



## Proposing a new clustering algorithm to Reduction of Energy Consumption using Fuzzy Logic and Genetic Algorithm for Wireless Sensor Networks.

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### Abstract:

The large-scale deployment of wireless sensor networks and the need for data aggregation necessitate efficient organization of the network topology for the purpose of balancing the load and prolonging the network lifetime. Clustering is one of the important methods for prolonging the network lifetime in wireless sensor networks. It involves grouping of sensor nodes into clusters and electing cluster heads for all the clusters. Clustering has proven to be an effective approach for organizing the network into a connected hierarchy. In this paper, using fuzzy system design and system optimization by genetic algorithm and colony of ants is presented approach to select the best cluster head in sensor networks. Using design and simulation a sensor network has been addressed to evaluation the presented fuzzy system in this paper, and finally the amount of energy consumption using proposed fuzzy system in comparison with LEACH method is calculated in select the cluster head. The result of evaluations is representative of a reduction of energy consumption in the proposed method in comparison with LEACH method for select the cluster head. The reduction of energy consumption directly is effective on lifetime of wireless sensor network and can cause increase the lifetime these networks.

**Keywords:** wireless sensor networks, fuzzy logic, fuzzy system, genetic algorithm, colony of ants, energy consumption, clustering.

### 1 . Introduction

With the advent and development of microelectronic technology in 70s, were considered the new sensors. Using microelectronic technology, were produced the low-cost sensors with small dimensions and low weight. New raw materials for fabrication of the sensor is discovered, and subsequently considered the new principles for practical purposes and data collection. The integration of sensor and electronic circuitry of signal anamorphic is created significant opportunities for the majority of applications. Today, reduce the size and weight of the sensors and increases their susceptibility is the main goal of many research laboratories and different companies. The small size of sensor nodes was sense of smaller their energy productive batteries. The main reason for the emergence and development of wireless sensor networks has been applications of continuous monitoring of environments that achieve and permanent human presence in them is difficult or impossible. Applications such as monitoring the eruption of active volcano, monitoring the battlefield or sensitive regions of military and etc. As a result, generally recharging or replacing the dead nodes (disabled due to the finish of the energy source) is not possible, because as was said these nodes usually placed in the environments and hard, rough and inaccessible conditions and often become scatter randomly and appropriately in environment. Therefore, two points are important in the performance of sensor networks: one is the lifetime and another is network coverage of these networks. Since monitoring applications are typically time-consuming, it is expected that the lifetime of sensor networks to be long enough. But if we total space the network divide into virtual areas, usually in each area there are several sensor node. Thus, in case of death some of nodes a area, other nodes can be partially maintain the network coverage. But if die all nodes of placed in the area of network, virtually is impossible the area monitoring and called will disappear the network coverage. Therefore, random and scattered death of sensor nodes, is better than aggregation the dead nodes in the area. Therefore, the solution that considered for achieve to increase lifetime and maintain the network coverage in sensor networks, is reduction of energy consumption of nodes, simultaneous with energy uniform consumption in all nodes in the network.

In this paper with studies conducted for problem of cluster-head selection in wireless sensor networks and using the uncertainties in the properties of each node at different times, we have proceed for fuzzy system design[3] to select the best cluster-head in every moment. For the proposed fuzzy system design and optimization of provided fuzzy system parameters, was used algorithm the genetic optimization and colony of ants[4]. The proposed fuzzy system is evaluated on the designed data set to evaluate of energy consumption level in sensor networks and the results is calculated to determine the reduction of energy consumption in the proposed method. The obtained results of cluster-head selection in



International Journal of Management and Information Technology wireless sensor networks using proposed fuzzy system in comparison with cluster-head selection method of LEACH, is representative of the reduction of energy consumption in the proposed method of study. Reduction of energy consumption in wireless sensor networks is effective directly on the performance and the increase of longevity of networks and can be considered an important step to achieve QOS in sensor networks. In the second part of this article has been addressed to review new recent studies of carried out in the cluster-head selection for wireless sensor network and also carried out studies to design of fuzzy systems using innovative algorithms and particular the genetic algorithm. In the third part is described the fuzzy system and in part IV has been addressed to examine the data set of used in the evaluation and also analysis of the obtained results to determine the reduction of energy consumption by using the proposed fuzzy system. In the final part also has been addressed to present the conclusion and recommendation for more studies in this field of research.

## 2. Related works

For the clustering in wireless sensor networks, is presented many algorithms that below refer to some of them. LEACH algorithms[5] which is most known as the clustering algorithm, select the cluster head node by a random process. The algorithm the act fully distributed and when a node the selected as a cluster head node, all nodes with select of the closest node to the cluster head node the placement in formed clustered. In this algorithm may in a period unselected any cluster head or to be select many number of cluster head. Another problem that there are in this method is that may all the cluster head to be select in the angle of network. The most important problem of LEACH is switching overhead of clusters and energy dissipation versus other algorithms. In algorithm of LEACH-C[6]which is an improved LEACH, each node the sent the location and the amount of remaining energy to SINK then sink, nodes of the cluster head the choose by a central algorithm. Furthermore in order to better understand the proposed methods for clustering and selection of cluster head in wireless sensor networks has been addressed to classify these methods in table 1.

Table(1): the most important proposed methods for clustering and selection of cluster head in wireless sensor networks.

Year	Disadvantages	Proposed method	Method
2002	Substitution overhead of clusters and loss energy	Cluster head node the selection in form of a random process.	LEACH[6]
2002	Is very sensitive and dependent on SINK position	SINK the select to cluster head nodes by central algorithm	LEACH-C [6]
2009	Clusters are fixed and have not very application dynamic sensor networks	Divide the network into several parts with equal size and then classification these parts to clusters with different sizes	PEBECES[7]

Then, according to the concepts of artificial intelligence such as fuzzy and genetic system in proposed method, using intelligent ways has been addressed to review the most important carried out studies for clustering and selection of cluster head in wireless sensor networks. For example, shiyuan jin using genetic algorithm, dynamically select the clusters and cluster heads, but in this method, fitness function only is considered the distance between the nodes and cluster head number and regardless of the remaining. But since the cluster heads the consumption the amount of more energy than conventional nodes, so one of the main parameters for the selection of the cluster heads is the amount of energy remaining of sensors. In table(2) using the concepts of artificial intelligence has been addressed to the most important proposed methods for clustering and selection of cluster head in wireless sensor networks and disadvantages of each of these methods are also investigated.

Table (2) : the most important proposed methods for clustering and selection of cluster head in wireless sensor networks using the concepts of artificial intelligence.

Year	disadvantages	Proposed method	Method
2008	Only is considered distance between nodes and number of cluster head and regardless of residual	Using genetic algorithm, clusters and cluster heads the select to dynamically	Shiyuan Jin[9]
2005	In each period be select only a cluster head	Is used fuzzy logic for find cluster heads	Gupta [10]
2002	The creation of the less number of cluster	LCA the select a node as cluster head that have more characteristic than neighbor	LCA[11]

Fuzzy logic is presented for the first time in 1965 by professor Zade and so far have been great advances[12]. Of the most important studies carried out for fuzzy logic can refer to present of fuzzy system by Mamdani and sugeno[13]. In order to design the optimal fuzzy system also was carried out studies among [14] and [15], that in each of them using innovative

### 3. Presentation of the proposed method

In this section, by review of proposed methods to discuss challenges in this study and with the use of fuzzy system we have to choose the best node of cluster head in sensor network.

In 1-3 and 2-3 sections due to the use of fuzzy logic and genetic algorithm, in proposed method of paper has been addressed to study the basic concepts. In section 3-3, using LEACH algorithm has been addressed to examine of how to choose the cluster head in sensor networks, and in section 4-3 has been addressed to description of the proposed method to reduction the energy consumption in wireless sensor networks.

#### 1-3 fuzzy logic

Uncertainty has been always one of the challenges of very important in different science. In recent years, researchers using study and recognition of uncertainty, the provide methods and models for the implementation of uncertainty in engineering sciences that result of them is offer of concepts such as fuzzy logic. Including the most modern advances in engineering systems is presentation and implementation of fuzzy system for control process. In fuzzy system that with two types of Mamdani and sugeno[13], using the concepts of fuzzy Logic, fuzzy inference, absolute numbers and fuzzy set to study the environment and uncertain decision, we have to make decision to solve problems[16.] In figure 2, has been addressed to examine the most important components in design the fuzzy system of sugeno that used in this study[17].

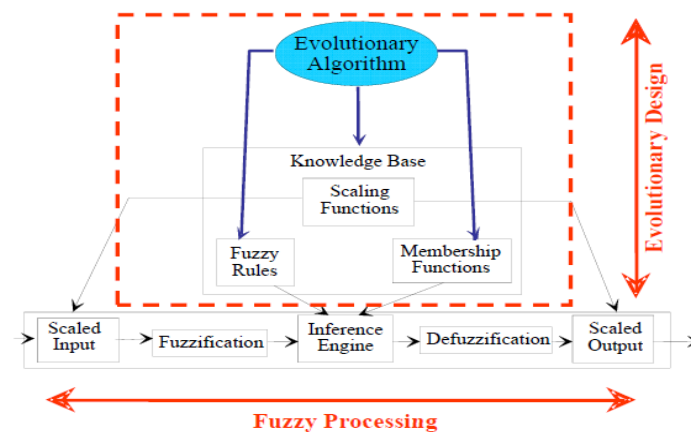


Figure2: study of most important components in design the fuzzy system of sugeno.

The most important components used in the fuzzy system, is part of the knowledge base, that using fuzzy rules and fuzzy logic to determine for fuzzy decision-making.

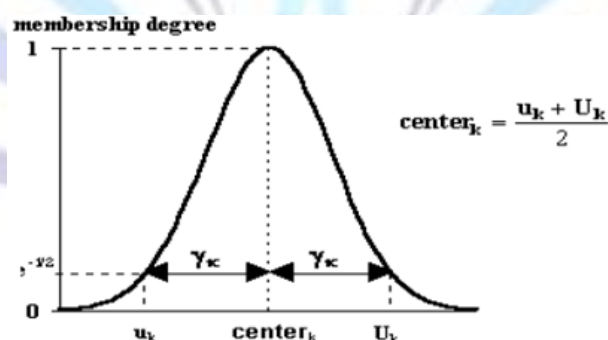


Figure (3): membership degree in fuzzy function of bell-shaped.

As indicated in figure 2, for design a fuzzy system is require to several parameters including optimal rules. For design the optimal parameters in design the fuzzy system, is presented different methods that in this study is used the genetic algorithm for determine of optimal rules and of colony algorithm of ants for determine of optimal membership functions.

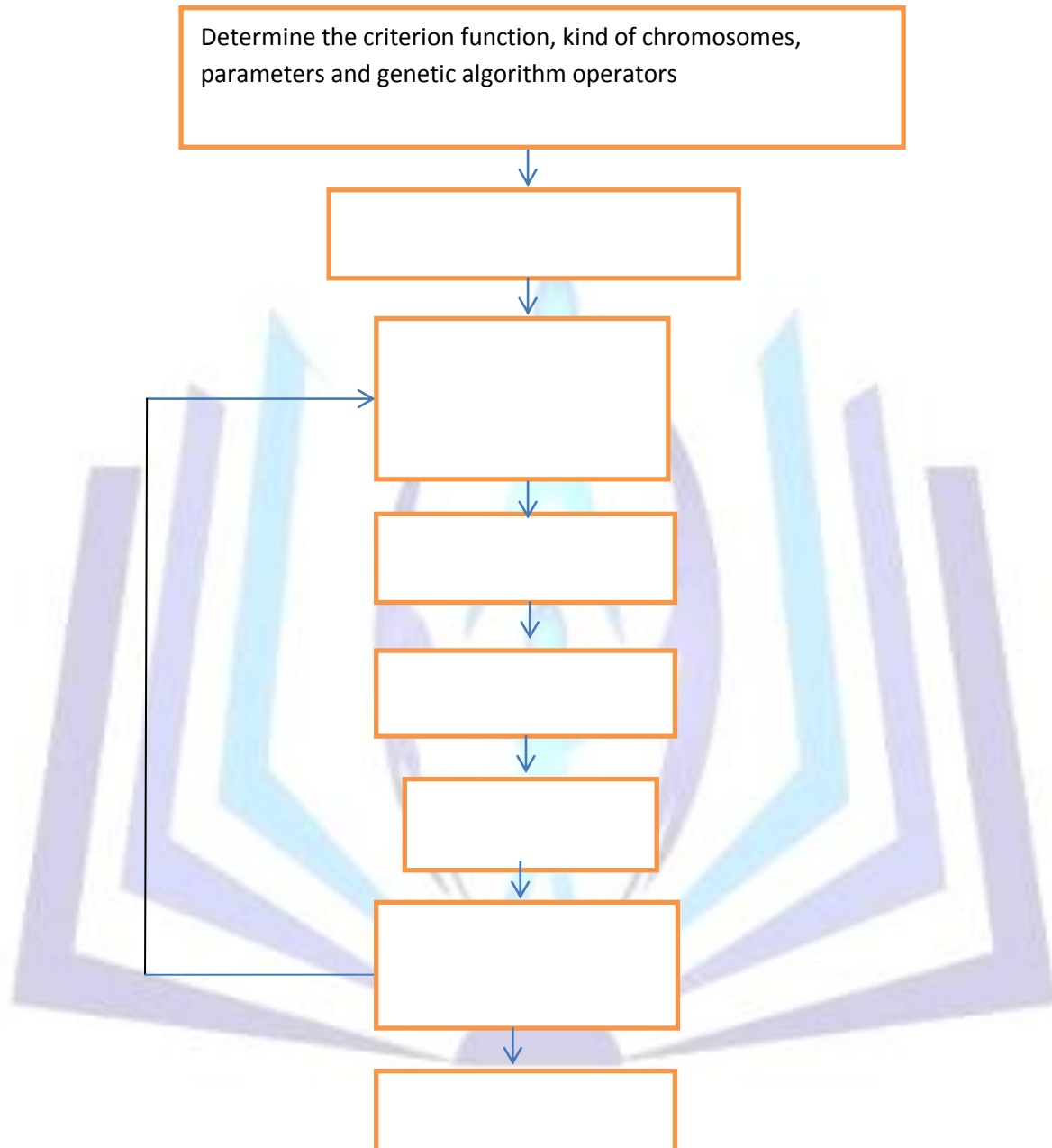
In next section has been addressed to a short presentation of the basic concepts of these algorithms.

#### 2-3. Algorithm thegenetic and colony of ants

In recent years, researchers are tried to use the concepts of nature in solving various problems. Including the concepts of under study in nature that is now widely used in computer systems also may be referred to a genetic algorithm [4]. In the

International Journal of Management and Information Technology genetic algorithm using the concepts of reproduction, gene and chromosome, has been addressed to decision-making or optimization to problems in engineering science. To implement the genetic algorithm in digital systems is conducted the extensive studies and have been proposed various models. In figure 4, have been mentioned to study the general structure to implement the genetic algorithm in computer systems in previous studies[19].

Figure 4: flowchart the method of write down the genetic algorithm for the use in computer systems.

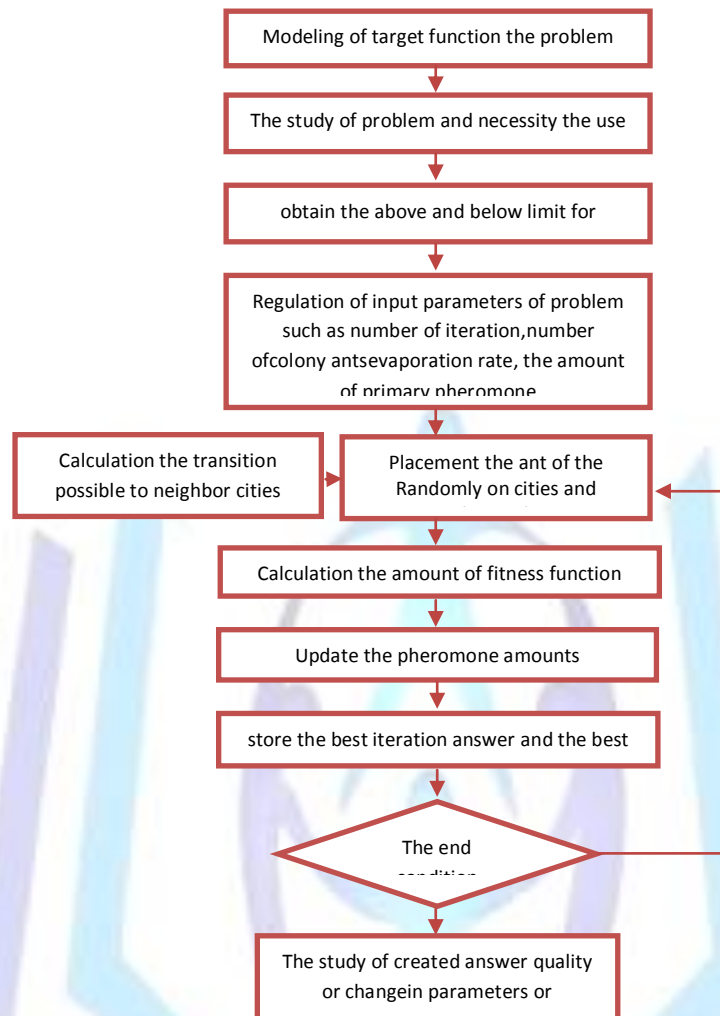


As in figure 4 is observable, for the use of genetic algorithm must be selection the parameters of such as cost function, that these parameters are design according to the problem definition and problem application. Colony optimization the colony of ants is a population-based search method that is inspired by the behavior of real ants. This method the first time is proposed on 1992 for solving TSP problem by Dr. Doigo[20]. Certain insects that live that in colonies, such as ants, termites and bees using simple rules such as touch, sound and sense of certain materials are able to solving complex problems in their daily life. These specific behaviors that occurs in a particular group of insects called swarm intelligence[20]. Different species of ants are given the ability that dispread the pheromone(a chemical substance that ants feel it) on their way.

In figure(5) using optimization algorithm of ants has been addressed to review the steps needed to solve the different problems [20]. Figure



5: flowchart the use of optimization algorithm the colony of ants.



According to the presented concepts in this section and the previous section, then using genetic algorithm and colony of ants has been addressed to describe the selection algorithm the standard LEACH cluster head and how proposed fuzzy system design and optimization of rules and membership functions of fuzzy system.

### 3-3. cluster head selection algorithm of LEACH

Clustering hierarchy protocol of adaptive with low energy is first and most well-known protocol based on clustering in wireless sensor networks, in which occur the creation of clusters in the form of distributed. The most important purpose of LEACH is have a local base stations (cluster head) for reduction the energy consumption result of data transmission to a remote base station. LEACH the chosen a small sensor node randomly as cluster head and organization the local nodes as local clusters. Assign of nodes to respective cluster head is done based on proximity(distance). Non-cluster head nodes(also called normal nodes), transfer the data to cluster head. Therefore, the only overhead that there are for them, is intra-cluster communication. Cluster head nodes than normal nodes the need to more energy. Therefore selection of fixed cluster head nodes lead to early energy discharge and their premature death. The balance of energy of cluster heads with periodic rotation the role of the cluster head is established between the different nodes. Also, the use of data collection or composition in the cluster heads, lead to reduction the message transfer to the base station and resulting in energy storage. LEACH protocol operation is divided into several rounds. Each round begin with installation stage(cluster form), where clusters are organize. Following the installation stage, there is data transfer stage in which normal nodes, send the data to the cluster heads and cluster heads after data collection or composition process, transfer the integrated packing into the base station until reduce the amount of data that must send to base station. In LEACH, timing of sensor data transmission is performed by protocol of code Division Multiple Access(CDMA) or time division multiple Access(TDMA). Select the cluster head is done through a probability function. Each node the select a random number between zero and one, and if the selected number is less than  $T(n)$ , that node is selected as current round cluster head(5).

$$T(n) = \begin{cases} \frac{P}{1 - P \left( r \bmod \frac{1}{P} \right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

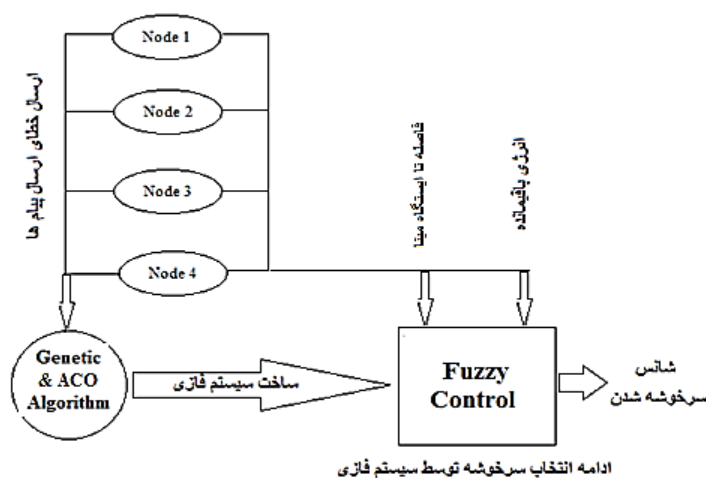
Formula1:

P is the probability of the cluster head, r is the current round number and G is set of nodes of that in current round 1/p were not a cluster head. Based on simulation model, has been shown that only five percent of the clusters are require to getting cluster head. The strength point of LEACH is in the rotation mechanism the role of the cluster heads and data collection also extend the lifetime of the network.

### 4-3 . Describe and simulation of the proposed method

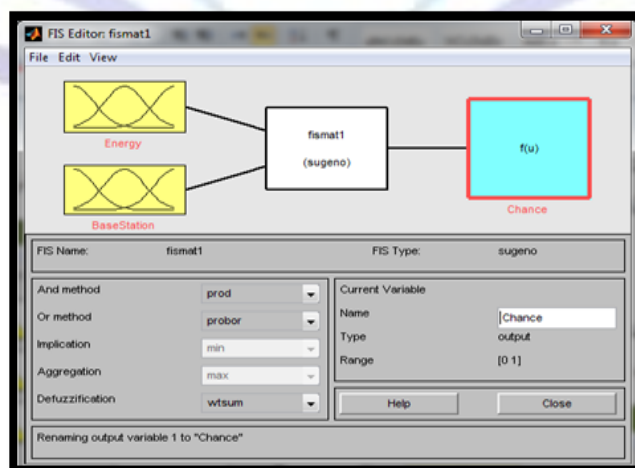
In this section to better understand the proposed fuzzy system, the overview of the presented system is presented I this paper in order to reduction of energy consumption in wireless sensor networks that in the view has been referred to several cases including the input and output number are visible in figure (6).

Figure(6): the overview of the presented system in this paper in order to reduction of energy consumption in wireless sensor networks.



As can be seen the figure above, characteristics of each sensor nodes, characteristics of the residual energy and the distance to the base station that is referred in this paper, will be sent to this system as an input the proposed fuzzy system and proposed fuzzy system also using rules and fuzzy membership functions that is extracted by algorithms of genetic optimization and colony of ants, respectively and on the basis of characteristics from other lines, choose the best cluster heads in sensor networks and the best cluster heads will display as system output. Then and in figure (7) overview of the proposed fuzzy system for selection the cluster heads is visible in sensor networks that is simulated in MATLAB software.

Figure(7): the overview of the proposed fuzzy system for selection the cluster heads in sensor networks.



Finally for better understanding, a summary of the parameters used in used genetic algorithm, is presented in table3.

Table3: The most important parameters used in the genetic algorithm to optimize of proposed fuzzy system rules.

Mutation	Population size	Selection	Crossover fraction	Elite count	Generations	Fitness
gaussian(0.1,0.1)	25	stochastic uniform	8	2	25	SE

After the fuzzy system rules be optimization, rules designed in the inference engine of proposed fuzzy system will be used for selection of the of best cluster head in sensor networks, that in figure 9 designed inference engine is visible for proposed fuzzy system.

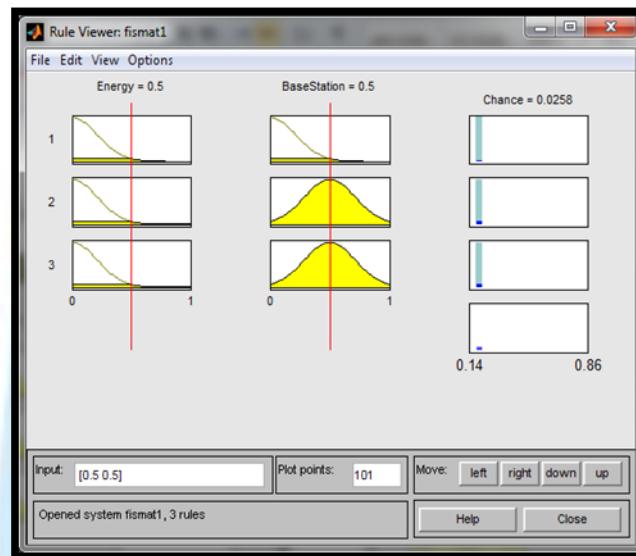


Figure8: The designed inference engine for proposed fuzzy system.

In figure 9 has been addressed to examine how to reduce the error rate in the rules used in the proposed fuzzy system that are designed by the genetic algorithm.

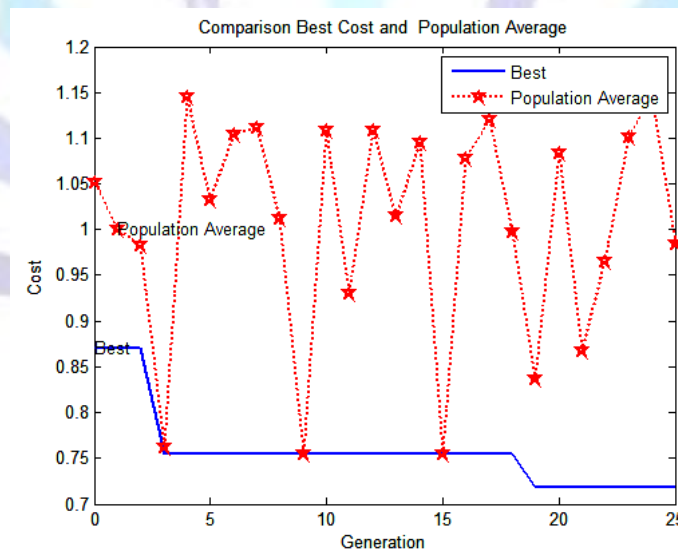


Figure10: the reduction the error rate in different generations used in the genetic algorithm.

In this example using production of 25 generations we have been able to the nearest value to zero the error rate in proposed fuzzy system rules for selection of the best cluster head in wireless sensor networks. The reduce the error rate in the selection of the best cluster head in wireless sensor networks will be lead to reduction the energy consumption in a time period and less energy in sensor networks is to sense of extend the lifetime of this type of network. In the next section to evaluate the proposed method in this paper has been addressed to present used data set in the evaluation and as well as the presentation and analysis of the evaluation results for reduction of energy consumption in sensor networks.



## 4 . Evaluation of proposed method

In this section, has been addressed to determine and evaluation of proposed method to reduction of energy consumption in sensor networks.

In section 1-4 is presented used data set in the evaluation of research, in section 2-4 has been addressed to describe the evaluation method and finally section 3-4 is presented analysis of evaluation results.

### 4-1 . Data set of evaluation

As also mentioned in the previous section, in order to evaluate the proposed method of this research, we have proceed to design and present a wireless sensor network with certain circumstances, that in this section for more transparency is presented all the used assumptions in designed wireless sensor network. In table(4) used parameters in the evaluation this study is presented for designed wireless sensor network.

Table(4): parameters of designed sensor network for evaluation the proposed method.

Network Size	4*4
Number of Node	16
Packet Size	5 Byte
Necessary energy of sender for a byte forwarding(ETX)	5J
Necessary energy of receiver for a byte receipt(ERX)	5J
Necessary energy of for data combination and integration(EDA)	50 J

Among the most important assumptions of intended to evaluate the proposed method in this research as well as designed wireless sensor networks can refer to the following cases:

1. In designed wireless sensor networks, the number of network clusters is fixed.
2. The number of nodes in each cluster is 4 nodes.
3. In each round only 4 nodes can be chosen as cluster head.
4. Primary energy of nodes is different.
5. Instead of sending package by each cluster head to the base station and instead of each meter the distance to the base station will 5J energy.

As mentioned in the previous sections, designed sensor networks in order study and evaluation in this research is with 16 nodes and each of these nodes must be available 2 parameters of residual energy and the distance to the base station. In the table(5) these of residual energy and the distance to the base station. In the table(5) these cases is presented as preliminary data in the evaluation of this paper.

Table (5): set of primary data the research evaluation including characteristics of designed wireless sensor network nodes for research evaluation.

Sensor node	Remaining energy(j)	Distance to base station(m)
N1	150	2
N2	175	7
N3	198	8
N4	225	11
N5	300	4
N6	552	12
N7	111	17
N8	228	20
N9	415	5
N10	378	1





N11	458	3
N12	336	9
N13	198	16
N14	200	5
N15	328	4
N16	199	17

Then, in the next sections using the data in the above table we have proceed to calculate the best cluster head in the proposed method and standard LEATCH and listed items is presented for evaluation analysis.

#### 4-2 . Describe the method and evaluation results

To evaluation the proposed method in this paper, at first, is designed and presented an example of wireless sensor networks that assumptions taken into account in designed example is presented in the previous section and then, at first using proposed method has been addressed to selection the cluster head in designed wireless sensor network and this action is also done using standard LEATCH algorithm and because comparison with proposed method. After performing the calculations needed to calculate the cluster head in listed methods according to the residual energy and distance the base station in each of the wireless sensor network nodes, in continuation the different periods until the end of the lifetime of the designed wireless sensor network in listed methods we have proceed to selection the cluster head and determine the amount of residual energy in each method after the end of each round of implementation the methods as well as the number of living nodes and amount of energy consumption each round.

As will be seen in the next section, in which it was conducted the evaluation of this article is seven rounds and after the end of seven rounds, obtained results of evaluation analysis is representative of reduction of energy consumption in different periods of implementation of this methodology in comparison with standard LEATCH algorithm to selection the cluster heads. After the implementation of the proposed method for designed wireless sensor networks to evaluation, is calculated the level of energy consumption in each periods of the implementation of the proposed method, in LEATCH algorithm and in proposed fuzzy system. In table(6) is presented the level of energy consumption in 16 nodes of designed example in proposed method.

Table (6): The level of energy consumption in different periods of proposed algorithm.

Sensor	Primary	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
N1	150	15	Death	Death	Death	Death	death	Death
N2	175	150	125	100	75	Death	Death	Death
N3	198	173	148	123	98	73	Death	Death
N4	225	200	175	150	125	100	Death	Death
N5	300	155	130	105	Death	Death	Death	Death
N6	552	527	502	477	292	132	Death	Death
N7	111	86	61	36	11	Death	Death	Death
N8	228	203	178	153	128	103	78	Death
N9	415	390	240	90	65	Death	Death	Death
N10	378	248	118	Death	Death	Death	Death	Death
N11	458	318	178	38	13	Death	Death	Death
N12	336	311	286	261	116	Death	Death	Death
N13	198	173	148	123	98	73	48	Death
N14	200	175	150	125	100	25	Death	Death
N15	328	303	278	133	Death	Death	Death	Death
N16	199	174	29	4	Death	Death	Death	Death



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Neighbors of selected clusters by proposed method in each presented period in the above table also for learn how to selection the clusters is presented in table(7).

Table(7): selected cluster heads in proposed method for designed example in research evaluation.

First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
N1	N9	N9	N5	N6	N2	N8
N5	N10	N10	N6	N9	N3	N13
N	N11	N11	N12	N12	N4	NULL
N11	N15	N15	N15	N14	N6	NULL

As can be seen from the above table, in selection the cluster in proposed method, more the selected nodes as cluster head in comparison with their remaining energy from distance each node to the base station has been the more amount the energy. Also, for selection the cluster heads in each round by proposed method, in the end of each round the check the chance all nodes and 4 nodes that has a better chance the select as a candidate node to getting cluster head in designed example and after the end of seven rounds, the lifetime of the designed network in table(8) is presented the chance each node in different periods to getting cluster head in proposed method.

Table(8): The level of chance the getting cluster head in nodes of presented sensor network for evaluation in periods of implementation to proposed method.

Sensor	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seven round
N1	75	7.5	Death	Death	Death	Death	Death
N2	25	21.4	17.8	14.2	10.7	7.14	Death
N3	24.7	21.6	18.5	15.3	12.25	9.12	Death
N4	20.4	18.18	15.9	13.6	11.36	9.09	Death
N5	75	38.7	32.5	26.2	Death	Death	Death
N6	46	43.9	41.8	39.7	24.33	11	Death
N7	6.52	5.05	3.58	2.11	0.64	Death	Death
N8	11.4	10.15	8.9	7.65	6.4	5.15	Death
N9	83	78	48	18	13	Death	Death
N10	378	248	118	Death	Death	Death	Death
N11	152.6	106	59.3	12.6	4.33	Death	Death
N12	37.3	34.5	31.7	29	12.8	Death	Death
N13	12.3	10.8	9.25	7.68	6.12	4.56	3
N14	40	35	30	25	20	5	Death
N15	82	75.7	69.5	33.25	Death	Death	Death
N16	11.7	10.2	1.7	0.23	Death	Death	Death

Another data set that is require in calculation the residual energy each node in each round is number the living comparisoneach node in designed sensor network that at the end of each round must be available the number of living neighbors each node to calculate the amount of require energy the cluster head in data forwarding. Listed items for the number neighbors of each node in different periods of implementation with proposed method is presented in table(9).



Table (9) :The number of neighbors of each node of designed sensor network in different periods of implementation

with proposed method.

Sensor	primary	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
N1	3	3	Death	Death	Death	Death	Death	Death
N2	3	3	2	2	2	2	Death	Death
N3	3	3	2	2	2	2	Death	Death
N4	3	3	2	2	2	2	Death	Death
N5	3	3	3	3	2	Death	Death	Death
N6	3	3	3	3	2	1	Death	Death
N7	3	3	3	3	2	1	Death	Death
N8	3	3	3	3	2	1	0	Death
N9	3	3	3	2	2	Death	Death	Death
N10	3	3	3	2	2	Death	Death	Death
N11	3	3	3	2	2	Death	Death	Death
N12	3	3	3	2	2	Death	Death	Death
N13	3	3	3	3	1	1	0	Death
N14	3	3	3	3	1	1	Death	Death
N15	3	3	3	3	Death	Death	Death	Death
N16	3	3	3	3	Death	Death	Death	Death

As can be seen in the above table by implementation of different the proposed method, a series of nodes with energy loss and consequently lead to node death and therewith will be low the number of neighbors of adjacent nodes to the number of ninety one. After wards that amount of used energy each of 16 nodes in designed example was calculated by proposed method, for compare the proposed method of LEATCH algorithm is require that all calculated items for proposed method that was calculated in the previous section also be calculate for standard LEATCH algorithm. In table (10) is above the amount of energy consumption in different periods the implementation of standard LEATCH algorithm on wireless sensor networks.

Table (10): The amount of energy consumption in each of periods the implementation of standard LEATCH algorithm for example the designed wireless sensor networks in evaluation.

Sensor	primary	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
N1	150	125	100	75	50	25	Death	Death
N2	175	150	125	100	75	50	25	Death
N3	198	33	8	Death	Death	Death	Death	Death
N4	225	200	20	Death	Death	Death	Death	Death
N5	300	275	250	225	130	105	10	Death
N6	552	367	342	317	182	47	22	Death
N7	111	86	61	Death	Death	Death	Death	Death
N8	228	203	Death	Death	Death	Death	Death	Death
N9	415	265	240	215	70	45	20	Death
N10	378	353	228	203	178	48	Death	Death
N11	458	433	408	268	128	Death	Death	Death



N12	336	311	142	136	111	86	Death	Death
N13	198	73	48	23	Death	Death	Death	Death
N14	200	50	25	Death	Death	Death	Death	Death
N15	328	303	278	158	133	63	Death	Death
N16	199	174	Death	Death	Death	Death	Death	Death

Nodes of that in each of periods the implementation of standard LEATCH algorithm for designed example were selected as cluster head also been presented in table(11) for use in the next calculations.

Table(11): the selected nodes as cluster head in each of periods the implementation of standard LEATCH algorithm for designed example in research evaluation.

First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
N3	N4	N3	N5	N6	N5	N2
N6	N8	N7	N6	N10	N10	N5
N9	N12	N11	N9	N11	N12	N6
N14	N13	N15	N11	N15	N15	N9

Similar the proposed method to the standard LEATCH algorithm for calculating the amount of energy in each round of implementation the algorithm is necessary that be available number of living neighbors each member of designed network. In table (12) is presented the number of neighbors in the standard LEATCH method.

Table (12): The number of neighbors each of node designed sensor network in different periods the standard LEATCH algorithm.

sensor	primary	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
N1	3	3	3	1	1	1	Death	Death
N2	3	3	3	1	1	1	0	Death
N3	3	3	3	Death	Death	Death	Death	Death
N4	3	3	3	Death	Death	Death	Death	Death
N5	3	3	2	1	1	1	1	Death
N6	3	3	2	1	1	1	1	Death
N7	3	3	2	Death	Death	Death	Death	Death
N8	3	3	2	Death	Death	Death	Death	Death
N9	3	3	3	3	3	2	0	Death
N10	3	3	3	3	3	2	Death	Death
N11	3	3	3	3	3	2	Death	Death
N12	3	3	3	3	3	2	Death	Death
N13	3	3	2	1	Death	Death	Death	Death
N14	3	3	2	Death	Death	Death	Death	Death
N15	3	3	2	1	0	0	Death	Death
N16	3	3	Death	Death	Death	Death	Death	Death

As can be seen in the above table, with the implementation of different and depending on the number of nodes, number of neighbors and each of nodes is low in designed example in wireless sensor network. In the next section using presented table in this section, we will continue to evaluation analysis the obtained results and reduction the energy consumption in proposed method this research in comparison with selection procedure the standard LEATCH cluster head will be calculation and will be present in the form of different diagrams and tables.



### 4-3 . Analysis of results

After the implementation of proposed method and the standard LEATCH algorithm on designed sensor network for research evaluation and specify the cluster heads and implementation round and selection the head in listed methods and was calculated the energy consumption by each node in each round of implementation of algorithm, in this section. At first has been addressed to study the number of living nodes in each round of implementation of the proposed algorithm in comparison with standard LEATCH. In table (13) and diagram (1), the number of living nodes are visible.

Table (13) : the number of living nodes in each round of implementation of the standard LEATCH algorithm in comparison with proposed method for designed example in research evaluation.

method	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
Proposed method	16	15	14	11	7	2	0
LEATCH method	16	11	10	9	8	4	0

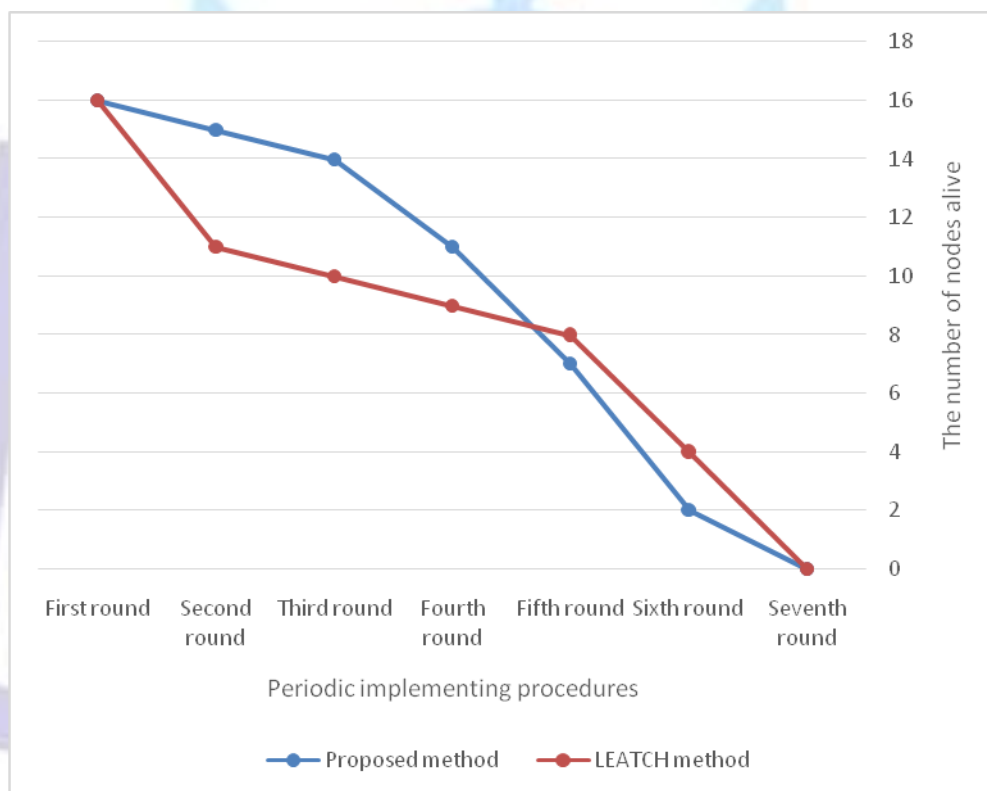


Diagram (1): the number of living nodes in each round of implementation of the standard LEATCH algorithm in comparison with proposed method for designed example in research evaluation.

As is indicated in the above table and diagram is visible, in all rounds of implementation of the proposed method the except the sixth round, is more the number of living nodes in proposed method in comparison with standard LEATCH method, that is meaning of optimal distribution the cluster heads in between network and is caused due to high energy consumption by cluster heads, less nodes likely to die and we have more living nodes in each round of implementation of the proposed method.

Another criteria used in this study for analysis the evaluation results is criteria the energy consumption in each round by LEATCH algorithm in comparison with proposed method, In table (14) and diagram (2), level the energy consumption in different periods is presented by listed method.

Table (14) : the amount of energy consumption in each round of implementation of the standard TEATCH algorithm in comparison with method for designed example in research evaluation.

method	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
Proposed method	850	855	825	797	562	430	126
LEATCH method	1050	1127	557	663	588	392	77

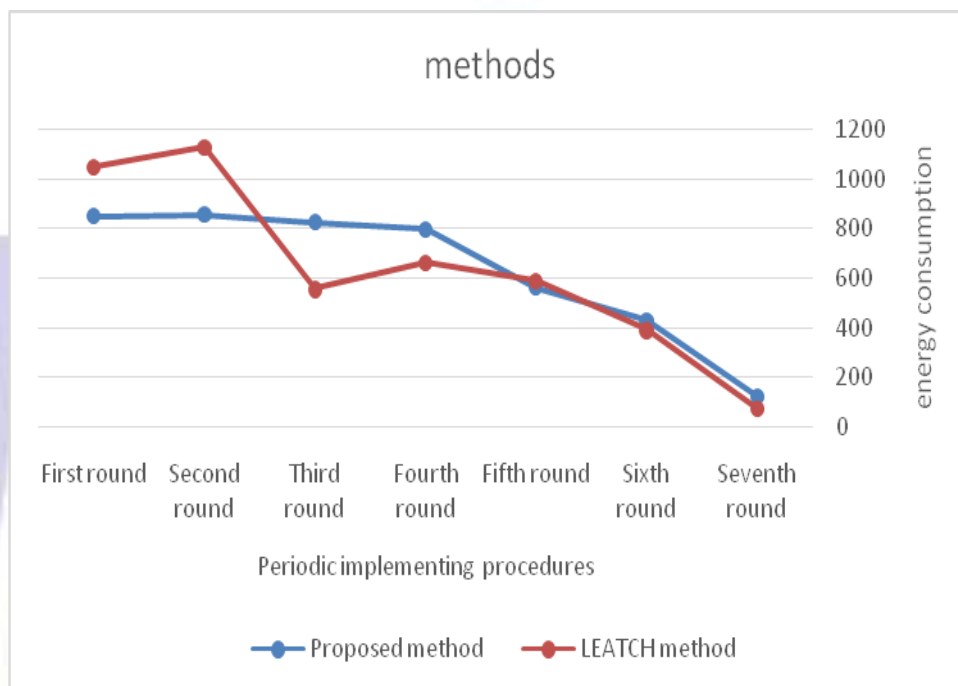
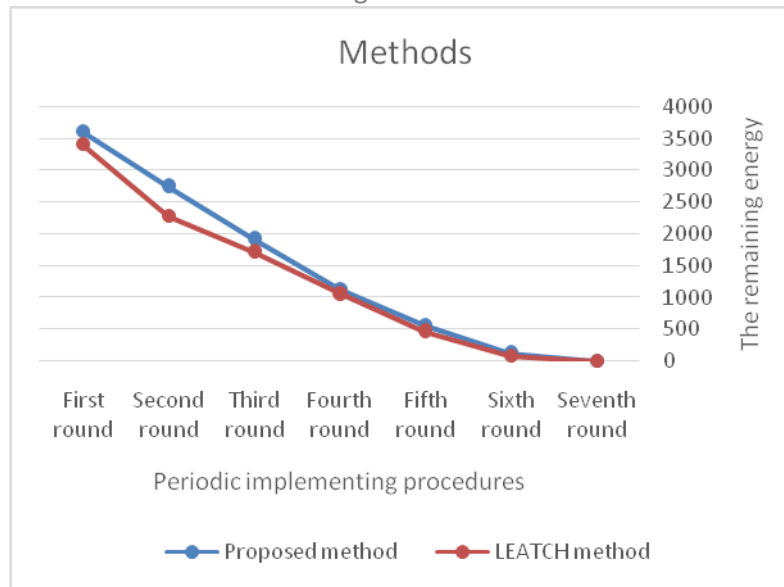


Diagram (2) : the amount of remaining energy in each round of implementation of the standard LEATCH algorithm in comparison with proposed method for designed example research evaluation.

As can be seen in the above table, in all periods of implementation of the algorithm except in the sixth and seventh period, the amount of energy consumption in proposed method is less than the standard LEATCH algorithm, that low energy consumption can cause network lifetime and ultimately prove the reduction of energy consumption of the proposed method in selection the cluster head in comparison with standard LEATCH algorithm, Then, for the final analysis at the end of each round we have proceed to calculate the amount of remaining energy for total wireless sensor network in evaluation, that obtained results is presented in table (15) and diagram (3).

Table (15) : the amount of remaining energy in each round of implementation of the standard LEATCH algorithm in comparison with proposed method for designed example in research evaluation.

Method	First round	Second round	Third round	Fourth round	Fifth round	Sixth round	Seventh round
Proposed method	3601	2746	1918	1121	556	126	0
LEATCH method	3401	2274	1720	1057	469	77	0



As can be seen in the above table and diagram, the amount of remaining energy in each round of implementation of the proposed algorithm in comparison with standard LEATCH algorithm is more until the end of the lifetime of the designed sensor network, that is meaning of reduction of energy consumption in different periods of implementation of the proposed method in comparison with standard LEATCH algorithm.

The reduction of energy consumption in wireless sensor networks in proposed method because optimal distribution and selection of cluster head and for the mentioned reasons in the previous sections, finally can cause extend the lifetime of wireless sensor networks.

## 5 . Conclusion and recommendations

Given the mentioned challenge in this study that is how to choose the best cluster heads in the wireless sensor networks, in this study has been addressed to provide a control way based on the use of genetic fuzzy systems. In the proposed method, the selecting cluster heads is done by proposed genetic fuzzy system and based on the properties of each node in the moment of forwarding messages that it may help to distribution of cluster heads in form of more balance in sensor networks.

For research evaluation, the proposed method is simulated in MATLAB software and using a hypothetical example of sensor network has been addressed to study the amount of energy consumption of the proposed method in comparison with standard LEATCH method selection the cluster head. The reduction of energy consumption of the sensor network in the proposed method, in turn, increase lifetime of the network in the proposed method in comparison with standard LEATCH method. One of most important recommendations is use of particle swarm optimization algorithm for determine the most optimal membership functions and rules in the proposed fuzzy system.

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