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Computational Intelligence In Wireless Sensor Network

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Abstract- *The wireless sensor networks are event-monitoring and data collecting devices which are tightly distributed, lightweight nodes deployed in large number to monitor the environment or system. They are generally deployed for periodic reporting and event detection in an environment. WSN faces many challenges like design and deployment of sensor nodes, localization and topology changes, mobility and physical distribution, clustering, data aggregation, security, and quality of service management. An intelligent-based approach works more efficiently as sensor nodes are deployed in dynamic environments. Computational intelligence provides autonomous behavior, flexibility, robustness against communication failure and topology changes. The most common computational intelligence (CI) paradigms such as fuzzy systems, evolutionary algorithm, artificial neural networks,, swarm intelligence, and artificial immune systems are explored in this paper.*

Keywords-*Computational intelligence, Fuzzy logic, Neural networks, Reinforcement Learning, Wireless sensor networks*

I. INTRODUCTION

A wireless sensor network are a group of sensor nodes which collectively work for several tasks like intrusion detection, weather forecasting, event detection, health and area monitoring, etc. Every single sensor node in WSN consists of one or more sensing devices that communicate to few other local sensor nodes via wireless channels. There are few major limitations in a sensor node, namely, storage capacity, battery power and communication bandwidth. The WSNs support a several real-world applications which lead to a engineering and challenging research problems because of the flexibility and the dynamic property of sensor nodes. Accordingly, To encompass the entire design space there is not a single technical solution and to clearly classifies all WSNs also there is no single set of requirements. Some of these applications distributeseveral basic characteristics. In many cases of the WSNs, the sources of data are the actual nodes that sense the data and the sink nodes are the delivery nodes of ultimate data shown in Figure 1.

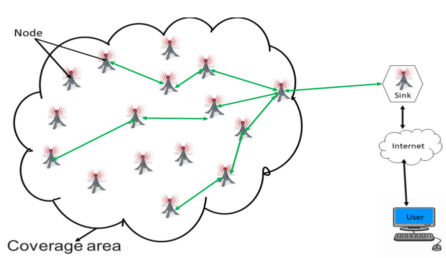

Fig. 1.Wireless sensor network

II. TYPES OF WIRELESS SENSOR NETWORK

Classification of Wireless Sensor Networks are given below [1].

2.1 Terrestrial WSNs The terrestrial WSNs includes multiple sensor nodes either in an structured or a unstructured manner for efficient communication with the base station. In unstructured mode, the nodes of the sensor are randomly dispensed within the target/monitoring area. The structured mode assess optimal placement of the sensor nodes.

2.2 Underground WSNs In terms of planning, deployment and maintenance, the underground WSNs are more costly as compare to the terrestrial WSNs. These WSNs are hidden in ground to supervise the underground circumstances. Besides, sink nodes are located on or above the ground to transmit the information from the sensor nodes to the base station. The wireless communication becomes a challenging by underground environment due to high level of attenuation and signal loss.

2.3 Underwater WSNs The underwater WSNs includes large number vehicles and sensor nodes deployed under the water. The data are collected from the sensor node using autonomous underwater vehicles. There are many challenges of underwater communication are long propagation bandwidth, delay and node failures. The issues of energy preservation for underwater WSNs include the evolution of networking techniques and underwater communication.

2.4 Multimedia WSNs The purpose of these WSNs is to enable tracing and observing of events in the aspect of multimedia data. These networks comprised of low-cost sensor nodes fitted with cameras and microphones. These nodes are interlinked with one another over a wireless connection for retrieval, compression and correlation of data. The challenge in the multimedia WSNs includeshigh bandwidth requirements, high energy consumption, data compression, and data processing.

2.5 MobileWSNs The mobile WSNs compose of a group of sensor nodes which can move their own and they can be communicated with the physical environment. The mobile nodes are having an ability to sense, compute, and communicate the data. The mobile WSNs are so much better than the static sensor networks. The advantages of these sensors over the static one includebetter energy efficiency, better and improved coverage, and superior channel capacity.

III. APPLICATIONS OF WSN

There are several applications of the WSNs like event detection, industrial control systems, environmental monitoring, health monitoring, battlefield surveillance, object monitoring including tracking the patterns and movements of objects, insects, or animals. The WSNs can be employed in mission critical applications such as surveillance of buildings and bridges, protection of key land marks etc. On the basis of application constraints and challenges the WSNs can adopt different forms, use different technologies, and communicate through different network topologies [2].

IV. THE PARADIGMS OF CI

Computational Intelligence can be defining as a analyzing of interchangeable mechanisms to facilitate intelligent action in complex and modifying environment [3]. It is a sub-branch of Artificial Intelligence (AI) which mainly emphases on those AI paradigms that exhibit an ability to learn and adapt to new situations, to generalize, abstract, and discover [4].

Types of Computational Intelligence paradigms

4.1 Fuzzy Sets

Classical set theory grants an element to be either comprised or excluded from set, whereas the fuzzy sets grant an object to be a partial member of a set. For example, a person is a member of the set tall to a degree of 0.8 [5]. In fuzzy systems the dynamic behavior of a system is distinguished by a set of linguistic fuzzy rules on the basis of knowledge of a human expert.Unlike human reasoning, which includes a measure of imprecision or uncertainty which is identified by the make use of linguistic variables such asfrequently, most, many, seldom etc.

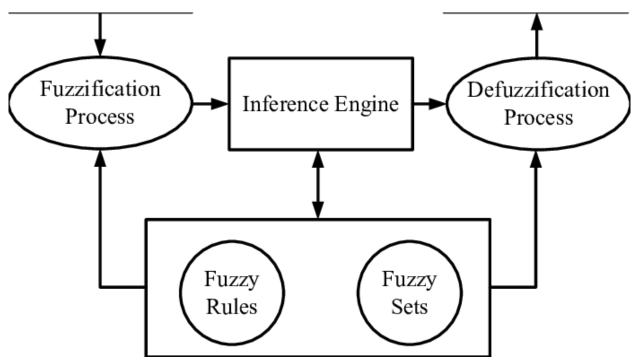

Fig. 2.Block Diagram of Fuzzy Inference system

This imprecise reasoning is modeled by fuzzy logic, which is a multivalued logic that lets intermediate values to be defined between conventional threshold values. Fuzzy systems let the use of fuzzy sets to draw inferences and to make decisions. The fuzzy rules have a common form as if antecedent(s) then consequent(s), where antecedents and consequents are propositions containing linguistic variables. As it is shown in Figure 2,The antecedent of a fuzzy rule creates a combination of fuzzy sets using logic operations. So, the fuzzy rules and fuzzy sets together form knowledge base of rule-based inference system [6].

4.2 Reinforcement Learning

It is a neurodynamics model which is neither supervised nor purely unsupervised. It is a CI based approach in which a system learn iteratively based on the reward it received for it previous action. To cause a transition of environmental state, agent acts on the environment and acquire an immediate reward for its action. RL acquires its knowledge by actively exploring its environment. At each step, it selects few possible actions and obtains a reward for this particular action from the environment. It does not have prior knowledge of the best possible action at some state. Subsequently, the agent has to test several different actions and orders of actions and learns from its experiences.

Reinforcement learning is suitable for distributed problems like routing and it is having medium preconditions for computation at the respective nodes and memory. It requirescertain time to converge but is highly flexible to topology variation and accomplish optimal results and easy to implement

4.3 Evolutionary algorithms

It is a process of transformation to improve survival capabilities through many processes such as existance-of-the-fittest, natural selection, mutation, reproduction, competition and symbiosis. EC encompasses different kind of EAs that all share a generalbasic idea of existence of the fittest. Chromosomes are made up of genes which represent a unique feature. The EA search for a fitness function toquantifies the fitness of an individual chromosome and optimizeover the generations.The Offspring chromosomes are mutated in order to improve heterogeneity. The fittest chromosomes are chosen to go into the next phase, and the rest are excluded. This process continues until we get fit enough solution or to reach a previously set computational limit.Genetic programming is defined as an automated programming in which we constructa computer's set of instructions from a top-level problem statement. It begins from a top-level statement of "do what is needed" and automatically invoke a computer program to fix the problem." It is a machine learning method used to optimize a population of computer programs to achieve a given computational task.

4.4Neural Networks

The person's brain is huge network which is made up of over 10 billion neurons and each of them is connected to around 10,000 other neurons, it possesses an amazing ability to learn, memorize and generalize. Each neuron accepts signals with the help of synapses, which control the effects of the signals on the neuron. These synaptic connections play a crucial role in the behavior of the brain. It has 2 types Feed-forward and Feedback networks. In Feed-forward, signals travels in single way only; the outputs of a layer are connected as the inputs to the next layer whereas in Feedback networks signal travels in both directions by introducing loop in network. Feed-forward n/w are generally used in pattern recognition, generation and classification. Feedback networks are generally used for speech recognition, image captioning, and motion detection [7].

(1) The line which provide weights Wj_1, to the n inputs of jth neuron xi, i = 1,.,n;

(2) An Summation function that sums the weight of inputs to calculate the input to the activation function uj = Θj+ $\sum_{i=1}^{n}$ xiWji, where Θj is the bias, which is a algebraic value associated with the neuron. Bias is like an intercept which is added in a linear equation and it is always equal to one, so that uj = $\sum_{i=0}^{n}$ xiWji

(3) An activation function Ψ which maps uj to vj = Ψ (uj), the output value of the neuron. Some examples are: step, sigmoid, an hyperbolic and Gaussian function.

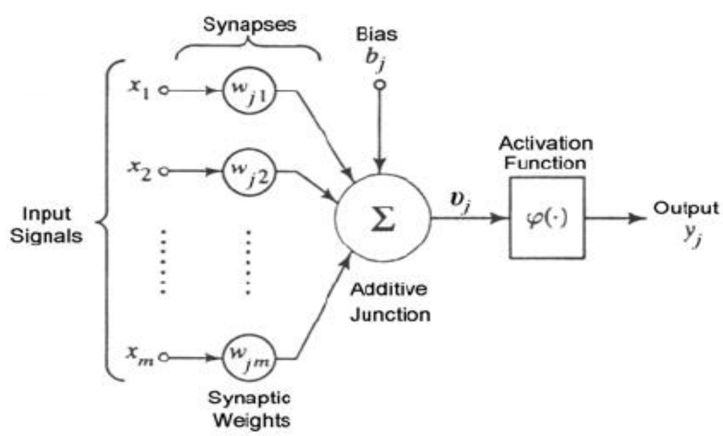

Fig. 3.Structure of artificial neuron

4.5 Swarm intelligence (SI)

It is used to solve complex problem. SI comprises cumulative analysis of the individual behavior of biological species such as shoals of fish, throng of birds, and colonies of ants and their interaction with each other locally. SI is the intelligence through which collective characteristics of primitive agents interacting regionally with their environment so it causes coherent functional universal patterns to emerge. While graceful but impulsive bird-flock choreography inspired the progress of particle swarm optimization, impressive ability of a colony of ants to find shortest path to their food inspired the development of ant colony optimization. As much as particle closer to solution, is having highest fitness as compare to a particle that is far away. Positions and velocities of all particles are changed in each phase to influence them to achieve better fitness. The process of upgrading continues iteratively either till we get a sufficiently large number of iterations or until a particle reaches the universal solution within acceptable tolerance limits.There is one experience by which dimension and direction of a fragment is affected, its previous velocity and the knowledge it gain from the swarm through social interaction. There is no unified control structure available in order to predict the properties of individual agents. The mostly used SI based algorithms are Bee Colony Algorithm, Particle Swarm and Ant Colony optimization etc. [8] [9][10].

4.6 The Artificial Immune System (AIS)

It is an artificial component of the natural immune system. The AIS is a problem-solving and powerful information processing model in both the engineering and scientific fields. It takes biological and nonlinear classification propertiessuch as positive and negative selection, self-identification, clonal selection, etc. The application of AIS is the computer security through detecting viruses and Trojans, abnormal detection, fault detection, learning and optimization of system [11].

V. APPLICATIONS OF CI

There are several applications of computational intelligence in designing and modeling intelligent systems and solving the real-world problems. The genetic algorithm can be applied to routing optimization in telecommunications networks[12][13].

The genetic programming can be used in empirical discovery, symbolic function identification, solving systems of equations, automatic programming, pattern recognition, concept formation, game-playing strategies, and neural network design.

The application of evolutionary programming is to evolve finite-state machines, optimize a continuous function, and train a neural network (NN) and real-world applications of evolutionary programming are in robotics, controller design, image processing, video games, power systems, scheduling and routing, etc. [14].

It can also be applied to train neural networks The Artificial Immune Systems (AIS)is used in many domains and some of these domains are robotics, pattern recognition and data mining network intrusion and anomaly detection, concept learning, virus detection, data clustering.

The AIS has also been applied to initialization of centers of a radial basis function neural network, initialization of feed-forward neural network weights, and optimization of multi-modal functions [15][16].

VI. CONCLUSION

In this paper, we studied wireless sensor network and their types and applications. Then we have presented computational intelligence and it's paradigm in brief. Thereafter, we have presented a systematically applications of computational intelligence in wireless sensor network. . From this study, it is clear that the CI based Paradigm can help to solve many complex problems in wireless sensor network.

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