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Computational Intelligence, Granular Computing and Soft Computing.

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***Abstract* : Computational intelligence, Granular computing and Soft computing are some of the major offshoot of artificial intelligence (AI). Computational intelligence is widely used in many computational fields in the contemporary world. Granular computing and soft computing are also two fields which are used in many intelligent machines.**

This paper gives an insight about the three computational methods used in intelligence. It will also give an idea on how these computing methods are used to create intelligent agents which can possess a similar intelligence as a human.

***Key words:* Fuzzy logic, Neural networks, Probabilistic methods, Granular Computing, Soft Computing, Intelligence .**

I. INTRODUCTION

The term computational intelligence clearly indicates or points to an intelligent computer. Although all computers are intelligent, using computational intelligence we can create a machine which can possess the same intelligence as a human brain. It will be basically known as an intelligent agent which can have an intelligent quotient (IQ) as well as emotional intelligence (EQ). The widely used definition related to computational intelligence is, "a system is called fully computationally intelligent if it deals with low level data such as numerical data, if it has pattern-recognition component and if it does not use knowledge as exact and complete as the artificially intelligent one" (Bezdek, 1994). Computational intelligence provides solution to the real world problems which the mathematical models could not provide because of uncertainty in the models. The purpose of the computational intelligence is to understand how the intelligent systems and agents work. The methodology is to design, build, and experiment with the computational systems that perform tasks commonly viewed as intelligent. A major question arises in the discussion that what is the difference between artificial intelligence and computational intelligence? The most basic answer is that computational intelligence is considered as a subset of artificial intelligence. Digging deeper on the technical level of artificial and computational intelligence, the former one is bases on hard computing techniques and the later one is based on soft computing techniques, which will be discussed later in the paper. Hard computing techniques work follows a binary logic which only works with two values(TRUE or FALSE) on which modern computers are based. But one of the main problems of this logic is that our natural language cannot always be easily translated into absolute terms of 0 and 1. This where soft computing comes in importance, it is based on a different logic, the fuzzy one. Much closer to a way human brain work by almost aggregating data to a partial truth, this logic of computational intelligence is one the most important aspect that differs it from the artificial intelligence. Computational Intelligence has 5 main principles and applications as shown in Fig. 1: Fuzzy logic, Neural networks, Learning Theory, Probabilistic methods and Evolutionary computation. In the section ahead we will discuss about some of the principles of the computational intelligence.

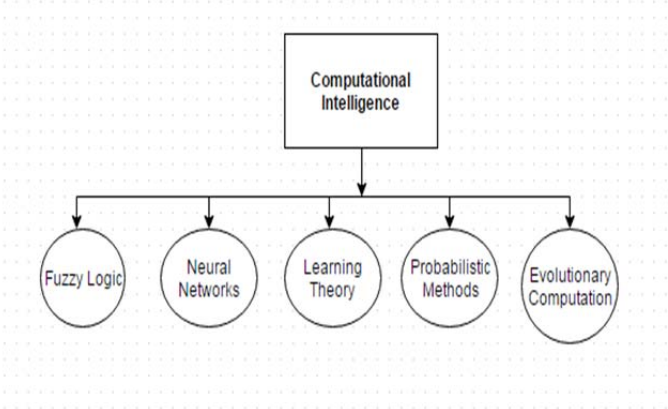

Fig.1 Five main base branches of Computer intelligence.

Fuzzy Logic:

Fuzzy logic is an approach to intelligent computing based on degrees of truth rather than the usual true or false (0 or 1) logic on which the modern computer is based. Fuzzy logic has been extended to handle the concept of partial truth. The term fuzzy logic was in 1965 (by Zadeh). The fuzzy logic technique is applies in a wide range of domains such a control, image processing, decision making and many household appliances. The computers cannot understand the natural language. Hence we convert it into binary (0 and 1), the problem arises when the natural language is not completely converted into binary. Hence the fuzzy logic was introduced. Fuzzy logic includes 0 and 1 as true facts but also includes various states of truths between the facts. For example we consider two moving objects comparing their speed, the result of the comparison cannot be "fast" or "slow" rather it should be "fast by x m/s". Fuzzy logic seems closer to the way our brain works. We aggregate data and form a number of partial truths which we aggregate into higher truths which in turn when a threshold is encountered, will carry out other results. The fuzzy logic does not contain an IF-ELSE relationship rather it has an IF-IS-THEN relationship. For example:

IF the temperature IS very cold THEN stop fan.
IF the temperature IS cold THEN turn down the fan.
IF the temperature IS normal THEN maintain fan.
IF the temperature IS hot THEN speed up fan.

Fuzzy logic is widely used in home appliances for example in the smart heater and coolers where fuzzy logic thermostats are used to control the heat. Fuzzy logic is also used in automation industry.

Neural Networks:

A neural network is a system of programs and data structures that approximates the operation of a human brain. A neural network usually involves a large number of operating in parallel, each with its own certain gathered knowledge and access to data in the local memory. The neural networks are the models inspired by biological neural network and are used to estimate approximate functions that can depend in large number of present inputs which are unknown. The neural network mathematics was started in the early 1940's and gained attention in the mid 1950's. A neural network is initially trained of fed large amount of data sets about the relationship between the data, after the program understand relation between the data it can tell the network how to behave to a newly generated external data and can initiate an activity on the data.

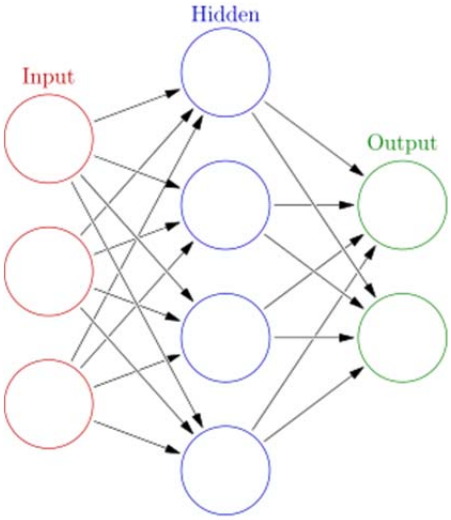

Fig. 2 The nodes connected in the artificial neural networks.

As shown in the above figure Fig. 2 a neural network is an interconnection of nodes similar to a human brain, where the input is stored and hidden in the brain and will give the output when encountered with a desired situation. Similarly, a neuron network is a large data set is given to the network and it will store the desired information about the relations between the data and will give a desired output. In making decisions neural networks use several principles and logics including fuzzy logic, Bayes algorithm. Neural network possess a feed forward system where learned relationships about a data can be "feed forward" to higher layers of knowledge. Neural networks are now widely used in oil exploration data analysis, whether prediction, health prediction, models of human thinking and behaviour, etc.

Probabilistic Methods:

Probabilistic methods was introduced in mid-1970's, it is one of the main element of fuzzy logic. Many problems in computational intelligence require the agent to operate with incomplete or uncertain information. Probabilistic algorithms can be used to filter, predict, smoothing and finding explanations for streams of data , helping perception system to analyse processes that occur over time. Precise probabilistic methods have been developed to analyse how an agent can make choices and plan on how to execute a data for a desired input.

II. GRANULAR COMPUTING

Granular Computing is a computer paradigm related to intelligent computing. Granular computing has a theoretical perspective rather than a practical and methodological. It concerns with the formation and processing of information granules which arise in the process of data abstraction and mining. Granular Computing aims at understanding the principles of human problem solving so that it can applied in the intelligent systems. Granular computing is a support system for computational intelligence as well as artificial intelligence. Granular way of problem solving is general and flexible enough to cover an important class of methods in human problem solving. Granular computing is an approach to recognize how different and uncertain can occur in the data at different levels of granularity. A good example depicting granular computing is explained as : "one might notice interesting cloud patterns representing cyclones or other large-scale weather phenomena, while in a higher-resolution image, one misses these large-scale atmospheric phenomena but instead notices smaller-scale phenomena, such as the interesting pattern that is the streets Manhattan. The same is generally true of all data: At different resolutions or granularities, different features and relationships emerge(wiki).

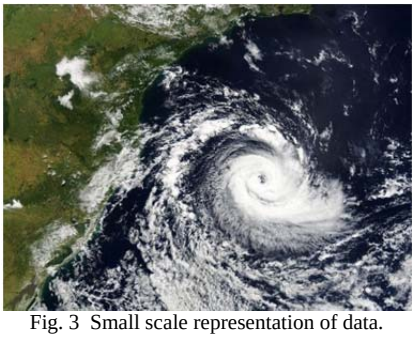

Fig. 3 Small scale representation of data.

Fig. 4 Large and detailed representation of data where relations are generated.

There are basically five types of granulation:

A. Value Granulation.
B. Variable Granulation.
C. System Granulation.
D. Concept Granulation.

Granular computing is usually studies from three perspectives that are : Philosophical perspective, Methodological perspective and Computational perspective. These are included as the main components of granular triangle.

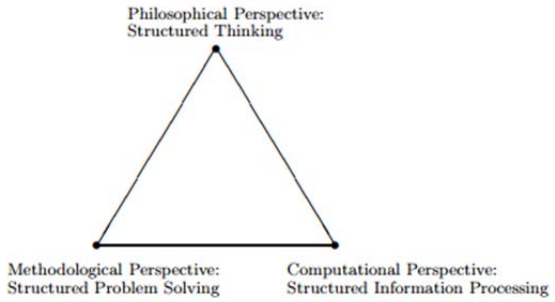

Fig. 5 Granular Computing triangle.

There are also different interpretations of granular computing like framework of theories, methodologies, techniques, and tools that make use of information granules in the process of problem solving. We elaborate on the rationale behind granular computing. Next, a number of formal frameworks of information granulation are discussed including several alternatives such as fuzzy sets, interval analysis, rough sets, and probability. The notion of granularity itself is defined and quantified. A design agenda of granular computing is formulated and the key design problems are raised. A number of granular architectures are also discussed with an objective of delineating the fundamental algorithmic, and conceptual challenges. It is shown that the use of information granules of different size (granularity) lends itself to general pyramid architectures of information processing. The role of encoding and decoding mechanisms visible in this setting is also discussed in detail, along with some particular solutions. We raise an issue of interoperability of granular environments. One of the main application of Granular computing will be in making intelligent computational systems and data mining processes.

III. SOFT COMPUTING

Soft computing is yet another field in intelligence. Where is the main supporting system for computational intelligence. Soft computing usually focuses on solutions of an intelligent system which are unpredictable i.e. between 0 and 1. Soft computing was developed in the early 1990's and became a part of the studies in the intelligent agents. Soft computing has its counter-part which is hard computing which is rather a support system for artificial intelligence. Unlike hard computing, soft computing is tolerant to imprecision, uncertain data, partial truth and approximations, whereas hard computing works on concrete data like true or false. The main motive of the soft computing is to exploit the tolerance of imperfect data to achieve tractability, robustness and low solution cost. In the contemporary world, soft computing is often used to make prediction technologies like bio-medicine prediction, weather prediction and making of intelligent personal assistants. Again the main components of soft computing are fuzzy logic, neural networks, machine learning and probabilistic methods. Strikingly interesting products like washing machines, air conditioners etc. use the "neurofuzzy" systems which are the core branches of soft computing. The employment of soft computing technologies leads to systems which have high Machine intelligence quotient.

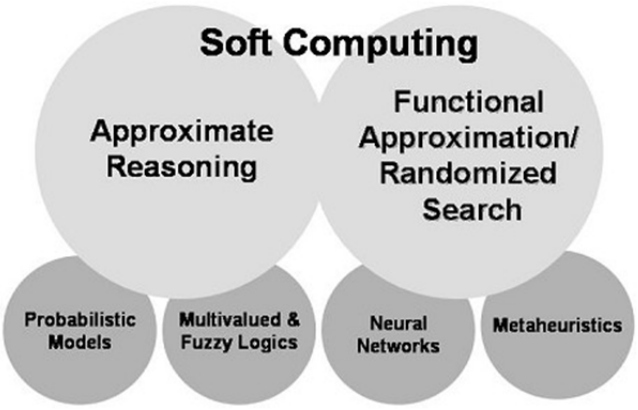

Fig. 6 Branching of soft computing.

As we can see from the above figure that Soft computing techniques almost has the same systems as computational intelligence and as we have discussed earlier in this paper about three of the systems i.e. Fuzzy logic, Probabilistic methods and neural networks, we will take the metaheuristics portion in the soft computing as it also plays a major role in soft computing technique.

A. etaheurisctics:

Metaheuristic plays a crucial role in the soft computing as it has a hybrid collection of the metaheurisctics which are capable enough to create an intelligent machine. Evolutionary metaheuristics are by far the most popular and define mechanisms for developing an evolution in the search space of the sets of solutions in order to come close to the ideal solution with elements which will survive in successive generations of populations. Relaxation metaheuristics are strategies for relaxing the problem in heuristic design, and which are able to find solutions for problems which would otherwise have been very difficult to solve without the use of this methodology. Examples of these are rounding up or down or adjustments in nature, as occurs when an imprecisely and linguistically-expressed quantity is associated to an exact numerical value. From this point of view, a real alternative is to make flexible exact algorithms, introducing fuzzy stop criteria, which eventually leads to rule-based relaxation metaheuristics; admitting the vagueness of coefficients, justifying algorithms for resolving problems with fuzzy parameters, and relaxing the verification of restrictions, allowing certain violations in their fulfilment. Search metaheuristics are probably the most important metaheuristics, and their basic

operation consists in establishing strategies for exploring the solution space of the problem and iterating the starting-point solutions. Although at first sight they might appear to be similar to evolutionary searches, they are not since evolutionary searches base their operation on the evolution of a population of individuals in the search space. These metaheuristics are usually described by means of various metaphors, which classify them as bio-inspired, sociological, based on nature, etc. and this makes them extremely popular. We even have a simple computer program to explain search Metaheuristic.

```
Begin
  While ( not-finalization ) Do
    /* the neighborhood scheduler is called */
    NS->Run(O, μ(), S_cur, S_new, ok);
    If (S_new is good enough in terms of μ()) Then
      S_cur = S_new;
      adaptFuzzyVal(μ(), S_cur);
    Else
      /* No good enough solution was found  */
      /* with the current operator */
      /* We change it with the operator scheduler */
      OS->Run(O);
    endIf
    If (trappedCondition()) Then
      doRestart();
    endIf
  endDo
End.
```

Fig. 7 Search Metaheuristic explained logically

IV. CONCLUSION

Using computational intelligence, granular computing and soft computing one can make intelligent systems which can adopt the thinking of a human brain and can act as intelligent as a human brain. The intelligent systems uses these computational systems to predict data with some relationships already established between the data with the help of previous datasets. Since we are proceeding towards a more digitalized age these intelligent agents will be really useful in easing out our day to day stuff.

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