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CLUSTER-HEAD SELECTION USING FUZZY CLUSTERING ALGORITHM

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ABSTRACT
A Sensor is a device that responds and detects some type of input from both the physical or environmental conditions, such as pressure, heat, light, etc. The output of the sensor is generally an electrical signal that is transmitted to a controller for further processing.

Wireless Sensor Networks (WSN) is composed of a collection of devices that transfer data through signals with each other through a wireless medium. A WSN comprise of a huge quantity of clusters of sensor nodes that can inter communicate with all nodes and with the base station by means of wireless link. All clusters are corresponding to a cluster head to provide a direct communication to the base station and in addition with other cluster heads. Cluster head selection turns out to be a considerable problem because of its dynamic circumstance. In this paper, proposed a novel technique to enhance the LEACH protocol by using Fuzzy Possibilistic Clustering Algorithm (FPCM). The experimental observation reveals that the FPCM based cluster-head selection algorithm performs better than the cluster head election approach used in LEACH and can enable the network lifetime longer.

KEYWORDS: Wireless Sensor Networks, Cluster Head, LEACH Protocol,Fuzzy Possibilistic Clustering Algorithm (FPCM).

I. INTRODUCTION
In the most recent years there has been a rise of attention in small, low power hardware platforms that incorporate sensing, processing data received from or to be sent to the atmosphere with wireless communication capability. These devices are called sensor nodes and grouped to from a wireless sensor network (WSN) [5].

A sensor network contains a huge number of sensing devices which are furnished with restricted computing and radio communication. Even though sensors possibly will be mobile, they can be judged to become motionless after deployment. The majority of application setting for sensor networks engage battery-powered nodes with inadequate power resources [6][7]. Recharging or swapping the sensor battery may perhaps be not convenient or even not possible in undesirable environment conditions.

The sensors which are available in a wireless sensor network are deployed arbitrarily surrounded by the region of importance or nearer to it. A distant internet equipped base station (BS) is employed to give instructions to all the sensors and collect information from the sensors. Together with sensing, the wireless sensors can also route the obtained information and transmit instructions to the BS as well as communicate to each other [2].

In this paper, the impact regarding the cluster-head selection on the energy utilization is discussed and proposed an approach for cluster head selection in wireless sensor network at the same time as the nodes are immobile. Here, Fuzzy Possibilistic Clustering Algorithm (FPCM) is used for determination of clusters and based on the identified clusters the centroid position of every cluster is found. The proposed approach is used to discover the nodes adjacent to this centroid position having highest residual energy and that node has been confirmed as the cluster head of that respective cluster. The approach adopted in this paper, is an effort to enhance the LEACH [6] protocol by means of a sensible choice of the objective function for head selection.

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II. RELATED WORKS

According to the examination on the flaws in LEACH together with the variation of the number of cluster heads and the ignorance of the node's enduring energy, Tong et al., [1] proposes a new technique known as LEACH-B (LEACH-Balanced). For ever step, initial choice of cluster head based on the LEACH protocol, next selection is established to alter the number of cluster head in thought of node's residual energy. As an outcome of this, the number of cluster head is not variable and close to optimal per round. The experimentation by MATLAB indicates that the enhanced protocol has balanced the system energy utilization and has good outcome of extending the network life span than LEACH protocol.

W. Heinzelman et al., [2] presented an Energy-efficient Communication Protocol for Wireless Microsensor Networks. In this paper, the author looks at communication protocols, which can have significant impact on the overall energy dissipation of these networks. Based on the findings that the conventional protocols of direct transmission, minimum-transmission-energy, multihop routing, and static clustering may not be optimal for sensor networks, the author propose LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses localized coordination to enable scalability and robustness for dynamic net-works, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station. Simulations show that LEACH can achieve as much as a factor of 8 reductions in energy dissipation compared with conventional routing protocols. In addition, LEACH is able to distribute energy dissipation evenly throughout the sensors, doubling the useful system lifetime for the networks we simulated.

Fan Xiangning et al., [3] investigates LEACH protocol, and developed energy-LEACH and multihop-LEACH protocols. Energy-LEACH protocol enhances the selection method of the cluster head, enables a number of nodes which have more residual energy as cluster heads in subsequent round. Multihop-LEACH protocol enhances communication mode from single hop to multi-hop among cluster head and sink. Experimental observation reveals that energy-LEACH and multihop-LEACH protocol provides enhanced performance than LEACH protocols.

A wireless sensor network comprises of an amount of clusters of sensor nodes that can communicate with each other by means of wireless link. Each cluster is denoted by node as the head of the cluster to provide a straight communication with the base station and also with additional cluster heads. Sudakshina Dasgupta et al., [4] proposed a new approach of cluster head selection approach embedded with the conventional Fuzzy c-means algorithm with reduced distance and highest residual energy.

III. PROBLEM FORMULATION

There are two phases in categorizing clusters (a) Initial step is to create the clusters. (b) Then the subsequent step is to choose the cluster head for every cluster this paper makes use of the Fuzzy Possibilistic Clustering Algorithm (FPCM) that can efficiently choose and rotate cluster heads in the network clusters.

FPCM is a technique of clustering which permits one portion of sensor node to fit into two or more clusters. With FPCM, the centroid of a cluster is calculates as being the mean of all sensor points, weighted by their degree of correspondence to the cluster. By iteratively modifying the cluster centers and the membership grades for every sensor node is also updated. The FPCM algorithm iteratively progresses the cluster centers to the correct location within a set of nodes.

IV. METHODOLOGY

The main objective is to propose an algorithm for discovering the cluster-head which can take the task of the cluster for communication to the BS in order that the entire network will be reliable for long period of time. Initially select FPCM algorithm for achieving more consistent dense node in all cluster. By means of this approach the centroid position of every cluster is found then discover the head node of that cluster on the basis of the following (a) Smallest distance from centroid position of that cluster. (b) Highest available energy in the node. (c) Greatest acceptance across adjacent nodes of that position is determined by the distance of each to that respective node.

Fuzzy Possibilistic Clustering Algorithm

The fuzzified translation of the k-means approach is Fuzzy C-Means (FCM). FCM is a clustering approach which lets one node to communicate to two or more clusters. Dunn in 1973 proposed this approach and it was enhanced by Bezdek in 1981. This approach is an iterative clustering technique that provides a most favorable c partition by diminishing the weight inside the group sum of squared error objective function JFCM:

$$J_{FCM}(V,U,X) = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m}\, d^2(X_j, v_i), 1 < m < +\infty \quad (1)$$

In the above equation $X = \{x_1, x_2, \ldots, x_n\} \subseteq Rp$ is the corresponding nodes in the p-dimensional vector space, the amount of node is indicated as p, c denotes the amount of clusters with $2 \le c \le n-1$. $V = \{v_1, v_2, \ldots, v_c\}$ is the c centers or prototypes of the respective clusters, v_i indicates the p-dimension center of the cluster i, and $d^2(X_j, v_i)$ denotes a euclidean distance measure between object x_j and cluster centre v_i. $U = \{\mu_{ij}\}$ represents a fuzzy partition matrix with $u_{ij} = u_i(x_j)$ is the degree of membership of x_j in the ith cluster; x_j is the jth of p-dimensional measured data. The fuzzy partition matrix satisfies:

$$0 \prec \sum_{j=1}^{n} \mu_{ij} \prec n, \forall i \in \{1, \ldots, c\} \quad (2)$$

$$\sum_{i=1}^{c} \mu_{ij} = 1, \forall j \in \{1, \ldots, n\} \quad (3)$$

m is a weighting exponent constraint on each fuzzy membership and sets up the quantity of fuzziness of the resultant cluster head classification; it is a predefined number which is higher than one. Based on the constraint U the objective function $JFCM$ can be diminished. In particular, the use of JFCM in accordance with u_{ij} and v_i and zeroing them correspondingly is essential but not adequate conditions for JFCM to be at its local extrema will be as the following:

$$\mu_{ij} = \left[\sum_{k=1}^{c}\left(\frac{d(X_j v_i)}{d(X_j v_k)}\right)^{2/(m-1)}\right]^{-1}, 1 \le i \le c, 1 \le j \le n. \quad (4)$$

$$v_i = \frac{\sum_{k=1}^{n} \mu_{ik}^{m} x_k}{\sum_{k=1}^{n} \mu_{ik}^{m}}, 1 \le i \le c. \quad (5)$$

In wireless atmosphere, the memberships of FCM do not constantly communicate well to the degree of belonging of the data, and possibly will be inexact. This is primarily because the real data inevitably involves some noises. To improve this limitation of FCM, the constrained condition (1) of the fuzzy c-partition is not considered to acquire a possibilistic type of membership function and PCM for unsupervised clustering is developed. The cluster head created by the PCM belongs to a thick region in the data set; every cluster is self-sufficient of the other cluster nodes in the PCM strategy. The formulation is the objective function of the PCM.

$$J_{PCM}(V,U,X) = \sum_{i=1}^{c}\sum_{j=1}^{n} \mu_{ik}^{m}\, d^2(X_j, v_i) + \sum_{i=1}^{c} \eta_i \sum_{j=1}^{n} (1-u_{ij})^m \quad (6)$$

Where

$$\eta_i = \frac{\sum_{j=1}^{n} \mu_{ik}^{m} ||x_j - v_i||^2}{\sum_{j=1}^{n} \mu_{ij}^{m}} \quad (7)$$

η_i is the scale parameter at the ith cluster,

$$u_{ij} = \frac{1}{1 + \left[\frac{d^2(x_j, v_i)}{\eta_i}\right]^{\frac{1}{m-1}}} \quad (8)$$

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u_{ij} indicates the possibilistic typicality value of sample x_j corresponding to the cluster i. $m \in [1,\infty)$ is a weighting factor said to be the possibilistic parameter. PCM is also dependent on initialization feature of other cluster techniques. The cluster heads do not have a huge mobility in PCM approaches, as each data point is categorized as simply one cluster node at a time rather than all the clusters at the same time. As a result, an appropriate initialization is essential for the algorithms to converge to nearly global minimum.

The distinctiveness of both fuzzy and possibilistic c-means algorithm is combined. Memberships and typicalities are extremely essential parameters for the right feature of data substructure in clustering problem. As a result, an objective function in the FPCM based on both memberships and typicalities can be denoted as below:

$$J_{FPCM}(U,T,V) = \sum_{i=1}^{c}\sum_{j=1}^{n}(\mu_{ij}^{m} + t^{n})\, d^2(X_j, v_i) \tag{9}$$

with the following constraints :

$$\sum_{i=1}^{c}\mu_{ij} = 1, \forall j \in \{1,\dots,n\} \tag{10}$$

$$\sum_{j=1}^{n} t_{ij} = 1, \forall i \in \{1,\dots,c\} \tag{11}$$

A solution of the objective function can be acquired through a recursive process where the degrees of membership, typicality and the cluster head centers are update with the equations as follows.

$$\mu_{ij} = \left[\sum_{k=1}^{c}\left(\frac{d(X_j,v_i)}{d(X_j,v_k)}\right)^{2/(m-1)}\right]^{-1}, 1 \le i \le c, 1 \le j \le n. \tag{12}$$

$$t_{ij} = \left[\sum_{k=1}^{n}\left(\frac{d(X_j,v_i)}{d(X_j,v_k)}\right)^{2/(\eta-1)}\right]^{-1}, 1 \le i \le c, 1 \le j \le n. \tag{13}$$

$$v_i = \frac{\sum_{k=1}^{n}(\mu_{ik}^{m} + t_{ik}^{\eta})X_K}{\sum_{k=1}^{n}(\mu_{ik}^{m} + t_{ik}^{\eta})}, 1 \le i \le c. \tag{14}$$

This concept can be summarized by the following algorithm:
Step1: Read number of sensor nodes.
Step2: Start residual energy of every node and fix the location of the nodes.
Repeat steps 3 to 8 until the battery power of the nodes in the network gets completed.
Step3: Apply FPCM algorithm and discover the centroid position of each cluster.
Step4: Compute the euclidian distance of all nodes from the centroid position of the cluster.
Step5: Estimate the fitness of each node using fitness function.
Step6: Find out the cluster-head whose fitness value is minimum.
Step7: Permit packet transmission between the nodes in the network.
Step8: Verify the residual energy of the cluster head. If this residual energy is not less than threshold then go to step7else find the substitute head node. If there is a substitute head node found that results in steady network then continue communication else goto step3.
Step9: Stop.

V. EXPERIMENTAL RESULTS

The experiment is carried out in 300x300m^2 region with 100 sensors deployed arbitrarily inside that region that assuming that they are deployed in clusters with inter-cluster message will occur only during cluster heads of the particular clusters. The base station is located at (150,150). A node is regarded as to be a dead node if its energy level is 0 and can be put is "sleep" mode if lower than 10% of its preliminary energy is remained. The performance of Leach algorithm is analyzed with the proposed approach in terms of sensing coverage over time and amount of dead nodes in the system over time using simulation based on MATLAB. The distance (d)

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between the sensors with in a cluster using the concept of Euclidian distance. The energy used to broadcast q bit of data at a distance d for each sensor node is:

$$E_{TX}(q,d) = qE_{Elec} + q \in f_s d^2 \quad (15)$$

The energy used to collect data for each node is:

$$E_{Rx}(q) = qE_{Elec} \quad (16)$$

where E_{Elec} is electronic energy, in these experiments, each node commences with an initial energy of 0.5 joule and unrestricted amount of data can be sent to the Base station via cluster head. The following table provides the parameters for the experiment setup:

Experiment Setup	
Parameters	**Value**
Network Size	300×300
Number of Sensors	100
Base station location	(150,150)
Packet generation Rate	1 packet/sec
E_{Elec}	50 nj/bits
$\in f_s$	10 nj/bits/m^2
Initial Energy	0.5 Jules
Data packet size (nodes to cluster head)	550 bytes
Data packet size (head to base station)	600 bytes

In the 1st experiment the sensing coverage of the network is taken into account with time for the two approaches. It has been examined that proposed approach provides more sensing coverage with time in contrast to LEACH algorithm[6] and LEACH with Fuzzy logic. LEACH algorithm the cluster head must alter in every round and it does not take the remaining energy of a node as there is no idea of sleep mode here. But in the proposed approach, the cluster head will alter in the network in addition to the re-clustering of the nodes are carried out based on the energy condition of the cluster heads in the network. A node posibly moves to sleep state based on its remaining energy level preceding to its dead state and the node will still continue in the network.

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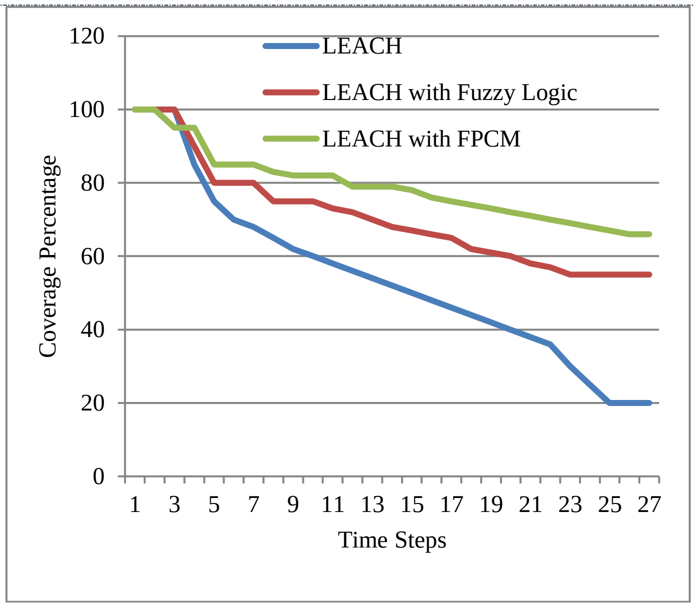

Figure 1: Sensing Coverage Over Time

Second experiment compared the quantity of dead nodes in the system with time and evaluated against the LEACH algorithm and LEACH with Fuzzy logic.

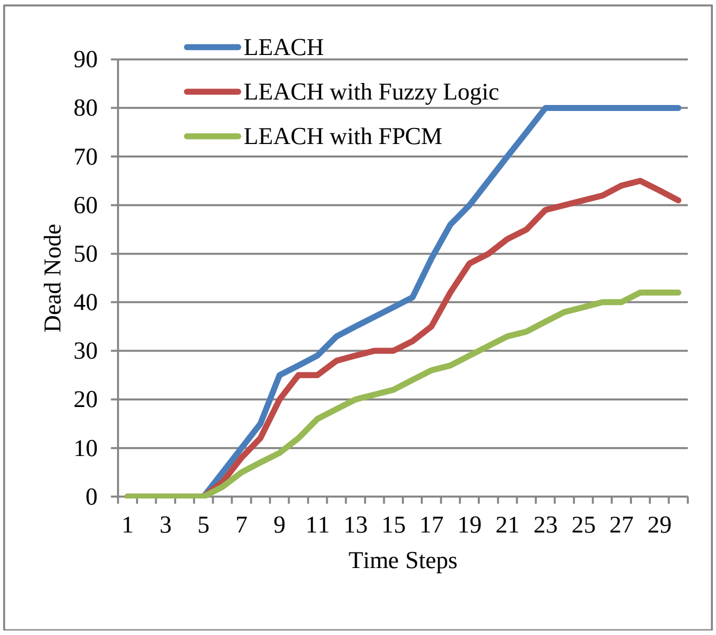

Figure 2: Number of dead nodes over time

VI. CONCLUSION

In the proposed approach, LEACH protocol is modified using the FPCM algorithm. This approach assumes that all the nodes are permanent at particular region and they are not movable. It is also assumed that the amount of clusters is predetermined and posses the equivalent initial energy. Several limitations of the LEACH protocol are overcome by the proposed approach. Since in this approach, the cluster head do not alter in every round but it alters on requirement to maintain the maximum network coverage. Two experiments were carried out to evaluate the proposed FPCM algorithm with LEACH and LEACH with FPCM algorithm. The experimental results reveal that, the proposed LEACH with FPCM provides more sensing coverage time and less number of nodes over time.

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