A Novel Energy Efficient Surveillance System with Adaptive Weighted Fuzzy C-Means Clustering based Routing for Healthcare Monitoring Applications

Alagumuthukrishnan S.[1*] and Geetha K.[2]
1. Department of Computer Science and Engineering, RVS College of Engineering and Technology, Coimbatore, INDIA
2. Department of Electronics and Communication Engineering, Karpagam College of Engineering, Coimbatore, INDIA
*alagumuthukrishnan@gmail.com

Abstract
Healthcare Monitoring system is one among the essentially utilized technologies in hospitals. It services users as caregivers to frequently observe patients in various intensive care units from one remote location. This technology might provide a supplementary layer of care that consists of software tools that aids study of patients' values, trends, vital signs, and so on. Additionally, from clinical observations, without a proper healthcare monitoring system, irregular activities in wards such as unequal walking, bed climbing, and uneven body posing can direct to serious issues, for instance, falling, care or harms. In any of these incidents occurring, the only information with the purpose of the medical staffs may be able to admission is the amount itself and possibly the degree of the incident. Surveillance systems are focused on the healthcare monitoring of the target positions through information collection and verification of the same for rendering accurate surveillance. The surveillance systems using the Wireless Sensor Networks (WSNs) yields better monitoring with hugely secured and robust communication of patients activities. Since the surveillance is more for the purpose of security, it has numerous risks involved that exert implementing the unmanned systems with WSNs particularly during military operations and health care monitoring applications. However, since most of the surveillance systems need a high level processing, the consumption of energy tends to become a critical problem. Resolution to this problem guarantees the duration of service concerned with surveillance missions. Consequently in this work, energy efficient surveillance system is introduced in order to surpass these challenges. This approach proposed carries out the routing by using the Adaptive Weighted Fuzzy C-Means Clustering Algorithm (AWFCC) based routing that is useful in the detection and tracking of the positions of mobile objects in the case of surveillance environments. The time synchronization for the GPS module for the surveillance system is used in the network initialization stage.

Also, the clustering process in the routing protocol guarantees the reduction in energy. The inter and intra cluster communication based routing is facilitated in this mechanism with the aim of minimizing the overall energy utilization thereby maximizing the network durability, confidentiality and efficiency of the surveillance procedure. The experimental results indicate that the new surveillance system with AWFCC based routing methodology yields a better performance compared to the other existing approaches.

Keywords: Surveillance System, Adaptive Weighted Fuzzy C-Means Clustering, Time Synchronization for GPS Module, Inter and Intra Clustering.

Introduction

In the recent times, a magnificent increase is seen in the usage of sensor networks for various applications especially health care and medical applications. This is probable by the diverse and distinctive features of sensors. Sensors are basically very small devices having the capability of sensing, processing and transmitting the necessary information. Wireless sensor networks are quickly developing like a basic structure to perform in distributed and wide-spread applications like domotics, environmental monitoring, habitat studies, and video-surveillance, and so on. Few of the known applications of sensor networks consists of warfare, environmental monitoring, surveillance, child education, micro –surgery, agriculture, industrial monitoring [1].Such networks generally comprise of tens to hundreds of compact-size and economic-cost nodes. Every node is fitted by means of a sensing device, which gathers information from the surroundings (for instance, vibrations, temperature, images), and transfers it to a gateway node through the network. These data are then evaluated and then the extraction of necessary info is done. Although there are several benefits rendered by wireless sensor networks, there are also several limitations and issues faced during the utilization of sensors.

Sensor networks are generally implemented in a sensing field for the collection of helpful information in medical and health care applications. Deployment is associated with the deployment of an operational sensor network in a practical-world environment. Typically the positioning of a sensor network is a work-intensive and difficult job since the real-life impacts cause bugs or reduce performance in a way that is noticed for the duration of pre-deployment. This is because of the fact that the sensor network functions have potential influence from the real world, controlling the output of the sensors [2].

Deployment of sensors in order to yield total area coverage is an additional important design challenge in several Wireless Sensor Network (WSN) applications. Normally, there are three alternate deployment techniques were introduced in the study. One is application-specific deterministic deployment, second one is random deployment and the final one is grid based (as well called pattern-based) deployment [3-4]. According to deterministic deployment, the sensor nodes will be positioned intentionally in the region needed. This kind of deployment is appropriate just for minor applications. Non-deterministic deployment [5] provides the option of scalability to extensive applications or aggressive environments. According to this deployment, the sensor nodes are put up in random to establish a WSN. On the other hand, it could become very expensive as excessive redundancy is wanted to survive the ambiguity. Grid-based deployment [6-7] is an appealing technique for medium to far-reaching coverage-oriented deployment owing to its easiness and scalability.

The chief issues that are faced are with respect to the hardware design so that resourceful communication is achieved. But the greatest and most critical problem in WSNs is the energy management [8]. A vital limitation in sensors networks is that the usage of batteries. Another restraint is that the sensors would be positioned with no supervision and in huge amounts; with the intension that it would be hard to have the batteries changed or recharged in the sensors [9-10].Hence, the whole systems, processes and communication protocols for sensors and sensor networks have to decrease the utilization of the power. The available research on energy utilization of sensors is dependent upon either hypothetical models or automated simulations. Energy is typically a non-renewable resource. Constant power supply is mandatory for the sensors to operate properly. But the magnitude of communication and the other processing necessary to be carried out by the sensors depletes the power at a significantly rapid rate [11]. In addition, it is cumbersome to get the power supply of a sensor replaced. Therefore there exists a requirement to implement methods for reducing the energy consumption in sensor networks.

In this work, the Adaptive Weighted Fuzzy C-Means Clustering (AWFCC) based routing is introduced to yield energy efficient surveillance system. The time synchronization scheme is used for the GPS module for providing suitable deployment of the nodes with awareness to energy. This mechanism enhances the network lifetime by maximizing the lifespan of the system.

The respite of this work is structured in the sections in this fashion. Section 2 discusses briefly about the related research works that are based on the proposed methodology; Section 3 gives the general idea of the proposed scheme of Adaptive Weighted Fuzzy C-Means Clustering for energy efficient surveillance system. Section 4 assesses the experimental results. At last, Section 5 provides a conclusion of this research work.

Review of Literature

Discovery and tracing of mobile objects is recognizing as a suitable application, for which the usage of WSN would be beneficial. One among the efforts in the early stage is to make use of small acoustic sensor devices for the purposes of tracing which could be seen in [12]. According to this technical work, the target is guesstimated by means of triangulation, i.e., in the sound propagation delays the comparison results are vary from source to acoustic sensors. In this research work the main concept is the sensor readings are supposed to not having the influence from the noise and this is not practicable for the real world deployments.

The lightweight multi-model detection algorithm is modeled by the researcher for the mote level micro sensors in [13]. In this instance, the modest fusion algorithms are absorbed by the researcher for instance moving averages with thresholds and it is very much beneficial for the object detection. It is making use of WSN. Nonetheless, this research work is affected by the same constraint as [12]. For designing a system that could be quickly positioned in actual environment, it is essential to have the noise and intervention accounted for, particularly when such networks can possibly be deployed in environments that are hostile. Besides the environmental noise, sensor readings are intrinsically noisy because of little form factor and unsophisticated nature of the sensors. Thus, there are more amount of application in the wireless sensor network are with low SNR.

In case of the vehicle detection, the diverse kinds of learning algorithms are utilized by Duarte et al. in [14]. The structural design of the two-level detection is proposed for increasing the trustworthiness. The k-nearest neighbor, Maximum Likelihood and support vector machine classifier are the some of the examples of target detection algorithm and it was processed at the local nodes level. After this process, the evaluation of the local nodes is delivered to the group level in which the data fusion is carried out. There are four types of data fusion algorithm is there namely Maximum A Posterior (MAP) decision fusion, Nearest Neighbor, Maximum Distance and Majority Voting. These algorithms are assessed efficiency of the new Maximum A Posterior Decision Fusion. The labor intensive activities are needed to be processed in the local nodes level such as Fast Fourier Transfer (FFT) in the proposed methodology. Therefore, this algorithm is not appropriate for the mote level sensors. The sniper localization system is implemented and deployed by Lodeczi et.al [15] dependent upon the acoustic signal processing as well as triangulation. In this case, the new digital signal processing board is modeled for the resource intensive acoustic signal processing activities. Likewise, the wireless sensor network is developed and realized it's having some sensors namely magnetic sensor, acoustic sensor, and motion sensors. This type of system is capable of categorize a moving target for instance vehicle or a walking person. In this proposed system, the motion sensor is very costly high-end micro-power impulse radar (MIR). Thus, it is not a proper selection for cost-efficient wireless sensor network systems, in which the deployment comprises of hundreds of sensors.

Several researchers have started the development of preliminary ideas on how these networks must function in addition to the suitable low-energy structural design for the sensor node itself [17], and thereby were faced with issues in sensor networks. Clare et al. designed an application-specific protocol for sensor networks, a time division multiple-access (TDMA) MAC protocol for operation in little energy condition. This technique on serves energy by means of letting the nodes to be in the sleeping state, accompanied by the radios being powered-down, for a long duration. Intanagonwiwat et al. studied about a directed diffusion protocol employing a model for achieving low-energy routing [18]. LAUCF makes use of FCM algorithm for making a novel ad-hoc cluster formation technique which is suitable for sensor network applications [19]. However several researchers have used FCM algorithm in many ways for the improvement of the network span.

Bagci et al. [20] introduced a fuzzy energy-aware unequal clustering algorithm (EAUCF) and the objective of this scheme is to reduce the intra-cluster overhead of the cluster heads, which are near to the base station or contains only less battery power. A fuzzy logic scheme is followed for handling the ambiguities in the cluster. This algorithm presented is then matched up with certain well-known clustering algorithms which are Cluster Head Election Mechanism using Fuzzy Logic (CHEF), LEACH and Energy-Efficient Unequal Clustering (EEUC).

A fuzzy based LEACH or LEACH-F was introduced by Karthikeyan et al. [21] that utilized fuzzy logic since this contains reasoning, which is an approximation in preference to being static and exact and it is not probable to get uniform cluster shape in real-world scenarios. In [22] researchers presented an evaluation amid five energy effective hierarchical routing protocol, intended from traditional LEACH protocol.

A fuzzy clustering technique was introduced by Raghuvanshi et al. [23, 27]for finding the ideal amount of clusters from the energy standpoint for positioning the nodes in WSNs and then the outcome was compared with the analytical technique. A fuzzy logic based energy-aware dynamic clustering technique was presented by Alim et al. [24] that designates the network lifespan in regard to the last node death. The researchers take two inputs into consideration in the fuzzy inference system and a node is chosen as a cluster head based on the fuzzy cost. This work does the comparison of the data transmission rate with LEACH protocol. But these approaches are not of much of a success in yielding a better performance with respect to energy consumption.

Proposed Methodology

Need for synchronization in sensor network based surveillance system: There are multiple reasons behind the focus over the synchronization issue in sensor networks. Primarily, these nodes are required to have coordination in their operations and then collaboration in order to accomplish a complicated sensing activity. Data fusion is an instance of such kind of synchronization, where the data gathered at various nodes are grouped into a significant outcome. For instance, in a vehicle tracking application, these nodes do the reporting of the location and time, for the period of which they recognize the vehicle to a sink node and this information, is combined for the estimation of the place as well as the velocity of the vehicle. Evidently, in case the sensor nodes do not have a general time scale (i.e., there is no synchronization) there will be inaccuracy in the estimate. Secondly, synchronization could be utilized by power saving methodologies for increasing the network lifespan. For instance, sensors might sleep (get into power-saving mode by powering off their sensors and/or transceivers) at suitable times, and rouse while required. While making use of power-saving modes, the nodes must sleep and get up at times those are coordinated, so that the radio receiver of a node is not powered off while there certain data is directed towards it. This needs an accurate timing amid the sensor nodes.

Scheduling techniques like TDMA could be utilized for sharing the transmission medium in the time domain, so as to reduce the transmission collisions and the energy is conserved. Therefore, synchronization becomes a vital element in transmission scheduling. Conventional synchronization mechanisms like NTP or GPS are not appropriate for the usage in sensor networks due to intricacy and energy problems, factors of cost and size. NTP is good in operation for the synchronization of the computers over the Internet, though is not developed keeping in mind the energy and computation drawbacks of sensor. A GPS device might be excessively costly to be attached on low cost sensor devices, and GPS service might not be existing in all the places, like within the buildings or underneath the water. Moreover, during accusatorial situations, the GPS signals might not be trustworthy. But inclusion of more suitable time synchronization in GPS module can help in resolving the challenges in GPS module and yields a better performance that is a justification to its costly nature. Therefore a new time synchronization approach is used in this approach proposed.

Network model: Presume a sensor field having a group of sensors that are arbitrarily deployed in a rectangular field with the GPS module for node localization. The sensing tasks and data reporting are episodic in nature in this network. The algorithm presumes the below characteristics regarding the sensor network model:

- Sensor nodes are deployed densely and are moving.
- Sensor nodes contains various abilities for sensing, processing and communication.
- Every sensor node possesses distinct ID.

- Sensor nodes transfer data to its next instant cluster head in the assigned time slots.
- The BS is static in place and positioned at a distance from the sensors.
- Every node could interact directly with the BS.
- Every nodes are energy restrained and carry out identical task.

Lightweight tree-based time synchronization for wireless sensor networks: The Lightweight Tree-based Synchronization (LTS) algorithms are introduced in order to operate with standard economical sensor nodes. This technique is focused over the minimization of overhead (energy) when being reliable and self-configuring. In specific, the method work appropriately during node failures, vigorously changing channels, and node mobility. Depending on the classification of the synchronization methods, the time synchronization is partitioned into three important components: remote clock estimation, resynchronization event detection, and clock correction.

Resynchronization event detection provides the identification of the time during which the nodes must have their clocks resynchronized. This detection could be carried in two means. The primary method is dependent on clocks that are primarily synchronized, which are resynchronized at a stable rate of kR. Here R refers to the period of a single synchronization round and k indicates a real number greater compared to one to avoid the overlap amongst the rounds. The second method for resynchronization identification depends on a particular node to transmit an initiating message to each node j in the system after the kR time is gone. When the message arrives at node j, node j then starts its own synchronization. This way, the accurateness of the synchronization relies over the message latency.

In this proposed technique, two algorithms are introduced for the multi-hop synchronization in wireless sensor networks using GPS module. The primary algorithm is typically a unified mechanism where the synchronization and episodic updates are produced from a reference node. The next mechanism is a distributed multi-hop synchronization technique in which the nodes are accountable for the initiation and accomplishment of resynchronization.

Centralized multi-hop lightweight tree-based time Synchronization: Centralized multi-hop synchronization is a direct expansion of the single-hop synchronization. The underlying principle of this method is constructing (offline or dynamic) a low-depth spanning tree T consisting of the nodes in the network. Generally, anew spanning tree is built all the time the algorithm is executed. For the purpose of synchronizing the nodes in the tree, pair-wise synchronizations are carried out alongside the edges of T. In the case of centralized multi-hop synchronization, the reference node does the initiation of the synchronization by synchronizing with every next (single-hop) children in T. Subsequently, every child of the reference node then synchronizes with their next level children. This procedure goes on till the leaf nodes of T are obtained. The algorithm ends if every leaf node is synchronized. This execution time of the algorithm is in proportion with the deepness of the tree.

Error analysis: The variance of the synchronization error sees an increase alongside every branch of the tree in the form of a linear function of the amount of hops. This is due to the fact that the errors because of the corresponding pair-wise synchronizations are autonomous and therefore additive. Just as in the discussion of pair-wise synchronization, the synchronization error amid two neighborhood nodes is a Gaussian random variable that consisting of a variance of four times the receiver variance σ. Therefore, for anode at depth d in the spanning tree, the anticipated error is zero but then again the variance of the error is 4*d* σ. The accumulation of error is largely related with the spanning tree utilized for synchronization, particularly its depth.

Spanning tree construction: The spanning tree has to be constructed in order to increase the synchronization accuracy. Therefore, an optimal spanning tree is the one, which is containing least depth. While taking the clock drift into consideration, the accurateness of synchronization suffers due to the execution time of the algorithm. For the purpose of minimizing the running time, the synchronization must happen parallel alongside every branch such that every leaf node finishes at same times. One kind of tree construction yielding both these characteristics is the breadth first search.

Breadth-first-search contains a greater communication overhead in comparison with other tree-construction techniques. The communication complexity (that is to say the amount of messages produced) of breadth first search could be reduced to 10*n*m½ where n refers to the amount of nodes and m indicates the amount of edges amongst them. It is tedious to be performed in a disseminated way. Along with breadth-first-search, there are additional tree construction techniques having suitable characteristics. Distributed depth first search (DDFS) is a computation wise efficient algorithm. Reduction in communication arises very node gives information to its adjacent while it gets visited for the initial time, beforehand it moves on to the recursive search amongst its children. This way, DDFS avoids the return calls along the non-tree edges. The communicational complexity of the algorithm sums up to 4*m (m refers to the amount of edges) and the time complexity is 4n-2.

Efficiency of multi-hop LTS: The cost involved in communication of the multi-hop synchronization technique rises from the construction of the spanning tree and then the pair-wise synchronization alongside the tree's n-1 edges. Pair-wise synchronization imposes a constant overhead of 3 messages for each edge for a sum of 3n-3 messages. The overhead for the construction of the spanning tree is dependent over the intricacy of the algorithm employed for constructing the tree. In case the DDFS is used, the overall overhead for centralized multi-hop synchronization sums to (3n-3+4*m) per network synchronization. Also, the network should be resynchronized every so often because of clock drift. Getting the minimum permissible resynchronization rate is studied in the below section.

Clock drift and resynchronization: According to the centralized multi-hop algorithm, the reference node has to do a periodic resynchronization of the network. There are two parameters are needed for the reference node for calculating a decent resynchronization interval: the immediate accurateness got from the synchronization of the whole network, and the anticipated rate of clock drift. In the case of centralized multi-hop synchronization, the deepness of the spanning tree decides the immediate accurateness of network synchronization. Every time the nodes get synchronized, the communication about the extreme deepness of the spanning tree should be done to the reference node. This, in turn, brings in the overhead of sending the depth information back along to the spanning tree while the synchronization is complete. With this extreme deepness, a solitary synchronization session can be deemed exact to inside $9.2*d*\sigma$ (where σ refers to the variance for each hop in units of time) along with 99% possibility.

Periodic resynchronization is complex since there is always a possibility for the initiation of a novel synchronization session B just beforehand the earlier session A is finished. The issue comes up as a novel spanning tree is generated for every novel synchronization session. There are chances for anode k to be matched with the novel information from session B, on the other hand at that point again resynchronized with old information from session A owing to few alterations in the construction of spanning tree. There are multiple means for solving this issue and guarantee that the information from the maximum current session is made use of. One means is to make the reference node incorporate a monotonically rising session number in the synchronization packets. Then the nodes present alongside the tree edges can leave out the synchronization packets from earlier sessions.

The centralized multi-hop synchronization technique is reliable in the sub sequent manners. Initially, though the technique has sensitivity towards letdowns in the reference node, backup or multiple reference nodes could be utilized. Secondly, with a novel spanning tree generated each time, the network gets synchronized, the method offers robustness to random channel variations, variations in topology, modifications in size, and node movement. In specific, channel properties in sensor networks with mobile nodes are supposed to be fixed corresponding to the time necessary for the synchronization of the network. The multi-hop algorithm could maintain the network in synchronized state to the desirable accurateness τ in during network variations. It is due to the fact that the reference node could compute the extreme probable tree deepness on the basis of the radio range and the network size and guarantees the updates happen sufficiently often in order to keep the accurateness.

Distributed Multi-hop light weight tree-based time synchronization: This algorithm carries out node synchronization in a distributed manner and it is not utilizing an overlay spanning tree to guide the pair-wise synchronizations. This technique transfers the accountability of synchronization from the reference node to the nodes itself. The resynchronization rate of an individual node can be decided by making use of the similar parameters which the reference node makes use in the centralized case. Hence, in order to decide their re synchronization rates, nodes would have to get the below information: the suitable accurateness τ, their distance d (in amount of hops) from a reference node, their clock drift ρ, and a record of the time, which is mean while passed they were synchronized last. A specific node j requires to resynchronize at a speed of at the smallest $(\tau - 9.2*dj*\sigma)/\rho j$. If a node j decides it should be resynchronized, j would issue a resynchronization request to the nearest reference node. For j to resynchronize, every nodes in the routing path from the reference node to j will get synchronized in a pair-wise manner.

In case it is presumed that the clock drift ρ remains a like for every nodes in the network, the nodes farthest from the reference node would possess the highest synchronization error and respectively the highest synchronization rate. Hence, the synchronization would be pushed by these edge-nodes alongside the paths, which just about seems similar to verse tree. One benefit of this technique is that some nodes might not need synchronization frequently. In case the rate of event observation of a node is considerably lesser compared to its necessary synchronization rate, it might not at all times have to be synchronized to the desired accurateness. Otherwise said, it is always superior to have the synchronization merely if the node contains a data packet to be sent. This way, the nodes can synchronize opportunistically.

If are quest for synchronization gets sent from a leaf node to the reference node, then a cycle can happen. A cycle happens if the node at the head of the synchronization chain makes a request for synchronization from a node, whose level is down lesser in the identical request chain. Cycle's happens the routing is dynamical and then a node making a request for synchronization might not have the knowledge of the whole routing path during the request. If cycles happen, they lead to deadlock, as the nodes are mutually dependent on one another for synchronization. The cycle's incidence could be reduced by sending the already well-known synchronization path from the child or the demanding node to the fresh parent node during the period of a synchronization request. Nonetheless, it is totally unlikely to ignore the cycles owing to the asynchronous and distributed characteristics of the synchronization requests. When a cycle is happened, a distributed graph-searching algorithm could be utilized for detecting it. As far as to the best of our acquaintance the searching algorithm having the lowermost complexity executes in O (2m) where m refers to the amount of edges in the sensor graph. This technique brings in a significant overhead.

Therefore an alternate technique is proposed, which doesn't depend on the detection of cycles, however it performs prevent potential cycles. The method operates as below: if a node transmits a synchronization request to one among its neighbors it actually fixes a timer relative to its distance from the reference node. In case the timer decease sprior to the arrival of a synchronization response from the adjacent, the node just initiates additional synchronization request with another neighbor. This approach doesn't avoid the cycles from happening on the other hand limits their effect with an overhead expense of extra synchronizations.

Adaptive weighted fuzzy C-means clustering (AWFCC) based routing: Clustering is known as the procedure of evaluating the associations amongst the nodes in the wireless sensor networks by grouping the sensors into many clusters with the intension that the nodes present in a cluster have more similarity compared to the nodes present in other clusters, so as to yield an energy efficient routing. There are several clustering techniques like K-means, Iterative Self-organizing Data Analysis Techniques Algorithm (ISODATA), Possibilistic C-means (PCM), Fuzzy C-means (FCM) [25], type-2 FCM [26], Fuzzy Weighted C-means (FWCM) [28], and adaptive FCM algorithms. But these approaches do not render energy resourcefulness in the clustering of wireless sensor networks. The k-means is basically a hard clustering mechanism that is sensible to the clustering centers and does not offer global optimal solution in clustering. In the same way, the result of PCM, FCM and type-2 FCM are poor clustering owing to their being non-adaptable to the number of clusters.

In this methodology proposed, the mechanism of splitting and lumping is integrated with the concept of Weighted-FCM, to design an Adaptive Weighted Fuzzy C-means Clustering Algorithm (AWFCC) for carrying out energy effective routing in wireless sensor network based surveillance systems. In this new algorithm, the minimum and maximum number of clusters and maximum number of iterations acts as the input and the adaptive clustering results is its result. The membership and the cluster heads are updated just as those utilized in the W-FCM. But, the AWFCC makes use of the splitting and merging method in the process of clustering. It decides to partition a cluster by considering the average membership of clusters, which weighs the cohesion degree; and determines to combine the clusters by the amount of nodes in both the clusters, which weigh the independency degree. Even though the initial cluster heads can be selected arbitrarily, it will affect the stability of the clustering results. Hence, a statistical technique is designed for selecting the initial cluster heads. During the start of the clustering, the range of the amount of clusters and the amount of iterations has to be provided. As the accuracy of clustering results of simple adaptive clustering algorithm is often due to the initial amount of cluster heads, AWFCC yields a statistical technique on the basis of the node density for initializing the amount of clusters and cluster heads.

At first, the number of clusters and cluster heads are initialized by making use of the statistical method. Then the membership matrix, cluster heads, weighted means, Lagrange multipliers will be computed in a sequence. At last the splitting or merging procedure is performed, then either it is break and continue the next iteration or stop the algorithm based on few applicable rules. The cluster heads are chosen depending on the weights that are again used in calculating the weighted means. The cluster heads are necessary to be chosen so as to generate accurate clusters to render routing with energy efficiency for the surveillance system. The cluster centers of every cluster can be considered to be the cluster heads that indicates that both the cluster centers and cluster heads mean the same. The nodes having high weights in every cluster are chosen to be cluster heads. The newly introduced AWFCC based routing protocol is illustrated in figure 1. The procedure of AWFCC is as below:

Step 1: The amount of clusters and cluster heads are initialized. Define the control parameters as below: the range of cluster number (c_{min}, c_{max}), the maximum number of iterations L, thecurrent number of iterations l, and the fuzzy index m. After this, initialize the number of clusters and their heads employing the statistical method

Step 2: Cluster head selection.

a) Since every node contains a distinct ID, the degree of every node is computed and the degree difference D_n gets estimated.
b) Discover the neighbors (N (n)) of every node n and n‘‘. Calculate its distance inside the transmission range and there after calculate the summation of the distances amid node n with all its neighbors S_n:

$$S_n = \sum_{n' \epsilon N(n)} \{dist(n, n')\} \tag{1}$$

c) Compute the cumulative time Tc for which a node has functioned as a cluster head and the speed of node T(n)
d) Calculate C_n the characteristics of each node n. It is computed by:

$$C_n = \frac{c * r_n}{E_n} \tag{2}$$

e) Compute the combined weight by:

$$W_n = w1 * D_n + w2 * S_n + w3 * T(n) + w4 * T_c + w5 * C_n \tag{3}$$

f) Choose the node with the maximum weight to be the cluster head.

Step 3: Compute membership matrix U

The AWFCC proposed targets at reducing the cost function.

$$J_{AWFCC} = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m} d_{ij}^{2} \quad (4)$$

$$d_{ij}^{2} = \|x_j - c_i\|^2 = (x_j - c_i)^T (x_j - c_i) \quad (5)$$

where u_{ij}refers to the membership grade showing that the j-th node belongs to the i-th cluster, $c_i$refers to the center of fuzzy cluster i, n indicates the amount of nodes, c stands for the amount of clusters, and m ∈ [1,∞] refers to a weighting exponent.

$$u_{ij} = | \frac{(d_{ij})^{-\frac{2}{m-1}}}{\sum_{k=1}^{c}(d_{kj})^{-\frac{2}{m-1}}} \quad (6)$$

Step 4: Calculate the weighted means.

In AWFCC for any c_i, the center of fuzzy cluster i, calculate the distances from the head to other nodes, S_n
In general, the nodes close toc_i belong to the identical class of c_i. The respective weights has to be large. Hence, the reciprocals of the above mentioned distances are utilized in place for weights. In case the sample x_k is near to $c_i$howeverx_k is not in class i, at that point the effect of $x_k$has to be minor. Multiplying by the membership grade u_{ik} couldhelp in resolving this issue. The weighted mean is the summation of all the weights of the nodes initialized at the cluster head selection process. Hence, the unsupervised weighted mean of $c_i$in class i is expressed by:

$$M_{ij} = \sum_{k=1,k\neq j}^{n} \frac{\|W_{n,k}\|^{-1} u_{ik}}{\sum_{t=1,t\neq j}^{n}\|W_{n,t}\|^{-1} u_{it}} x_k \quad (7)$$

Based on the analysis, it can be decided that the unsupervised weighted mean M_{ij} is nearer to $x_j$thanc_i. The cost function is re-expressed as:

$$J_{AWFCC} = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m}\|x_j - M_{ij}\|^2 \quad (8)$$

By utilizing the technique of Lagrange multipliers, a new formulation of objective function $\bar{J}_{AWFCC}$ is shown below.

$$J_{AWFCC} = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m}\|x_j - M_{ij}\|^2 + \sum_{j=1}^{n}\xi_j(\sum_{i=1}^{c} u_{ij} - 1) \quad (9)$$

Where ξj , j = 1, 2, . . . , n refer to the Lagrange multipliers for the n restraints. By discriminating$\bar{J}_{AWFCC}$regarding all of the arguments, the clustering results are received.

Step 5: Update the Lagrange multiplierξ_j

$$\xi_j = \left(\sum_{i=1}^{c}\left(\|x_j - M_{ij}\|^2 \times m\sum_{i=1}^{c} u_{ij}^{m-1}\right)^{\frac{1}{1-m}}\right)^{1-m} \quad (10)$$

Step 6: Bring up-to-date the membership grade u_{ij}

$$u_{ij} = \xi_j^{\frac{1}{m-1}}\left(\|x_j - M_{ij}\|^2 \times m\sum_{i=1}^{c} u_{ij}^{m-1}\right)^{\frac{1}{1-m}} \quad (11)$$

Step 7: Identify if it requires to merge or split

a) If$c < c_{min}$(too less clusters), go to Step 8 for splitting.
b) else if $c > c_{max}$ (too many clusters), go to Step 9 for merging.
c) else, go to Step 10.

Step 8: Splitting is to compute the average of membership of a cluster as the cluster cohesion to decide whether it is for splitting finally

$$\bar{u}_i = \frac{1}{N_i}\sum_{x_j \epsilon C} u_{ij}, \quad i = 1,2, \dots c \quad (12)$$

Step 9: Merging for every sample, find the cluster heads of its two greatest memberships, and these two memberships should not be smaller compared to threshold and is selected in accordance with the necessity of independence within clusters

Step 10: End in case the current iteration number arrives at the maximum number of iterations, i.e. l ≥ L, else go to Step 3.

Intra-cluster and Inter-cluster communication: The routing process is ensured using the intra-cluster and inter-cluster routing concept with the purpose of minimizing the energy loss. The intra-cluster routing occurs between the nodes and the cluster head of a cluster while the inter-cluster routing occurs between the cluster heads of different clusters.

.In Inter-cluster routing, if the request for inter cluster route happens; the source node forwards the inter-cluster routedem and packet to the border nodes. This method is to obtain the neighboring cluster's intra-cluster routing information. If anode (source node) in a cluster wants to interact with other node (destination node) in some other cluster, it sends the packet to the border node. The border node in turn will check whether that particular node is in its own cluster. If it is present, it will forward the packet to the target node via the shortest path. In case the node is not present in its cluster, it broadcasts the packet to its border node. This procedure is repetitive until the packet arrives at the correct target.

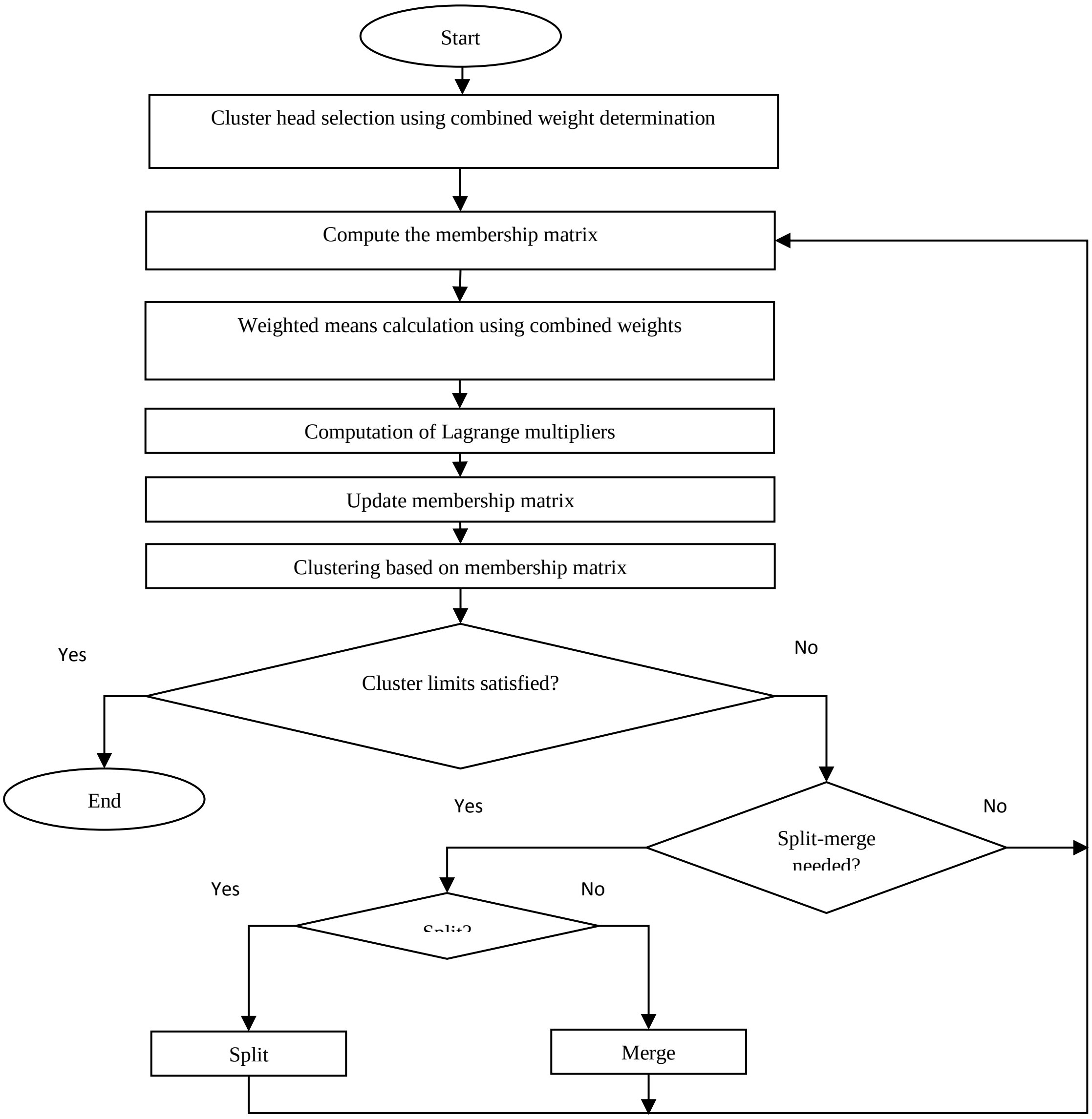

Figure 1: Adaptive weighted fuzzy C-means clustering algorithm

In intra cluster routing, the source node newscasts a route query packet to each node till the border nodes in neighboring clusters everywhere the local cluster obtain it. Each node keeps the routing information of other nodes (for next hop, instanced estimation, sequence number and the cluster id of the destination node) inside its cluster. It restricts the broad cast range inside the cluster and the subsequent hop of it to lower control overhead and to decrease interference of the shared media. If a node needs to forward packet to other node in its own cluster it can make use of the routing table and it can choose these or test path to deliver the packet. It is observed that the high energy loss is occurred during the intra-cluster communication and hence an approach of reducing the energy consumption by utilizing a command node is proposed.

1. Initialization: Command node (CN), Cluster heads (CH)
2. CH forwards every sensor nodes position, throughput, energy level, delay, SINR, packet loss ratio to CN.
3. CN constructs the routing table and forwards the routing table to CH.
4. CH forwards the subsequent info to every member nodes: back-up next-hop node, the next-hop node and status of the node with soft and hard threshold values.
5. Member sensor nodes act in keeping with the defined state and forwards data to CH dependent upon the routing table.
6. CH compress the data and forwards to the command node.

Thus, the energy utilization could be minimized in the wireless sensor network based surveillance system using the proposed AWFCC based routing protocol.

Experimental Results

The experimentations are performed in the NS-2 simulator, which was designed in C++, with Tcl-based scripting of simulation scenarios well suited for simulations for health care applications for medical data. The performance of the presented AWFCC based routing protocol is matched up with the Cluster based routing protocol, FCM based routing and W-FCM based routing protocol. The routing protocol is assessed in regard to Packet loss, Packet delivery ratio, Energy consumption and Network Lifetime.

Packet loss:

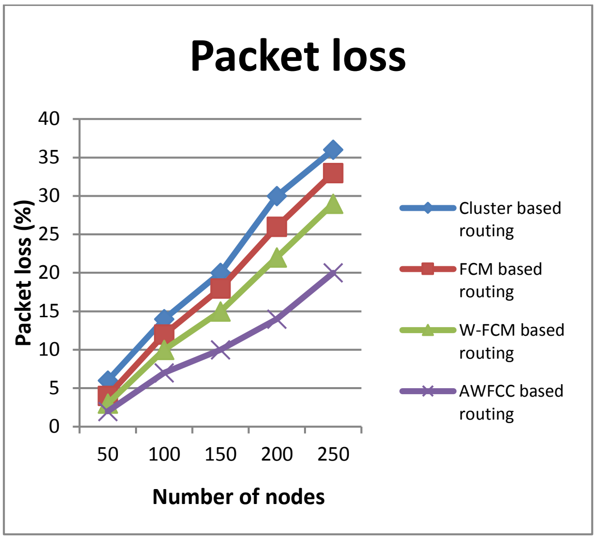

Figure 2: Packet loss Vs number of Nodes

Figure 2 shows the evaluation of the routing protocols in regard to packet loss. From the graph, it is clear that the presented AWFCC based routing protocol beats the other previous schemes with reduced packet loss. If the number of nodes is 250, the packet loss in AWFCC based routing is 20% which 9%, 13%, 16% less than W-FCM, FCM and Cluster based routing respectively.

Packet delivery ratio:

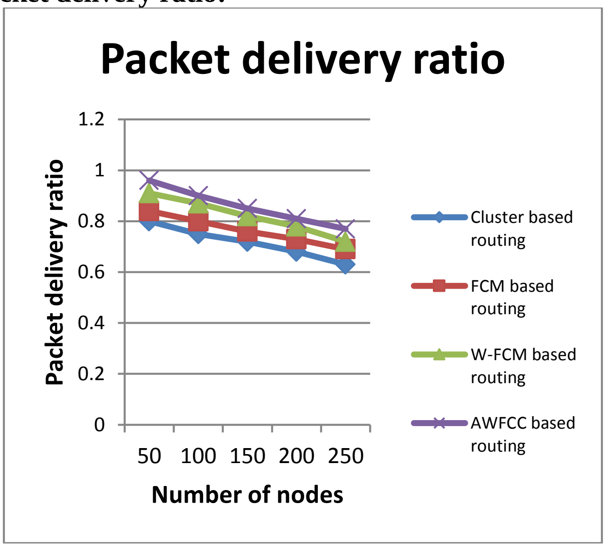

Figure 3: Packet delivery ratioVs Number of nodes

Figure 3 shows the evaluation of the routing protocols in keeping with the packet delivery ratio. When the number of nodes is 250, the packet delivery ratio in AWFCC based routing is 0.77 which 5%, 9%, 14% greater than W-FCM, FCM and Cluster based routing protocols respectively. From the graph, it is clear that the presented AWFCC based routing protocol beats the other previous schemes with high packet delivery ratio.

Energy consumption:

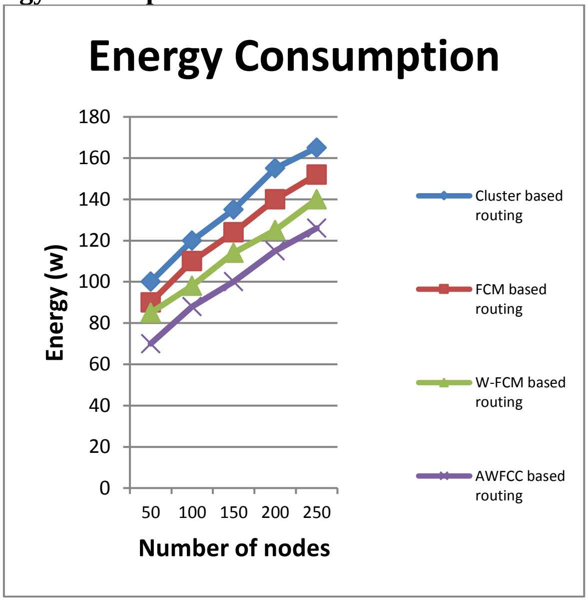

Figure 4: Energy Vs number of nodes

Figure 4 shows the evaluation of the routing protocols in keeping with the energy consumption. When the number of nodes is 250, the energy consumption is in AWFCC based routing is 126w which 10%, 17%, 23% less than W-FCM, FCM and Cluster based routing protocols respectively. From the graph, it is clear that the presented AWFCC based routing protocol works well compared to the other previous schemes with low energy consumption.

Network Lifetime:

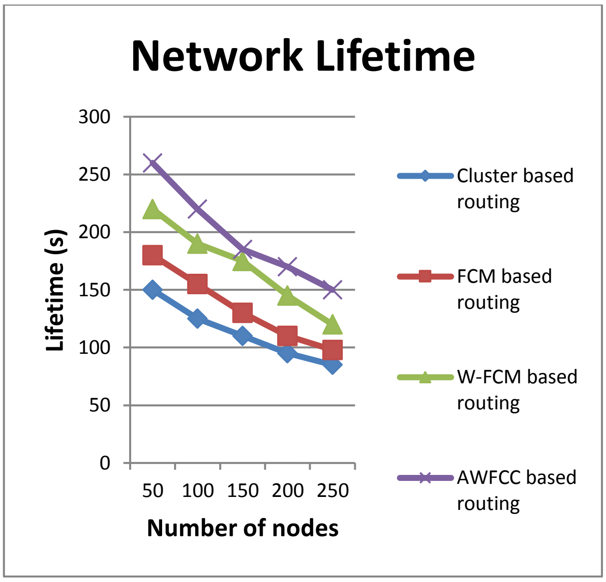

Figure 5: Lifetime Vs number of nodes

Figure 5 shows the evaluation of the routing protocols in terms of network lifetime. When the number of nodes is 250, the network lifetime is in AWFCC based routing is 150s which is better than the other protocols. From the graph, it is clear that the presented AWFCC based routing protocol performs better than the other previous schemes with increased network lifetime.

Conclusion

Patient Monitoring system is one among the major significant devices utilized in hospitals. In the recent work, there have been several works developed to monitor patients automatically by using Wireless Sensor Network (WSN) technologies. Previously, technologies in traffic surveillance system and computer vision are widely used to make health care monitoring tasks easier and more successfully. Instead of providing more attending staffs, the technologies can help in gathering information of the patients and actions for better assessments.

In this work, the Adaptive Weighted Fuzzy C-Means Clustering (AWFCC) based routing is introduced to yield energy efficient surveillance system. The routing process is ensured using the intra-cluster and inter-cluster routing concept in order to minimize the energy loss. The intra-cluster routing occurs among the nodes and the cluster head of a cluster while the inter-cluster routing occurs among the cluster heads of different clusters.

The intra-cluster and inter-cluster routing concept enhances the network lifetime by reducing the power consumption.
This protocol is energy efficient with reduced packet loss, high packet delivery ratio, low energy utilization and high network lifetime.

Thus, it could be employed for the surveillance system. In future, the location problem which is not considered for energy consumption can be investigated with optimal node deployment process.

References

1. Jiang, B., Ravindran, B., & Cho, H. (2013). Probability-based prediction and sleep scheduling for energy-efficient target tracking in sensor networks. IEEE Transactions on Mobile Computing, 12(4), 735-747.

2. Ringwald, M., &Romer, K. (2007). Deployment of sensor networks: Problems and passive inspection. In Fifth Workshop on Intelligent Solutions in Embedded Systems, pp. 179-192.

3. Xu, K., Takahara, G., &Hassanein, H. (2006). On the robustness of grid-based deployment in wireless sensor networks. In international conference on Wireless communications and mobile computing, pp. 1183-1188.

4. Biagioni, E. S., & Sasaki, G. (2003). Wireless sensor placement for reliable and efficient data collection. In 36th Annual Hawaii International Conference on System Sciences, pp. 10.

5. Howard, A., Matarić, M. J., &Sukhatme, G. S. (2002). Mobile sensor network deployment using potential fields: A distributed, scalable solution to the area coverage problem. In Distributed Autonomous Robotic Systems 5, Springer Japan, pp. 299-308.

6. Iranli, A., Maleki, M., &Pedram, M. (2005). Energy efficient strategies for deployment of a two-level wireless sensor network. In international symposium on Low power electronics and design, pp. 233-238.

7. Li, J., Bai, Y., Ji, H., Ma, J., Tian, Y., &Qian, D. (2006). Power: Planning and deployment platform for wireless sensor networks. In Fifth International Conference on Grid and Cooperative Computing Workshops, pp. 432-436.

8. Ye, M., Li, C., Chen, G., & Wu, J. (2005). EECS: an energy efficient clustering scheme in wireless sensor networks. In 24th IEEE International Conference on Performance, Computing, and Communications, pp. 535-540.

9. Younis, O., Krunz, M., &Ramasubramanian, S. (2006). Node clustering in wireless sensor networks: recent developments and deployment challenges. IEEE network, 20(3), 20-25.

10. Shah, R. C., &Rabaey, J. M. (2002). Energy aware routing for low energy ad hoc sensor networks. In Conference on Wireless Communications and Networking, 1, pp. 350-355.

11. Kamyabpour, N., & Hoang, D. B. (2010). A hierarchy energy driven architecture for wireless sensor networks. In 24th International Conference on Advanced Information Networking and Applications Workshops (WAINA), pp. 668-673.

12. Wang, Q., Chen, W. P., Zheng, R., Lee, K., &Sha, L. (2003). Acoustic target tracking using tiny wireless sensor devices. In Information Processing in Sensor Networks. Springer Berlin Heidelberg, pp. 642-657.

13. Gu, L., Jia, D., Vicaire, P., Yan, T., Luo, L., Tirumala, A., & Krogh, B. H. (2005). Lightweight detection and classification for wireless sensor networks in realistic environments. In Proceedings of the 3rd international conference on Embedded networked sensor systems, pp. 205-217.

14. Duarte, M. F., & Hu, Y. H. (2004). Vehicle classification in distributed sensor networks. Journal of Parallel and Distributed Computing, 64(7), 826-838.

15. Lédeczi, Á., Nádas, A., Völgyesi, P., Balogh, G., Kusy, B., Sallai, J., & Simon, G. (2005). Counter sniper system for urban warfare. ACM Transactions on Sensor Networks (TOSN), 1(2), 153-177.

16. He, T., Krishnamurthy, S., Stankovic, J. A., Abdelzaher, T., Luo, L., Stoleru, R. & Krogh, B. (2004). Energy-efficient surveillance system using wireless sensor networks. In Proceedings of the 2nd international conference on Mobile systems, applications, and services, pp. 270-283.

17. Pottie, G., &Kaiser, W. (2000).Wireless integrated network sensors. Communications of the ACM, 43(5), 51–58.

18. Intanagonwiwat, C., Govindan, R., &Estrin, D. (2000).Directed diffusion: A scalable and robust communication paradigm for sensor networks. In Proceedings of the fourth annual ACM international conference on mobile computing and networking (MobiCom), Boston, MA, pp. 56–67.

19. Qing, L., Zhu, Q., & Wang, M. (2006). Design of a distributed energy-efficient clustering algorithm for heterogeneous WSNs. International Journal of Computer Application, 29, 2230–2237.

20. Bagci, H., &Yazici, A. (2013). An energy aware fuzzy approach to unequal clustering in wireless sensor networks. Applied Soft Computing, 1(3), 1741–1749

21. Karthikeyan, A., Sarkar, S., Gupte, A., &Srividhya, V. (2013). Selection of cluster head using fuzzy adaptive clustering for energy optimization in wireless sensor network. Journal of Theoretical and Applied Information Technology, 53(1), 6–12.

22. Mhatre, V., & Rosenberg, C. (2004) Design guidelines for wireless sensor network: Communication, clustering and aggregation, Ad Hoc Networks, 2(1), 45–63.

23. Raghuvanshi, A. S., Tiwari, S., Tripathi, R., &Kishor, N. (2010) Optimal number of clusters in wireless sensor networks: An FCM approach. In International conference on computer & communication technology (ICCCT'10), pp. 817–823.

24. Alim, A., Wu, Y., & Wang, W. (2013) A fuzzy based clustering protocol for energy-efficient wireless sensor networks. In Proceeding of the 2nd international conference on computer science and electronics engineering (ICCSEE 2013), pp. 2874–2878.

25. Zhang, M., & Yu, J. (2004). Classification Based Fuzzy Clustering Algorithm. Journal of Software, 15, 858-868.

26. Rhee, F. C. H., & Hwang, C. (2001). A type-2 fuzzy C-means clustering algorithm. In Joint 9th International Conference IFSA World Congress and 20th NAFIPS,. 4, pp. 1926-1929.

27. Thangaraj, P & Geetha, K, (2015) FGT2- ABR: Fuzzy Game Theory Trust Associativity Based Routing to Mitigate Network Attacks in Pervasive Health Monitoring Systems, Journal Of Pure And Applied Microbiology, Volume 9, Pages 161-168.

28. Li, C. H., Huang, W. C., Kuo, B. C., & Hung, C. C. (2008). A novel fuzzy weighted c-means method for image classification. International Journal of Fuzzy Systems, 10(3), 168-173.