Unit-1

Introduction to Soft Computing

"Soft computing is a collection of methodologies that aim to exploit the tolerance for imprecision and uncertainty to achieve tractability, robustness, and low solution cost. Its principal constituents are fuzzy logic, neurocomputing, and probabilistic reasoning. Soft computing is likely to play an increasingly important role in many application areas, including software engineering. The role model for soft computing is the human mind."

It consists of distinct concepts and techniques which aim to overcome the difficulties encountered in real world problems. These problems result from the fact that our world seems to be imprecise, uncertain and difficult to categorize. For example, the uncertainty in a measured quantity is due to inherent variations in the measurement process itself. The uncertainty in a result is due to the combined and accumulated effects of these measurement uncertainties which were used in the calculation of that result .

Soft computing is the name of a family of problem-solving methods that have analogy with biological reasoning and problem solving (sometimes referred to as cognitive computing). The basic methods included in cognitive computing are fuzzy logic (FL), neural networks (NN) and genetic algorithms (GA) - the methods which do not derive from classical theories.

Soft computing Development history:-

Soft		Evolutionary		Neural		Fuzzy
Computing	=	Computing	+	Network	+	Logic
Zadeh		Rechenberg		McCulloch		Zadeh
1981		1960		1943		1965

Constituent Methodologies of Soft Computing

Constituents of Soft Computing "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".

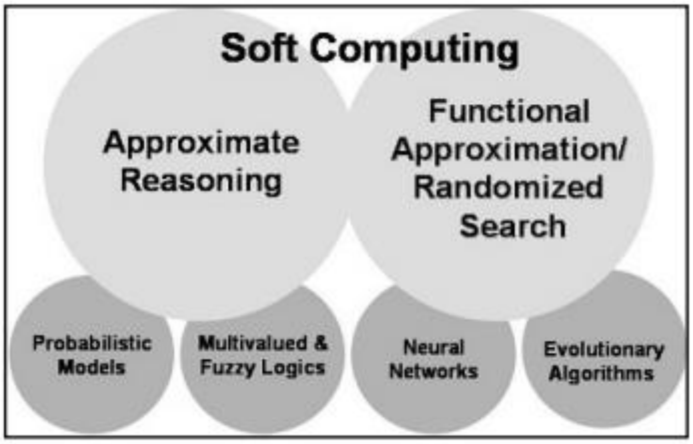


Fig. 1: Relationship in the Fields of Soft Computing

In the soft computing framework, the basic idea which has been developed so far has consisted in supposing that there is a set of resolving agents which are basically algorithms for solving combinatorial optimization problems, and to execute them cooperatively by means of a coordinating agent to solve the problem in question, taking the generality based on minimum knowledge of a problem as a fundamental premise. Each solving agent acts autonomously and only communicates with a coordinating agent to send it the solutions as it finds them and to receive guidelines about how to proceed. The coordinating agent receives the solutions found by each solving agent for the problem, and following a fuzzy rule base to model its behavior, it creates the guidelines which it then sends to them, thereby taking total control of the strategy.

Soft Computing Constituents and Conventional Artificial Intelligence

"SC is an emerging approach to computing which parallel the remarkable ability of the human mind to reason and learn in a environment of uncertainty and imprecision".

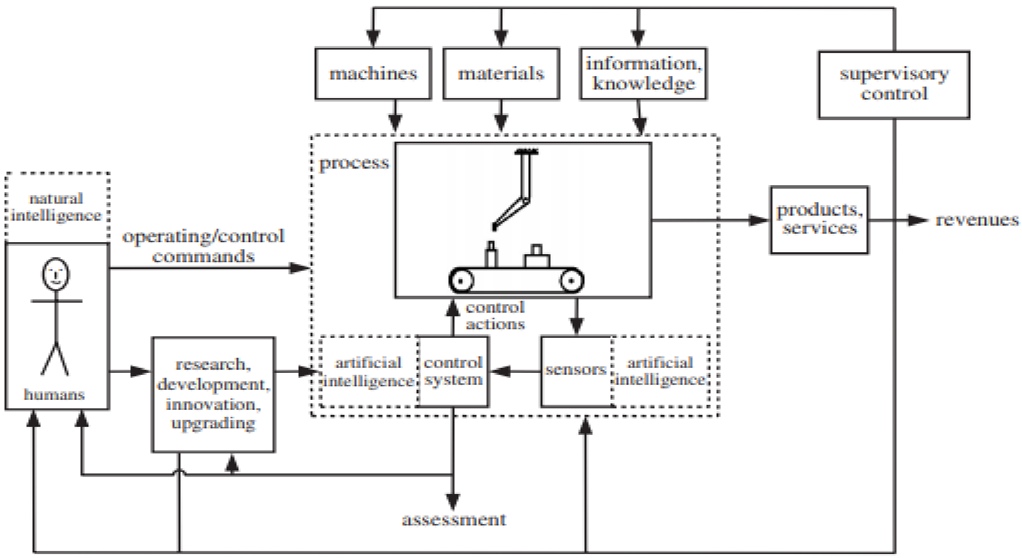
SC consists of several computing paradigms including: - Neural Networks - Fuzzy set theory - Approximate reasoning - Derivative-free optimization methods such as genetic algorithms (GA) & simulated annealing (SA)

Methodology	Strength
Neural Network	**Learning and Adaptation**
Fuzzy set theory	**Knowledge representation via fuzzy if-else**
Conventional AI	**Symbolic manipulation**

These methodologies form the core of SC.

- In general, SC does not perform much symbolic manipulation
- SC in this sense complements conventional AI approaches

From conventional AI to computational intelligence - Conventional AI manipulates symbols on the assumption that human intelligence behavior can be stored in symbolically structured knowledge bases: this is known as: " The physical symbol system hypothesis" - The knowledge-based system (or expert system) is an example of the most successful conventional AI product



The role of soft computing in intelligent machines

Overview of the History of SC

	Conventional AI	Neural networks	Fuzzy systems	Other methodologies
1940s	1947 Cybernetics	1943 McCulloch-Pitts neuron model		
1950s	1956 Artificial Intelligence	1957 Perceptron		
1960s	1960 Lisp language	1960s Adaline Madaline	1965 Fuzzy sets	
1970s	mid- 1970s Knowledge Engineering (expert systems)	1974 Birth of Back-propagation algorithm 1975 Cognitron Neocognitron	1974 Fuzzy controller	1970s Genetic algorithm
1980s		1980 Self-organizing map 1982 Hopfield Net 1983 Boltzmann machine 1986 Backpropagation algorithm boom	1985 Fuzzy modeling (TSK model)	mid- 1980s Artificial life Immune modeling
1990s			1990s Neuro-fuzzy modeling 1991 ANFIS 1994 CANFIS	1990 Genetic programming

EVOLUTION OF COMPUTING

Many inventions have taken several centuries to develop into their modern forms and modern inventions are rarely the product of a single inventor's efforts. The bits and pieces of a computer (including the software) came together over many centuries, many people each adding a small contribution. Each of the inventions listed below were only one small step on the road to the ultimate goal.

c3000 BC	The Chinese abacus was developed about 5000 years ago. It was built out of wood and beads. The abacus was so successful that its use spread form China to many other countries.
c800	In the ninth century, the Persian mathematician Abu Abdullah Muhammad bin Musa al-Khwarizmi developed the concept of a written process to be followed to achieve some goal, and published a book on the subject that gave us it's modern name—algorithm.
1623	German scientist Wilhelm Schikard invented a machine that used 11 complete and 6 incomplete sprocketed wheels that could add and, with the aid of logarithm tables, multiply and divide.
1642	The mechanical adding machine was invented by a nineteen-year-old French boy named Blaise Pascal way back in the year 1642.
1801	The Jacquard loom not only cut back on the amount of human labor, but also allowed for patterns to now be stored on cards and to be utilized over and over again to achieve the same product.
1820	Charles Babbage, British mathematician and inventor, who designed and built mechanical computing machines - The Difference Engine, on principles that anticipated the modern electronic computer.
1843	Ada Lovelace's set of instructions was a forerunner of modern computer program, and historians have credited her as the first computer programmer.
1890	Herman Hollerith devised a system of encoding data on cards through a series of punched holes, a punch card machine. This system proved useful in statistical work and was important in the development of the digital computer.
1939	In December 1939, the first prototype of the Atanasoff Berry Computer (ABC) was ready. The ABC showed some of the potentials of a computer and it amazed the University. So in 1939, Dr.John Vincent Atanasoff and his assistant Clifford Berry built the world's first electronic digital computer.
1940	Alan Turing introduced the concept of a theoretical computing device now known as a Turing machine. The concept of this machine, which could

	theoretically perform any mathematical calculation, was important in the development of the digital computer.
1944	Howard Aiken with his colleagues at Harvard - and with some assistance from International Business Machines - by 1944 he had built the Mark I, the world's first program-controlled calculator; an early form of a digital computer.
1946	John Mauchley, an American physicist, and J. Presper Eckert, an American engineer, proposed an electronic digital computer, called the Electronic Numerical Integrator And Computer (ENIAC), completed in 1946 and is regarded as the first successful, general digital computer.
1947	Teams of Bell Labs scientists, such as Shockley, Brattain, Bardeen, and many others met the challenge.--and invented the information age. They produced the greatest invention of the our time: the transistor.
1951	Jay W, Forrester invented the first random-access magnetic core store (memory) for an electronic digital computer. He also supervised the building of the Whirlwind digital computer and studied the application of computers to management problems, developing methods for computer simulation.
1952	Grace Hopper was credited with devising the first computer compiler, a program that translates instructions for a computer from English to machine language.
1954	Machine vision used computers to analyze digitized images from a video camera. It was a breakthrough invention and the one of which Jerome Lemelson was most proud despite the hundreds of others that he produced over the next forty-five years.
1958	It was a relatively simple device that Jack Kilby showed to a handful of co-workers gathered in TI's semiconductor lab. Only a transistor and other components on a slice of germanium. Kilby's invention, called an integrated circuit, was about to revolutionize the electronics industry.
1966	The hand-held calculator was invented at Texas Instruments, Incorporated (TI) in 1966 by a development team which included Jerry D. Merryman, James H. Van Tassel and Jack St. Clair Kilby.
1967	Robert Heath Dennard invented the one-transistor dynamic random access memory DRAM in 1967. It has become the standard for the RAM industry and enabled the microcomputer revolution.
1968	Ted Hoff's knowledge of computers (then still very large machines) allowed him to design the computer-on-a-chip microprocessor (1968), which came on the market as the Intel 4004 (1971), starting the microcomputer industry.

	Douglas Engelbart had invented a number of interactive, user-friendly information access systems that we take for granted today: the computer mouse was one of his inventions.
1973	Robert Metcalfe needed something that was fast, could connect hundreds of computers and span the whole building, Something like a local area network, which Metcalfe developed in a rudimentary form in 1973 and dubbed Ethernet. The Internet and Transmission Control Protocols (TCP/IP) were initially developed in 1973 by American computer scientist Vinton Cerf. Xerox Palo Alto Research Center (PARC) invents protoype of the world's first personal computer, the Alto, with innovations including the first what-you-see-is-what-you-get editor, first commercial use of a mouse, graphical user interface, and bit-mapped display. Its commercial descendant was the 8010 Star.
1976	In what is now the Silicon Valley, Steve Jobs and Steve Wozniak created a homemade microprocessor computer board called Apple I Personal Computer..
1977	Dennis C. Hayes and Dale Heatherington invent the PC modem in 1977, establishing the critical technology that allowed today's online and Internet industries to emerge and grow.
1982	The HX-20, the first notebook-sized portable computer is introduced by Epson.
1991	The World Wide Web is a system of resources that enable computer users to view and interact with a variety of information.

Machine Learning-Basics

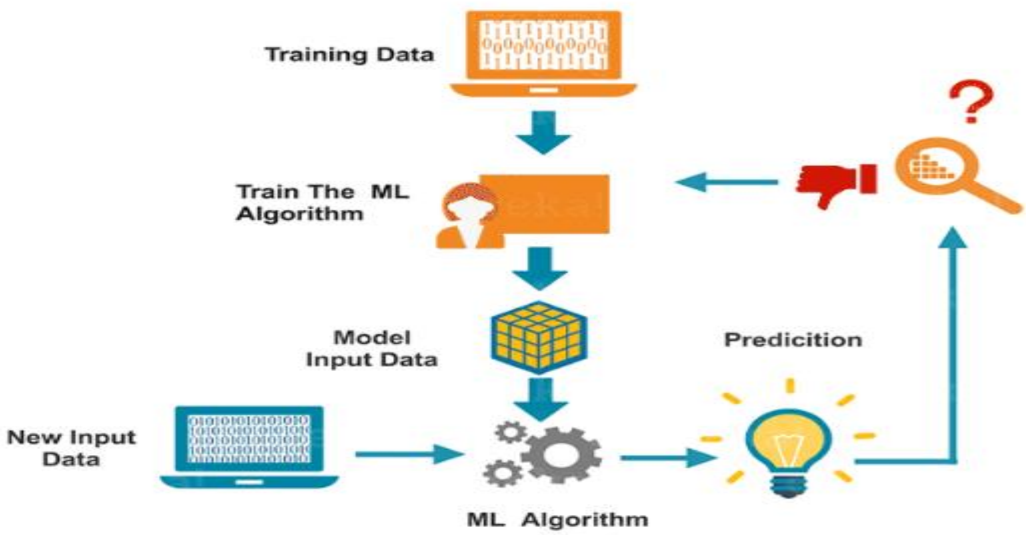
Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.

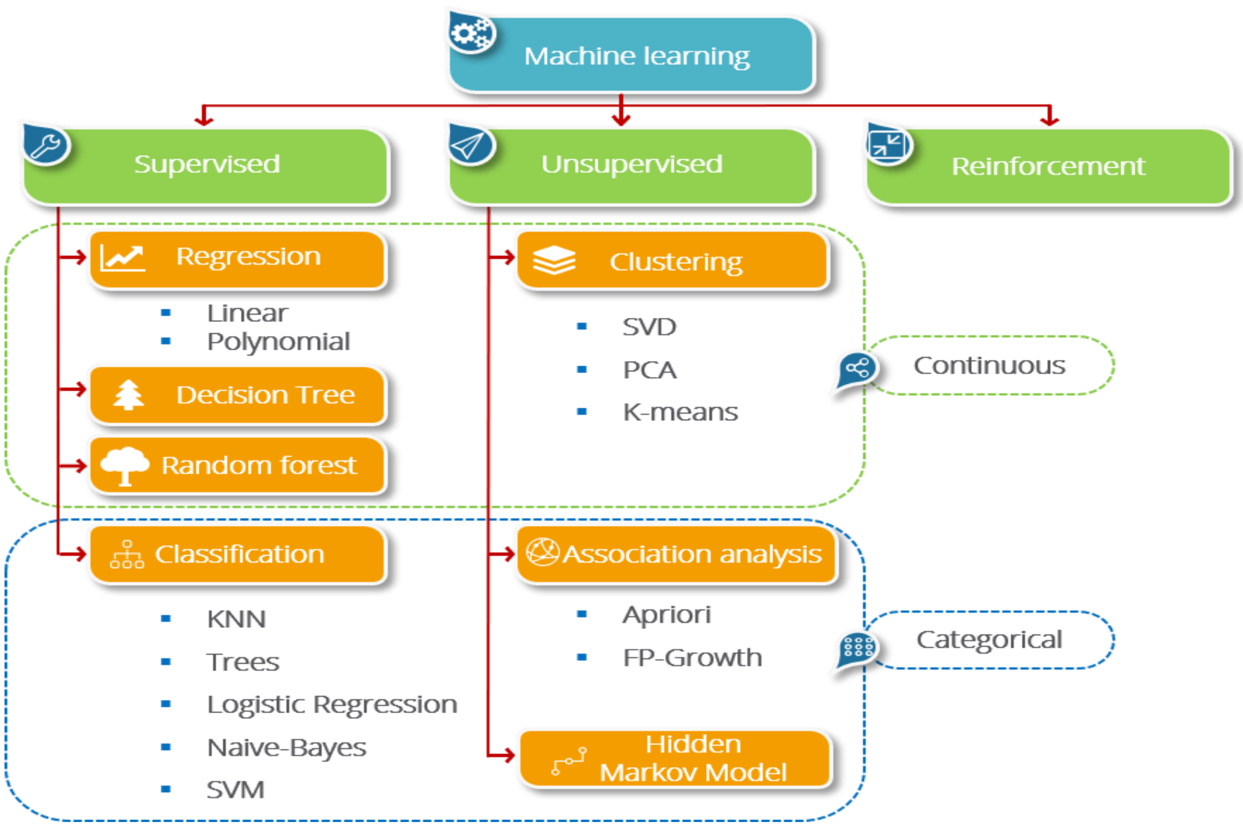
Working of Machine Learning

Machine Learning algorithm is trained using a training data set to create a model. When new input data is introduced to the ML algorithm, it makes a prediction on the basis of the model.

The prediction is evaluated for accuracy and if the accuracy is acceptable, the Machine Learning algorithm is deployed. If the accuracy is not acceptable, the Machine Learning algorithm is trained again and again with an augmented training data set.

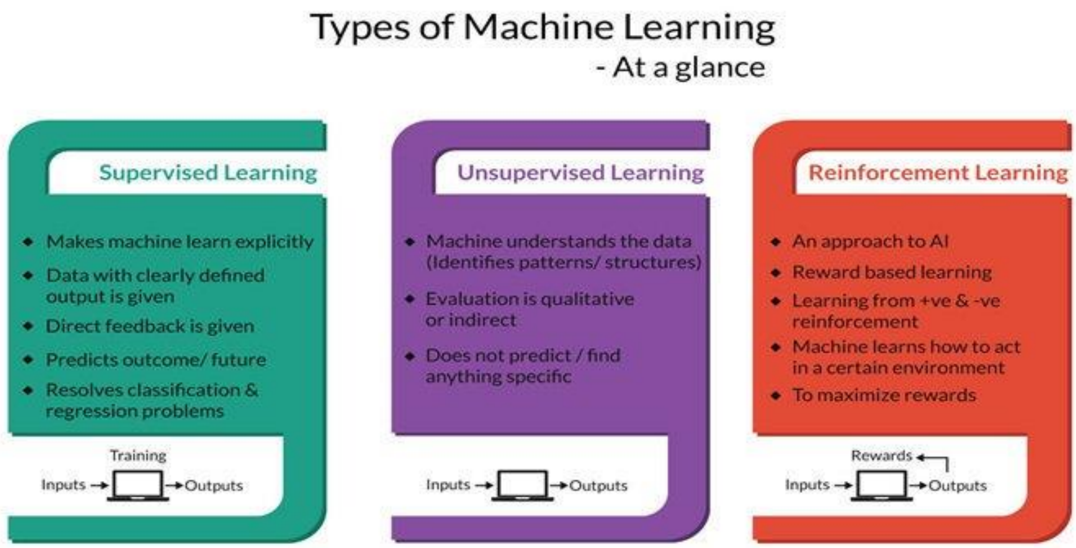
This is just a very high-level example as there are many factors and other steps involved.





Types of Machine Learning:-

- **Supervised machine learning algorithms** can apply what has been learned in the past to new data using labeled examples to predict future events. Starting from the analysis of a known training dataset, the learning algorithm produces an inferred function to make predictions about the output values. The system is able to provide targets for any new input after sufficient training. The learning algorithm can also compare its output with the correct, intended output and find errors in order to modify the model accordingly.
- **Unsupervised machine learning algorithms** are used when the information used to train is neither classified nor labeled. Unsupervised learning studies how systems can infer a function to describe a hidden structure from unlabeled data. The system doesn’t figure out the right output, but it explores the data and can draw inferences from datasets to describe hidden structures from unlabeled data.
- **Semi-supervised machine learning algorithms** fall somewhere in between supervised and unsupervised learning, since they use both labeled and unlabeled data for training – typically a small amount of labeled data and a large amount of unlabeled data. The systems that use this method are able to considerably improve learning accuracy. Usually, semi-supervised learning is chosen when the acquired labeled data requires skilled and relevant resources in order to train it / learn from it. Otherwise, acquiringunlabeled data generally doesn’t require additional resources.
- **Reinforcement machine learning algorithms** is a learning method that interacts with its environment by producing actions and discovers errors or rewards. Trial and error search and delayed reward are the most relevant characteristics of reinforcement learning. This method allows machines and software agents to automatically determine the ideal behavior within a specific context in order to maximize its performance. Simple reward feedback is required for the agent to learn which action is best; this is known as the reinforcement signal.


Types of Machine Learning
- At a glance
Supervised Learning
Makes machine learn explicitly
Data with clearly defined output is given
Direct feedback is given
Predicts outcome/ future
Resolves classification & regression problems
Training
Inputs
Outputs
Unsupervised Learning
Machine understands the data (Identifies patterns/ structures)
Evaluation is qualitative or indirect
Does not predict / find anything specific
Inputs
Outputs
Reinforcement Learning
An approach to AI
Reward based learning
Learning from +ve & -ve reinforcement
Machine learns how to act in a certain environment
To maximize rewards
Rewards
Inputs
Outputs