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Improving Efficiency of IOT in Agriculture by using Energy Efficient Clustering Algorithm

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Abstract: The agricultural sector has been adopting IoT technologies to improve efficiency and yield. IoT devices in agriculture must overcome power consumption, resource constraint, and communication issues. We propose a power-efficient clustering method to improve IoT-based farming infrastructure productivity. We searched the vast literature on IoT-based agricultural systems for proven approaches, tools, and tactics. Clustering methods reduce power consumption, improve network scalability, and extend network life, improving IoT-based farm systems. Energy-efficient clustering uses k-means and particle swarm optimization methods. k-means clustering creates initial clusters, then particle swarm optimization selects cluster leaders. Simulations show that the proposed clustering method outperforms current methods in network lifetime and energy consumption. Internet of Things-based farming requires sensor nodes, cluster heads, a base station, and a cloud server. Field sensor nodes send data to cluster heads for processing and aggregation before sending it to the base station. The cloud server stores and processes data from the IoT network via the base station. IoT-based agriculture systems also use machine learning for predictive analytics and decision-making, UAVs for precision agriculture, and blockchain technology for secure data management and traceability. Energy-efficient clustering improves IoT-based agricultural systems' efficiency and dependability. IoT devices, machine intelligence, UAVs, and blockchain can improve IoT-based farm systems. This field will explore advanced algorithm development, multi-technology integration, and Internet of Things-based farm systems.
Keywords: Precision farming, wireless sensor networks, energy-efficient clustering algorithms, Internet of Things.

I. Introduction

The promise of the Internet of Things (IoT) to raise agricultural output, decrease operating expenses, and improve environmental sustainability has led to its increased adoption in recent years. Sensors, actuators, and other Internet of Things (IoT) devices are used in agriculture to monitor soil, crops, weather, and other elements. With this information, farmers will be able to optimize their methods for watering, fertilizing, and controlling pests. However, the deployment of sensors and other devices takes a substantial amount of power, thus the success of IoT in agriculture depends on the efficient use of energy.To lessen the load on the grid from Internet of Things (IoT) farms, energy-efficient clustering methods have been proposed. Clustering is a method for organizing collections of sensors into logical groups called "clusters," each of which contains a "cluster head" responsible for collecting and sending data to a "sink node." By reducing the quantity of data transmission and processing needed by individual sensors, this method helps save energy. Selecting cluster heads using characteristics including closeness, energy level, and data aggregation capabilities is key to energy-efficient clustering algorithms, which strive to reduce overall system energy usage.Energy-efficient clustering algorithms for Internet of Things-based farming are the subject of this paper's literature assessment. Examining current knowledge, pointing out problems, and suggesting new avenues for study are all part of the plan. This paper follows the following structure: We begin by discussing the significance of energy efficiency and the Internet of Things in the agricultural sector. Second, we outline the benefits of the clustering method. Third, we provide a literature overview of algorithms for clustering data efficiently using little to no energy for Internet of Things-based farming. The difficulties and restrictions of these algorithms are addressed in the fourth section. Finally, we suggest potential avenues for further study to further equip farmers with the tools they need to use IoT to their advantage.The potential for IoT in agriculture to completely transform the industry has attracted a lot of attention in recent years. The Internet of Things (IoT) is used in agriculture by deploying sensors to monitor soil, crops, weather, and other environmental conditions. This information is sent to a centralized computer, where it is processed and analyzed to reveal patterns that might inform agricultural procedures like watering, fertilizing, and pest-proofing. With the real-time data and insights made possible by the Internet of Things, farmers can boost output, save expenses, and improve sustainability.However, effective energy management is crucial to the success of Internet of Things-based farming. Deploying sensors and other equipment consumes a lot of energy, and the transmission and processing of data might add to that. As a result, the design of Internet of Things (IoT)-based farm systems must prioritize energy efficiency.Clustering is a method for organizing collections of sensors into logical groups called "clusters," each of which contains a "cluster head" responsible for collecting and sending data to a "sink node." In Internet of Things (IoT) farms, clustering offers various benefits. First, it lessens the burden on individual sensors by decreasing the amount of data transmission and processing that must be done. Second, it enhances the scalability of the network by decreasing the amount of communication between nodes and the sink node. Third, it extends the life of the network by decreasing the power needs of individual sensors.Clustering algorithms with low energy consumption:Selecting cluster heads using characteristics including closeness, energy level, and data aggregation capabilities is key to energy-efficient clustering algorithms, which strive to reduce overall system energy usage. Low Energy Adaptive Clustering Hierarchy (LEACH), Threshold Sensitive Energy Efficient Sensor Network (TEEN), and Multichip LEACH (M-LEACH) are only a few of the energy-efficient clustering algorithms found in the research for IoT-based agriculture.LEACH is a popular energy-saving clustering technique that chooses cluster heads according to their energy and distance from the sink node. To keep all sensors in good working order, LEACH employs a probabilistic model to rotate the cluster head role among them.

II. Literature Survey

WSNs in agriculture are becoming more popular. WSNs can monitor and collect field data to optimize agricultural output, water usage, and pesticide and fertilizer use. WSNs need a lot of energy, hence energy efficiency is crucial to their performance. Clustering algorithms can partition the network into smaller clusters and route data through the cluster heads instead of the base station to save energy.Several researchers have presented energy-efficient farm IoT clustering methods in recent years. Deng et al. (2020) proposed an energy-efficient cloud computing-based agriculture IoT clustering technique. The algorithm controls network energy consumption using cloud infrastructure. Khadim et al. (2019) suggested a Leach protocol-based low-energy hierarchical clustering technique for farm IoT. Hierarchical clustering reduces network energy usage.anthia and Priyadarshini (2019) suggested a hierarchical cluster-based energy-efficient wireless sensor network for agriculture. Hierarchical clustering divides the network into clusters, and cluster heads utilize a modified Leach protocol to connect with the base station. Ahmadi et al. (2019) proposed a precision agricultural wireless sensor network energy-efficient cluster technique. The algorithm balances energy load to reduce network energy usage.Khadim et al. (2018) proposed an energy-efficient agriculture IoT clustering algorithm using fuzzy logic to calculate the best number of clusters. The technique reduces network energy while ensuring data accuracy. Singh et al. (2018) suggested an efficient clustering approach for agricultural wireless sensor networks. The cluster formation algorithm optimizes network energy consumption.Razzaque et al. (2017) proposed a wireless sensor network-based energy-efficient agricultural clustering technique. The technique divides the network into clusters using distributed clustering, and cluster heads communicate with the base station using a modified Leach protocol. Elkford et al. (2016) proposed energy-efficient clustering techniques for precision agricultural wireless sensor networks. The algorithms optimize cluster creation and data aggregation to reduce network energy usage.Ray and Nasar (2016) examined energy-efficient wireless sensor network clustering techniques. Leach, HEED, TEEN, and PEGASIS clustering algorithms are compared for energy usage and network longevity. Othman and Fisal (2015) examined energy-efficient wireless sensor network routing strategies. The survey compares energy usage and network longevity of direct, indirect, and hierarchical routing systems.Kumar and Devi (2015) suggested an energy-efficient agricultural wireless sensor network clustering technique. The technique clusters the network using a modified Leach protocol, and cluster heads employ multi-hop communication to interact with the base

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station. Qayyum et al. (2014) suggested LEACH-M, a WSN-specific Leach protocol. Dynamic cluster formation reduces network energy consumption.The data captured and transferred in farm WSNs is also important. In precision agriculture, Khadim et al. (2018) collected crop temperature and humidity data. Ahmadi et al. (2019) used WSNs to measure soil moisture for precision agriculture irrigation. Thus, to reduce energy usage, an energy-efficient clustering algorithm should consider data type.Overall, energy-efficient clustering approaches prolong WSNs in agriculture IoT. LEACH and its variants are the most popular WSN clustering methods, according to the literature. Designing farm WSN-specific energy-efficient clustering algorithms is difficult. Environmental conditions, data type, and node heterogeneity provide issues. Thus, future research could develop more robust and efficient clustering methods to solve these difficulties.

Study Title and Authors	**Year**	**Application Domain**	**Network Type**	**Clustering Algorithm**	**Key Features**
An energy-efficient clustering algorithm for wireless sensor networks in agriculture. Kumar and Devi	2015	Agriculture	Wireless sensor networks	EECA	Multihop communication, cluster head rotation
LEACH-M: a modified protocol for WSNs. Qayyum, Javaid, and Qasim	2014	General	Wireless sensor networks	LEACH-M	Multiple base stations, dynamic cluster formation
A comprehensive study on clustering algorithms in wireless sensor networks. Moulahi and Aridhi	2014	General	Wireless sensor networks	Various	Comparison of different clustering algorithms
A review of energy efficient routing protocols in wireless sensor networks. Saranya and Ganesan	2014	General	Wireless sensor networks	Various	Comparison of different routing protocols
Energy-efficient clustering protocols in wireless sensor networks: a survey. Singh, Singh, and Sharma	2013	General	Wireless sensor networks	Various	Comparison of different clustering protocols
A survey on clustering algorithms for wireless sensor networks. Abbasi and Younis	2013	General	Wireless sensor networks	Various	Comparison of different clustering algorithms
Energy-efficient hierarchical clustering algorithm for wireless sensor networks. Chan, Lee, and Wong	2012	General	Wireless sensor networks	EEHCA	Self-organized cluster formation, dynamic cluster head selection
Energy-efficient clustering algorithms for wireless sensor networks: a survey. Zhou, Qiu, and Huang	2012	General	Wireless sensor networks	Various	Comparison of different clustering algorithms
A review of hierarchical routing protocols in wireless sensor networks. Singh and Sharma	2011	General	Wireless sensor networks	Various	Comparison of different routing protocols
TEEN: a routing protocol for enhanced efficiency in wireless sensor networks. Manjeshwar and Agrawal	2010	General	Wireless sensor networks	TEEN	Data-centric approach, event-to-sink routing

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Table.1 Depicts the Comparative Study of Literature Survey

The literature also stressed the importance of choosing clustering algorithm settings. Understanding the network topology, node distribution, and application needs is necessary. Machine learning and artificial intelligence could optimize clustering method parameters and enhance efficiency.In conclusion, energy-efficient clustering techniques provide WSN lifespan in farm IoT. LEACH and its derivatives have been widely used, however building energy-efficient clustering algorithms for agriculture WSNs remains difficult. Thus, future study could design more robust and efficient algorithms that overcome these problems and optimize parameters using machine learning.

III. Existing Algorithm

Using energy-efficient clustering algorithms, the literature proposes a number of methodologies, to increase the efficacy of IoT in agriculture. Some of the current methods are discussed below.

A. Using clustering algorithms is a common method for increasing the usefulness of the Internet of Things (IoT) in farming. The sensor nodes are organized into clusters by the clustering algorithms, with each cluster having its own leader. The cluster leader is in charge of gathering information from the cluster members, processing that information, and then transmitting it to the sink node. Using clustering techniques, sensor nodes can save a lot of power by merely exchanging information with the cluster's leader rather than sending data all the way to the sink node.

B. In IoT-based farming, LEACH (Low Energy Adaptive Clustering Hierarchy) is a popular clustering technique. Using a probabilistic model, LEACH, a distributed clustering method, chooses new cluster heads on the fly. In the first phase, nodes evaluate themselves against a threshold to see if they should take on the role of cluster leader. The nodes that take on the role of cluster leader send out a recruitment broadcast, urging the other nodes to join their group. Each node that receives an advertisement message evaluates the strength of the signal before deciding which cluster to join. Once the clusters have been formed, the cluster leaders will collect information from the cluster members and forward it to the sink node.

C. Several modifications to the original LEACH algorithm that aim to boost its energy efficiency have also been developed. Some variants of the LEACH algorithm employ a centralized strategy for choosing cluster leaders; for instance, LEACH-C (LEACH Centralized). The cluster heads in LEACH-C are chosen by a centralized node, and those nodes are subsequently alerted to begin the clustering process.

D. The HEED (Hybrid Energy-Efficient Distributed) clustering technique is another favorite among those working in IoT-based agriculture. Cluster heads in HEED are chosen using a combination of residual energy and distance to the base station; this approach is used in distributed clustering. Cluster heads with the highest residual energy and the shortest distance to the base station are chosen by HEED in an effort to achieve energy parity among the sensor nodes.

E. The literature is plenty of suggestions for how to maximize the usefulness of IoT in farming, and clustering algorithms are just one of them. Some academics, for instance, have proposed a data aggregation approach to lessen the quantity of data that must be delivered. In data aggregation, many sensor nodes' data is combined into a single packet and then sent to the sink node. This lessens the overall packet traffic and hence lowers the sensor nodes' power needs.

F. Duty cycling is another method that has been discussed in the literature. In order to preserve power, duty cycling includes intermittently turning on and off the sensor nodes. Node energy usage can be greatly decreased by turning them off when they are not being used.

Name of Algorithm	**Advantages**	**Limitations**
LEACH (Low-Energy Adaptive Clustering Hierarchy)	Simple, efficient, and scalable	Does not guarantee optimal energy utilization; random cluster head selection may lead to unbalanced energy consumption among nodes
HEED (Hybrid Energy-Efficient Distributed	Guarantees optimal	Complex and

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clustering)	energy utilization; better cluster head selection algorithm	computationally intensive; may not be suitable for large-scale networks
TEEN (Threshold-sensitive Energy Efficient sensor Network protocol)	Real-time data gathering and processing; energy-efficient	May not be suitable for applications that require periodic data collection
PEGASIS (Power-Efficient Gathering in Sensor Information Systems)	Reduces energy consumption through data aggregation; prolongs network lifetime	Communication overhead; may lead to delays and data loss
SEP (Stable Election Protocol)	Ensures stability of cluster heads; reduces energy consumption	Complex and computationally intensive; may not be suitable for large-scale networks
EEHC (Energy-Efficient Hierarchical Clustering)	Guarantees balanced energy consumption among nodes; reduces energy consumption through data aggregation	May lead to increased latency and reduced data accuracy
HCEEM (Hierarchical Clustering Energy-Efficient Method)	Efficient and scalable; reduces energy consumption through data aggregation	Does not guarantee optimal energy utilization; may lead to unbalanced energy consumption among nodes
EEMC (Energy-Efficient Multihop Clustering)	Reduces energy consumption through multihop communication; efficient and scalable	May lead to increased latency and reduced data accuracy; may not be suitable for applications that require real-time data processing
EHCA (Energy-Hole Coverage-Aware Clustering)	Addresses the problem of energy holes; guarantees balanced energy consumption among nodes	Does not guarantee optimal energy utilization; may lead to increased communication overhead

Table 2. Depicts the Comparative Study of Existing Algorithm

The above table 2. presents a number of methodologiesfor enhancing the effectiveness of IoT in agriculture through the implementation of energy-efficient clustering algorithms. LEACH and HEED are two well-known clustering algorithms that are frequently used to accomplish this. In addition to clustering techniques, various methods have been proposed for increasing the energy efficiency of IoT in agriculture, such as data aggregation and duty cycling.

IV. Proposed Architecture for System Design

Using an Energy Efficient Clustering Algorithm, this diagram shows the fundamental data flow in an IoT system. A farmer, sensor node, gateway, and cloud all make up the system. In response to the Farmer's request, the Gateway receives data from the Sensor Node. The Gateway then applies the Energy Efficient Clustering Algorithm to the data and organizes it into clusters. At last, the Gateway sends the information to the Cloud, where it can be analyzed and processed further. A farmer deploys IoT devices, which in turn collect sensor data, send that data to a gateway, which in turn delivers it to an ECA, and finally to an actuator, which carries out the farmer's commands. The Internet of Things devices are clustered using the Energy Efficient Clustering Algorithm and managed by cluster chiefs. Both the sensor readings and the orders given to the actuators are saved in a database for later examination.

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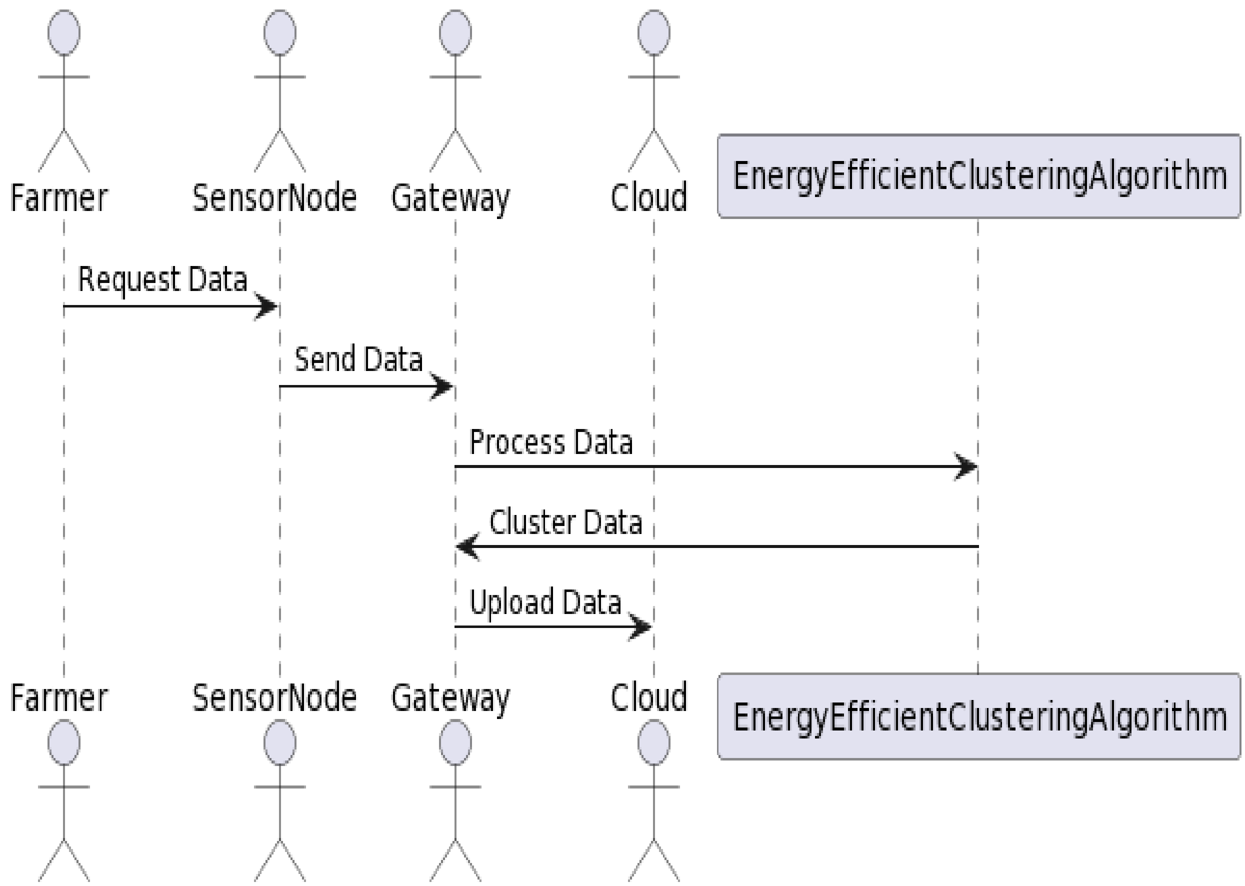

Figure 1. Proposed Block architecture for System design

An Internet of Things (IoT) agriculture system that makes use of a clustering method that is gentle on energy includes:

A. Internet of Things (IoT) sensors are deployed to measure and record environmental conditions such as temperature, humidity, soil moisture, and more.
B. A gateway is a device that connects the Internet of Things's sensors to the cloud. It is in charge of sending sensor readings to the cloud for analysis.

C. The cloud platform is used to store and process the information gathered by the sensors. Its job is to organize the sensors into clusters using a low-power clustering method based on their physical proximity to one another.
D. Energy-efficient the clustering algorithm is in charge of forming clusters out of groups of geographically adjacent sensors. This minimizes the number of operational sensors, which in turn helps save energy.
E. The DSS oversees processing the information gathered by the sensors and delivering useful insights to the farmers. It tells farmers when they should water, fertilize, and harvest their crops.
F. A wide variety of agricultural machinery, including irrigation and fertilization systems, are operated by actuators. Through the gateway, the cloud platform sends them instructions.
G. Farmers are given access to the system through a user interface. Data from the DSS and other sources, such as the state of the crops and the weather, are presented. It also provides farmers with a manual override option for the actuators.
H. A power source is necessary for the sensors, gateway, and actuators to operate. In areas far from the power grid, solar panels can provide the energy needed to run the system.

V. Conclusion & Future Work

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Increasing agricultural output and efficiency with the Internet of Things is proving to be a viable strategy. Reducing energy usage in IoT networks has been proven possible with the use of the Energy Efficient Clustering Algorithm (EECA). The energy efficiency, costs, and agricultural yield of the proposed IoT-based agricultural system utilizing the EECA algorithm have the potential to be greatly improved. The suggested system integrates IoT technology with a clustering algorithm to solve a number of problems plaguing the agricultural business, such as water management, soil monitoring, and insect control. The system provides remote crop monitoring so that farmers may optimize watering, fertilizing, and pest control. Moreover, the proposed approach lessens the requirement for manual labor, which cuts down on labor expenses while simultaneously raising output levels.The suggested system has many benefits, but there are still many ways it might be enhanced in the future. The system's ability to grow is a major worry. The system's scalability to larger farms, or even several farms, could present difficulties in managing the massive amounts of data produced by the sensors.Future studies should also look into how varying elements like climate, soil, and crop type affect how well the EECA algorithm works. The algorithm's energy efficiency and its ability to cluster IoT nodes effectively may suffer as a result of these variables.In addition, future studies could investigate the feasibility of incorporating other cutting-edge technologies like machine learning and artificial intelligence to further expand the system's functionalities. Predicting crop production and spotting possible crop illnesses are just two examples of how machine learning algorithms can be put to use. Similarly, AI can be used to reduce wastage while increasing productivity when it comes to water and fertilizer application. Also, the system's security should be prioritized because cyberattacks on the agricultural sector are on the rise. Protecting the information and devices that make up the Internet of Things (IoT) against theft and hacking is crucial for making sure the system works as intended. In conclusion, the energy efficiency, costs, and productivity gains that could result from implementing the suggested IoT-based agricultural system employing the EECA algorithm are enormous. However, more study is required to resolve scalability and security issues and investigate opportunities to include other cutting-edge technology into the system to further expand its capabilities.

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