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Comparative Analysis of Computational Intelligence Paradigms in WSN: Review

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***Abstract**: Computational Intelligence is the study of the design of intelligent agents. An agent is something that react according to an environment—it does something. Agents includes worms, dogs, thermostats, airplanes, humans, and society. The purpose of computational intelligence is to understand the principles that make intelligent behavior possible, in real or artificial systems. Techniques of Computational Intelligence are designed to model the aspects of biological intelligence. These paradigms include that exhibit an ability to learn or adapt to new situations,to generalize, abstract, learn and associate. This paper gives review of comparison between computational intelligence paradigms in Wireless Sensor Network and Finally,a short conclusion is provided.*

***Keywords:** Computational Intelligence, Computational Intelligence Techniques, Swarm Intelligence ,Genetic Algorithm, Artificial Neural Network.*

I. Introduction

Computational Intelligence is a technique which is inspired from nature. It is used for complex problem solutions.Computational Intelligence is used to make systems which can work in real time. Computational intelligence is different from artificial intelligence. In artificial intelligence like robots, they are used to do predefined things like they can place things from one place to another, opening or shutting of the door etc. All such things are already inserted into the memory of the robot to perform all those tasks. Purpose of CI is to introduce such intelligence in the system that it can take decisions like humans do, according to an environment like they can select best solution from a set of available options.

Computational intelligence is defined as "The computational models and tools of intelligence, able of inputting raw numerical sensory data directly, manage them by exploiting the representational parallelism and pipelining the problem,generating authentic and timely responses and withstanding high fault liberality" [1].

CI has been a source of providing solutions in various fields. Computational Intelligence techniques have been successfully employed in a wide range of application areas ,including decision support, genetic clustering and classification, consumer electronic devices, stock market and other time-series prediction,combinatorial optimization ,medical, bioinformatics problems and many others.

The rest of this paper is organized as given: Characterstics of Computational Intelligence in Section II. Applications of Computational Intelligence is discussed in Section III. In Section IV A brief overview on Computational Intelligence techniques.In Section V in which comparative analysis of computational intelligence are given and last section VI concludes the work.

II. Characterstics Of CI

The characteristics of Computational Intelligence[2] with the following points:

- Adaptation: As these systems are designed to work in real time and can react to different situations accordingly like node failure or topology change. They are very adaptive so they can adjust to changing situations
- High Computational Speed: As these systems are working on real time so they must be very fast. For that aim they have high computational speed so that they meet the requirement of real time applications.
- Versatility: Versatility is another characteristic of CI. They are very adjustable and can handle highly non-linear mappings without external help.
- Robustness: It imposes little or no necessity on the objective function.
- Self Organizing: Due to many reasons network topology gets changed. Self organization is the characteristic which deals with this problem and also used in the initial stages of network deployment.
- Self Learning: In self learning systems are given a set of instructions and rules. System then takes the input from environment and then on the basis of that input processing is done. On the basis of that processed information and given set of instructions, system gives output according to real time scenario but that output was not fed into the memory of that system.

III. Computational Intelligence Applications

CI's applications are diverse, including medical diagnosis, robots for hazardous environments, chess playing, autonomous vehicles, natural language translation systems, and cooperative systems. Rather than treating each application individually, we abstract important points of such applications to allow us to study principles behind intelligent reasoning and action. The three application domains of computational intelligence are:

- Autonomous delivery robot: It can roam around a building delivering packages and coffee to people in the building. This delivery agent requires to be skill to, for example, find paths, assign resources, receive requests from people, make decisions about priorities, and supply of packages without injuring people or itself.
- Diagnostic assistant: Assistant helps a human troubleshoot problems and suggests repairs or treatments to rectify the problems. An example is of a medical diagnostician that finds potential diseases, possible tests, and appropriate treatments based on knowledge of a particular medical domain and a patient's symptoms and history. This assistant needs to be able to explain its reasoning to the person who is carrying out the tests and rebuilt, as that person is eventually supervise for what they do. The diagnostic assistant must append valuable value in order to be worth using.
- Infobot: One of the best application of computational intelligence can search for users such as company managers or people off the street. In sequence to do this the infobot should find out, using the user's real language, what data is requested, determine where to find out the information, and gain the information from the appropriate sources. It then must explain its findings in an appropriate format so that the human can understand the information found, including what they can infer from the lack of information.

IV. Computational Intelligence Paradigms

Computational Intelligence is the study of the design of intelligent agents. An intelligent agent is a system that behave intelligently and what it does is appropriate for its circumstances and its goal,flexible to changing environments and goals, gain from experience, and suitable choices given perceptual limitations and finite computation."[2].Better computer systems and improved performance of computational tasks such as flexibility, adaptability, decentralization and fault tolerance are few important traits of CI.Paradigms of CI are planned to model the aspects of biological intelligence. CI encompasses paradigms such as artificial neural networks, reinforcement learning, swarm intelligence, evolutionary algorithms, fuzzy logic and artificial immune systems.CI has been a source of producing solutions in various fields. Computational Intelligence techniques have been successfully employed in a wide range of application areas ,including decision support, genetic clustering and classification, consumer electronic devices, stock market and other time-series prediction, combinatorial optimization ,medical, bioinformatics problems and many others.The CI paradigms address a multidisciplinary, rich, and, diverse area of research in a number of applications in various fields. Such as WSN, digital communications, RF and microwave communication, radars communication, signal processing, acoustics, power, and lots more.

A. Artificial Neural Networks

Human brain is performing different tasks and working them faster than computers. Design of artificial neural networks(ANN) is taken from brain's neural network. ANNs have abilities of learning, memorizing etc. Huge numbers of nerve cells (neurons) combine to make a biological neural network. Axon, dendrites and cell body creates up a neuron. Axon of one neuron join with dendrite of another neuron for communication. In same way number of neurons gets interconnected. The connection between axon and dendrite is known as synapse.

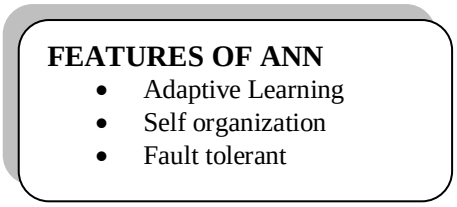

Fig 1:Features of ANN

Signal moves from axon of one neuron to the dendrite of another neuron.Inside a neuron signal moves from dendrite to body and then to axon and then axon passes that signal to all connected dendrites. "A signal is transferred to the axon of a neuron only when the cell "fires".

A neuron either can inhibit or excite a signal." [3]. Artificial Neuron is raise on the basis of biological neuron. It gathers the information from the environment or connected neurons and transmits the information to the connected neurons only when it is fired. Neural Networks need very high processing and large memory. It usually supply centralized solutions. Solutions are basically slow in speed. It usually provides centralized solutions. It is good for data aggregation and fusion [4].Applications of Artificial Neural Network are Diagnosis of diseases, Speech Recognition,Data mining,Image processing,Robot control,Pattern recognition and Compression and many others.[5]

B. Genetic Algorithm

Inspired by Charles Darwin's theory of evolution: 'the survival of the fittest", Genetic Algorithm (GA) was initiated formally by John Holland in 1970s [6]. GA is an adaptive heuristic search algorithm that models biological genetic evolution. It displayed to be a robust optimizer that searches among a group of solutions, and showed flexibility in solving dynamic problems.It has been successfully obtain to many NP-hard problems. The main challenge in solving a problem with GA is the encoding of the problem into a set of chromosomes; each representing a solution to the problem. The status of each chromosome is evaluated using a fitness function.

According to their fitness value, crossover 3 and mutation processes are applied on selected chromosomes. The crossover process produces new solutions, called offspring,by interconnecting parts of two selected chromosomes. Transmutation changes one or more genetic element in the produced offspring to prevent being trapped in local minima.Applications of Genetic Algorithm are Data mining, Combinatorial optimization,Fault diagnosis,Clustering and Scheduling.

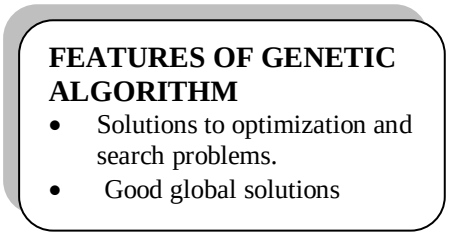

Fig 2:Features of Genetic Algorithm

C. Fuzzy Logic

Fuzzy means vague, indistinct or difficult to perceive.Unlike Boolean where values are integer i.e. '1' or '0', where'1' represents true and '0' represents false, it (fuzzy) takes continuous values between '0' and '1'. In fuzzy systems '0' represents absolute wrong and '1' represents absolute correct and give continuous values for other conditions.Let's take an example of fan, if we are using Boolean system then it would either TURN ON or TURN OFF the fan,If it is tough or easy, if it is cold or hot. But if we use fuzzy system then it will set the speed of fan from stop to slow, slow to medium and so on,depending on the value of temperature [6]. Fuzzy logic is used in optimization, clustering heuristic and routing. The solutions it provides are not optimal. It is good for security and QoS problems. It usually provides centralized solutions. It is good for data aggregation and fusion [7].Applications of fuzzy logic are control systems,gear transmission,braking systems in vehicles, controlling lifts,Home appliance and controlling traffic signals.

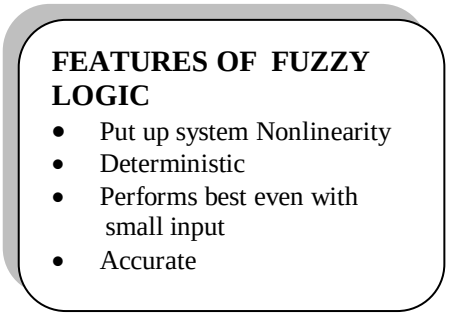

Fig 3:Features of Fuzzy Logic

D. Swarm Intelligence

Swarm intelligence is based on the study of swarms that how they live, communicate, forage for food etc. They have no central control, no direct communication but still they manage to find shortest paths, find

foods and manage their resources well. Swarm introduce the large no of insects or other small organized entities, esp. when they are in motion. Global intelligent behavior to which the individuals are entirely unknown is emerged due to the local, self-organized and decentralized interaction of swarm's agents.

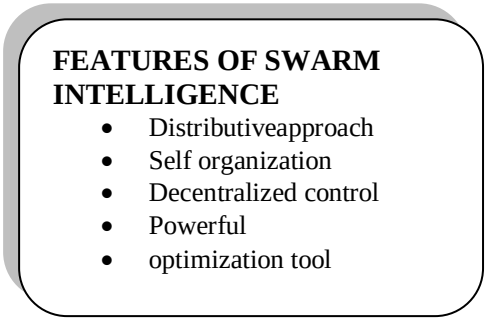

Fig 4:Features of Swarm Intelligence

Swarm intelligence (SI) is one of the aspiring solutions from bioinspired computing for such heuristic optimization problems e.g. routing Natural examples of SI include ant colony, bird flocking, animal herding, bacterial growth, fish schooling, drop water, fireflies etc. Examples algorithms under the head of SI are Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Gravitational Search Algorithm (GSA), Intelligent Water Drop (IWD), Charged System Search (CSS) and Stochastic Diffusion Search (SDS) etc.Swarm intelligence gives effective solutions for routing in the ad-hoc networks.It consumes vast amount of energy on communication when it send to ants for route discovery. Applications of Swarm Intelligence are Function approximation, Clustering, Optimization of Mechanical structures, Solving systems of Equations, Routing optimization and Graph Coloring.

- Partial Swarm Optimization: Particle Swarm Optimization (PSO) was developed in 1995 by James Kennedy, and Russell Eberhart . PSO is a robust stochastic nonlinear- optimization technique based on movement and intelligence of swarms.It is stimulate from social behavior of bird or fish, where a group of birds search for food in an area by following the nearest bird to the food. It merge local search methods with global search methods depending on social interaction between particles to locate the best achieved position so far. PSO and GA are very similar. Both are population based stochastic optimization that starts with a group of a randomly generated population. They have fitness values to evaluate their population, and update the population and search for the optimum with random techniques. However, PSO differs from GA in that there is no crossover and mutation. PSO particles do not die.They update themselves with the internal velocity. Finally, the information sharing mechanism in PSO is significantly different. Each particle is treated as a point in a multi-dimensional space, and modifies its position influenced by two components: the cognitive component and the social component resulting from neighbor communication.

E. Artificial Immune System

Artificial immune system is basically inspired from natural or real immune system and it models some aspects of artificial immune system. Natural immune system (NIS) is having a great pattern matching ability. It is used to differentiate between foreign cells entering the body (antigen or non-self) and the cells belonging to the body (self). NIS fights the antigens and memorizes their structure for faster future response if they try again to enter the body. The four models of natural immune system are Classic view, clonal selection theory, danger theory and network theory. Artificial immune system is use to give security, fault detection, optimization and abnormality detection.

- Immune network models: Immune network models are based on the hypothesis that the immune system uses an idiotypic network of interconnected B cells - a component of the adaptive immune system - for antigen recognition. The power of interconnection between two B cells is directly proportional to the affinity they share. A B cell population has two kinds of sub-populations: the initial population and the cloned population. The initial subset is produced from raw training data, and the rest are used for antigen training items. Antigens are randomly choosed from training set and presented to areas of the B cell network.

In case of successful binding, the B cell is cloned and mutated, leading to a diverse set of antibodies. When a new B cell is produced, it is added into the network at the closest B cells. If the new cell cannot be added, it is deleted from the population. If all binds fail, a B cell is produced using the antigen as a template and is then included into the network.Applications of Artificial Immune System are Pattern Recognition problems, Classification, Clustering, Anamoly Detection,Computer virus Detection.[8]

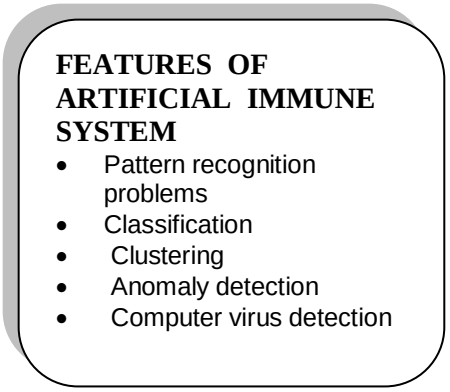

Fig 5:Features of Artificial Immune System

V. Comparative Analysis Of CI Paradigms In WSN

The CI paradigms untie the restriction of obstruction by its vast and multiobjective nature. State variables, no of search points, runtime, target problem, are efficient to compare and analyze CI paradigm algorithms to solve WSN issues .It can also be applied to a huge amount of fields to give and optimal and solve the issues of different application fields of CI. Here optimized energy aware routing is approved. These are all helps to optimize a particular problem. Table 1 shows a comparative analysis of each CI paradigms algorithms.The important subheads are discussed below.

A. State variables:

S.NO	Computational Intelligence / Assessment	Artificial Neural Network	GENETIC ALGORITHM	FUZZY LOGIC	SWARM INTELLIGENCE	ARTIFICIAL IMMUNE SYSTEM
1.	Development Epoch	1969	1986	1987	Late 1960's	Late 1990's
2.	State Variable	Mixed Variable	Continuous and Discrete Variable	Discrete Variable	Discrete Variable	Discrete,Continuous And Mixed Variable
3.	No. of Search Points	Multi-Point Search	Multi-Point Search	Multi-Point Search	Multi-Point Search	Multi-Point Search
4.	Solution Guarantee	Rarely offers entire solution	Best for Time Varying Solution	Appropriate	Definite in Favorable Ways	Precise
5.	Run Time	Long	Medium	Short	Medium	Medium
6.	Target Problem	Combinatorial And Multiobjective Optimization	Combinatorial, Multiobjective And Continuous optimization	Combinatorial And Multiobjective Optimization	Combinatorial, Global and Nonlinear optimization.	Combinatorial, Continuous and Nonlinear optimization.

Table 1:Comparative Analyis of Computational Intelligence Paradigms in WSN

B. No of search points

Multipoint search is basically used in every CI based algorithms Where the search point gives a framework to construct an optimal solution of a problem among existing solutions to find the result in optimality .

C. Solution guarantee.

It usually deals with the efficiency of the algorithm that under what conditions it is working and how its performance is evaluated based on the computational cost and optimality.

D. Run time

The run time feature of CI based algorithm is the measure of the time taken to compute the job at hand unlike FL which has short run time due to the fact that it works on initial subset selection from the actual data and then compute the deterministic results efficiently, all others ANN, AIS, GA and SI have the runtime of long to medium respectively. Though AIS has more computation then GA but proves to be more optimal in results then GA. Similarly the distributed and decentralized feature of the SI gives the cutting edge superiority as optimizer among others for routing in CI paradigm.

E. Target problem

There are optimization problems the Computational Intelligence focused as combinatorial optimization, multi-objective optimization, continuous optimization, nonlinear optimization and global optimization. Each paradigm in Table 1 shows a variation of optimization problems. A continuous optimization and combinatorial optimization problem varies in respect to their feasibility of available solutions by maximizing and minimizing of continuous and discrete function values respectively i.e. in continuous optimization an infinite feasible solutions are available for selection of an

optimal solution, and in combinatorial optimization an optimal solution is selected from a finite number of solutions .Multiobjective optimization problems deals with the multitudes objectives, which are to be optimized simultaneously or a trade off exists between the multiple objectives for an optimal solutions. Nonlinear optimization problems are used to optimize the problems of non linear objective functions. Similarly the global optimization is responsible for the problems of certain criteria which need to be optimized.

VI. Conclusion

This paper represents the concept of computational intelligence and various applications are given. All the computational intelligence paradigms are useful in various areas and every day paradigms are modified for future use. Basically, In this paper we show the comparative analysis of Computational Intelligence techniques in Wireless Sensor Network to solve the WSN issues. This review paper gives idea about basic computational intelligence paradigms and comparative analaysis of CI techniques in WSN.

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