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Neural Network in Wireless Sensor Network

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ABSTRACT: Widespread use of Wireless sensor network leads to involving new technologies in combination to overcome constraints. Analogy existing between wireless sensor network and neural network emphasizes on coupling both the techniques to better utilize Wireless sensor network. Neural network not itself being energy conservation scheme helps in energy conservation in wireless sensor network. This paper focuses on back propagation neural network as a supervised method of training neural network. Back propagation neural network helps in data aggregation in WSN. This paper also gives overview of Wireless sensor network properties.

I. INTRODUCTION

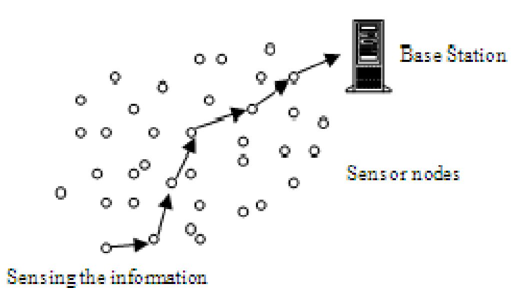
The emerging technology utilized for monitoring environmental aspects is Wireless Sensor Network Technology. Tiny sensor nodes are basic units of Wireless sensor network. They observe the environment, record the readings and send the readings to the base station or sink. WSNs are used in regions where it is difficult or impossible for human beings to reach. WSNs are equipped with self organizing, flexibility and processing capability.

A Sensor node is made up of various units [1]:

(i) Sensing Unit: It consists of sensors and an analog to digital converter to convert observed readings to digital for processing

(ii) Processing Unit: It handles the computation required on the data observed by node. There is small memory unit in it to store routing tables or other information.

Fig. 1. Wireless Sensor Network.



(iii) Transceiver Unit: The communication within the network is carried out by transceiver unit.

(iv) Power Unit: This holds the battery the sensor node operates with. The battery power is limited and cannot be recharged.

Sensor nodes can be deployed in an area in either of the 2 ways:

(i) Ad-hoc manner: Large uncovered regions are deployed by large number of nodes automatically.

(ii) Pre-planned manner: This requires a proper method with proper planning for deployment. This is followed when area is limited and we need to deploy lesser number of nodes.

Types of WSN

Different types of WSNs have different requirements. Types of WSN are listed below [2]:

(i) Terrestrial WSN: Nodes are usually deployed in ad-hoc manner in a given land area. In this nodes can be equipped with secondary power.

(ii) Underground WSN: To monitor underground conditions like in caves, mines. These need reliable routing to communicate information between nodes and sink. It is difficult to recharge batteries of these nodes.

(iii) Underwater WSN: Underwater deployment needs expensive nodes. Only few nodes are used to explore the area. The batteries of these nodes cannot be recharged.

(iv) Multimedia WSN: Sensor nodes are equipped with cameras, microphones to capture video, audio, images. These are deployed in pre-planned manner.

(v) Mobile WSN: Mobile sensor nodes can reposition by monitoring themselves and get organized in the network.

Challenges in Wireless sensor network

To support wide range of applications, WSN must address the challenges [3] listed below:

1. Resource constraint: Sensor nodes are equipped with limited energy. Once the energy of a sensor node is depleted it is of no use. Efficient use of energy is required to improve the lifespan of the sensor node.

2. Dynamic and extreme environment conditions: The surroundings where sensor nodes are deployed have dynamic and harsh climatic conditions. Sensor nodes should be capable of processing signals in that environment.

3. Data redundancy: To encourage fault tolerance, additional nodes are deployed to collect data in case of node failures. This leads to data redundancy. Data fusion and localized processing is required to avoid transmitting redundant data to sink.

4. Node failure: Node failure occurs unexpectedly due to depletion of energy, damage or when communication between nodes fails. Some fault tolerant measure is required to maintain sensor network functionalities.

5. Large-scale deployment: Large numbers of nodes are required to be deployed for correct observation. This requires low cost and small-sized nodes with ability to self organization.

II. ENERGY CONSTRAINT A MAJOR ISSUE

With the presence of microelectronics though the size, weight and cost of sensor hubs got decreased but their batteries also became littler. Thus energy provided to a sensor node is very scarce.

A sensor node consumes its energy not only usefully but also wastefully [4]. Useful energy consumption is done in sensing, transmitting and processing data. Wasteful consumption is done when a node performs any one of the following operations:

(i) Idle listening

(ii) Collision

(iii) Overhearing

(iv) Over emitting

The above points show that communication subsystem consumes far more energy than computation subsystem. As the energy of nodes deplete they do not perform any function. The failed nodes are nearly very difficult to replace or reenergize due to deployment in troublesome environment which is out of reach of humans. Even the failure of a single node affects the lifetime of entire WSN application and hence the whole network fails. Thus energy protection is a genuine and discriminated issue in planning of WSN with a long lifespan.

III. OVERVIEW OF NEURAL NETWORKS

Neural Networks are networks of interconnected simple units called neurons that are based on a greatly simplified model of brain. These neurons are associated through weighted associations called neural connection. These join the system data layer to the yield layer.

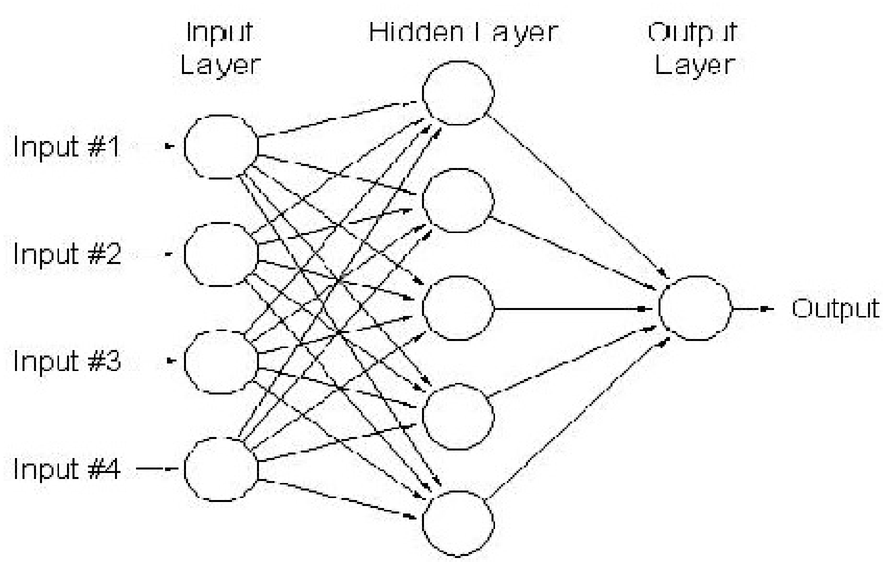


Fig. 2. Neural network.

A simple neural network works in the following way as mention in [5]:

1. Input layer represents raw information that is fed in the network.

2. Every single input to the network is duplicated and send down to the noded in the hidden layer. The hidden layer accepts data from the input layer.

3. Hidden layer uses the input values and modifies them using weight values among them, this new value is send to output layer
4. Output layer modifies by using weights between hidden and output layer and processes information received from hidden layer and produces the output.
5. This output is then processed by action function.

The above steps indicate the working of feed forward neural networks.

Analogy between Neural network and WSN

1. Neurons relate to sensor hubs in processing and perceiving capability
2. Associations compare to radio connections.
3. Neural Networks can predict sensor readings at Base Station, which diminish unneeded interchanges and recovery extensive energy.

The entire sensor network arranges as a neural system and inside of every sensor hub inside the WSN there could run likewise a neural system to settle on the yield activity.

Neural networks can be trained to perform a particular task in two ways:

1. Supervised training
2. Unsupervised training

IV. BACK PROPAGATION NEURAL NETWORK

Back propagation networks are *feed forward networks* with input, output, and hidden layers. The units function basically like perceptrons, except that the transition (output) rule and the weight update (learning) mechanism are more complex.

The fig. 3 presents the architecture of back propagation networks. There can be any number of hidden layers, and any number of hidden units in any given hidden layer. Note that units within the same layer are not interconnected. The working of feed forward step is same as that of neural network.

Once activation is feed forward from input units to the output units, the network's response is compared to the desired output which given along with the training pattern. There are two types of error.

1. The first error is the *error at the output layer.* This can be directly computed.
2. The second type of error is the *error at the hidden layers.* This cannot be computed directly since there is no available information on the desired outputs of the hidden layers. For this the back propagation of error is called for.

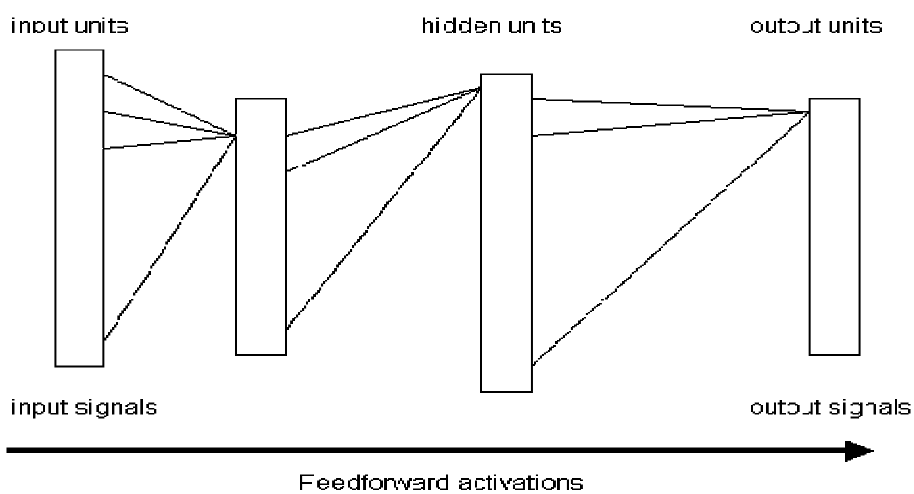


Fig. 4. Feed forward back propagation neural network.

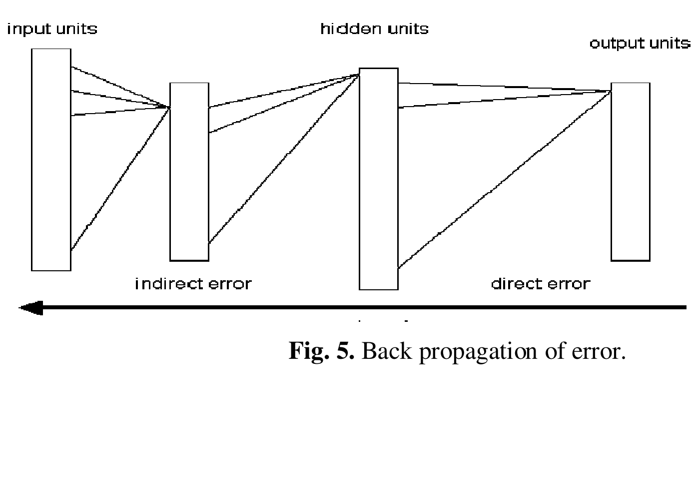


Fig. 5. Back propagation of error.

Essentially, the error at the output layer is used to calculate the error at the hidden layer immediately preceding the output layer. Once this is computed, this is used in turn to compute for the error of the next hidden layer if any. This is done sequentially until the error at the very first hidden layer is computed. The back propagation of error is illustrated in the Fig. 5. The errors at the other end of the outgoing connections of the hidden unit h have been earlier computed. These could be error values at the output layer or at a hidden layer. These error signals are multiplied by their corresponding outgoing connection weights and the sum of these is taken.

After computing for the error for each unit, whether it is at a hidden unit or at an output unit, the network then updates its connection weights wkjt+1. The weight update rule is uniform for all connection weights.

Data aggregation using back propagation neural network

An intelligent and computational system which can combine heterogeneous data obtained from different nodes, automatically and efficiently is an important need of WSN. Data fusion can reduce the redundant data. Data fusion method should beable to classify and recognize data affected by noise or any intentional change. Comprehensive survey study on sensor fusion approaches in target tracking is done. Neural networks using back propagation is an intelligent tool for data aggregation.

The nodes in the network are arranged in neural network with input layer as cluster members and hidden and output layer as cluster heads. As cluster member and cluster changes after every round, neural network is trained at the sink and historical records are referred after every round [6].

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