International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Energy Efficient Clustering Based On Neural Network and Routing in Wireless Sensor Network

Shweta Parit[1], Padmapriya Patil[2]

[1]M. Tech, Department of Electronics and Communication Engineering,
Poojya Doddappa Appa College of Engineering, Gulbarga, Karnataka, India

[2]Associate Professor, Department of Electronics and Communication Engineering,
Poojya Doddappa Appa College of Engineering, Gulbarga, Karnataka, India

Abstract: ***Energy is a valuable resource in wireless sensor networks. The status of energy consumption should be continuously monitored after network deployment. It can also be used to perform energy efficient routing in wireless sensor networks. In this neural network based energy efficient clustering and routing in wireless sensor network the life time of the network is maximized by balancing the energy consumption among different sensor nodes. In This paper we propose a neural network for energy efficient clustering and routing in wireless sensor network with the objective of maximizing the network life time. In This proposed system we use a self-organizing map neural network for clustering which can cluster nodes based on multiple parameters: Energy level and coordinate of sensor nodes. We applied some maximum energy nodes as weight on self organizing map units and form energy balanced clusters in order to better balance energy consumption in whole network which will prolong the network lifetime. And then it finds multiple paths through ad-hoc on demand distance vector (AODV) Routing Protocol and uses linear programming for the optimization of multiple paths and data transmission.***

Keywords: Self Organizing map Neural Network, linear programming, Wireless Sensor network;

1. Introduction

Wireless sensor network is a class of wireless adhoc networks consisting of large number of battery powered sensor nodes and one or more base stations. Sensor nodes collect, process, and communicate data acquired from the physical environment to an external base station. But this network have several challenges such as sensor nodes in wireless sensor networks are normally battery powered and energy has to be carefully used in order to avoid early termination of sensor life times.

Low energy adaptive clustering hierarchy protocol the goal of LEACH is to have local base stations to reduce the energy, cost of transmitting data from normal nodes to a distance base station. In LEACH, nodes organize themselves in to local clusters with one node acting as a cluster head. All non-cluster head node transmit their data to the cluster heads. Cluster head nodes do some data aggregation and data fusion function on which data should be transmitted to the base station. The operation of LEACH is divided into rounds. Each round begins with a setup phase when clusters are organized, followed by a steady-state phase when data packets are transferred from normal nodes to cluster heads. After data aggregation cluster heads will transmit the messages to the base station.

Neural networks have solved a wide range of problems and have good learning capabilities. Their strength includes adaptation, ease of implementation, parallelization, speed and flexibility. A Self organizing map neural network that implements the idea of competitive learning is used. The nodes in the input layer admit input patterns of sensor nodes competing for cluster head and are fully connected to the output nodes in the competitive layer. Each output node corresponds to a cluster and is associated with the weight.

K-means clustering is the process of partitioning a group of data points into a small number of clusters. The goal is to assign a cluster to each data point-means clustering method aims to find the positions of the clusters that minimize the distance from the data points to the cluster-means clustering also generates a specific number of disjoint, on hierarchical clusters. Linear programming also called linear optimization is an optimization method to achieve maximum profit or lowest cost and optimizes the traffic load balancing among a node and its neighbors in coverage.

Here we address the issue of energy efficient clustering using self organizing map neural network which consist of a input layer, output layer and competitive layer which can classify data set of vectors with any number dimensions into as many classes as layer in the neurons. the self organizing map network is trained with a batch algorithm ,presents the whole data set to the network before any weights are updated.

2. Related Works

In [1] proposed clustering protocols such as LEACH, PEGASIS, HEED, EEUC, and FLOC. The cluster formation overhead of the clustering protocols includes packet transmission cost of the advertisement, node joining and leaving, and scheduling messages from sensor nodes. All these protocols do not support adaptive Multi-level clustering, in which the clustering level cannot be changed until the new configuration is not made. Therefore, the existing protocols are not adaptable to the various node distributions or the various sensing area. If the sensing area is changed by dynamic circumstances of the networks, the fixed-level clustering protocols may operate inefficiently in terms of energy consumption.

In [2] They proposed a distributed randomized clustering algorithm to organize the sensors in a wireless sensor network into clusters. We then extend this algorithm to generate a hierarchy of cluster heads and observe that the energy savings increase with the number of levels in the hierarchy. Results in stochastic geometry are used to derive solutions for the values of parameters of our algorithm that minimize the total energy spent in the network when all sensors report data through the cluster heads to the processing center.

In [3]They proposed a PEACH protocol, which is a power-efficient and adaptive clustering hierarchy protocol for wireless sensor networks. PEACH forms clusters without additional overhead and supports adaptive multi-level clustering. In addition, PEACH can be used for both location-unaware and location-aware wireless sensor networks. The PEACH significantly minimizes energy consumption of each node and extends the network lifetime, compared with existing clustering protocols. The performance of PEACH is less affected by the distribution of sensor nodes than other clustering protocols.

In [4] k-means clustering is a partitioning method. The function k-means partitions data into *k* mutually exclusive clusters, and returns the index of the cluster to which it has assigned each observation. Unlike hierarchical clustering, k-means clustering operates on actual observations (rather than the larger set of dissimilarity measures), and creates a single level of clusters. The distinctions mean that k-means clustering is often more suitable than hierarchical clustering for large amounts of data.

3. Problem statement

K-means clustering and bayes probability transmission has a norm in sensor networks. However K-means fails to consider multiple parameters and past values of the parameters for clustering .Therefore it requires a technique which can incorporate learning based cluster formation Also Currently sensors forward their data in every round to the nearby sink or cluster head as and when the data is available. It increases the packet collision hence the problem Statement can be summarized as to propose a sensor network with neural network based clustering and linear programming based Flow optimization.

4. Methodology

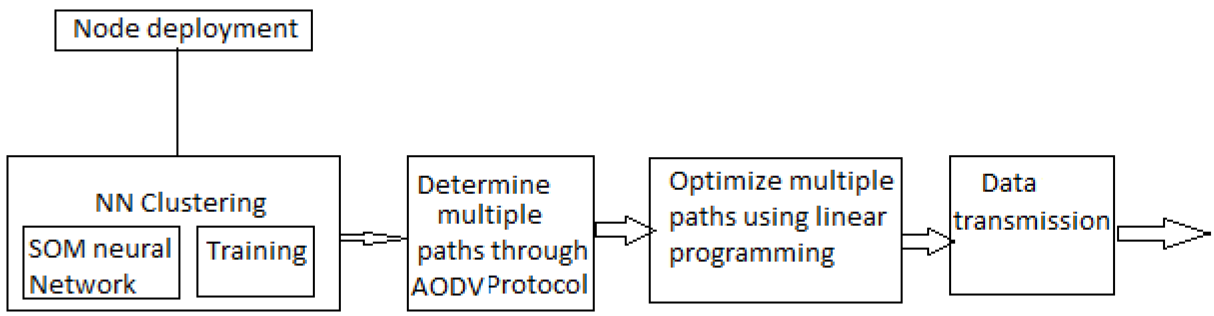

Figure: Block diagram

Module 1: Node deployment
Here we deploy N number of Homogeneous sensor nodes randomly in a given space and with the same energy level.

Module 2: Neural network for clustering
Here we are using the self organizing map neural network which is an unsupervised neural network structure consist of neurons organized on a low dimensional grid each neurons is presented by an n dimensional weight vector where n is the dimension of input vectors. Weight vectors connect the input layer to output layer which is called map or competitive layer. Every input vector activates a neuron in output layer based on its most similarity. The similarity is usually my Euclidean distance of two vectors.

$D = \sum_{k=1}^{m}(Si - w(t))2$

Where S_i is the i^{th} input vector and w(t) is the weight connecting input to the output.

Training using the batch algorithm which presents the whole data set to the network before any weights are updated. The algorithm determines the winning neuron for each input vector then moves to the position of all the input vectors for which it is a winner.

$W_j(t+1) = W_j(new) + \mu(S_i - w_j(old))$

Where µ is the learning rate parameter
If µ=0 there is no learning.
If µ=1 there is fast learning

Module 3: Determine multiple paths through AODV protocol
After the cluster head selection we are using the Energy based AODV Protocol it saves the neighbours node energy and then it calculates the distance of all nodes .If all the nodes are reachable then out of all possible neighbours select the minimum energy node and then selects the next with the minimum energy

Module 4: Optimization of multiple paths using linear programming.
The routing cost is calculated as R_C =
Here we will consider 3 parameters distance, Energy left, cost
The cost will be calculated as
$Cost = 1/E_{left}$
Run linear programming that optimizes the distance and energy and produces a matrix with minimum cost

Module 5: Data transmission

After running the linear programming the nodes data will be forwarded to the next node and then the node will aggregate its own data forwarded data from other node and then transmit the data multiple packets and only the data with a factor of linear programming is transmitted to the sink node.

Algorithm for cluster head selection

1) Initialize the Vector $S = \{ S1, S2, ..., Sm\}$ of sensor nodes competing for Cluster head.//Processing at Input Layer
2) Choose a winner k from sensor nodes as CH Whose E_i^D is minimum as follows
   $k = \arg\min \{E_i^D\}$ // Competition Layer
3) Also E_i^D smallest Euclidean distance to BS i.e.
   $E_i^D = K \sum_{i=1,2,...,m} E - BS$
   Where k is proportionality constant
4) Update the value of weight vector as follows: $Wj\ (new) = wj\ (old) + \mu\ (Si - wj\ (old)$, where μ is learning rate of the neurons. $0 \leq \mu \leq 1$
5) Repeat Steps (2-4) iteratively
6) Neuron with smallest value of E_i^D is the winner.//output layer

Algorithm for Routing and data transmission

1. Sort the paths $p_1, p_2, ..., p_m$ according to E_i^D
 As $E_{i\ 1}^D < E_{i+1}^{Di+1} < .... < E_m{}^D{}_m$
2. $j = 1$ // initialize the counter for available Paths.
3. Repeat and calculate $E \leq P_{maximum}$ (Constraint 6)
4. Repeat
 If(E_n<E_{min} && n ia part of a path)
 Recalculate path
 end
5. $E_{C,m} = \sum_{i=1,2,..,m} m\ E_{max}\ L$ // $E_{C,m}$ is use to
 Store the minimal energy consumption per bit with M paths and is assigned maximum value initially.
6. $R\_C = 0$ // initialize the value of routing cost
7. Repeat
8. Solve equation (1) and get the corresponding Optimal energy distribution with respect to Constraints defined in equations (3),(4),(5).
9. Calculate
 $E_{C,m} = \sum_{i=1,2,..,m} Ei\ L$
10. Calculate the value of R_C from equation (1) and $R\_C^{updated} = R\_C$ // Update value of routing cost
11. **Until** $|R\_C^{updated} - R\_C| < \delta_1$ (predefined threshold)
12. Update the values of energy for each data Transmission as $E_{C,m}^{updated} = E_{C,m}$ **Until** $|E_{C,m}^{updated} - E_{C,m}| < \delta_2$
13. $j = j + 1$ // Update the counter of the paths
14. **Until** $m > Destination\_node$
15. Compare all paths using R_C metric and select the smallest one.
16. Send the data across the multiple paths defined.

5. Simulation and Results

We simulate clustering using the self organizing map neural network in MATLAB-2012 the result demonstrate that the energy consumption of proposed neural network based clustering is smaller than K-means clustering. In the graph below shows for certain nodes and rounds the mean square error and total node dead will be less for the proposed system compared to the K-means clustering and the average energy left for the proposed is more than the K-means clustering.

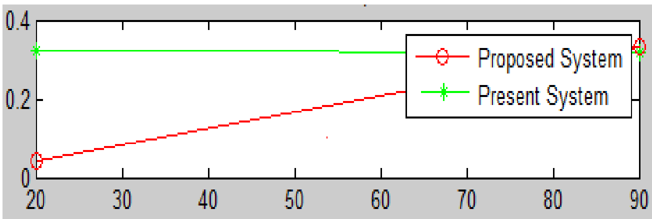

Figure 1: Node vs mean square error

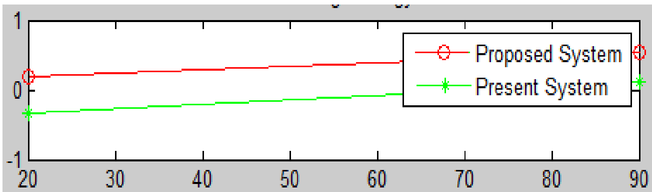

Figure 2: Node vs average energy left

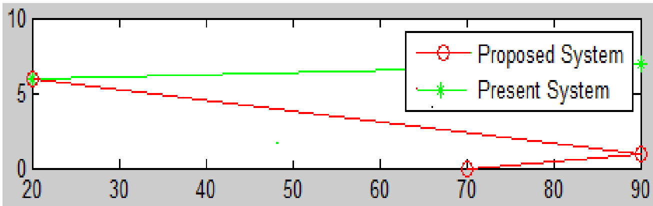

Figure 3: Node vs total node death

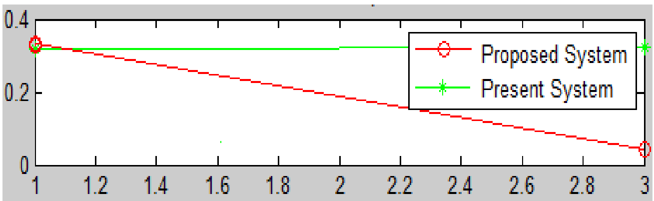

Figure 4: round vs mean square error

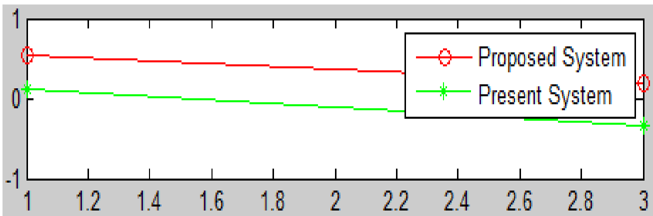

Figure 5: Round vs. average energy left

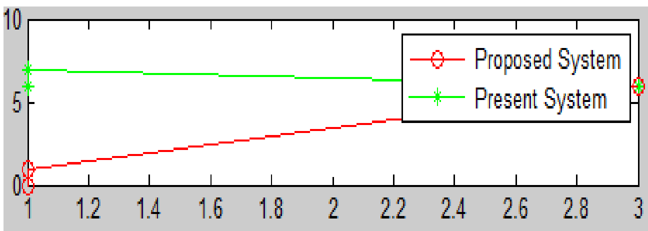

Figure 6: Round vs total node death

6. Conclusion

This paper has proposed a neural network for energy efficient clustering and routing. The selection of cluster head is done using self organizing map neural network followed by training and the linear programming based flow optimization .Simulation result shows that energy consumption is balanced among the sensor nodes and clustering is more efficient that number of nodes dead will be less and energy left is more hence the network life time will be maximized**.** So the proposed scheme can be used in a wide area of sensor networks where the energy efficiency is a critical issue.

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Author Profile

Shwetaparit, Department of E&CE , Poojya Doddappa Appa College of Engineering, Autonomous Institution under Visvesvaraya Technological University, Belgaum, Karnataka, India

Padmapriya Patil is working as Associate Professor, Department of Electronics and Communication Engineering, Poojya Doddappa Appa College of Engineering, Autonomous Institution under Visvesvaraya Technological University, Belgaum, Karnataka, India