct labels. Correct labels are used to check the correctness of the model using some labels and tags. Supervised learning technique helps us to predict future events with the help of past experience and labeled examples. Initially, it analyses the known training dataset, and later it introduces an inferred function that makes predictions about output values. Further, it also predicts errors during this entire learning process and also corrects those errors through algorithms.

Example: Let's assume we have a set of images tagged as "dog". A machine learning algorithm is trained with these dog images so it can easily distinguish whether an image is a dog or not.

2. Unsupervised Learning

In unsupervised learning, a machine is trained with some input samples or labels only, while output is not known. The training information is neither classified nor labeled; hence, a machine may not always provide correct output compared to supervised learning.

Although Unsupervised learning is less common in practical business settings, it helps in exploring the data and can draw inferences from datasets to describe hidden structures from unlabeled data.

Example: Let's assume a machine is trained with some set of documents having different categories (Type A, B, and C), and we have to organize them into appropriate groups. Because the machine is provided only with input samples or without output, so, it can organize these datasets into type A, type B, and type C categories, but it is not necessary whether it is organized correctly or not.

3. Reinforcement Learning

Reinforcement Learning is a feedback-based machine learning technique. In such type of learning, agents (computer programs) need to explore the environment, perform actions, and on the basis of their actions, they get rewards as feedback. For each good action, they get a positive reward, and for each bad action, they get a negative reward. The goal of a Reinforcement learning agent is to maximize the positive rewards. Since there is no labeled data, the agent is bound to learn by its experience only.

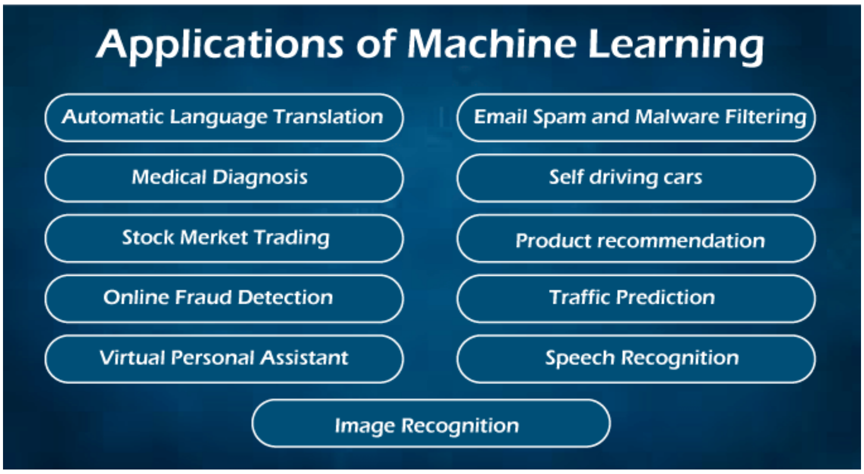
4. Semi-supervised Learning

Semi-supervised Learning is an intermediate technique of both supervised and unsupervised learning. It performs actions on datasets having few labels as well as unlabeled data. However, it generally contains unlabeled data. Hence, it also reduces the cost of the machine learning model as labels are costly, but for corporate purposes, it may have few labels. Further, it also increases the accuracy and performance of the machine learning model.

Sem-supervised learning helps data scientists to overcome the drawback of supervised and unsupervised learning. Speech analysis, web content classification, protein sequence classification, text documents classifiers., etc., are some important applications of Semi-supervised learning.

Applications of Machine Learning

Machine Learning is widely being used in approximately every sector, including healthcare, marketing, finance, infrastructure, automation, etc. There are some important real-world examples of machine learning, which are as follows:



Healthcare and Medical Diagnosis:

Machine Learning is used in healthcare industries that help in generating neural networks. These self-learning neural networks help specialists for providing quality treatment by analyzing external data on a patient's condition, X-rays, CT scans, various tests, and screenings. Other than treatment, machine learning is also helpful for cases like automatic billing, clinical decision supports, and development of clinical care guidelines, etc.

Marketing:

Machine learning helps marketers to create various hypotheses, testing, evaluation, and analyze datasets. It helps us to quickly make predictions based on the concept of big data. It is also helpful for stock marketing as most of the trading is done through bots and based on calculations from machine learning algorithms. Various Deep Learning Neural network helps to build trading models such as Convolutional Neural Network, Recurrent Neural Network, Long-short term memory, etc.

Self-driving cars:

This is one of the most exciting applications of machine learning in today's world. It plays a vital role in developing self-driving cars. Various automobile companies like Tesla, Tata, etc., are continuously working for the development of self-driving cars. It also becomes possible by the machine learning method (supervised learning), in which a machine is trained to detect people and objects while driving.

Two Different Approaches to AI

There were two different global approaches to Artificial Intelligence. First one deals with development of artificial intelligent system as a collection of rules or other knowledge structures given by men or partially self-learned, and a powerful inference engine, which could derive results similar to ones, which expert human being could produce. Alternative approach to AI suggests creation of relatively simple agents and their evolution to more complex and fittest structures, trying to reach the same goal - an intelligent machine. This distinction transformed later into symbolic and non-symbolic AI; into up-bottom and bottom-up approaches. New techniques emerged and were placed on one or another part. Soft Computing and Artificial Life are two relatively new areas of AI which are both growing fast and gaining acceptance. Both of them are representative of non-symbolic wing of AI and their unification practically covers this area as a whole. Some people feel that artificial life and soft computing are distinct areas with little overlap except when artificial life researchers occasionally use evolutionary computation techniques like genetic algorithms and fuzzy logic to control their artificial beings. It may also be well argued that Artificial Life and Soft Computing are very closely related fields. Soft Computing (SC) are Fuzzy Logic (FL), Neural Computing (NC), Evolutionary Computation (EC) Machine Learning (ML) and Probabilistic Reasoning (PR), The complementarities of FL, NC, GC, and PR has an important consequence: in many cases a problem can be solved most effectively by using FL, NC, GC and PR in combination rather than exclusively. An example of a particularly effective combination is what has come to be known as “neurofuzzy systems.” Such systems are becoming increasingly visible as consumer products ranging from air conditioners and washing machines to photocopiers and camcorders. Less visible but perhaps even more important are neurofuzzy systems in industrial applications. What is particularly significant is that in both consumer products and industrial systems, the employment of soft computing techniques leads to systems which have high MIQ (Machine Intelligence Quotient). In large measure, it is the high MIQ of SC-based systems that accounts for the rapid growth in the number and variety of applications of soft computing. The conceptual structure of soft computing suggests that students should be trained not just in fuzzy logic, neuro-computing, genetic programming, or probabilistic reasoning but in all of the associated methodologies, though not necessarily to the same degree. II. Applications of Soft Computing In many cases a problem can be solved most effectively by using Fuzzy Logic, Neural Networks, Evolutionary Computation in combination rather than exclusively. A good example of a particularly effective combination is what has come to be known as NeuroFuzzy systems. The examples of SC application are the usage of Evolutionary Computation techniques, like Genetic Algorithms to evolve Neural Nets, Fuzzy / NeuroFuzzy Systems and Cellular Automata. When the problem is nearly decomposable, like structural and parametric learning in Neural Nets, it’s more convenient to apply the techniques which better suit for particular sub-problem. For instance, GA and other EC methods showed good results in development of network architecture, while other techniques like back propagation, well fit for parametric learning. Soft Computing is dedicated to system solutions based on soft computing techniques. It provides rapid dissemination of important results in soft computing technologies, a fusion of research in evolutionary algorithms and genetic programming, neural science and neural net systems, fuzzy set theory and fuzzy systems, and chaos theory and chaotic systems. Soft Computing encourages the integration of soft computing techniques and tools into both every day and advanced applications. By linking the ideas and techniques of soft computing with other disciplines, as a unifying platform that fosters comparisons, extensions, and new applications.

Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation. Soft computing is likely to play an especially important role in science and engineering, but eventually its influence may extend.