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IoT based Sensor Networks using Self Organization algorithm for Precision agriculture

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Abstract

The movement toward mechanisation of agriculture, the tendency toward redesigning agricultural systems, the preservation of the agricultural environment, and the advancement of computer technology may all be used to increase agricultural productivity. The sensor network contains a high number of nodes since there is a wider region of agricultural produce that is being monitored, while this also keeps the network's overall cost low. To ensure a thorough surveillance of agricultural fields, the nodes will be dispersed over diverse locations. The likelihood of node failure is quite high since the energy available to the sensor node is restricted. In this research, the use of sensor networks with Self-Organizing Algorithms has emerged as a promising technology to increase agricultural productivity. By collecting real-time data on several parameters such as soil moisture, humidity, temperature, and light intensity, and processing it using Machine Learning algorithms, farmers can make informed decisions that optimize crop yields, reduce costs, and ultimately contribute to global food security. This technology is low-cost, low-power, and scalable, making it suitable for use in remote or developing regions than the Duty Cycle Algorithm. The integration of sensor networks with self-organizing algorithms with other technologies such as Internet of Things (IoT) can further enhance its effectiveness in increasing energy and the total power consumption in the network is minimized. Thus, the sensor network's efficiency is increased for the betterment of the agriculture environment.

Keywords: Agriculture, Self-Organizing algorithm, Monitoring, Duty Cycle Algorithm, Internet of Things (IoT), Intelligent system, Production.

Introduction

Self-organization is a technique or a process that allows a system to alter its leadership strategy without a specific order throughout execution. Thus, if we use our system's self-organizing algorithms, the manual task of executing instructions utilizing a high-cost intelligence system and manual labour to monitor the system would be decreased. Sensor networks with self-organizing algorithms have emerged as a promising technology to increase agricultural productivity. The basic idea is to use a network of sensors for data collection from various points in a farm, such as soil moisture, humidity, temperature, and light intensity, among others. The data is then processed using self-organizing algorithms to provide actionable insights to farmers.

One of the main benefits of using sensor networks with self-organizing algorithms is that they allow farmers to make data-driven decisions. For example, they can determine the optimal time to plant or harvest crops based on soil moisture levels or detect potential crop diseases early on by monitoring changes in temperature and humidity. Monitoring leads to improved crop yields and reduced costs for farmers.

Moreover, these systems can be designed to be low-cost, low-power, and scalable, making them suitable for use in remote or developing regions. It can also be integrated with other technologies, such as precision agriculture systems, which use data to optimize water, fertilizers, and pesticides.

Sensor networks with self-organizing algorithms are a promising technology that can help increase agricultural productivity by providing farmers with real-time data and insights. By leveraging the power of data analytics and machine learning, farmers can make informed decisions that optimize crop yields, reduce costs, and ultimately contribute to global food security.

A review of the body's knowledge of self-organization processes in multiagent systems is presented in this work by the authors. The authors also highlight a future focus on critical multiagent systems research questions [1]. In the state-of-the-art Internet of Things, this study presented a four-layer heterogeneous IoT, a new area of research [2]. To improve the efficiency and quality of farming without constantly monitoring things manually, the system will be designed and developed utilizing a wireless sensor network [3]. To help the academic community better understand how Wireless Sensor Networks might apply in new and creative sectors, this study [4] covers a variety of WSN applications. In this study[5], the Self Organizing (SO) approach was used to send the data to the Metric Evaluation component, which then applied the different metrics and produced the results for the Evaluation System.

Literature Review

This study studies clustering algorithms for wireless sensor networks (WSNs), network management, and data aggregation [6]. The research author examined the power consumption performance of hierarchical clustering algorithms; [7] provides a summary of the clustering techniques' operation. This work introduces FLAG and I-FLAG in response. In these two hybrid hierarchical AI-based clustering algorithms, I-FLAG is an improved version of FLAG that considers energy and distance while selecting CHs [8]. The Fault-resilient The Energy-efficient Hierarchical Clustering Algorithm (FEHCA) presented in this research for Wireless Sensor Networks (WSNs) (CHs) exemplifies the energy-efficient clustering and fault-tolerant operation of cluster heads [9]. The author of this research [10] suggested a mechanism for clustering sensor nodes under gateways, or CHs, into distinct, load-balanced clusters regardless of their physical location. The authors of this study [11] developed LEACH-SF, an adaptive fuzzy clustering protocol, in response to the deficiencies of conventional clustering approaches, which limit their use in existing networks. The performance of ALBA-R, a cross-layer technique for descend casting in wireless sensor networks, and an adaptive load balancing algorithm protocol for converge casting in WSNs was examined [12]. According to the findings of the experiments presented in this work [13], the enhanced locating approach for WSNs provides high noise resistance for range noise. It is helpful for WSN node finding in the presence of high-range noise. A revolutionary strategy for energy optimization employing the Firefly Algorithm was provided in this paper [14], coupled with an enhanced threshold distributed energy sustainable categorization method for multifunctional wireless sensor networks. In this proposed investigation, the Enhanced Deep Convolutional Neural Network (ECNN) method and the Region of Interest (ROI)-based Bat Algorithm (BA) is utilized to predict multi-label leaf illnesses [15]. This study offers a convolutional neural network with an attention mechanism that may train to identify false photographs on microblogging platforms [16]. This author has developed a model that forecasts ozone measurements up to twenty-four hours in advance. In Texas, twenty-one continuous ambient monitoring stations (CAMS) were employed to evaluate the model [17]. To identify false news, the author of this study focused on the content of news stories and the prevalence of echo chambers on social media [18]. Using machine learning and deep learning approaches for stress categorization analysis [19], the author addresses the subject of predicting social media stress in this work. This study employed Multi-Label Convolutional Neural Network (MLCNN) to assess 13,346 attributes per user to estimate their interest in 15 labels [20].

Proposed System

The most crucial elements affecting plant growth, productivity, and quality in agriculture are heat, moisture, temperature, and atmospheric carbon concentrations. Therefore, this sensor collects these characteristics regularly inside the fields, allowing farmers or agricultural professionals to view the readings online concurrently.

Additionally, a farmer will be informed by a smartphone messaging app and email by an agriculture specialist when a significant change in one of the metrics occurs. The producer may assess the ideal environmental conditions to achieve maximum crop yield, improve productivity, and gain exceptional energy savings by continuously monitoring several ecological data

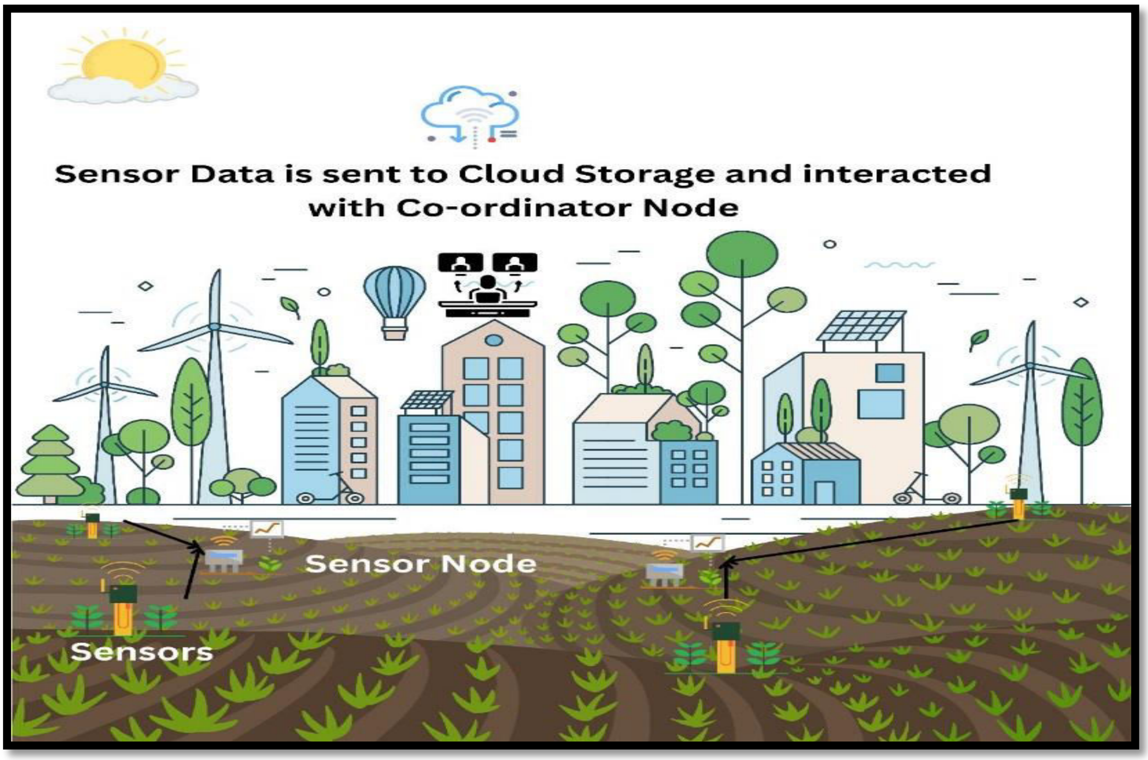

Figure 1: Architecture of the Proposed System in Increasing Agricultural Production

The authors of [24] and [25] proposed a scheduling algorithm named Duty Cycle Algorithm (DCA). This algorithm focuses on monitoring the area or collecting data on a scheduled order. However, the agricultural area will be in need of continuous monitoring and data collection to perform effective decision. In this research, Self-Organizing Algorithms (SOA)is implemented to increase agricultural productivity. As numerous data is collected from the agricultural area and as it need effective data analysis under various dimensions, SOA is considered in this research. This proposed system would consist of the following components and is represented in Figure 1:

- Sensor nodes: These are small, low-cost devices deployed throughout the farm to collect data on different parameters. The nodes can be connected to a central gateway using wireless communication technologies such as Wi-Fi or LoRaWAN.
- Gateway: This device gathers data from the available sensor nodes and sends it to a cloud-based server for processing. The gateway can be a simple single-board computer such as Raspberry Pi or a dedicated device designed for this purpose.
- Cloud-based server: This is where the data collected by the gateway is processed using self-organizing algorithms to provide insights to farmers. The server can be hosted on a public cloud platform such as AWS, Azure, or on-premise using dedicated hardware.
- Dashboard: This is a user interface that farmers can use to access the insights provided by the system. The dashboard can display real-time data on various parameters such as crop growth, soil moisture levels,

and weather conditions. It can also provide alerts and notifications to farmers when certain conditions are met.

- Machine learning models: These algorithms are used to analyze the data the system collects and provide insights to farmers. For example, machine learning models are utilized to predict the optimal time to plant or harvest crops based on soil moisture levels or detect potential crop diseases early on by monitoring changes in temperature and humidity.
- Integration with other systems: The proposed method can be integrated with other technologies, such as precision agriculture systems, which use data to optimize resources such as water, fertilizers, and pesticides.

A proposed system for using sensor networks with self-organizing algorithms to increase agricultural productivity would consist of sensor nodes, a gateway, a cloud-based server, a dashboard, machine learning models, and integration with other systems. This system can help farmers optimize crop yields, reduce costs, and contribute to global food security by providing real-time data and insights. Figure 2 represents the various phases involved in Self Organizing Algorithm from device establishment till maintenance of the system that aids in the effective agricultural production.

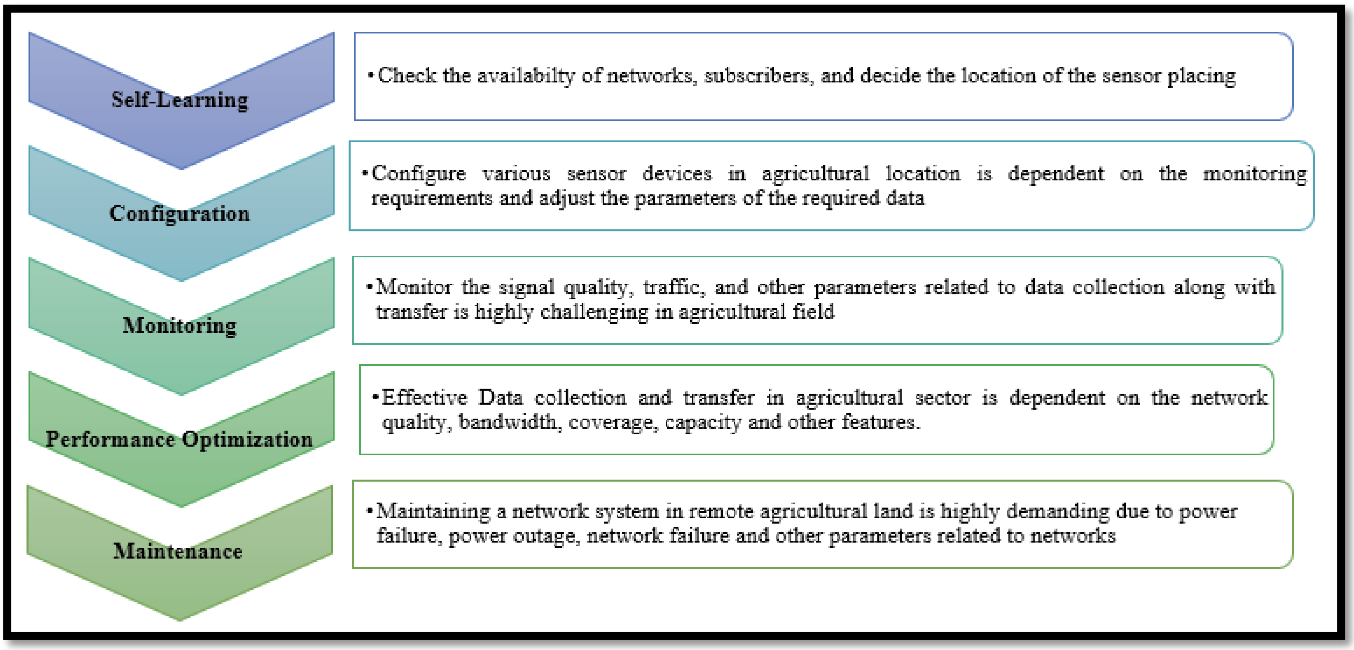

Figure 2: Phases of the Proposed Self Organizing Algorithm for Agricultural Productivity

$x_{j,l}$ will compute the square of the Euclidean distance of weight vectors (z_i) associated with each output node$y_{j,l}$, which is represented in Equation (1).

$$x_{j,l} = \sum_{l=1}^{m}\left(y_{j,l} - z_{i,l}(P)\right)^2 \quad (1)$$

In Equation (1), output node j with the weight vector's smallest value is chosen for P sensor.

The unit that has the shortest Euclidean distance, denoted by i, is shown to be the winner unit. In terms of mathematics, the successful unit is given in Equation (2).

$$i = arg\ \min_i\{\|y_m - z_i\|\} \quad (2)$$

The lateral feedback between neurons is sometimes referred to as the Gaussian function model since the self-organizing feature map employs a compulsive learning strategy (y_m) with reduced learning rate of i. Given in Equation (3) is the neighbourhood function around the weighted winning neuron z_i at time t.

$$\Delta(z_i, p) = \exp\left(-\frac{di}{\sigma(p)^2}\right), i = 1,2 \ldots, m. \quad (3)$$

$$y = z_i(p+1) = z_i(p) + \eta(p)\Delta(z_i, \mathrm{p})[\mathrm{y(p)} - z_i(p)], \mathrm{i} = 1,2, \ldots \mathrm{m} \quad (4)$$

The weight update rule$\Delta(z_i, \mathrm{p})$, which is outlined in Equation (4), should then be used to update the weights of all nodes within a certain topological distance as calculated by y.

Results and Discussion

As the DCA focuses only on the scheduling of the work, the existing methods that focuses on energy efficient data collection are considered for analysis in this research. Some of the algorithms considered are EERAA, MLA, and DDMA. The performance of the proposed system is evaluated in terms of metrics like accuracy, precision, recall and F1–score.

- True positive (TP):TP displays the positive predictions of the class for which the model's predictions were accurate.
- True Negative (TN):shows the negative class predictions that the model accurately labels.
- False Positive (FP):showing the negative class predictions that are mislabeled by the classifier as positives.
- False Negative (FN):demonstrates the positive prediction for the class that the model incorrectly labels as negative.

Accuracy is the percentage of accurately predicted instances to all expected instances. It may be determined with the Equation (5).

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (5)$$

Figure 3 depicts the comparative evaluation of accuracy in suggested and traditional methods. As a result of the performance evaluation, it has been determined that SOA has a greater accuracy rate of 94% than the other existing methods. Our proposed method has higher accuracy making a minimum difference of 4% than the other existing methods.

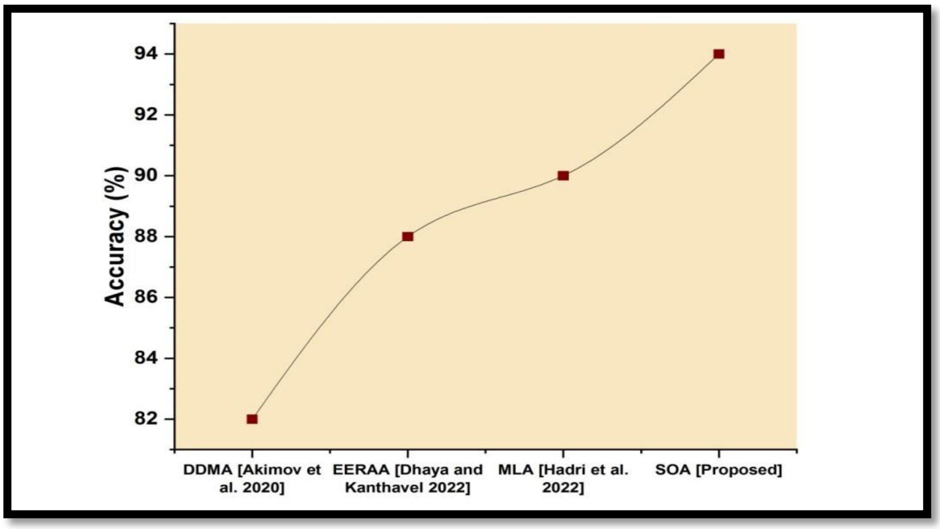

Figure 3: Comparative evaluation of accuracy in suggested and traditional methods

The ratio of positive cases to all instances that were predicted to be positive is known as precision. The Equation (6) below may be used to compute it and the graphical representation is presented in Figure 4.

$$Precision = \frac{TP}{TP+FP} \quad (6)$$

As a consequence of the performance evaluation, it has been determined that proposed method has a greater precision rate than the other existing methods. In conclusion, SOA performs better than the EERAA, MLA, and DDMA.

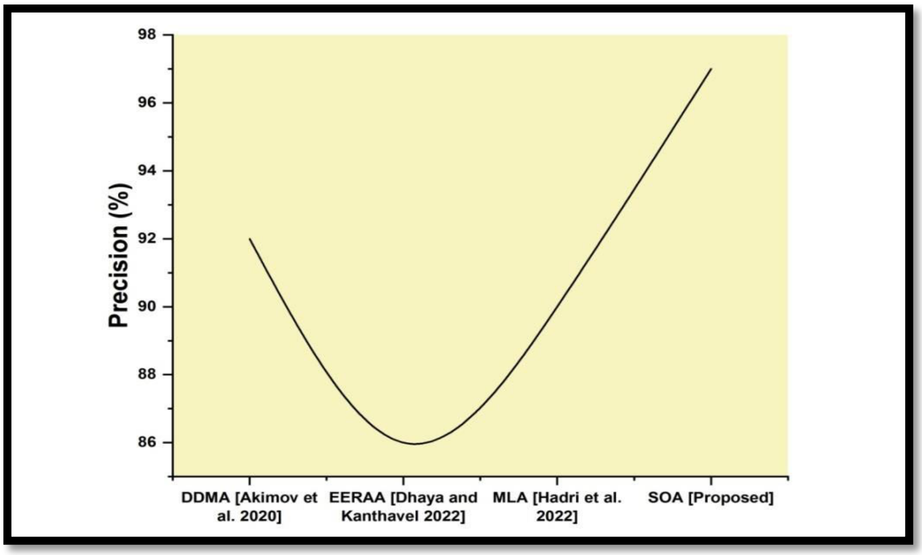

Figure 4: Comparative evaluation of precision in suggested and traditional methods

It displays the proportion of occurrences of true positives with accurate labels. It may be computed as in Equation (7).

$$Recall = \frac{TP}{TP+FN} \quad (7)$$

As performance result shows that the recall of SOA is higher than the other existing methods. The EERAA, MLA, and DDMA are outperformed by our suggested SOA and is presented in Figure 5.

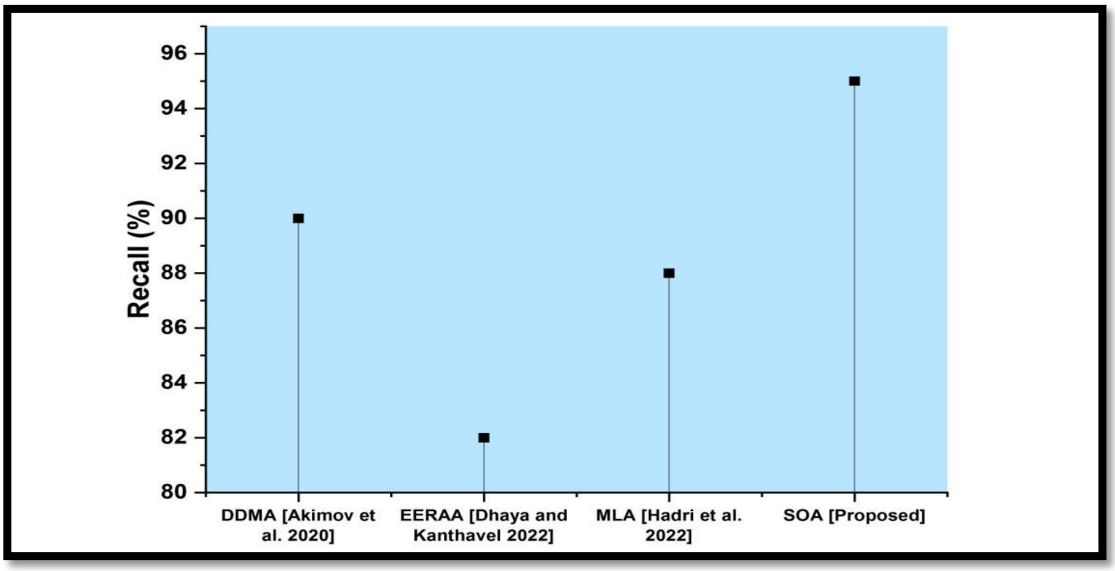

Figure 5: Comparative evaluation of recall in suggested and traditional methods

It combines recall and accuracy, and it is regarded as a model's balanced and accurate performance. The harmonic mean of recall and accuracy is the F1 score [Ref: Figure 6]. It may be determined using Equation (8).

$$F1\ score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \quad (8)$$

As a consequence of the performance evaluation, it has been determined that proposed method has a higher F1 rate than the other existing methods. In conclusion, SOA is better than the EERAA, MLA, and DDMA.

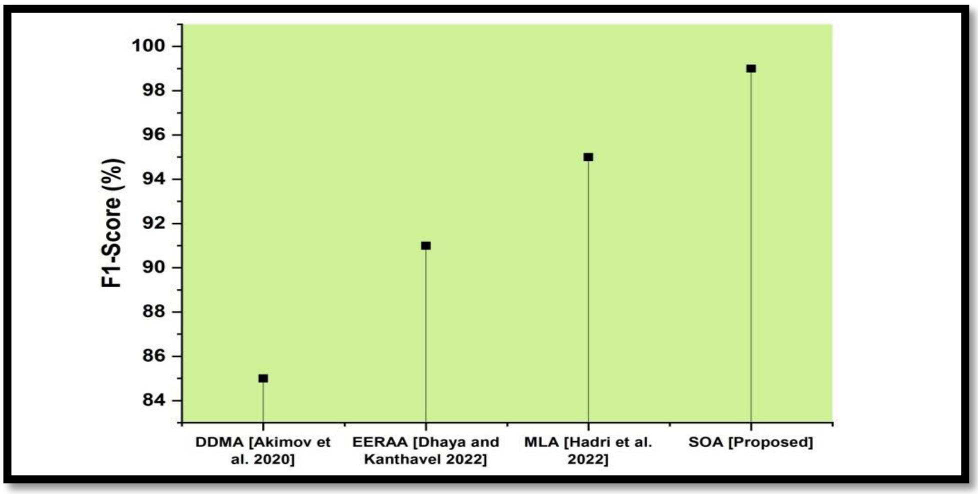

Figure 6: Comparative evaluation of F1- score in suggested and traditional methods

From the above discussions for the various parameters in the sensor network the nodes consume low energy for the communication among themselves. It yields the less power consumption which is calculated from the SOA by testing the parameters from the graph shown above.

Conclusion

When a system self-organized, it meant that individual entities' cooperative activity resulted in some kind of pattern without any outside control or influence. Multiagent systems, grid computing, sensor networks, and other industrial applications are just a few of the areas where the principles of self-organization have been investigated and employed extensively. It has been demonstrated that self-organization is an effective method for handling the dynamic needs of distributed systems over the duty cycle algorithm. Duty cycle algorithm concentrates on scheduling activities, whereas the agricultural application is in need of algorithm or model that handles data of different dimensions. Therefore, this researchhave explored the incorporation ofenergy and power consumption in the sensor networks and self-organisation algorithm is used to enhance better yield in order to make farmers happier and also assist them in using computer technology to address their issues.

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