Soft Computing based Clustering Protocols in IoT for Precision and Smart Agriculture: A Survey

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Abstract

Industrial developments in the Internet of Things (IoT) have lined the way for new fields for the use of wireless sensor network (WSN) technologies. Agricultural monitoring is a case in point where IoT can help improve production, quality and output yield. The use of WSN and data mining techniques will significantly improve many of the agricultural activities. One such activity is the management of the amount of water in planted fields. In addition, during recent years, WSN has become a more evolving field in precision farming. The key problem in the development of WSN is the use of energy and the improvement of the life of the nodes. This paper provides a systematic analysis of the clustering protocols based on soft computing approaches that are used in the agricultural domain to increase WSN's lifetime. Classification is carried out according to different soft computing techniques: swarm intelligence, genetic algorithm, fuzzy logic, neural networks. The survey will then present a comparative analysis of soft computing techniques with a focus on their goals along with their merits and drawbacks. This survey enables the researchers to choose the suitable soft computing technique used by clustering protocols for WSN-based precision agriculture.

Keywords

Internet of Things, Sensor Network, Swarm Intelligence, Genetic Algorithm, Precision Farming, Neural Network, Soft Computing

1. Introduction

Everyday objects are fitted with microprocessors and transmission devices in the Internet of Things (IoT) era, which can work collectively to support us turn our environment for the better. In agriculture it is a favourable field where IoT devices can mitigate several problems and deliver favourable solutions. Agriculture uses around 70 per cent of the water supplies available. There is a shortage of food and water, due to the growing population and declining rainfall [1]. Therefore, in recent years there has been a proliferation of research in this area. Over the past decade, the conventional farming has been oriented towards the latest use of technology called 'Precision Agriculture'. Precision farming essentially uses wireless sensors for data aggregation, irrigation control, and information transmission arrangements to farmers [2]. Farmers' knowledge of well-growing field will lead to creative and accurate farming. Innovative farming techniques can be utilized by using IoT devices and Wireless Sensor Networks (WSN) in farming. The authenticity is that agriculture is nowadays smart, precision, information storage, multi-storage, and data based. PA allows for greater flexibility in crop growing and livestock rearing. The productivity can be improved by using crop monitoring technology, and costs can be minimised as more effective treatments

ISIC'21: International Semantic Intelligence Conference, February 25–27, 2021, New Delhi, India
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can be applied to crops. IoT devices can be utilized in monitoring techniques comprising of nodes that communicate with the atmosphere using sensors to collect information in actual time and relay it to a command room for further handling [3].

A WSN incorporates automatic sensing, handling and wireless communication systems into small units called as sensor nodes. These self-governing sensor nodes deploy the geographic areas randomly and closely, track the ambient environment or detect events, digitise the data collected, and route information to the resource-rich electronics system, stated to as the base station (BS) for additional handling and analysis [4]. However, the nodes have constrained bandwidth, power, and resource processing and limited lifespan. The main task of the node is to sense the target phenomenon like heat, light, pressure, and then apply the data as a query response to the BS or sink. For WSNs, relative to data transmission, the computing energy consumption is less.

Therefore, Data produced from neighbouring sensors are often redundant and highly correlated in precision agriculture. Therefore, instead of transmitting the data individually to the sink each time, a large amount of redundant data is removed if data is first accumulated and grouped using aggregate functions and then transmitted to the sink, thereby saving energy [5]. Data collection can be seen as a basic mechanism to minimize energy consumption and to conserve scarce resources. A successful strategy for data accumulation would decrease the amount of network traffic in WSN environments leading to substantial energy savings. We have examined the clustering in the literature [6] and are the most widely used techniques for data aggregation in WSN. Clustering the sensor nodes is an important mechanism that enables data to be distributed in a hierarchical network by splitting the network into small groups. In order to allocate the management tasks efficiently between the nodes, few of them are chosen as the head of each cluster, commonly referred to as the cluster heads (CHs), and non-CH nodes called member nodes join their closest CH as presented in Figure 1. The member nodes transmit data to the appropriate CHs, then CHs send collected data to the BS. Since there is an equal quantity of data produced by the sensor nodes, the clustering uses the similarity between the data and then, by combining it, decreases the network load, resulting in a further effective energy utilization. Soft computing seeks to

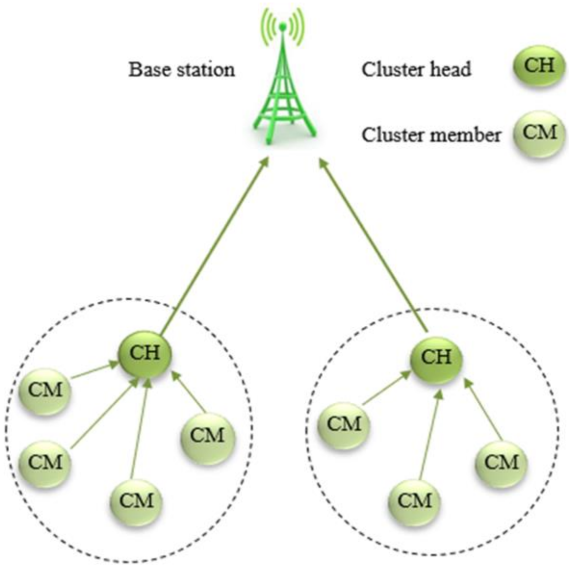

Figure 1: Cluster architecture

find precise approximation, which provides a robust, computationally efficient and cost-effective solution that saves time in the computation. Most of these methods are essentially optimistic about influenced biological processes and patterns of social behaviour. With the quick growth of soft computing techniques over the past period [6-7], clustering protocols based on particle swarm optimization, ant colony optimization,

genetic algorithms, fuzzy logic, and neural networks have been proposed for WSN based precision agriculture. A concept of using soft computing techniques in WSN is to deliver adaptability and robustness in relation to network breakdown, and changing wireless conditions in WSN. Thus, in this paper lately proposed soft computing techniques based clustering protocols is examined which are used for precision agriculture. The rest of the paper is designed as below. Section 2 presents the use of IOT in agriculture. Section 3 discusses the clustering characteristics in WSN. In section 4, the soft computing techniques based clustering protocols are momentarily examined. Section 5 delivers a relative and systematic evaluation of the studied protocols. After All, Section 6 introduces the conclusion and future research trends.

2. IoT in Agriculture

The idea of IoT caught attention through MIT's Auto-ID centre and its related publications on market exploration. IoT is basically an aggregation of various devices that connect, sense and cooperate with their

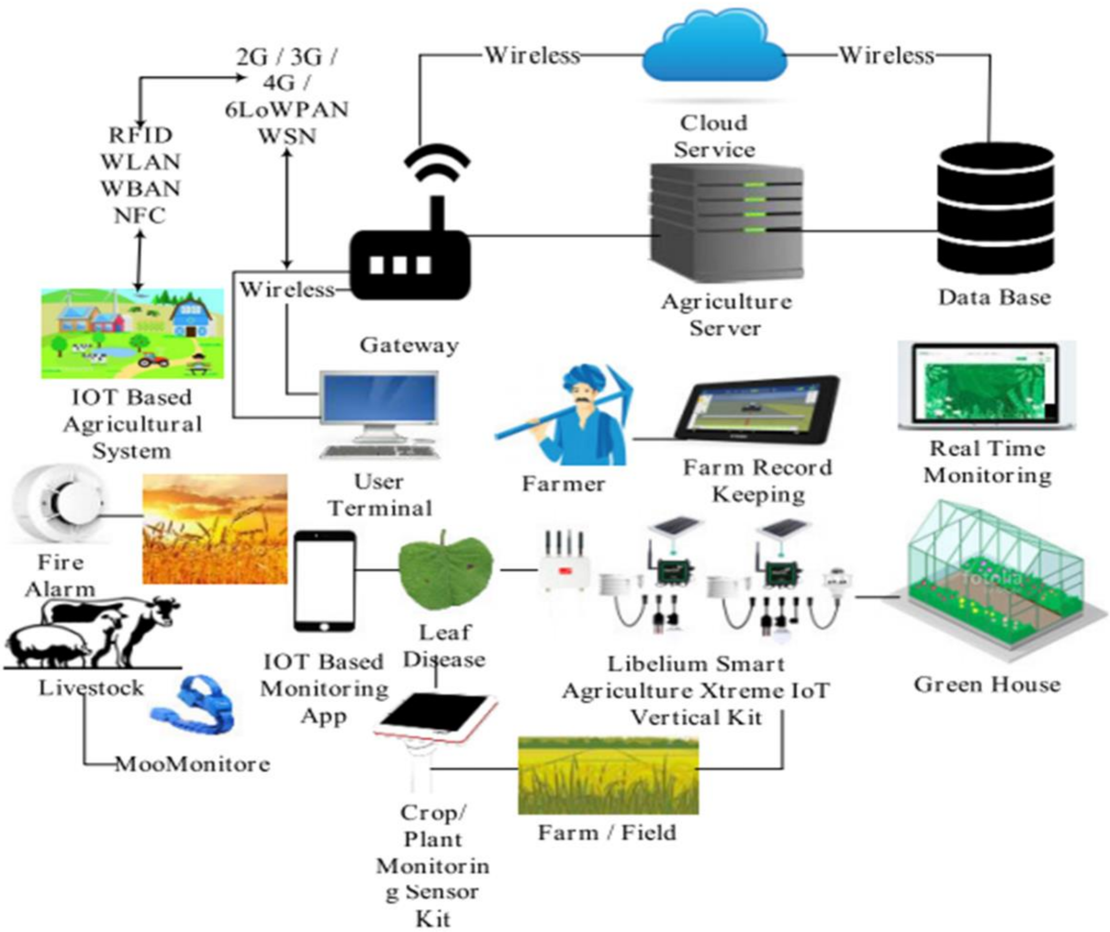

Figure 2: IoT in Agriculture

interior and exterior via the embedded technologies found in IoT. IoT has developed the megatrend for next-invention technology that can affect the entire market continuum with expanded benefits that are advanced end computer, system, and service connectivity. IoT IoT technology to build smart farming results [4]. By exploring various problems and challenges in agriculture, IoT has brought a huge change in the agricultural atmosphere. Currently, with the advent of technology, it has been predicted that farmers and technicians can find the resolution to the problems faced by farmers such as water deficiencies, cost control and production issues by using them. State-of-the-art IoT techniques observed all the problems and provided results to improve efficiency while reducing costs. Attempts made on networks of sensors allow us to gather data from nodes and to transmit it to central servers. Data gathered the sensors provides information on different environmental conditions for proper monitoring of the entire system [8]. Monitoring ecological conditions or crop production is not only an element in crop assessment, but there are many other factors influencing crop production, such as field managing, land and crop monitoring, unwanted object progress, wildlife attacks, and theft etc. Furthermore, IoT offers a well-established arrangement of restricted resources ensuring that the greatest usage of IoT improves effectiveness. Figure 2 indicates a schematic diagram displaying agricultural designs that deliver easy and cost-effective connexions across individual Greenhouse, Livestock, and Field monitoring through secure and perfect connectivity. The figure indicates that two sensor kits have been introduced to monitor soil humidity, temperature, efficiency, and air flow [9].

3. Clustering in WSN

The benefits of separating the networks into clusters are a) it improves scalability b) it is

provides suitable results for multiple applications, like smart healthcare, smart cities, protection, industrial management and agricultural traffic congestion. In the agricultural field a large quantity of effort has been performed on

easy to manage b) it declines the quantity of data to be transmitted by aggregating and summing up the data, c) it reduces the number of relay nodes d) load balancing between clusters e) it improves energy efficiency and f) it increases network longevity etc.[10].

3.1 Clustering characteristics

Typically, we describe individually clustered WSN as having three key attributes: cluster properties, CH properties, and procedure properties for clustering.

Cluster properties

Cluster properties are separated according to cluster requirements, such as cluster number, cluster volume. Below is a short description of each:

- *The number of clusters:* The quantity of clusters that were created may either be constant (preset) or variable. This number is flexible in the methods which randomly select the CHs between the nodes.
- *Cluster size:* The size of the clusters may be identical or inequitable, depending on the uniform dissemination of the load amongst all clusters created. The cluster inequality is based on the distance among sensor nodes and sink.
- *Intra-cluster communication:* The transmission inside a cluster can be either precise or multi hop depending on the clustering algorithm. Some clustering approaches that involve multi-hop transmission among the CH and members when quantity of CHs is low and volume of the clusters high.

- *Inter-cluster communication:* Because the nodes have small-range transmitters, the multi-hop solution is a suitable method. Nonetheless, several WSN applications presume that there is direct contact among the CHs and the BS.

CH properties

Since the CH option is the key component of each clustering algorithm, the selected CHs have a major impact on the efficiency. The following features of the CHs are:

- *Mobility:* The CHs can be static or mobile. Mobile CHs can travel for a restricted distance but mobile CHs' topology managing method is more complex than in a stationary CHs network.
- *Node type:* Compared to the normal nodes, the distributed CHs around the network may be rich in resources; that is, the network supports node heterogeneities or, the network may be similar, and regular nodes choose the CHs.
- *Role:* The chosen CHs will play different roles in the network, depending on the algorithm. Those are relay and fusion functions.

Clustering process

- *Method:* An algorithm for clustering can be either distributed, or centralized. Due to the fact that WSNs with a large amount of nodes, disseminated approaches have become more common than integrated methods.
- *CH selection:* That clustering algorithm has its own method for choosing a CH. But the CH selection systems can generally be divided into three groups: fixed, random, and attribute based techniques. The CHs are chosen in preset earlier nodes are deployed in the sector. The CHs are chosen randomly in random strategies, and attribute-based processes pick them based on a few of their attributes, such as remaining energy and distance from the sink.
- *Algorithm complexity:* It shows how an algorithm converges. Several algorithms converge based on the requirements of the network such as the amount of CHs and several converge in a continuous time irrespective of the requirements of the network.
- *Clustering nature:* Within the literature several clustering protocol have recommended for WSNs. A limited number of such solutions are based on the data centric system, known as reactive networks. Some of the solutions suggested are constructive and do not embrace the reactivity and some of them use a mixture.

4. Soft Computing Techniques based Clustering Protocols

This section reviews the existing soft computing techniques based clustering protocols proposed for agriculture monitoring.

4.1 PSO

PSO [11] algorithm is a simulated by the collective conduct of bird gathering, and fish schooling. It contains a swarm of particles N_P in search area, in which a particle i captures a position $X_{i,d}$ and a velocity $V_{i,d}$ in the d th dimension of global space. Throughout the search area, each particle examines its personal best called $pBest_i$ and a global best identified as $gBest$. After obtaining the $pBest_i$ and $gBest$, P_i revises its velocity and position in every iteration by utilizing equation (1) and (2) respectively.

$$V_{i,d}(t+1) = w \times V_{i,d}(t) + c_1 r_1 (pBest_{i,d} - X_{i,d}(t)) + c_2 r_2 (gBest - X_{i,d}(t)) \quad (1)$$

$$X_{i,d}(t+1) = X_{i,d}(t) + V_{i,d}(t+1) \quad (2)$$

where, w signifies the inertial weight, r_1, r_2 signify random number and c_1, c_2 show two non-negative constants termed acceleration factor generally set to 2.0. This procedure is iteratively repetitive until a static amount of iterations $I_{\max}$ is achieved.

Wang et al. [12] implemented a PSO-based clustering procedure with a mobile BS known as EPMS, to resolve the hop spot problem in WSN. EPMS algorithm combines strategies for the mobile BS and virtual clusters to reduce delay and optimise system life. The virtual clustering in the EPMS takes into account remaining energy and node position for improved choice of CH. The mobile BS transmits Hello packages to the CHs for information group after cluster formation, and the CH with high remaining energy is selected for data transmission within its contact range. Results from the simulation indicate substantial decrease in energy consumption and delay in transmission thus optimising network life. While the EPMS algorithm's fault-tolerant mechanism restores network connectivity by evaluating the broken path, it may cause large overheads for communication at the same time.

Kaur et al. [13] suggested a PSO-based clustering protocol with unequal and fault tolerance denoted as PSO-UFC in WSN. The protocol solves the problem of clustering and fault tolerance for the network's long-run service. It uses unequal clustering method to stabilize energy utilization among the Master CHs (MCHs) to resolve the hot spot issue. The BS manages to choose best MCHs with greater remaining energy, smaller intra-cluster transmission cost and improved location to solve the hot problem and to maximize the network lifetime. The PSO-UFC therefore elects more MCHs in region closer to the BS, so that the MCHs nearer to the BS have lesser cluster sizes to save their energy for maximum relay traffic. Through using unequal clustering method, the PSO-UFC effectively balances energy consumption between the nodes and increases the existence of the network.

4.2 Genetic Algorithm

GA is identified as an evolutionary approach, and it replicates the mechanism of growth to iteratively produce optimal resolution. The flow diagram for GA appears in Figure 3. It begins with the collection of randomly produced individual population, known as chromosomes based on unique information about the challenge. -- chromosome is an collection of genes containing a portion of the solution. The fitness value is assessed on the basis of the specific problem and in the next generation the chromosomes linked with large fitness cost are selected for the reproduction procedure. In following step, chromosome recombination is attained using a crossover process to replicate different embryos. Crossover processing fuses the two parents' genetic components to produce new offspring. After fusion, the elected chromosomes go through a mutation procedure to produce new children by accidentally altering genes of specific chromosomes. When the population converges so quickly, the mutation mechanism restores any missing genetic values. This would change the parent chromosomes with minimum fitness cost with a novel series of genes generated utilizing crossover and mutation processes. This process is repeated till an optimal solution is attained [14].

Rani et al. [15] Proposed an Improved vigorous clustering-associated approach and frame relay nodes (RN) to pick the most desired node in the cluster. A Genetic Analytics method is used for this purpose. The simulations show that the recommended method affects the clustering algorithm Dynamic Clustering Relay Node (DCRN) regarding slot consumption, throughput in communication. In this study, a basic routing method based on GA is intended to optimise the performance metric of WSNs which helps to escalate both theoretical analyses and simulations for IoT applications. High accessibility and productivity have been

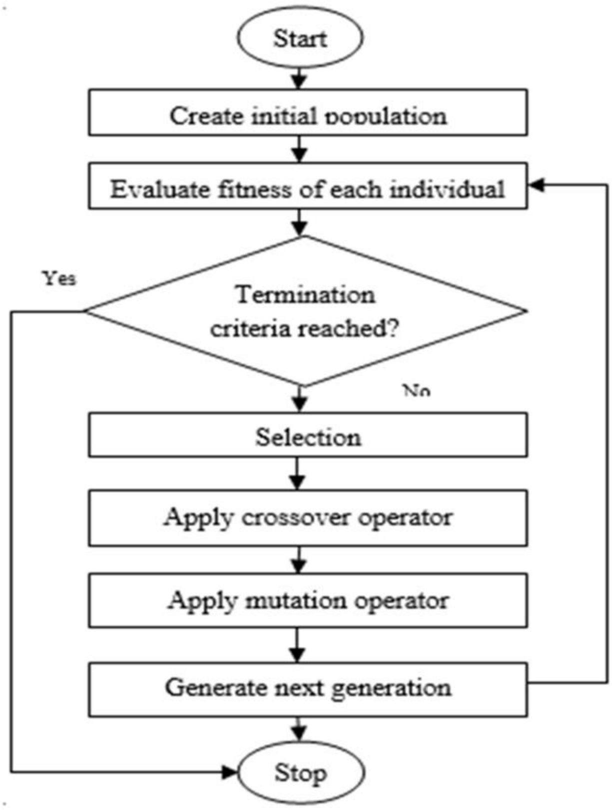

Figure 3 Flowchart of Genetic Algorithm.

increased in the system based on the execution metrics of the Fitness function and the results obtained are related through simulations. It is noted that proposed approach is a much better solution associated with previously utilized methods and in terms of network planning would be a novel development in IoT applications.

4.3 Fuzzy Logic

FL is a statistical method used to convey approximate human thought. Contrasting a classic set theory in which results are either real or false, FL produces intermediary values according to laws of interpretation and variables of language. A FL system contains four essential parts, specifically fuzzification, defuzzification, a rule base and inference engine as described in Fig. 4. The fuzzification component represents the input to the respective fuzzy sets and designates membership level to each input set defined by a language such as "big," "low," "medium," "small" and "huge." If-then rules are stored by the fuzzy inference engine, by which the fuzzified values are mapped to linguistic output variables with the support of rule base. The results achieved from the inference system are converted by defuzzification process like averaging approach, and centroid technique, into the crisp values [16].

Pandiyaraju et al. [17] suggested a novel intelligent routing protocol to enhance the longevity of the network and to ensure energy effectiveness to supply irrigation data. This new, smart routing protocol utilizes fuzzy rules is termed terrain dependent routing. The inference method was utilized to take routing choices. Two routing processes called Region Dependent Routing and Equalized CH Election Routing were introduced and compared with the framework. The agricultural region in the first process is divided into small areas of similar size called terrains. The nodes convey the data through multi-hop to the BS. In the second stage CH is chosen utilizing fuzzy rules that take into account the distance to the sink and the remaining energy. Ultimately, relay node choice is performed utilizing Fuzzy rules. Fuzzy laws are constructed using the remaining energy value, the distance from the BS and the head-degree. From the simulation outcomes it is noted that algorithm works better in terms of lifespan, energy consumption than the other current algorithms.

Rajput et al. [18] recommended a clustering algorithm focused on fussy methods to enhance WSN's stability. Fuzzy methods are employed to resolve inconsistencies that exist in WSN. Clusters are created using the algorithm Fuzzy-c-means (FCM). The goal is to cluster the sensors appropriately to minimise contact gaps in the intra-cluster. It then selects the CHs based on the FL. The efficiency of the protocol proposed for a rise in reporting region and node intensity is observed. It can be utilized for IoT-based WSN, due to improved network reliability and sustainability. Compared to similar recent traditional protocols, the proposed FCM algorithm-based clustering maximizes the lifetime in the event of a rise in node intensity. As the contact gaps inside the intra-cluster are greatly reduced. The proposed clustering protocol offers reliable and sustainable network efficiency on different scenarios. The simulation results indicate that regarding lifetime and energy efficiency the proposed approach outperforms the recent traditional protocols.

Mahajan et al.[19] suggested an Effective and scalable protocol for distant monitoring of farms in rural areas, called the CL-IoT. A cross-layer algorithm has been developed to minimise network transmission delay and energy usage. The cross-layer dependent optimal selection solution for the CH presented to resolve the energy irregularity issue. The sensor's factors of dissimilar layers such as a physical, MAC, and routing layer utilized to determine optimum CH. The nature-inspired procedure with a new probabilistic choice rule acts as a fitness value to determine the best path for data transfer. The performance of CL-IoT is evaluated by using energy consumption, computational effectiveness, and QoS-effectiveness.

Yassine et al. [20] suggested a Fuzzy-based clustering methodology applied to agriculture. The authors utilized FCM procedure to boost the CH selection and cluster creation scheme. Each node contributing in the CH selection assesses its fitness cost, which is expressed in terms of node intensity, and energy utilization. The cluster forming process also takes advantage of FCM algorithms and effectively shapes clusters. The proposed procedure is contrasted with the existing routing protocols by considering measurement metrics like the quantity of live nodes, network energy usage and number of data packets collected by sink. The presented procedure is evaluated by performing multiple simulation experiments, and all the plotted results are based on multiple simulation test averages. It is clearly detected from the results obtained that the topology achieves efficiently in both random and grid-based network topology.

Rajput et al. [21] effort is produced to project a clustering algorithm to achieve balanced WSN while optimising node intensity and exposure area. The main goal is to maximise energy

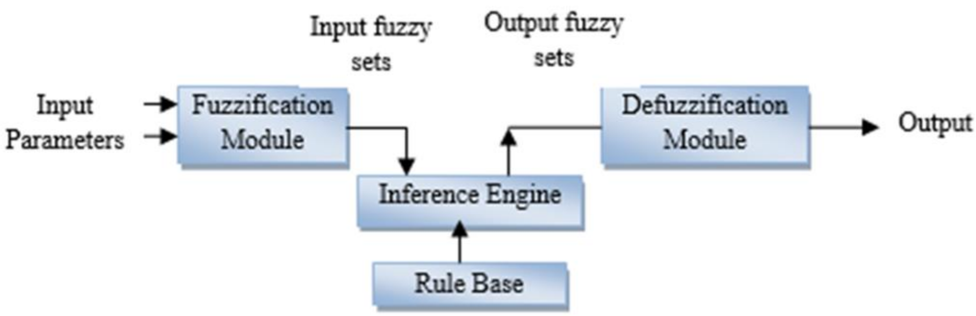

Figure 4 Fuzzy Logic System.

productivity by dropping the space of nodes to data transmission using the clustering algorithm FCM. The next goal is to pick an effective CH node based on apparent likelihood to achieve scalability. The outcomes attained suggest that the proposed protocol is more energy effective than other related approaches. Thus it can be used effectively in IoT systems for farm monitoring. FCM algorithm is implemented in order to shape optimum network clusters with Node positions and cluster number are the inputs. It approximates cluster centre points for better cluster structure in surveillance property. This greatly decreases the data communication distances between the nodes. The results demonstration that the protocol can shape larger clusters to maximize the WSN lifetime.

Pandiyaraju et al. [22] suggested a new intelligent routing algorithm to expand the network lifetime and to deliver energy efficient routing. This new smart routing protocol utilizes fuzzy rules precision farming. This algorithm operates in three stages, namely the phase of terrain forming, the phase of election of Terrain Head and the phase of routing based on terrain. The farmland in the first procedure is divided into small parts of similar size known as terrains. In the next phase CH is chosen utilizing fuzzy rules that take into account the distance to the sink and the remaining energy. The TH which functions as a relay transmits information from source to sink. The relay node is chosen taking into account the residual resources, the departure from the sink and the node-degree. But lastly, in the third step, relay node selection is performed utilizing fuzzy rules. The laws are constructed utilizing the residual energy, the distance from the BS and the head-degree. From the results of the simulation, it is noted that the proposed protocol improves network lifespan, energy consumption than the other current algorithms.

4.4 Artificial Neural Networks

A neural network is a wide interconnected network of elements generated by the human neurons. -- neuron conducts a small amount of processes, and the total process is the weighted number of these. A neural network must be trained to generate the necessary outputs by a known collection of inputs. Training is typically achieved by feeding patterns of teaching into the system and letting the network change its weighting role according to some previously established rules of learning. The learning may be supervised or unmonitored. An ANN essentially comprises of three layers: input, hidden layer, and output, where each layer can have numbers of nodes in it. This tests the output of the neural network against the desired output, and if the results are not as planned, the weights among layers are adapted and the procedure is repeated until a very minor error remains [23].

Thangaramya et al. [24] proposed a new IoT-based sensor network routing algorithm that uses a clustering approach based on neuro-fuzzy rule to perform cluster-based routing to improve network presentation. In this method, the cluster forming in WSNs used the energy modelling to proficiently route the packets by applying machine learning using convolutionary NN with fuzzy weight adjustment laws, thus extending the lifetime of the network. The authors also considered four elements, namely the remaining energy, the distance among the CH and BS, the distance among the node and the CH, and the CH-degree, that are essential features for the usage of energy and the lifetime of the network. They tested the proposed algorithm using MATLAB simulations. The NFIS output value was utilized to establish the CH for the member node to meet. It has been observed that the proposed protocol performed better regarding energy consumption and device life span because of the usage of neuro-fuzzy rules.

4.5 Harmony Search Algorithm

Harmony Search (HS) is an important evolutionary approach intended to imitate the process of jazz musicians improvising. HS creates random resolutions that are called Harmony Memory. In each iteration a new solution is created and compared with the worst resolution. It is substituted with the severest resolution if new resolution is better. Phase continues until condition of termination is fulfilled. HS algorithm's strength lies in its capability to effectively arrive at global solution. [25].

Bongale et al. [26] Two stage Chief Election Plan for the cluster. The quest algorithm for harmony in the first stage is utilized to evaluate energy efficient CHs which are adequately divided by some ideal distance from each other. The tentatively chosen CH are then enhanced by the firefly algorithm, taking the parameters like node intensity, cluster density and energy consumption. During the CH election method, all fireflies undergo a recursive update and estimation process before the CH are finalised. The approach proposed guarantees that chosen CHs have high remaining energy and can consume less energy in clustering. It also guarantees that clusters designed to have large intensity, minimal transmission costs and chosen CHs are well disconnected from each other so that CHs include the whole sensing area. The advantage of the proposed method of cluster creation is that the energy utilization is spread through the various network CHs.

4.6 Glowworm Swarm Optimization

In GSO, a colony of glowworms is initially distributed in solution space at random. -- glowworm in search space represents a solution of objective function and carries along with it a certain amount of luciferin. The level of luciferin is correlated with the health of the actual location of the agent. The lighter individual means better positioning (is a better solution). Using a probabilistic process, each agent can only be attracted within the local-decision domain by a neighbour whose luciferin intensity is higher than his own, and then shift toward it [27].

Li et al. [28] proposed a new paradigm of cluster head selection to optimise network lifespan and energy consumption. In addition, this paper suggests a Glowworm swarm based on Fitness with Fruitfly Algorithm (FGF), which is the hybridization of GSO and Fruitfly Optimization Algorithm to pick the best CH in WSN. Despite this, GSO should deal with non-linear problems; the model fails in solving problems of large dimensions. The algorithm also reduces the processing speed and has limited local search capabilities. Similarly, in search space the FFOA algorithm also has drawbacks including lower convergence rate. Therefore it hybridises the best attributes of given algorithms to solve all the problems of the traditional algorithm. The proposed system will minimise the negative search ability, while the enhanced search functionality can be used for convergence. Consequently, the various goals were successfully addressed as compared with the conventional algorithms.

4.7 Gravitational search algorithm

This approach is stimulated by Newton's laws of movement and does not need a derivative to find fitness function solutions. The non-convex fitness function can be extended to random search algorithms which are differentiable. Masses are the agent in the GSA which can explore the feasible region. Each agent shows a solution to the problem of optimisation where the value of each mass shows the modality of that solution assessed by the function of fitness. Thus agents with higher mass values provide better solutions; they can entice other masses by gravitational force. Thus, the agents' global movement is towards a better solution [29].

Dhumane et al. [30] suggested a multi-objective fractional GSA to locate the optimum CH for IoT. The Fractional GSA

(FGSA) is intended to locate the optimal CH in the IoT network in an iterative way to prolong the node's lifetime. In FGSA, the CH node is elected which is estimated by the fitness value utilizing numerous goals like distance, linking duration and residual energy, called the multi-objective FGSA (MOFGSA). The proposed technique comprises of two important characteristics, (1) the implementation of a MOFGSA algorithm and (2) the creation of a novel fitness model with several goals to prolong the lifespan. The IoT network is initially shaped together with one or more sink nodes, with the greater quantity of nodes. The FGSA algorithm contains both the fractional principle and GSA which is used to approximate agent power, velocity, and position. Then the fractional principle is understood with GSA to change the location of the agent to optimally figure out CH. Thus, in the proposed FGSA algorithm, the four multiple targets such as distance, latency and connect lifetime are used to measure novel fitness cost. The MOFGSA thus ensures the lifespan of the IoT nodes is extended.

4.7 Hybrid

Lipare et al. [31] combined two bio-inspired techniques specifically Grey Wolf Optimization (GWO) and GA for balancing traffic load in agriculture-WSN. There is progress in the initial population process of both algorithms. The crossover and mutation process has been improved to achieve the safe off-spring to improve the network's balanced charge and effective energy usage. For crossover operation, the authors substituted only the worst solution instead of switching all the parental solutions. This improves to save population's best option. In the mutation process we modified the task of the node associated with the remote gateway to their closest gateway instead of varying a random bit. This cuts the sensor node's energy consumption. GWO and GA's best suited systems undergo the operations of crossover and mutation to generate stable offsprings. The clusters achieved from proposed GWO-GA is stable in terms of balancing network load, and energy efficiency.

Arikumar et al. [32] proposed an Energy Efficient LifeTime Maximization (EELTM) methodology that uses PSO and FIS. PSO-based fitness method to assess the fitness function of every node, based on the main energy, intensity and distance factors. Additionally, an efficient CH – CR (cluster router) selection algorithm that utilizes the fitness functions determined by PSO is proposed to decide two optimum sensor nodes in every cluster to serve as CH and CR. The elected CH collects the data entirely from its associated members, while the CR is responsible for collecting and transmitting the data collected from its CH to the sink. So CH's operating cost is lowered. Additional smart strategy is that FIS can evaluate the radius for CH and divide the network into unbalanced clusters. To evaluate the ability of EELTM, parameters like residual-energy, FND and 50% node die are used. Thus, the EELTM method enlarges the network lifetime.

Robinson et al. [33] proposed an Energy Aware Clustering utilizing Neuro-fuzzy method (EACNF) to generate energy efficient clusters in the network. The proposed structure comprises of a fuzzy and neural network which attains energy effectiveness in cluster formation and CH election. EACNF utilized the neural network to deliver an appropriate training set for the energy and node density of each sensor node in order to evaluation the energy consumed by Unknown CHs. The nodes with higher residual energy are qualified to pick energy conscious cluster heads with different base station location. Fuzzy if – then mapping rule is utilized to form clusters and CHs in the fuzzy logic component which inputs. For WSN, EACNF is designed to manage Confidence factor for network security. EACNF used three metrics like the range of transmission, the residual energy, and the Confidence aspect to enhance network lifetime.

4. Comparative analysis

This section delivers a comparative study of several soft computing techniques based clustering protocols in IoT-WSN. Table 1 emphasizes the soft computing technique, clustering parameters, and transmission mode of the reviewed clustering protocols. This survey will also enable the researchers to rapidly analyse several soft computing techniques reviewed in this paper and elect the suitable soft computing technique based on their merits and limitations as given in Table 2.

5. Conclusion

Since the great potential of IoT in all phases of the latest life has been broadly recognized sensors, wireless networks and software applications have become an essential and significant asset of modern agricultural structure. This paper surveys soft computing techniques based clustering protocols employed in agriculture domain in WSN. The importance of soft computing techniques in WSN reflects a thorough study of various clustering schemes with focus on their goals. The comparative analysis enables the selection of suitable soft computing technique based clustering schemes used in WSN to enable energy-efficient aggregation in smart agriculture system.

Table 1: Comparative Analysis of Soft Computing Techniques Based Clustering Protocols

Protocols	Soft Computing Technique	**Clustering Parameter**	**Transmission type**
EPMS [12]	PSO	Residual energy, Location	Single hop
PSO-UFC [13]	PSO	Residual energy, Intra-cluster distance, Inter-cluster distance	Multi-hop
DCRN-GA [15]	GA	Residual energy, Location, Distance to BS	Multi-hop
Pandiyaraju et al. [17]	Fuzzy logic	Distance to BS, Residual energy	Multi-hop
Rajput et al. [18]	Fuzzy logic	Coverage area, Node density	Single hop
CL-IOT [19]	Fuzzy logic	Residual energy, distance to BS	Multi-hop
Yassine et al. [20]	Fuzzy logic	Node density, Cluster fairness, Expected energy consumption	Multi-hop
Rajput et al. [21]	Fuzzy logic	Node location, Number of clusters	Single hop
Pandivaraju et al. [22]	Fuzzy logic	Distance to the BS, Residual energy	Multi-hop
Thangaranga et al. [24]	Neural networks	Residual energy, distance among CH and the BS, Distance among sensor node and CH	Single hop
Bongale et al. [26]	HSA	Node density, Cluster compactness, Energy	Single hop
Le et al. [28]	Glowworm search optimization	Inter-cluster distance, Intra-cluster distance, Energy	Single hop
MOFGSA [30]	GSA	Distance, Link lifetime, Energy	Single hop
Lipare et al. [31]	Grey wolf optimization, GA	Energy, Intra-cluster Distance, Inter-cluster distance	Single hop
EELTM [32]	PSO, Fuzzy Logic	Energy, Distance, Density	Multi-hop
EACNF [33]	Neural network, fuzzy logic	Energy, Density	Single hop

Table 2: Summary of soft computing techniques

Soft Computing Approaches	**Merits**	**Limitations**
Fuzzy Logic	• The implementation of FL needs minimum growth rate, and design period. • The clustering protocols based on FL have the ability to deal with contradictory conditions without needing any complex statistical model.	• Fuzzy laws are not flexible about the network changing aspects and needed to be re-learnt with vigorous requirements.
Particle swarm Optimization	• PSO is used due to its simplicity to implement on software, and extremely optimum resolution. • PSO based clustering algorithms indicate considerable progress in terms of strength and flexibility	• The iterative factor of PSO does not make it appropriate for multimedia applications. • PSO has significant memory limitation which involves resource-rich BS.
Genetic Algorithm	• GA-based clustering proficiently resolve multi-objective problem where data regarding the network like network topology, intensity, and dimension is not essential.	• GA has sluggish convergence rate which limits its realization in multimedia applications. • It does not have the capability to contract with dynamic system topology and transmission connection breakdowns.
Harmony search	• HS algorithm has relatively less parameters to calculate the fitness value • It has the capability to detect areas with improved results.	• For complex issues, HS is not effective in detecting the global solution in large search space.
Neural Networks	• NNs can contract with inadequate data sets. • NNs are effective in forecast.	• Unnecessary training may be needed in convoluted ANN systems
Glow worm Swarm Optimization	• GSO does not utilize velocities, and hence has no difficulty as that related with velocity in PSO. • The rate of convergence is maximum in possibility of discovering the global optimized response.	• GSO has not applied for high dimensional challenges.
Gravitational Search Algorithm	• It involves only two parameters to adapt i.e. mass & velocity to achieve near global optimal solution.	• GSA has large computational cost. • GSA has convergence issue if preliminary population not created well

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