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Collating Techniques of Computational Intelligence Paradigms: An Ingenious Approach

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Abstract

Wireless Sensor Network (WSN) is a collection of thousands of spatially disperse nodes that can sense various physical or environmental characteristics such as light, temperature etc. WSNs face many issues, especially due to failures in communication network, storage of data and limited power supply. Multiple Paradigms of computational intelligence (CI) had been addressed various challenges successfully in recent years and by using these paradigms many limitations will also be reduced. In this paper some main challenges and comparison between different paradigms on the basis of several issues are defined. In this paper some advantages and disadvantages are also defined.

Keywords: WSN, Fuzzy logic, Neural Network, AIS, Swarm Intelligence.

1. INTRODUCTION

Wireless sensor network is a collection of thousands number of sensor nodes. These sensor nodes sense the data on the basis of various parameters like temperature, distance etc. Typically, sensor nodes are collected in a form of group which is known as cluster and each cluster has a node that acts as the cluster head. All nodes transmit their sensory data to the cluster head, which in turn routes it to a specialized node (or base station) through a multi-hop wireless communication. When sensor nodes transmit the data between nodes to base station, various challenges are defined. Researchers have used these CI techniques to find out the solutions and they will also address many issues in WSN.

2. CHALLENGES IN SENSOR NETWORKS

For deployment of nodes in WSN generally used one of the given applications[1]:

- ❖ Periodic reporting
- ❖ Event detection
- ❖ Database storage.

Periodic reporting is one of the simplest application in which data can be sensed and stored at regular intervals and send it to the base station(s). This is used in most monitoring applications in agriculture, military operations, and disaster relief. Prediction about traffic in data is the most important feature of periodic reporting. In event detection applications, nodes sense the environment and find out that data is useful or not. If data is found useful, it will transmit to the base station(s). In third, all data which was sensed according to environment is stored locally on the nodes. When Base stations need that data they can search and retrieve it directly from the nodes. The main issue in these applications is to storing the data so when related data is search it will give faster and better outcome. Some major WSN issues addressed by CI techniques are discussed in the following subsections:

A. Design and deployment

In WSN, to get a complete information network are designed according to the requirement So for getting better results sensor node should be placed accurately at their proper places.

B. Localization

Node localization is used to detect the location of sensor nodes. Only awareness of location is not sufficient beside that data is also need to be sensed by nodes. To search and store any event or record or any information about location of nodes geometric routing is used.

C. Data Aggregation and Sensor Fusion

Collection of data from the various sources at a single place definitely it will provide some better result but also increase the communication overhead. Due to nodes deploy at a very large scale, data is also generated in a huge volume, so collecting data in an efficient manner is a big challenge. Most widely used non-CI methods for sensor fusion include Dempster-Shafer method, Bayesian networks.

D. Energy Aware Routing and Clustering

Energy is one of the most important issues in WSN. In some areas lifetime of battery is playing an important role. Changing the battery very frequently is very dangerous and it will also increase the cost. Routing is defined in such a way that it determined a proper route for transmitting a message from source to its particular destination. Routing is classified in two categories, first one was proactive and second one was reactive routing. In proactive routing methods, whenever the routes are used, it will store in the form of table. In reactive routing

methods, routes are computed as according to its requirement.

E. Security

Security is also one of the most important issues in WSN. Main key issue of the security was to secure or protect the data from any type of internal or external attacks and to provide an adequate security. Administration becomes more difficult and applies various security techniques or methods to provide more security so data will be more secure. Now days, various security challenges in WSN are addressed and to protect our data from these intruders is a key issues.

3. PARADIGMS OF CI

Computational Intelligence contains various paradigms such as neural networks, SI, evolutionary algorithms, fuzzy logic and AIS. These paradigms are described in the following subsections

3.1 Neural Networks

Human brain is an excellent ability to learn and memorize any new thing very easily and in a faster manner. Artificial neural network is defined such as, it is a parallel computing systems, consists of large number of interconnected neurons having simple processors to solve a computational challenges with the help of human brain. Neural network works on three basic components are as follow [6]:

1) W_{ji} provide weight to the n inputs of j^{th} neuron x_i,

$$i = 1,2, \ldots, n;$$

2) To compute the sum of input of activation function an aggregation function is used, u_j =, where Θj is the bias, which is a numerical value associated with the neuron.

3) An activation function Ψ that maps uj to vj = Ψ(uj),the output value of the neuron

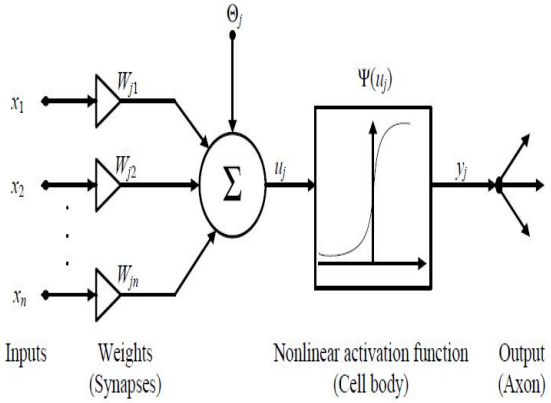

Fig 1: Structure of Neuron

3.2 Fuzzy Logic

Fuzzy deals with uncertainty or imprecise data, which is represented by the use of linguistic variables such as most, few, very few etc. Fuzzy logic is a framework in which it includes fuzzy sets, fuzzy rules and membership functions. Fuzzy rules are defined in if-then format[11]. For example-if service is good then food is delicious. Knowledge base is formed with the combination of fuzzy rules and fuzzy sets

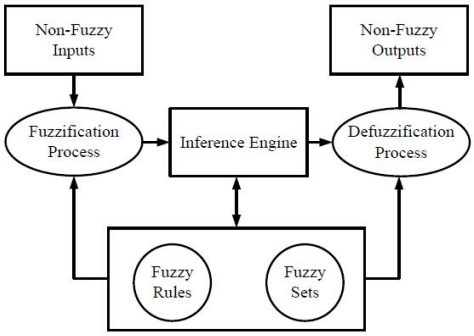

Fig 2: Fuzzy Structure

3.3 Evolutionary Algorithms

Evolutionary algorithms are stochastic search methods which defines the natural biological evolution. EAs use a population of solution candidates called chromosomes. Chromosomes are a combination of genes, which represent a different characteristic. At each level next level chromosomes will be choose on the basis of fitness. In reproduction process two parent chromosomes are mix into a new one which is called as offspring. Chromosomes which having highest fitness is selected and it will go into the next generation, and the rest are discarded. The process is repeated until a final result can't be obtained.

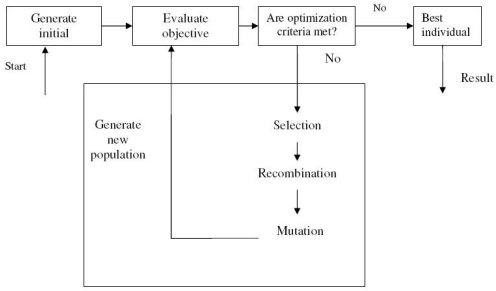

Fig 3: Structure of evolutionary algorithm

3.4 Swarm Intelligence

Swarm Intelligence (SI) is one of the most powerful paradigms of computational intelligence [4,10]. Swarm intelligence is defined as a study of behavior of biological species such as colonies of ants. SI is also very compatible with WSN routing. Due to environment ontological match, various efficient routing techniques can be addressed by the help of SI and WSN.

In SI, a collective behavior of agents is collected in a system which interacts with environment locally and cause coherent functional global pattern to emerge. Highly dynamic behavior of biological species is addressed in decentralized and self-deployed systems.

3.4.1 Particle Swarm Optimization

PSO consists of a swarm of s particles, which represent a best candidate solution among them. Each particle works on two factors, first was velocity id and second one was position id. Swarm particles are randomly assigned an initial level and then calculate the fitness for each particle[9]. PSO system combines local search methods with global search methods, attempting to balance

exploration and exploitation As such a particle is near to the solution its fitness value is as much higher compared to other particles. The main objective of Particle Swarm Optimization is to find the location of an optimal point in a Cartesian coordinate system. PSO work as follows:

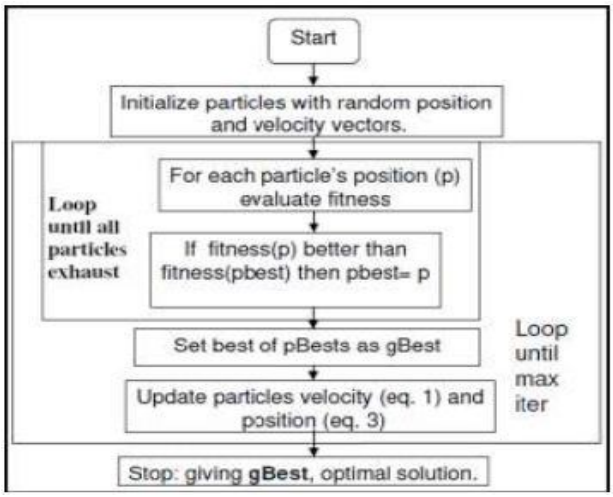

Fig 4: Flow chart of PSO

3.4.2 Ant Colony Optimization

ACO was defined as a metaheuristic approach, which is used for finding the solution of the optimization problem. The basic idea of the ant colony optimization (ACO) is searching the food by using the shortest path without directly communication. Real ants are communicated indirectly with the help of pheromone. Ants are classified in two categories: First one was FANT and second one was BANT. In ACO approach ants find out the good quality of food in a good quantity and stored it to their nest when they return to their nest they use trail of chemical pheromone, which also guides other ants to reach that particular place where the food source is stored[8]. ACO works in a following manner:

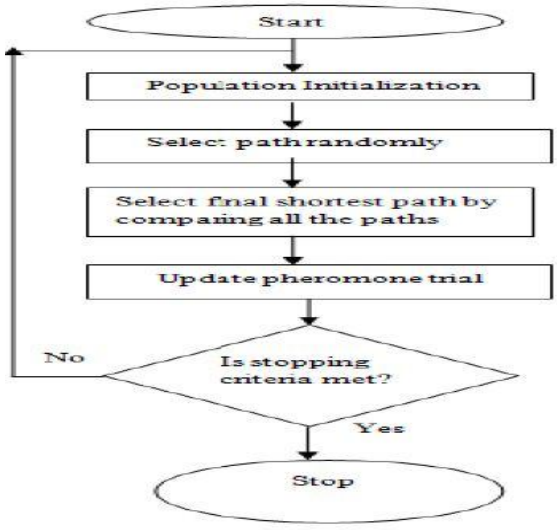

Fig 5: Flow chart of ACO

The main idea of the ACO metaheuristic is to find out the best path in a "construction graph" that represents the states of the problem. Artificial ants used this graph and find out best path among all of them. They communicate each other by the help of pheromone and they choose their path with respect to previously available probabilities.[12]

3.5 AIS

AIS are abbreviation of Artificial Immune System. This is a paradigm of computational intelligence which is used for solving a problem. This approach is inspired from the biological human capabilities to perform some computation task. Recently AIS shows that clustering and cluster head selection can be efficiently applied. Main problem of using routing and clustering in WSN are fixed number of clusters. AIS are a very new area in field of research so it can't be well studied yet. In Paper, mainly concentrate on the number of cluster heads and to minimizing the energy consumption of the overall transmission. In this, researcher minimizes the communication distance with guarantee that it will increase the lifetime of network. It concentrate mainly on reduce the level of used energy in each node. In this main priority was to reduce the level of consumed energy and extend the lifetime of network.

Table 1: Comparison on the basis of energy conservation

S.N	Inspired systems	Natural systems	"CI in WSN energy conservation scheme
1	ANN Simple parallel computation, having large number of neurons to solve a variety of challenging computational problems.	Human brain	-Clustering and routing as duty cycling topology control -Data fusion as energy efficient data acquisition -Security as power management MAC protocol
2	AIS Artificial immune system used to perform some computational task.	Immune system To protect the body from external attacks	-Routing as data driven data reduction -Design and deployment as duty cycling topology
3	Genetic algorithm Generates metaheuristic solution to solve optimization problems with the help of biological evolution.	Biological evolution Inheritance, mutation, selection and crossover	-Deployment, routing and clustering as duty cycling
4	Swarm intelligence Distributed problem solution of decentralized ,self organized systems in a collective manner	Global behavior Colonies of ant, flocks of bird, bacterial growth and shoals of fish	-Data acquisition as mobility based mobile sink -Routing and clustering as duty cycling topology control
5	Fuzzy logic Generates solution according to membership functions and fuzzy rules	Shades of human decisions e.g. little, few, most, many.	-Clustering as duty cycling -Scheduling as power management MAC protocol -Routing and security as power management sleep wake up protocol"

Table 2: Comparative Analysis of CI Algorithm Evolution of Energy Aware Routing in WSN

Computational Intelligence / Assessment	Artificial Neural Network	Artificial Immune System	Fuzzy Logic	Genetic Algorithm	Swarm Intelligence
Development epoch	1969	1986	1987	Late 1960's	Early 1990's
State variable	Mixed variable	Continuous Variable and Discrete variable	Discrete variable	Discrete variable	Continuous variable , discrete variable and mixed variable
No of search points	Multi-point search	Multi-point Search	Multi-point search	Multi-point search	Multi-Point search
Solution guarantee	Rarely offers entire solution	Best for time varying solution	Appropriate	Definite in favorable ways	Precise
Run time	Long	Medium	Short	Medium	Medium
Target problem	•Combinatorial optimization •Multiobjective optimization	•Combinatorial optimization •Multiobjective optimization •Continuous optimization	• Combinatorial optimization • Multiobjective optimization	•Combinatorial optimization • Global optimization • Nonlinear optimization	• Combinatorial optimization • Continuous optimization • Nonlinear optimization
Features	• Adaptive learning • Self organization • Fault tolerant	• Provides tools in local and global search • Powerful optimization tool • Self adaptive and self learning.	• Put up system nonlinearity • Deterministic • Performs best even with small input • Accurate	• Solutions to optimization and search problems. • Good global solutions.	•Distributive approach •Self organization •Decentralized control •Powerful optimization tool

Table 3: Advantages and Disadvantages of CI Paradigms

Algorithm	Advantages	Disadvantages
PSO (ParticleSwarm Optimization)	-Based on intelligence -No overlapping and mutation calculation -Simple calculation	-Due to its Iterative nature it can't be use for high-speed real-time applications -It can't work with problems of scattering and optimization -It needs a huge memory for processing.
ACO (AntColony Optimization)	-Powerful robustness -It used in dynamic manner -Positive Feedback increase the number of good solutions -Whole process was performed in organized manner	-Analysis of data in a theoretic manner is a very difficult task. -For each laval, probability distribution is changed - Guaranteed Convergence, but time isn't fixed.
GA (Genetic Algorithm)	-Optimization problem solved by chromosome encoding -GA process is independent, so we can solve multi-dimensional, non-differential.	- It will take too much time for processing - Time limit for optimization response isn't fixed - It can't work with multiple subjects
FUZZY	- Only sensory data can be used - Easily understandable	-Crisp values aren't accepted in fuzzy. -It is very difficult to given any proof for characteristics of Fuzzy system.
Neural Network	-Parallel processing -Perform tasks that a linear program can not -No Need to be reprogrammed	-It require trained operator -In this high processing time for large network is needed.

4. Conclusion

In this paper various paradigms of CI are discussed along with their issues and challenges. CI paradigms propose non-conventional approach to solve the various issues in different fields and in WSN. Comparative analysis of CI paradigm algorithms shows algorithms which can be best suited for energy aware routing and optimization criteria in WSN can be a hybrid techniques which can be the solution for optimized energy aware routing techniques to make computationally efficient and better choice for WSN optimized energy aware routing

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