

Underground WSN Optimization By Sleep, Awake Mode And Genetic Clustering

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Abstract:

Along with the goals of safe and efficient underground mining operations, reliable communication is a high-stakes problem in the mining industry, which is a tough place to work. Automation through remote and automatic systems has led to improvements in the health and safety of the workplace for workers, the control of operations, the use of energy and money, and the ability to respond to events in real time. In this situation, Wireless Sensor Networks (WSNs) have been used a lot in underground monitoring and communication systems to track workers and tools, watch operations, and keep an eye on the environment. This paper has proposed a model that works in sleep and awake mode to increase the life span of network. Further paper has proposed a modified bio-geographical optimization genetic algorithm for the clustering of the nodes as per energy and distance of nodes. Both of the approach increases the performance of the underground WSN network. Experiment was done on different situation of the WSN and results that proposed model has improved various evaluation parameters values.

Index Terms— Energy Optimization, Clustering, UWSN, Routing.

I. INTRODUCTION

Wireless Sensor Network (WSN) is a system that could help mining and other businesses in a number of ways. It goes without saying that keeping an eye on the surroundings, especially in underground coal mines with tunnels that can be several kilometres long and a few metres wide, has always been a very important part of making sure workers

are safe. Also, the underground environment is hostile because there are many poisonous and flammable gases, dust, wetness, and water. For safety reasons, it is important to pay close attention to the underground environment. The setting is also hard because the roof and side halls are dangerous and could fall at any time. So, it's important to take samples in a few key spots to get a full picture of the underground geotechnical and environmental parameters. This way, miners can be warned before a roof or side gallery falls or the amount of toxic and flammable gases goes over a certain limit. Obviously, it needs a lot of gadgets that can sense things. Monitoring the underground world is usually done either sparsely or by hand at the moment. The tracking devices can be linked by a wire to a central processing unit that is far away and safer. But it requires a lot of cables to be put in place in the underground tunnels, which can be hard to do in a hostile setting and cost a lot to maintain.

It's not a new idea to use WSNs to keep an eye on the surroundings in coal pits [1]. WSN methods have been looked into for this purpose before. Yang has suggested ways to set up a long-distance WSN in an underground coal mine [2], Akyildiz has written about the difficulties of using WSNs in underground environments [3], and Xiao has suggested a multi-path WSN routing protocol for monitoring mine security [4]. Most of these works are academic study that focuses on a specific technology or just on the WSN's technologies. In this study, a system for monitoring that uses both the WSN and the CMS is built so that it can be used in real life.

"Energy-efficient routing" has been the subject of a lot of work lately. In [5], it is suggested that power control and schedule should be done together. To make networks last longer, [6] suggests a hierarchical cross-layer design method based on mutual adaptation of node transmission powers and route selection.

Here's how the rest of the paper is put together: In Section II, the latest work in the field of WSN is summed up. In Section III, the suggested method to make underground WSN last longer is explained. In Section IV, the actual values of the proposed model are compared with the

current underground WSN method. Section V gives background information and ideas for work in the future.

II. Related Work

In [8], the problems with coal mines, such as the tight and complicated work environment and the problems the tracking system in sensor networks faces, as well as their flaws in terms of energy use and cost, are looked at. Also, a way is made for the sensors to be spread out fairly in the mine's narrow tunnels. The amount of data shared is also changed based on how much energy it uses, and it is dynamically split between the sensor nodes. The suggested moving algorithm works better than other algorithms, makes the network last much longer, and makes sure that each node uses its energy as efficiently as possible.

In [9], it is shown how to use a WSN in a certain area to collect data from IoT units that are spread out. The experts describe two problems with clustering and routing in large-scale IoT-based WSNs. They then create a new clustering-based routing system to solve both of these problems at once. The protocol chooses the cluster headers in a way that offers fail-safe routing. It then finds a suitable routing path based on the minimum number of hops and the availability of other routing paths. The analysis of the suggested protocol shows that it makes the network last longer and makes it easier to handle the nodes.

In [10], the authors show how the cluster head selection method can be used in a WSN to reduce power usage by using a mixed algorithm. The algorithm is based on a process called "Sparrow Search," which works to extend the life of the nodes by figuring out their most important functions and whether they are alive or dead. This can be done by looking at the nodes' leftover energy and output and then using a detailed model to choose the CHs. The research shows that the suggested algorithm works better than other algorithms like LEACH, LEACH ABC, and TABU_PSO.

In [11], the authors suggest using mixed optimisation methods to make clustering and routing safe in a WSN

context. Here, cluster-based routing was done by combining whale optimisation and grey wolf optimisation. This method picks the best CH based on distance, energy, security, and delay. Qualitative fuzzy logic was used to figure out how safe the CH was. This gave five levels of safety, such as low, very low, medium, high, and very high. Limitations: In this case, trust values were figured out using fuzzy logic, which gives only a rough answer and lowers security. Also, the estimated trust values were saved in a way that anyone could see. This makes the security weak because attackers can easily break it.

In [12], writers suggested a way to make WSNs use less energy by choosing relays based on how close they are to each other. At first, a network is put together using both fixed and moving pieces. After the network was built, the cluster heads were chosen. The information that static nodes have is sent to all mobile nodes. Mobile nodes choose the right cluster head based on where it is and how much energy it has. A more energy-efficient method was used to choose the relay nodes. Limitations: In this case, static nodes are chosen as transport nodes to send data gathered from other nodes to the base station. But a lack of sending power and the fact that the network is static cause the network to use more energy and cause transmission delays, which slows down the rate at which packets are delivered.

Yu et al. [13] showed an energy optimisation clustering method (EOCA) that is better. At both the target and the underwater sensor nodes, the leftover power of each node that moves the underwater sensor network is kept separate. Using the curve parameter, this makes a consistent link between the transfer power of each underwater member node and the shape of the curve. It works well, is possible, can be scaled up, and the frequency of packages will be high.

III. Proposed Work

The proposed work is explained by two modules. The first module explains how the nodes are grouped together, and the second module explains how the packets from the nodes are sent to their final destinations. So, reading this

part will help you fully understand the whole work. In this work, a method called "Modify Biogeographic Optimisation" was used to find the best set of cluster centres. Here, the whole job depends on how the energy in the different nodes changes over time. In this work, the energy from the nodes is an important part of choosing where the cluster centre is. Routing was done by making a straight route to the base station so that there would be less chance of packets colliding.

Develop Region and Assign Node position

Make a $M \times M$ area and put N nodes in it. Set their starting energy level before they start to send and get any packs. Here, you need to figure out how much energy each node uses. Transmission energy (E_{Tx}) and receiving energy (E_{Rx}) can be used in the following ways:

$$E_{Tx}(L,d) = E_{elec} \times L + a \times L \times d^b$$

$$E_{Rx}(L,d) = E_{elec} \times L$$

where L is the length of the information bit, d is the distance between the source and the destination node, and E_{elec} is the amount of energy used per bit. Estimations of a and b depend on estimates of c and d . If d is less than d_0 , a and b will be a_{fs} and 2. If d is more than d_0 , they will be a_{amp} and 4 [9,10]. Note that a_{fs} and A_{amp} are the energy cost of the amplifier. If the goal is farther away than d_0 , the amplifier should use a lot more energy to get there. In short, the goal of a WSN's grouping problem is to boost "the alive sensors" and "the rest of the energies" of the many sensors.

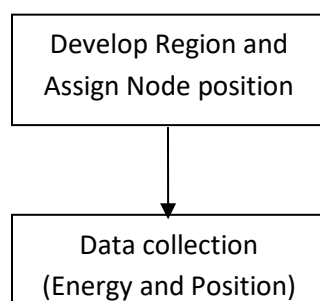


Fig. 1 Block diagram of proposed work.

Estimate K Cluster

So as to ascertain the k number of cluster value that limits the aggregate energy utilization, this work compute the subsidiary of E_{total} with k and set the subordinate as zero so as to prompt the ideal number of bunches k_{opt} to limit the absolute energy utilization of the system [14].

$$K_{opt} = \sqrt{\frac{N \times \epsilon_{fs} \times M^2}{2\pi(2E_{elec} + E_A)}}$$

Where ε_{fs} is amplifier power consumption of the free-space, E_A is energy consumption required for nodes to fuse k-length data.

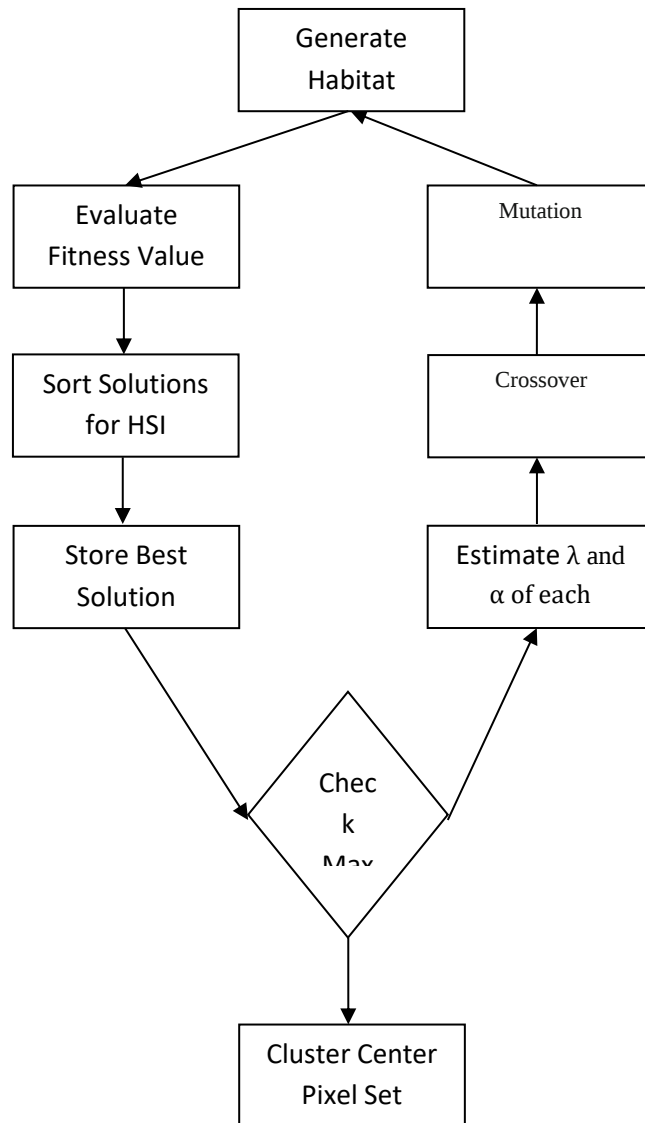


Fig. 2 Block diagram of bio-geographic genetic algorithm.

Clustering by Modified BBO (Bio-Geographic Optimization)

A random set of nodes from the w nodes were chosen for Generate Habitat. In the genetic code, a population is a group of places. Gaussian, a tool for distributing noise, is used to pick a random point. Eq. 4 shows the number of people.

$$H = \text{Gaussian}(w, f, C) \text{---Eq. 4}$$

In above eq. C is number of cluster center, hence each habitat have c number of nodes [15]. F is population size, in other work total number of frogs.

Fitness Function Each type of environment has its own area where it looks for food. So, the fitness of the habitat has to be estimated in order to find the best chromosome in the local population. Energy needed to send one packet from each node through a cluster centre to the base station. In the fitness value review, two types of energy were measured: the energy from the sensor node to the cluster centre and the energy from the cluster centre to the base station. So the fitness value of an environment is the sum of all the energy lost from cluster centres and sensor nodes.

$$H = T_{\text{sensor}} + (T + R)_{\text{cluster_center}} \text{-----Eq. 5}$$

Immigration and Emigration Some of basic terms of immigration λ and Emigration α was done by Eq. 1, 2 [15]:

$$\lambda_R = (1 - \alpha_R) \text{-----Eq. 1}$$

$$\alpha_R = \frac{R}{h} \text{-----Eq. 2}$$

Where R is rank of habitat in terms of HSI value, while h is total number of habitats.

Crossover In this part of the genetic algorithm, the crossover was done by choosing the best possible father from the group [15]. So, to make them healthier, they moved into another environment. So, the amount of fitness will determine which normal parent is chosen. When the value of immigration is high in this habitat, the value of immigration goes for crossing over operations with habitats that have a high value of immigration.

Mutation In this work, mutation was also done after the crossing, so the chance of finding a new answer went up. For this study, the likelihood of mutation was used, and mutation was done in certain environments based on the HSI value. But instead of estimating the mutation chance number, as is done in the standard BBO algorithm, this one uses a different method. This work uses the crossover process in habitat to make it more likely that the cluster centre nodes are the best ones. So, this study changes the part of BBO that has to do with variation.

Cluster Nodes Cluster centres group WSN nodes together. Once the nodes are grouped together, transmission can start and sensing data can be sent. This sending of data goes on for a few rounds, and the cluster centre is updated with the new position and energy of each node.

Sleep, Awake Mode: In this step, half of the cluster centre nodes sleep on even rounds and the other half sleep on odd rounds. This makes the network last longer because it keeps working even though it uses less energy.

Routing: As secondary nodes send data to the base station, energy loss is cut down by routing the nodes. So the total amount of energy needed for the packet movement is less. Every round, the routing of packets from the sensor node to the base station should be the same, because figuring out or identifying the way during gameplay wastes more energy.

IV. Experiment And Result

Experiment was perform on machine having i3 processor with 4 Giga Bytes of RAM hardware configuration, while MATLAB software was used for developing the WSN environment. Different network size were develop with various range of nodes 100, 150, 200. Comparison of proposed model was done with E-DEECP model proposed in [16].

Results

Table 1 First node discharge based Underground WSN optimization models comparison.

Region size	Nodes	SAGUWNO	E-DEECP
100	100	4747	4309
100	150	4168	3987
100	200	3883	3681
100	250	3312	3042
100	300	3438	2690
120	200	2480	2403
140	200	4947	3338
150	150	2503	1105

Table 1 shows that proposed SAGUWNO has increase the number of rounds to get first node discharge. As clustering by modified BGO algorithm has improved the underground node energy utilization. Further use of the sleep and awake mode of the node has reduces the loss of the energy while node is inactive.

Table 2 Total number of rounds based Underground WSN optimization models comparison.

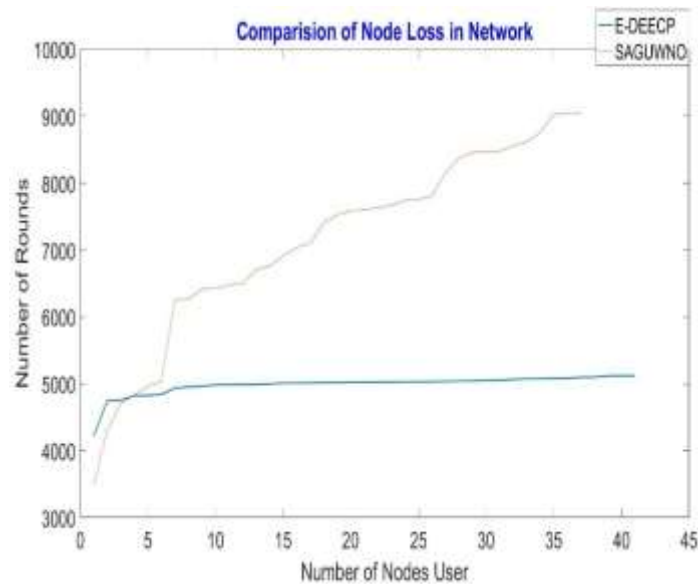
Region size	Nodes	SAGUWNO	E-DEECP
100	100	5122	9057
100	150	9037	4446
100	200	9345	4417
100	250	9640	3530
100	300	9460	4429
120	200	4501	3369
140	200	7372	3235
150	150	8954	3858

Table 2 shows that proposed number of rounds taken by the network in different set of nodes and region. It was found that proposed SAGUWNO has high number of rounds to get all node discharge. E-DEECP number of rounds were improved by SAGUWNO model by 42.7%. Hence genetic based clustering of underground nodes were improved.

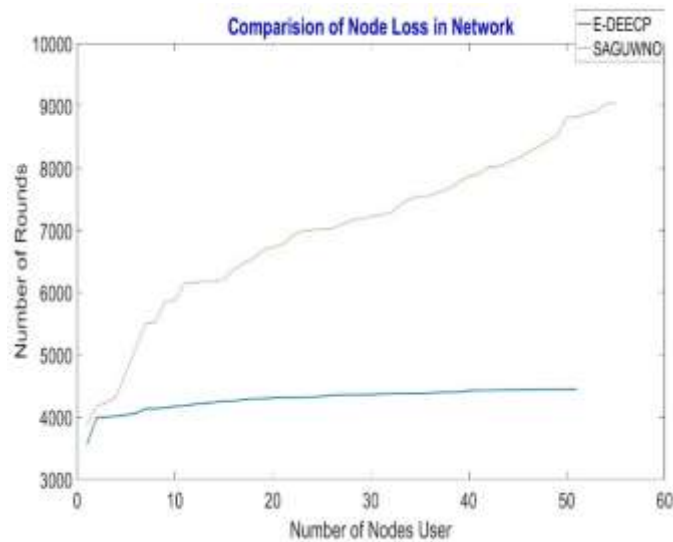
Table 3 Total packet transfer based Underground WSN optimization models comparison.

Region size	Nodes	SAGUWNO	E-DEECP
100	100	429700	424644
100	150	703450	538868
100	200	871548	709583
100	250	985635	699946
100	300	1034307	969791
120	200	250628	144982
140	200	512819	484337
150	150	761971	667918

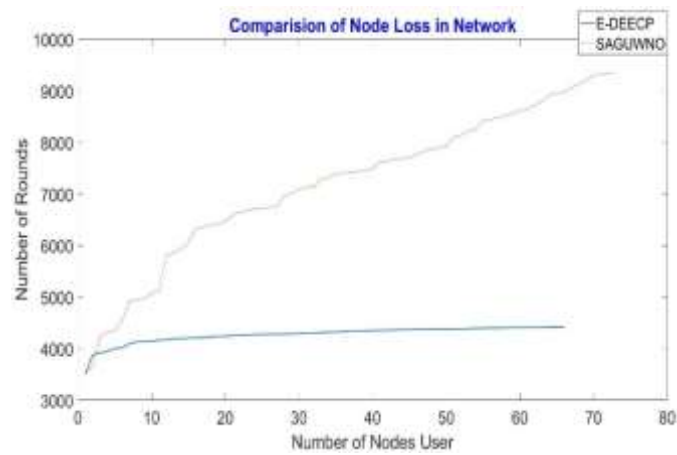
Total number of packets transfer by all the network nodes in different experimental setup shown in table 3. It was found that sleep awake concept has improved the life span of the network and that directly increases the packet count. Number of packet transfer count was enhanced by 16.3% as compared to E-DEECP model.



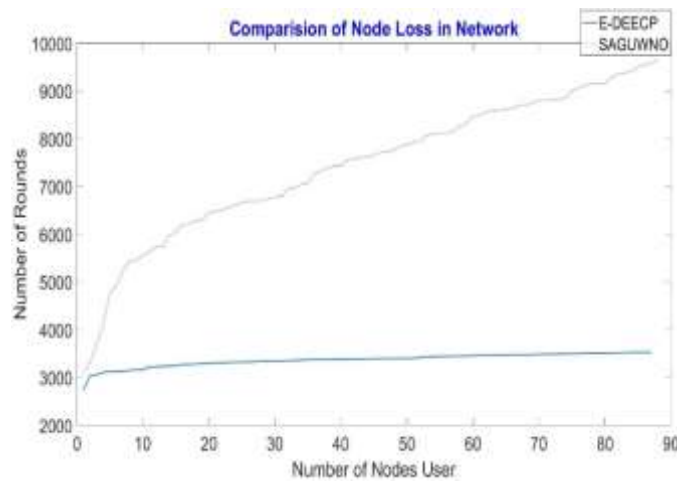
(a) 100x100 Region and 100 Nodes



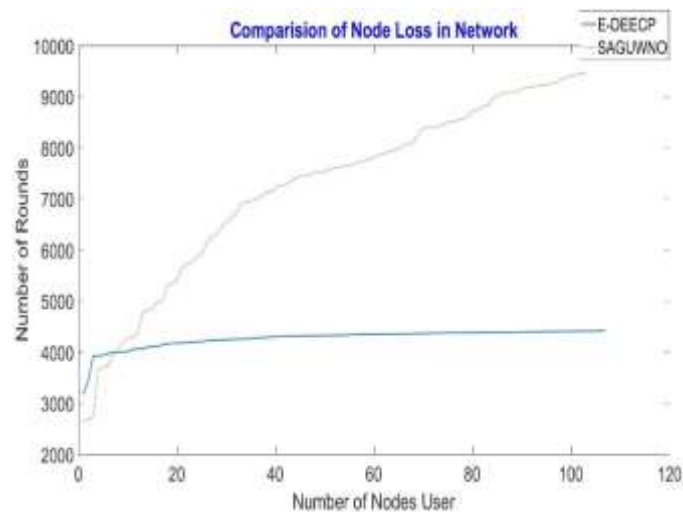
(b) 100x100 Region and 150 Nodes



(c) 100x100 Region and 200 Nodes



(d) 100x100 Region and 250 Nodes



(e) 100x100 Region and 300 Nodes

Fig. 2 Experimental graph of varying number of nodes and its loss in underground WSN.

Table 3 Execution time based Underground WSN optimization models comparison.

Region size	Nodes	SAGUWNO	E-DEECP
100	100	0.0373	0.167
100	150	0.019	0.2899
100	200	0.0204	0.204
100	250	0.013	0.303
100	300	0.0309	0.31
120	200	0.0213	0.253
140	200	0.0324	0.289
150	150	0.0445	0.2334
200	200	0.0227	0.372

Table 4 shows that use of modified bio-geographical optimization genetic algorithm has reduces the execution time of clustering of nodes. This reduce the network cost of maintenance.

V. Conclusion

This paper is mostly about the safety issues in the underground coal mine business. To stop the accident from happening, there needs to be a tracking and early warning system based on sensor data. So, use the WSN network to replace mine transmission cables underground in the coal working area. In this work modified biogeographic optimization based underground WSN model was optimized. This MBGO gives cluster center and communication is done in heirarical network to the base station. Apart from clustering sleep and awake model concept was also used in the work for further enhancing the network energy uses. Experiment shows that number of packet transfer count was enhanced by 16.3% as compared to E-DEECP model. Similarly E-DEECP number of rounds were improved by SAGUWNO model by 42.7%. In future scholar can reduces the energy by use of learning model as well.

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