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Radial Basis Function (RBF) Based Routing Optimization for Wireless Sensor Network

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Abstract: Wireless Sensor Network (WSN) is supposed as the network of number of sensors nodes which are ready to communicate with one another through radio interface like wireless medium. Power consumption, routing and quality of service are the main concerning issues of WSN applications. We have been investigating the problem of optimization of routing in WSN based on radial basis function networks RBFN to increase the lifetime of wireless sensor networks. This approach of routing optimization of WSN is based on accuracy, training time of the sensor network that is needed to enhance the performance of optimized routing path. RBFN is very simple, adaptable and efficient method to increase the lifetime of networks.

Keywords: Wireless sensor networks, RBFN, link cost, accuracy and mean square error (MSE)

I. INTRODUCTION

In this new World of rapid technology Wireless Sensor Networks (WSNs) can be developed as the most important technology among all others. Wireless sensor networks have different concerning issues like storage capacity and power management and these give a lot of contribution in VLSI. These networks have many advantages so they have military and civil applications like target tracking, space investigation, environmental control, environmental monitoring and patient care [1], [2],[3], and [4].

Wireless sensor network is made up of a large number of micro sensors which are small in size like in cubic centimeter and these sensors are spread out in specific area to have that particular application. Micro sensor has many important features such as capability of sensing data from the environment, ability to solve complex computations and transmission of data over wireless medium from a node to gateway or vice versa.

In wireless sensor networks, routing protocols can be either proactive or reactive that gives determination of route to destination by source. Before routes are required, they are work out in proactive routing. On the other way, in reactive routing the routes are work out only when it is required.

Depending upon the application of WSN, the design component of the routing protocol varies because of the application's travel demand and pattern may very much. Power consumption, mobility, scalability and QoS are the other most important issues in designing routing protocols in WSN. Routing is the main concerning issue in WSN. We are using the back propagation neural network system that will optimize the routing path. This approach is depending on the different parameters: transmission energy, energy consumption, data transmission rate, and distance from gateway, queue size and weight [5]. Here it is presented a routing protocol based on fuzzy logic for the selection of best sensor node among all sensor nodes which will be used for forwarding the packets to the sink [12]. It has been investigating the problem of optimization of routing of WSN based on Back propagation neural networks BPNN to increase the lifetime of wireless sensor networks. BPNN is very simple, adaptable and efficient method to enhance the lifetime of networks [13].

The paper is organized as follows: Section II describe WSN system model, Section III describe radial basis function networks (RBFN), the implementation and results are given in Section IV. Section V presents the conclusion

II. ARCHITECTURE OF WIRELESS SENSOR NETWORKS

Wireless sensor network comprises a number of sensor nodes to generate high-quality information to the environment. The different functions like sensing, dealing, transmission, location finding, and power consumption are existing in each of the nodes. These main features are building discrete, local measurement and make a wireless network by communicating over a wireless medium and accumulate information and route information back to the user that is Base Station through sink. The sink (Base Station) is communicated with the user through internet or satellite communication. This medium is positioned near the sensor field or whether it is nearby a well equipped node of the sensor network [6].

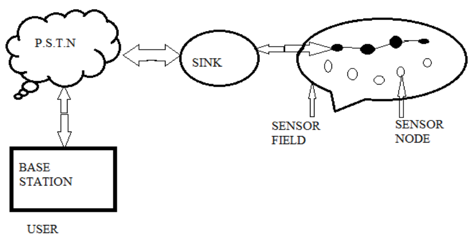

Figure1: shows the architecture of a typical Wireless Sensor Network

Requirements of WSN:
WSN should follow these requirements in developing various fields: scalability, reliability, responsiveness, mobility, and power efficiency. These can be described as:

- Reliability- The capability of the network for reliable data transmission should be updated for continuous change of network system.
- Scalability- It is the capability of the network to produce without extreme overhead.
- Responsiveness - The capability of the network to adapt itself quickly as soon as possible to changes in topology.
- Mobility- It is the capability of the network to hold mobility of nodes and unreliable data paths.

Characteristics of Wireless sensor networks:
The characteristics of WSNs are discussed as:

- Reduction of power consumption
- Ability to manage with node breakdown
- Mobility feature of nodes
- Communication breakdown
- Heterogeneity of nodes
- Large scale use
- Withstand in critical environmental conditions and Easiness of use [7]

III. RADIAL BASIS FUNCTION NETWORKS

The theory of function approximation tells about the thought of radial basis function of neural networks. RBF Networks has a different approach in contrast to Multi-Layer Perceptron (MLP) networks with a hidden layer of sigmoid unit. It has many characteristics that are discussed as:

They are created as two-layer feed-forward networks and the hidden nodes of feed forward networks are applied as a set of radial basis functions like Gaussian functions.

The output nodes are acting as linear summation functions as in case of MLP and the training of network is divided into two stages: in first stage the weights from the input to hidden layer are firstly calculated, and then the weights from the hidden layer to output layer are evaluated in second stage. The training or learning is very fast and the networks are very good at interpolation function [8], [9], and [10].

Radial Basis Function Networks (RBFN) are comprised of three layers

- input layer
- hidden layer
- output layer

The hidden units are representing a set of functions that has an arbitrary basis for the input patterns. Hidden units are called radial centers and these are represented by the vectors c1, c2… ch. The process of transformation from input layer to hidden unit layer is nonlinear on the other side transformation from hidden unit layer to output layer is linear and the dimension of each center for a p input network is p * 1

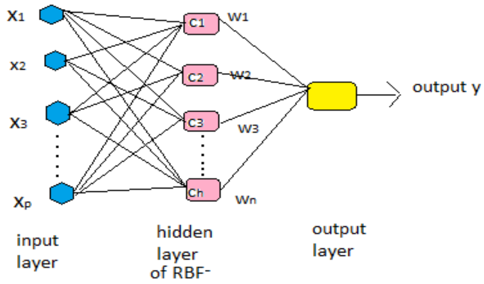

Figure 2: Radial basis function model

A radial basis function in the hidden layer produces a significant non-zero response only when the input falls within a small localized region of the input space. Each hidden unit has its own receptive field in input space. An input vector xi which occurs in the open field for center cj will be activated as cj and by proper selection of weights the target output is attained. Here the output of field is related as

$$y = \sum_{j=1}^{h} \phi_j w_j, \qquad \phi_j = \phi(\|x - c_j\|)$$

Wj: weight of jth center, ϕ some radial function.

Learning of RBFN
RBFN is needed a most favorable selection of the parameters vectors ci and wi, i = 1… h.
Both layers are optimized using different techniques and in different time scales. Following techniques are used to update the weights and centers of a RBFN.

- Pseudo-Inverse Technique (Off line)
- Gradient Descent Learning (On line)
- Hybrid Learning (On line)

Pseudo-Inverse Technique
This is a least square problem. Here we suppose radial basis functions such as Gaussian functions and the centers are chosen randomly and function is normalized. The standard deviation (width) of the radial function is determined by an ad hoc choice.

Gradient Descent Learning
One of the most popular approaches to update c and w, is supervised training by error correcting term which is achieved by a gradient descent technique.

Hybrid Learning
In hybrid learning, the radial basis functions relocate their centers in a self-organized manner while the weights are updated using supervised learning. In both layers, the parameters are updated with the help of gradient descent or a new center is created if the pattern is new.

IV. PROPOSED APPROACH

In this paper, we have created a manual data set of 2100 samples by using i5 core processor and Matlab R2009b based on different parameters used for investigating the routing optimization problem wireless sensor networks. These parameters are transmission energy, energy consumption, data transmission rate, distance to gateway, queue size and weight and the corresponding output parameter link cost. This manual data set has 2100 total

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samples corresponding to all above parameters, out of which 2001 are taken as training data and 99 samples are taken as testing data. We are utilizing a Radial Basis Function network method for routing optimization in wireless sensor networks by using manual data set. With the help of this RBFN network method, we are able to determine the accuracy of the networks of different number of neurons at different values of time having different performance values in terms of its mean square error.

Table:determination of link cost using RBFN

Sr. no	No. of neurons	Accuracy (%age)	MSE	Time (sec)
1	50	55	0.21	0.58
2	100	60	0.17	0.64
3	150	64	0.089	0.69
4	200	68	0.07	0.8
5	250	74	0.05	1.25
6	300	78	0.048	1.55
7	350	82	0.04	1.57
8	400	84	0.035	2
9	450	86	0.031	2.1
10	500	88	0.03	2.5

Performance: performance of the network system is evaluated in terms of mean square error. With the number of neurons increases, accuracy of the system and also increases time to execute the process. The value of the mean square error decreases as increasing the number of neurons.

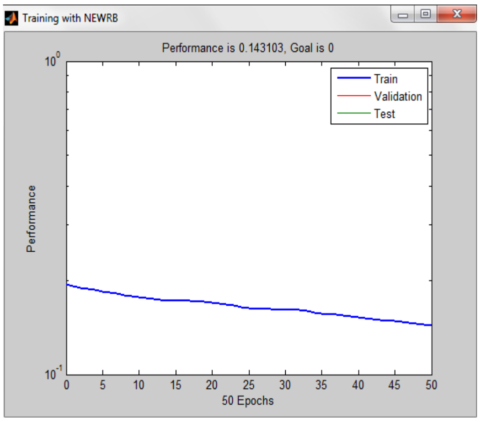

Figure 3: performance in terms of mean square error of the network at 50 neurons using RBFN

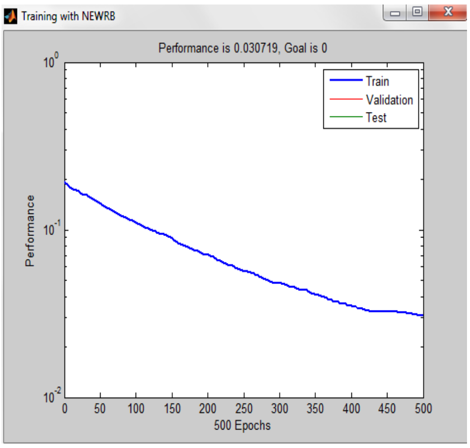

Figure 4: performance in terms of mean square error of the network using RBFN

The performance for the system is evaluated at 50 and 500 neurons and we see that MSE is reducing as increase in number of neurons. At 50 neurons the value of MSE is 0.14310 and at 500 neurons the value of MSE will be decreasing up to 0.0307. The following graph is shown a relationship between number of neurons and mean square error of the network system. Its result shows that with the increase in number of neurons in network system by using RBFN, the mean square error decreases. The value of MSE is very less approximately(0.03) at 500 neurons. For better performance of the system, this parameter should be decreases.

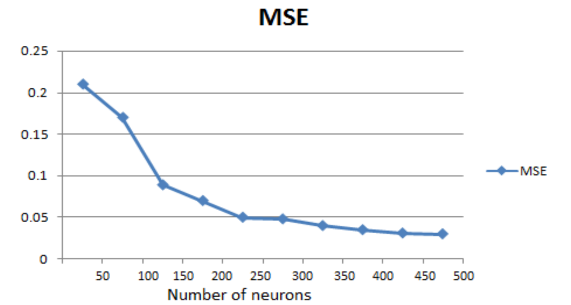

Figure5: Graph between number of neurons and mean square error

Now we have an another graph which gives a relationship between number of neurons and training time taken by neurons.This graph shows that as increase in number of neurons,training time of neurons for processing also increases.These both terms are important to have better performance of network system.

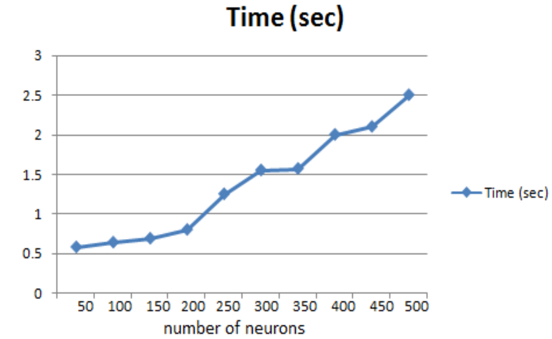

Figure 6: Graph between numbers of neurons and training time

Now, we have one more graph which shows a relationship between numbers of neurons and accuracy of the network system. With increase in number of neurons, the accuracy of network also increases. This is also a very important parameter to give better performance

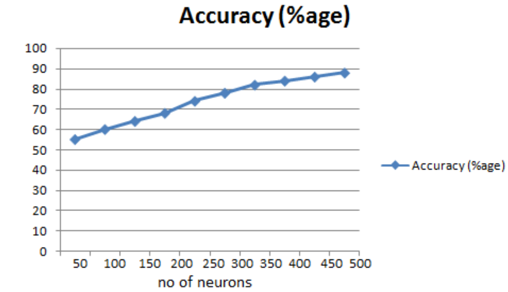

Figure 7: Graph between numbers of neurons and accuracy

The optimum value of accuracy of the system is 88% of 500 numbers of neurons and its corresponding training time is 2.5min.

V. CONCLUSION

In this paper, performance and accuracy of the wireless sensor networks have been evaluated with the help of Radial Basis Function Networks RBFN. This method gives some accurate values of performance which helps to determine best link cost for routing optimization of WSN. This enhances the lifetime of sensor network and reduces battery consumption. Indeed RBFN method is very simple, best adaptable and efficient. This method is giving accurate results of performance of system than BPNN.

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