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Computational Intelligence Techniques for Wireless Sensor Network: Review

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ABSTRACT
Wireless sensors (nodes) in the network sense extract data from the various surrounding environment, sequence the sensed data locally, and then transfer the data to a base station for further processing through wireless communication. WSNs face various problem, communication failures, storage and computational constraints and limited power supply. The main challenge occur in WSN to save energy and prolong the network lifetime. Clustering is a technique that is used for managing energy consumption. However, clustering is NP hard optimization problem that can't be solved effectively by traditional methods. Different Computational Intelligence (CI) techniques are used to alter WSN dynamic nature.

General Terms
Wireless Sensor Network.

Keywords
Clustering, Computational Intelligence, Wireless Sensor Networks.

1. INTRODUCTION
WIRELESS sensor network is a network of distributed autonomous devices in which physical conditions can be sensed [1]. WSNs are helpful in different various applications such as environmental monitoring, prediction, agriculture applications House and office buildings, medical monitoring and structural health monitoring [2].

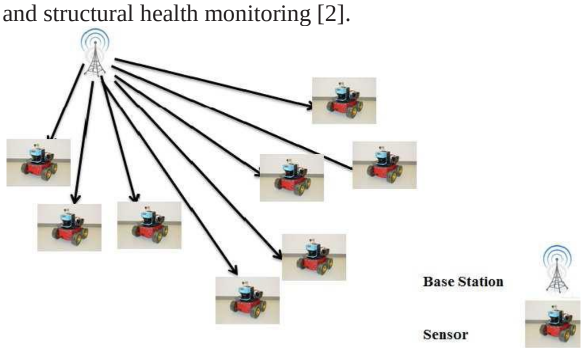

Fig1.Architecture of Wireless Sensor Network

WSNs includes a large number of small, inexpensive, disposable and autonomous sensor nodes that are deployed in a particular ad hoc manner in vast geographical areas for remote operations. The wireless sensors in the network sense external data from the surrounding environment, process it locally, and then send the data to a base station for further processing via wireless communication, as shown in Figure 1. Today, hundreds to thousands of these heterogeneous sensors are deployed over a geographic area of interest and communicate together forming a wireless sensor network. WSNs are deployed in ground and underwater [2]. They are designed to work for months and years according to the application. The sensors deployment need not be with fixed infrastructure or centralized.

The rest of this paper is organized as follow: In Section 2 Application of WSN are given. The challenges of Wireless Sensor Network are given in Section 3. The WSN Technology is discussed in Sections 4. In Section 5,how clusters can be used to help solving energy saving problem in WSN. A brief overview on Computational Intelligence techniques in Section 6 and finally, Section 7 concludes the work.

2. APPLICATIONS OF WSN
WSN operation, the applications can be divided into two categories: event detection and periodic sensing. In the following sub-sections, some of these are discussed, but not all, applications and some well-known projects.

2.1 Defense and Military Applications
The Defense Advanced Research Projects Agency (DARPA) adopted the Sensor Information Technology (SENSIT) and National Science Foundation (NSF) Programs explored WSN for more tracking features and capabilities. The sensors were programmed in order to collect measurements, communication between them, and send notification in case of object movement detection [7]. Latest military projects were the detection of nuclear, chemical and biological toxins as well as calculation of their concentration levels.

2.2 House and Office Buildings
Smart buildings are those equipped systems that do some intelligent actions, such as opening a door. Wireless sensors are beneficial in studying the effect of wind, monitor the employees and students. In 1990s, research has been adopted for the use of smart buildings to disabled people. WSN is incorporated in smart building for more easygoing and quality of life.

2.3 Agriculture Applications
Precision agriculture means applying the right amount of input (water, fertilizer, etc.) at the right location and at the right time to intensify productivity and improve quality, while protecting the environment. It is accomplished with WSN that monitors parameters as: soil moisture and air temperature, then estimates the amount of water and fertilizers needed.Also, irrigation management, accepted by WSNs, helps farmers to prevent damages to their crops and increasing crop production. WSNs are used to control the green house temperature and humidity levels raising from messaging to using controller.

2.4 Health Applications

Health care is considered a potential application of WSN whose research is dominant WSN will allow the patient to be under constant supervision without hospital admission. Different applications are being investigated: glucose level and artificial retina. The diabetic patient can be implanted with glucose meter that monitors the sugar level and alerts the patient in case of serious condition detection. The second project considers implanting a chip of micro-sensors in the human eye to improve vision. Important functional requirements as reliability, communication, and safety are challenging issues.

3. SENSOR NETWORKS CHALLENGES

The main challenge is to store the data in a smart way for fast search and retrieval.

3.1 Wireless Ad-hoc Nature

There is no existence of a fixed communication infrastructure. The shared wireless medium places additional restrictions on the communication between the nodes and poses new problems like unreliable and asymmetric links. But, it provides advantage: A packet transmitted by a node to another is received by all neighbors of the transmitting node.

3.2 Mobility and Topology Changes

Dynamic scenarios can be involved in WLANs. New nodes may join the network, and the old nodes may either pass through the network or out of it. Nodes may close the function, and surviving nodes may go in or out of transmission radii of other nodes.WSN applications have to be robust against node failure and dynamic topology.

3.3 Energy Limitations

Nodes in most WSNs have limited energy. The basic scenario includes a topology of sensor nodes and a limited number of more powerful base stations. Maintenance of the batteries on sensor nodes is not possible after deployment. Communication task consume maximum power available to sensor nodes and in order to ensure maintain the long-term sensing operation, communication tasks need to be work carefully.

3.4 Physical Distribution

Each node in a WSN is an autonomous computational unit that communicates with its neighbors via messages. Data is distributed among the nodes in the network and can be collected at a central station only with high communication costs. Therefore, different algorithms that require global information from the entire network become very expensive. Thus, restrained distributed algorithms are highly desirable.

4. WSN TECHNOLOGY

Wireless sensor is mainly consists of sensing unit, processing unit, transceiver and a power supply [8]. The size of the sensors has decreased dramatically to about 1 inch after the development of Micro-Electro-Mechanical System (MEMS). The sensing unit have at least one sensor that measures the data from its surrounding environment. Various sensing units exist according to the application deployed. The processing unit, with the help of embedded memory, processes the data estimated by the sensing unit as well as data gathered from neighbor sensors. The data is send and received by transceiver. The sensors that are communicate by infrared, or most commonly radio waves. Each sensor has a battery that has limited lifetime. The restricted powered sensors are deployed in hostile areas; making recharging or replacing the battery infeasible. Recently, some sensors are equipped with renewable energy, or energy harvesting module. However, their expensive cost almost ceased their deployment. The death of the particular node was preferred economically. Any useful or useless operation performed by the sensor consumes energy. Useful energy consumed includes sensing, receiving, transmitting, and processing, but idle listening, collision and overhearing is considered as useless.

5. CLUSTERING

In terms of computer clustering, the term clustering is used for connecting two or more computer to acts like a single computer and is used for parallel processing, fault tolerance and load balancing. In wireless sensor networks clustering define as centralize based grouping or clustering of sensor nodes with cluster head (CH) for their management. Each node in the cluster collects information and forwards it to the CH. The CH then communicates with the other CH or directly communicating with base station. In wireless sensor networks there may be hundreds or thousands of sensing nodes communicating with each other and the base station, which consuming more energy in exchanging information, and have problems of load balance, fault tolerance etc. By clustering, these problems can be intercepted, so in wireless sensor networks nodes may be divided into groups or clusters. Ever cluster has cluster head; non cluster members in the cluster forward the collected information to the CH. The CH work as a gateway between nodes and the base station. The selection of CH changes at regular interval for the long life time of the network [4].Figure 2 shows an example of clustered WSN.

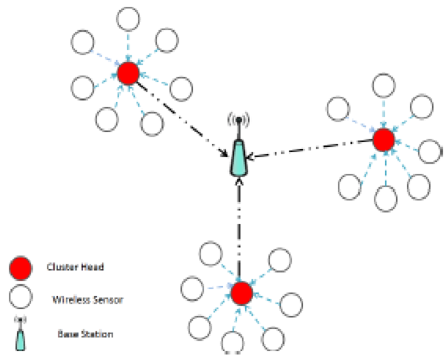

Fig 2. Clustered WSN

The issue of load balancing can be overwhelm by clustering that a high energy node known as Each node in the cluster communicates with the base station via cluster head. Without clustering in sensor networks there may be hundreds or thousands of nodes communicating with base station (base station is also known as command node). If any node is far away from the base station in the network then sending information to the base station consumes more energy and minimizes life time of node. The issue of unbalance distribution of energy is tackle by clustering.The characteristics of good clustering techniques in wireless sensor networks are: centralize behavior to manage the network, efficient use of energy, scalability, equal classification of load, and minimization the over heading loads. Clustering give many advantages like scalability, reduce the size of routing table for each node, saves bandwidth, stabilize the network topology, management strategies. With these advantages there are also some issues in clustering techniques. In clustering sensor network all nodes send data to the cluster head which cause over loading for CH and consume more energy and sometime in excess. Clustering has major problem such as latency, data accuracy etc.

Clustering technology has many advantages as follows:

- minimizes communication overhead
- enhances resource use.

For example, non-neighbor clusters can use the same communication frequency.—scalability; nodes can join or leave the group without affecting the entire network.

6. COMPUTATIONAL INTELLIGENCE

Computational Intelligence is a technique which inspired from nature. Computational Intelligence is used to make systems which can work in real time.

Figure 3 shows Computational Intelligence paradigms from

real to artificial systems**.** In artificial intelligence like robots, they are used to do predefined things like they can place things from one location to another, opening or shutting of the door etc. [4] All such things are already fed 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, like they can select best solution from a set of available options.[4] Computational intelligence is an intelligent computational methodology that uses heuristic algorithms to obtain approximate solutions to NP hard problems efficiently. CI paradigms are meant to adapt to the dynamic nature of WSN. The AIS mimic the same principle solving Techniques of CI are designed to model the aspects of biological intelligence. CI surrounds paradigms such as neural networks, swarm intelligence, fuzzy logic and artificial immune systems. These paradigms are briefly introduced in the following subsections. These paradigms, such as

Neuro-fuzzy systems, fuzzy-immune systems etc. Certainly there exist more CI techniques, which are not explained here because they have not been applied to WSNs problems yet and their properties do not suit the requirements well. A broader discussion of CI can found.Fuzzy Logic which is inspired by the shades of human decisions.The Ants communicate via stigmergic information.

Optimization problems due to its adaptive nature and distributive system properties. WSN nodes based on AIS using Antigen expressions, antibody expressions and the initialization of antibody optimizes the problems. The idea of genetic evolution [6] of nature has immensely impressed the humans to use the ideology behind them in different disciplines of life and this gave birth to the energy awareness. SI is a computational technique, which is originality from ant colonies, bird flocking, animal herding, and fish schoolings. A collective behavior in each BI system shows that single agent is not efficient and so their collective collaboration makes system intelligent. Decentralized and self-organized behavior of SI helps to solve the various optimization problems SI are Ant colony Optimization (ACO).

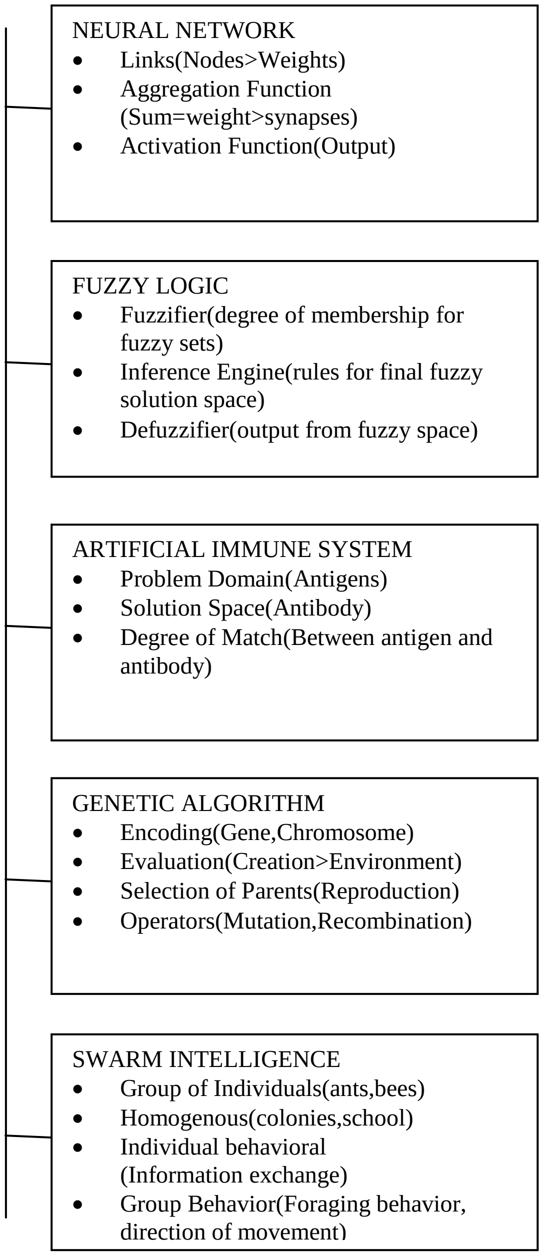

Fig 3: Computational Intelligence paradigms from real to artificial systems.

The ACO algorithm is totally based on foraging behavior of ants like in real ant colonies. FL which is inspired by the shades of human decisions. It deals with analysis of information by fuzzy sets. Each unit of it which is described by the range of real values over which the main set is mapped, called domains and membership functions of optimization capabilities of the FL has dramatically optimized the problems.The next following subsections briefly describe CI techniques which are used in clustering WSN.

6.1 NEURAL NETWORKS

The human brain, which possesses an extraordinary ability to learn, remember and generalize, is a dense network area of over 10 billion neurons, each neuron connected on average to about 10,000 other Neurons. Each neuron receives the signals through synapses, and have the power to control the effects of the signals on the neuron. These synaptic connections play major role in the behavior of the brain. These findings have inspired modeling of biological neural systems by means of NNs

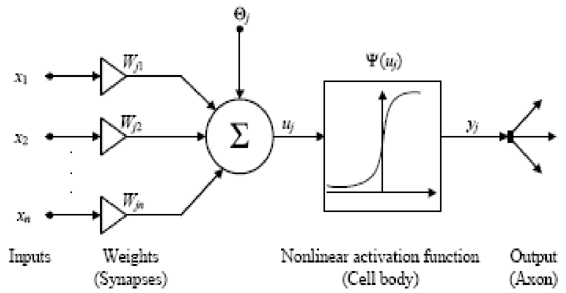

Fig 4: Structure of an artificial neuron

The three Basic components of an artificial neuron shown in Figure 4 are:

6.1.1 Links

The links that provide weights Wji, to the n inputs of jth neuron xi, i= 1, . . . , n;

6.1.2 Activation Function

An activation function Ψ that links uj to vj= Ψ(uj),the output value of the neuron.Some examples of activation functions are given step, sigmoid, tan hyperbolic and Gaussian function.

6.1.3 Aggregation Function

An aggregation function that sums the weighted inputs to compute the input to the activation function

$$uj=\Theta_j+\sum_{i=1}^{n} x_i W_{ji}$$

where Θ*j* is bias, a numerical value associated with the neuron. It is helpful to think of the bias as the weight for an input *x*0 whose value is equivalent to one, so that

$$u_j= \sum_{i=0}^{n} x_i W_{ji}$$

6.2 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 ongoing values between ‘0’ and ‘1’. In fuzzy systems ‘0’represents absolute wrong and ‘1’ represents correct and give continuous values for other conditions. Let us take an example of fan, if we are using Boolean system then it would either SWITCH ON or SWITCH OFF the fan, if it is cold or hot. But if we use fuzzy system then it will give the speed of fan from stop to slow, slow to medium and so on, depending on the value of temperature [4].Applications which are used in Fuzzy Systems are in control systems, gear transmission in vehicles, home appliances, controlling traffic signals etc. [4].Fuzzy logic is used in optimization, clustering heuristic and routing.

6.3 ARTIFICIAL IMMUNE SYSTEM

Artificial immune system is inspired from natural 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 with 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.Applications of AIS are in pattern recognition problems, classification, clustering, anomaly detection, computer virus detection etc. [4].Artificial immune system is used to provide security, fault detection, and optimization and abnormality detection .The biological immune system protects the body from foreign pathogens.

6.4 GENETIC ALGORITHM

Inspired by Charles Darwin’s theory of evolution: ’the survival of the fittest”, Genetic Algorithm (GA) was initiated by John Holland in 1970s. [1] GA is characterized by heuristic search algorithm that models biological genetic evolution. It demonstrate to be a robust optimizer that searches among a population of solutions, and showed easy going in solving dynamic problems. It has been successfully applied to many NP-hard problems. The main challenge we are facing in solving a problem with GA is the encoding of the problem into a set of chromosomes; each representing a solution to the problem. Each chromosome is evaluated with the help of a fitness function. Based on fitness value, crossover 3 and mutation processes are applied on selected chromosomes. The crossover process produces new solutions, called offspring, by concatenating the parts of two selected chromosomes. Mutation changes one or more genetic element in the produced offspring to prevent being trapped in local minima. Binary representation is used in which each bit corresponds to one sensor node [2]. “1“means that corresponding sensor is a cluster head and a “0” means that it is a regular node.

6.5 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 to reach their goal, find foods and manage their resources as well. Swarm refers that large number of insects or other small organized entities, esp. when they are in motion. [4]Global intelligent behavior in which the individuals are entirely unknown is emerged due to the local, self-organized and decentralized interaction of swarm’s agents. Swarm intelligence (SI) is one of the best solutions from bio inspired 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. Applications of SI are, function approximation, clustering, routing optimization, graph coloring etc. [4]. Swarm intelligence gives solutions for routing in ad-hoc networks. It consumes huge amount of energy on communication when it sends ants for route discovery.

6.5.1 Particle Swarm Optimization (PSO)

Particle Swarm optimization was developed in 1995 by James Kennedy, and Russell Eberhard.PSO is a robust stochastic nonlinear- optimization technique based on movement and intelligence of swarms. It is inspired from social behavior or bird or fish, where a group of birds randomly search for food in particular area by following the nearest bird to the food. It joins 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 methods are population based stochastic optimization that initialize with a group of a randomly generated population. They have fitness values to analyze 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 dead.

7. CONCLUSION

A summary of WSN applications was given. The Problem of Energy consumption problem was occur. Clustering were apply to solve the problem of energy consumption. Clustering has major problem such as latency, data accuracy. To solve the clustering problem we use CI techniques proved promising results in solving energy consumption problem in WSN. It was found that there is still no clear decision about what the optimal number of clusters should be. Computational Intelligence such as PSO showed more adaptability to the dynamic nature on WSN.

8. ACKNOWLEDGMENTS

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