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Computational Intelligence in wireless sensor network

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Abstract- *The wireless sensor networks (WSNs) 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, mobility and topology changes, localization 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 topology changes, communication failures. The most common computational intelligence (CI) paradigms such as fuzzy systems, artificial neural networks, evolutionary algorithm, 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 (WSN) is a group of sensor nodes that collectively work for several tasks like intrusion detection, weather forecasting, event detection, health and area monitoring, etc. In a WSN, each sensor node 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, there is not a single technical solution that encompasses the entire design space and also there is no single set of requirements that clearly classifies all WSNs. Several of these applications share some basic characteristics. In most 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.

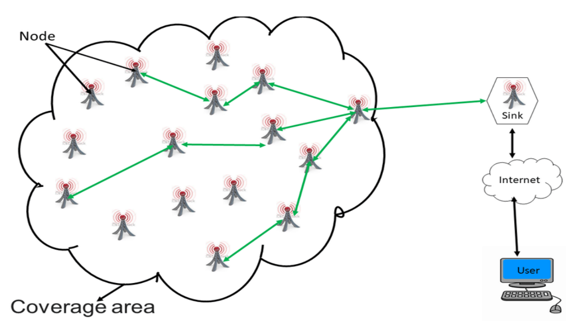

Fig. 1. Wireless sensor network

II. TYPES OF WIRELESS SENSOR NETWORK

Different types of Wireless Sensor Networks (WSNs) are given below [1].

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

2.2 Underground WSNs The underground WSNs are more costly than the terrestrial WSNs in terms of planning, deployment and maintenance. 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 underground environment makes wireless communication a challenging due to high level of attenuation and signal loss.

2.3 Underwater WSNs The underwater WSNs includes large number of sensor nodes and vehicles deployed under the water. The autonomous underwater vehicles are employed for collecting the data from these sensor nodes. A challenge of underwater communication is long propagation bandwidth, delay and node failures. The issues of energy conservation for underwater WSNs include the development of underwater communication and networking techniques.

2.4 Multimedia WSNs The purpose of these WSNs is to enable tracking and monitoring of events in the form of multimedia data. These networks comprised of low-cost sensor nodes equipped with microphones and cameras. These nodes are interconnected with each other over a wireless connection for data retrieval, data compression and correlation. The challenge in the multimedia WSNs includes high bandwidth requirements, high energy consumption, data compression, and data processing.

2.5 Mobile WSNs The mobile WSNs compose of a collection of sensor nodes that can move their own and they can be interacted 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 include better 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 deployed in mission critical applications such as surveillance of buildings and bridges, security of key land marks etc. Depending on the 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 (CI) can be defining as a analyzing of adaptive mechanisms to enable or facilitate intelligent behavior in complex and changing 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 included 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 marked by the use of linguistic variables such as most, many, frequently, seldom etc.

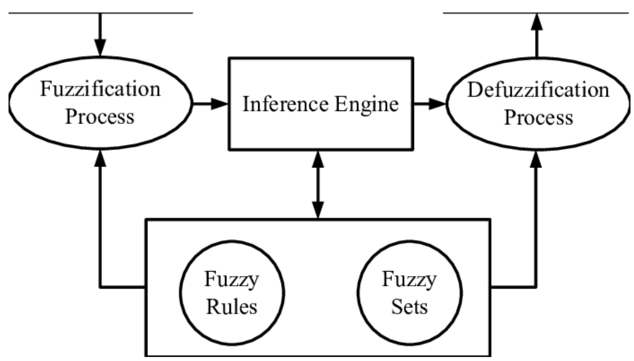

Fig. 2. Block Diagram of Fuzzy Inference system

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 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 the knowledge base of a 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 receives an immediate reward for its action. RL acquires its knowledge by actively exploring its environment. At each step, it selects few possible actions and receives a reward from the environment for this particular action. It does not have prior knowledge of the best possible action at some state. Subsequently, the agent has to try many different actions and sequences of actions and learns from its experiences.

Reinforcement learning is suitable for distributed problems like routing and it has medium requirements for memory and computation at the individual nodes. It needs some time to converge but is highly flexible to topology changes and achieves optimal results and easy to implement

4.3 Evolutionary algorithms

It is the process of transformation with the goal of improving survival capabilities through processes such as natural selection, survival-of-the-fittest, reproduction, mutation, competition and symbiosis. EC encompasses a variety of EAs that all share a common underlying idea of survival of the fittest. Chromosomes are made up of genes which represent a distinct characteristic. The EA seeks a fitness function to maximize over the generations, quantifies the fitness of an individual chromosome. Offspring chromosomes are mutated in order to increase diversity. The fittest chromosomes are selected to go into the next generation, and the rest are eliminated. The process is repeated until either a fit enough solution is found or a previously set computational limit is reached. Genetic programming (GP) is an automated programming in which we build a working computer program from a high-level problem statement. It starts from a high-level statement of "what it needs to be done" and automatically generates a computer program to resolve the problem. It is a machine learning technique used to optimize a population of computer programs to perform a given computational task.

4.4 Neural Networks

The human brain possesses an amazing ability to learn, memorize and generalize, is a dense network of over 10 billion neurons, each connected on average to about 10,000 other neurons. Each neuron accepts signals with the help of synapses, which control the effects of the signals on the neuron. These synaptic connections play a vital role in the behavior of the brain. It has 2 types Feed-forward and Feedback networks. In Feed-forward, signals travels in one 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 networks are commonly used in pattern recognition, generation and classification. Feedback networks are commonly used for speech recognition, image captioning, and motion detection [7].

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

2) An aggregation function that sums the weighted inputs to compute the input to the activation function uj = Θj + $\sum_{i=1}^{n}$ xiWji, where Θj is the bias, which is a numerical value associated with the neuron. It is convenient to think of the bias as the weight for an input x0 whose value 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 of the activation functions are: sigmoid, step, tan hyperbolic and Gaussian function.

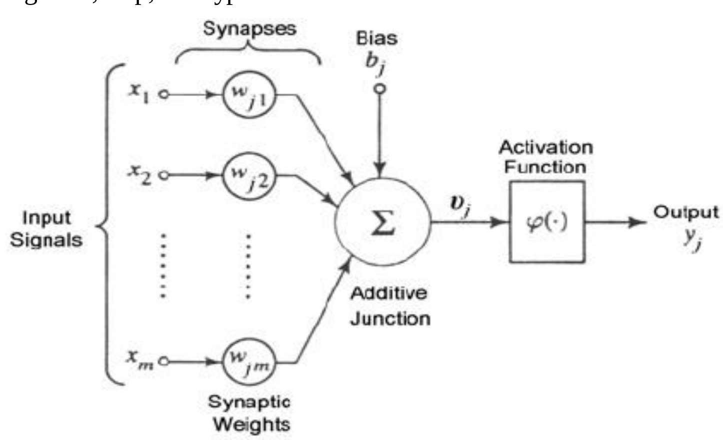

Fig. 3. Structure of artificial neuron

4.5 Swarm intelligence (SI)

It is used to solve complex problem. SI includes collective analysis of the individual behavior of biological species such as flocks of birds, shoals of fish and colonies of ants and their interaction with each other locally. SI is the intelligence through which collective characteristics of unsophisticated agents interacting locally with their environment so it causes coherent functional global 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. The fitness is defined in such a manner that a particle closer to the solution then has higher fitness value than a particle that is far away. Positions and velocities of all particles are updated in each iteration to persuade them to achieve better fitness. The process of updating is repeated iteratively either until a sufficiently large number of iterations is reached or until a particle reaches the global solution within permissible tolerance limits. Direction and magnitude of movement of a particle is influenced by its experience, its previous velocity and the knowledge it acquires from the swarm through social interaction. There is no centralized control structure exists in order to predict the behavior of individual agents. The popular algorithms based on SI are Artificial Bee Colony Algorithm, Particle Swarm Optimization (PSO), 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 paradigm in both the scientific and engineering fields. It takes nonlinear classification properties along with the biological properties such as self-identification, positive and negative selection, 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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REFERENCES

[1]Agarwal, T Wireless Sensor Networks and Their Applications. Accessed on 25 January 2021 https://www.elprocus.com/introduction-to-wireless-sensor-networks-types-and-applications/

[2] Bader, S Enabling Autonomous Envionmental Measurement Systems with Low-Power Wireless Sensor Networks, Mid Sweden University licentiate thesis, ISSN: 1652-8948, ISBN: 978- 91-86694-14-2:http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A387560&dswid=4599

[3}Engelbrecht, A.P.Computational Intelligence: An Introduction. Wiley, New York (2018) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5770681/

[4] Bezdek, J.C.What is computational intelligence?. CONF-9410335– ON: DE95011702; TRN: 95:004731–0002, United States https://www.google.co.in/books/edition/Computational_Intelligence_in_Wireless_S/4hbjDQAAQBAJ?hl=en&gbpv=1&dq=Bezdek,+J.C

[5] L. A. Zadeh, "Soft computing and fuzzy logic," IEEE Trans. Software Eng., vol. 11, no. 6, pp. 48–56,https://dl.acm.org/doi/10.1109/52.329401

[6] . Kulkarni, R.V., Förster, A., Venayagamoorthy, G.K.: Computational intelligence in wireless sensor networks: a survey. IEEE Commun. Surv. Tutor http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.156.8711

[7] S. Haykin, Neural Networks: A Comprehensive Foundation. Prentice Hall https://dl.acm.org/doi/10.5555/521706

[8] K. Langendoen, A. Baggio, and O. Visser, "Murphy loves potatoes: experiences from a pilot sensor network deployment in precision agriculture," in Proc. 20th Int. Symp Parallel Distributed Proc https://europepmc.org/article/PMC/3264477

[9] . Kulkarni, R.V., Venayagamoorthy, G.K.: Particle swarm optimization in wireless-sensor networks: a brief survey. IEEE Trans. Syst. Man Cybern. Part C Appl. https://ieeexplore.ieee.org/document/5518452

[10] Poli, R., Kennedy, J., Blackwell, T.: Particle swarm optimization. Swarm Intell. 1(1), 33–57https://www.sciencedirect.com/science/article/pii/S2212017312003271

[11] D. Dasgupta, "Advances in artificial immune systems," IEEE Computational Intelligence Mag., vol. 1, no. 4, pp. 40–49 https://ieeexplore.ieee.org/document/4129847/

[12] Ferentinos, K.P., Tsiligiridis, T.A.: Adaptive design optimization of wireless sensor networks using genetic algorithms. Comput. Netw. 51(4), 1031–1051 https://dl.acm.org/doi/abs/10.1016/j.comnet.2006.06.013

[13] Jia, J., Chen, J., Chang, G., Tan, Z.: Energy efficient coverage control in wireless sensor networks based on multi-objective genetic algorithm. Comput. Math. Appl. 57(11), 1756– 1766 https://www.sciencedirect.com/science/article/pii/S089812210800552X

[14] Shahabadkar, R., Pujeri, R.V.: Secure multimedia transmission in p2p using recurence relation and evolutionary algorithm. In: Security in Computing and Communications, vol. 377, pp. 281–292

[15] Kulkarni, R.V., Venayagamoorthy, G.K.: Particle swarm optimization in wireless-sensor networks: a brief survey. IEEE Trans. Syst. Man Cybern. Part C Appl. Rev. 41(2), 262–267 https://ieeexplore.ieee.org/document/5518452

[16] Morteza, J., Hossein, M., Kasra, M., Mohammad, F., Shahaboddin, S.: A Method in Security of Wireless Sensor Network Based on Optimized Artificial Immune System in Multi-Agenta https://arxiv.org/abs/1508.01706