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UNDERGROUND WSN OPTIMIZATION BY ARTIFICIAL IMMUNE BASED CLUSTERING AND HIERARCHICAL ROUTING

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Abstract: Most of the underground work is highly risky as safety of human and instrument need escape time. For this continuous monitoring of such mines is on demand. As mining networks are temporary hence wireless networks were preferred this increases the dependency of node life. This paper has proposed a underground mines wireless sensor network model that increase the life of network. Sensor nodes were lcustered by the artificial immune genetic algorithm this reduces the energy cost of the distanced node. Further routing of packet is static after clustering and in hierarchical structure, so runtime path calculation get reduces. Both these approaches increases the life span of UWSN. Experiment was done on different nodes conditions and result shows that proposed model has increases the number of rounds and packet counts.
Index Terms— Energy Optimization, Clustering, UWSN, Routing.

I. INTRODUCTION

Indian is a big country with lots of coal mines. But the safe level of production in coal mines is still low. This is especially true since disasters in coal mines happen often and cause a lot of damage and loss of life. Over time, safety issues in coal mines have become a major worry for the country and society as a whole. Coal mine accidents happen because the working conditions are so different and the environment is so complicated. This is why it is so important to keep an eye on the mine working environment. Most of the time, wired network systems are used for traditional coal mine tracking. These systems are an important part of keeping coal mines safe. As the coal mine's working areas and depths keep getting bigger, many lanes turn into blind spots where there are lots of secret risks. It's also difficult to lay wires, which costs money and takes time. Our plan is to create a wireless underground sensor network (WUSN)-based coal mine safety tracking system that will help fix the issues. This will raise the level of monitoring production safety and lower the number of accidents in coal mines. A wireless sensor network is made up of many microsensor nodes, which are small and cheap.

However, underground coal mines are mostly made up of random paths and branch tubes. This makes it hard to set up any kind of networking framework. In this situation, using a wireless underground sensor network (WUSN) and other tracking devices might be the best way to automate monitoring and control of the underground because they can be set up quickly and easily.

The multi-hop transmitting method can also easily adapt to the structure of the tunnel, making it scalable enough to be used in the construction of a mining system. It is also perfect for full monitoring and control in coal mines, making up for the flaws in the current underground cable monitoring system. Even though mine tracking methods have gotten better as technology has improved, explosions still happen in deep coal mines.

The rest of the paper is put together like this: What's new in the field of WSN is put up in Section II. In Section III, we talk about the suggested way to make underground WSN last longer. In Section IV, we compare the proposed model's real values with those of the present buried WSN method. Part V talks about the history and gives thoughts for future work.

II. Related Work

In [6], H. Zhang et al. describe the basic structure of a Mine IoT (MIoT) system based on a popular three-layer IoT architecture. They also list the different types of sensors that are commonly used in underground mines and explain how they can be used. Finally, they talk about wired and wireless communication technologies and network topologies that can be used in underground mines. This piece talks about the latest developments in using the Internet of Things (IoT) in deep mines to keep an eye on things like mine gas and dust levels, temperature, humidity, airflow, groundwater, ground support, and earthquake activity. Researchers have also looked into how the Internet of Things can be used to find fires and other dangers, track people and equipment, and control workplace safety. Some of the biggest problems with using IoT technology in deep mines are that it can interrupt operations, cost a lot, have short battery lives, make contact in the mines less reliable, and be hard to keep track of all the data.

According to [7], R. Alsaqour et al. suggested a better way to choose a CH based on three levels of sensor energy: low, high, and super. They also suggested measuring the lengths between base stations and possible CH nodes to make the CH selection method work better.

The work by Zhang, Y., et al. [8] is mostly about the WSN and how it connects to the CMS. To make the WSN work in deep coal mines, two work modes are created: periodic inspection and stop service. Supporting technologies like a route mechanism, collision avoidance, data aggregation, interconnection with the CMS, and more are suggested and studied. An integrated network management plan is made with four parts: topology management, location management, energy management, and fault management. This is because WSN nodes have limited power, energy source, and processing power.

Based on Q-learning, Xiliang Ma et al. [9] suggested a way for wireless sensor networks to set up their own route system. It looks at a lot of things, like the distance, the number of hops, the amount of energy that is still left over, and the transmission loss and energy at each point. A map is made between each node in the wireless sensor networks and an Agent. Training is done on a regular basis to make the route choice better. According to the estimated Q evaluation value, each Agent picks the best way to send data.

In [10], Lalatendu Muduli et al. suggest a WSN-based fire tracking system for deep coal mines that uses fuzzy logic to make decision-making more reliable and lower the risk of mine fires. The Mamdani fuzzy inference system is used as a fuzzy model to make choices about tracking data in real time. The Fuzzy Logic Toolbox in MATLAB is used to model the system in great detail. The simulations showed that the proposed system is more accurate and quick to respond to fire risks than the offline tracking system used in underground coal mines.

III. Proposed Work

Two sections were used to explain the suggested Modify Artificial Immune Underground Wirelss Network Optimization (MAIUWNO) model. The first module talks about how the nodes are grouped together, and the second module talks about how the nodes get from the sensor node to their end targets. This part will help you understand the whole thing. "Artificial Immune Optimization" was used to find the best set of cluster centers in this work. Here, the whole job is based on how the distance and energy change over time. The energy from the nodes is a big part of picking the cluster center based on how far it is from the base station in this work. Layered routes were used to connect the nodes to the base station, which made it less likely that packets would miss each other.

Develop Region and Assign Node position

Put N nodes in an area that is MxM. Set how much energy they have to start with before they send and receive packs. You need to find out how much power each node uses. Getting energy (ERx) and sending energy (ETx) can be used in the following ways:

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

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

Eelec is the amount of energy used per bit, L is the length of the bit, and d is the distance between the source node and the target node. The estimates of a and b depend on the values of c and d. a and b will be afs and 2 if d is less than d0. They will be aamp and 4 [9, 10] if d is greater than d0. When you look at afs and Aamp, you can see how much energy they use. The amp should use a lot more power to get to the goal if it is farther away than d0. To put it simply, the grouping problem in a WSN is about increasing "the alive sensors" and "the rest of the energies" of all the sensors.

Estimate K Cluster

To find the kth number of clusters that will limit the total amount of energy used, this work computes the derivative of Etotal with k and sets the derivative to zero. This gives us the ideal number of clusters kopt that will limit the total amount of energy used by the system [11].

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

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

Clustering by Artificial Immune Optimization

A random set of nodes from the w nodes were chosen for Generate antibodies. Gaussian, a tool for distributing noise, is used to pick a random point. Eq. 4 shows the number of people.

$A = Gaussian(a, c)$----Eq. 4

In above eq. c is number of cluster center, hence each antibody have c number of nodes [12]. A is matrix of a number of antibodies.

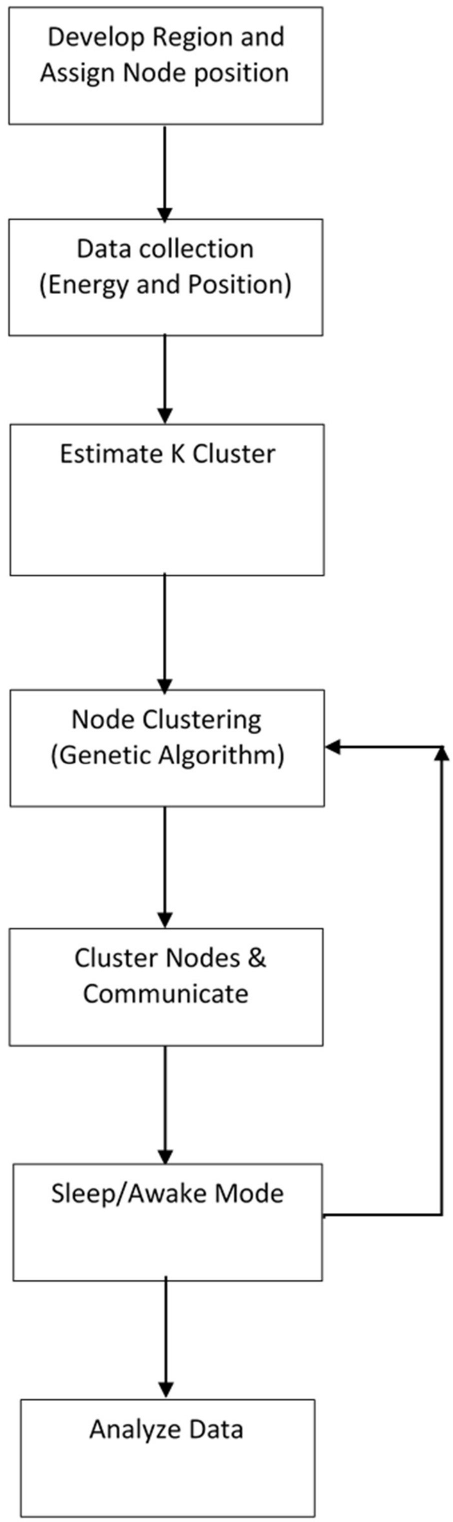

Fig. 1 Block diagram of proposed MAIUWNO model.

Affinity So, the fitness of the antibody 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.

$A = T_{sensor} + (T + R)_{cluster\_center}$----------Eq. 5

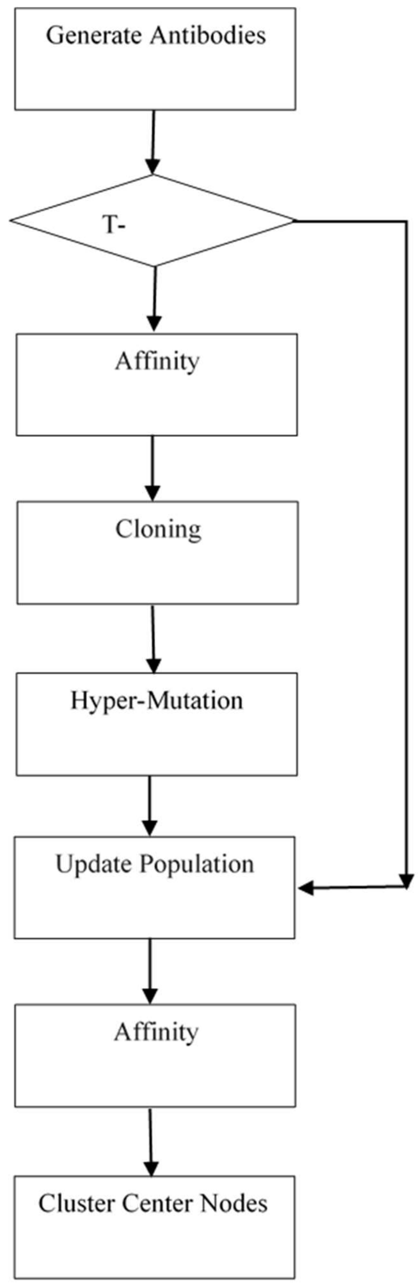

Fig. 2 Block diagram of artificial immune optimization.

Cloning
As per affinity value of each antibody in population, best solution A_b is obtained. As per best antibody A_b feature set few status were randomly change. By change in feature status present to absent or absent to present cloning of the model is done.

$A \leftarrow Cloning(A_b, A)$

Hypermutation
The clones are then subjected to a hyper mutation procedure, in which they are mutated in inverse proportion to their affinity, with the best antibody's clones being mutated the least and the poorest antibody's clones being mutated the most. The clones and their original antibodies are then analysed, and the best N antibodies are chosen for the next iteration [13]. It's possible for the mutation to be uniform, Gaussian, or exponential.

$A \leftarrow Hypermutation(A)$

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 [14]. 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 [15].

Results

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

Region size	Nodes	MAIUWNO	E-DEECP

100	**100**	6327	3395
100	**150**	9207	3729
100	**200**	9108	3344
100	**250**	8992	3867
100	**300**	8129	3553
120	**200**	7974	4123
140	**200**	5358	3305
150	**150**	3562	3083

Total number of rounds shows that how long the work work till the last node has battery. Table 1, shows that under different situations of number of nodes and area round counts of proposed model is high as compared to existing models E-DEECP. Use of artificial immune algorithm has increase this parameter values.

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

Region size	**Nodes**	**MAIUWNO**	**E-DEECP**
100	**100**	9411	3662
100	**150**	4826	3467
100	**200**	4721	2909
100	**250**	4426	3551
100	**300**	3181	3149
120	**200**	3408	2783
140	**200**	1851	1707
150	**150**	1260	840

First node discharge shows routing approach of the model. It was found that proposed model has discharge first node with higer number of rounds as compared to previous model. Routing by hierarchical approach has increases the work efficiency by 33.29% as compared to previous model.

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

Region size	**Nodes**	**MAIUWNO**	**E-DEECP**
100	**100**	348347	303077
100	**150**	638923	438848
100	**200**	859385	535456

100	**250**	974285	823613
100	**300**	1052270	691661
120	**200**	679236	669453
140	**200**	192355	178896
150	**150**	290864	192987

All work of WSN is to communicate packets hence higher number of counts shows that clustering and routing model work efficiently. Table 3 shows that proposed model has high number of packets as life span of nodes got increased in all set of experimental situations.

Table 4 Execution time based Underground WSN optimization models comparison.

Region size	Nodes	MAIUWNO	E-DEECP
100	**100**	0.0432	0.167
100	**150**	0.0393	0.2899
100	**200**	0.0422	0.204
100	**250**	0.0339	0.303
100	**300**	0.0438	0.31
120	**200**	0.0772	0.253
140	**200**	0.0337	0.289
150	**150**	0.0445	0.2334
200	**200**	0.0227	0.372

Table 4 shows that use of modified artificial immune optimization algorithm has reduces the execution time of clustering of nodes. This reduce the network cost of maintenance.

V. Conclusion

This paper has proposed a underground mine wireless sensor optimization. For this paper has doen clustering by the artificial immune genetic algorithm to reduce the distance between the sensor node and base station. Further routing was improved by hierarchical method that increases the life of the model, as runtime routing is costly. Both approach was evaluated under different environmental conditions and result shows that proposed model has increase the packet count by 23.86% as compared to previous model. Routing by hierarchical approach has increases the work efficiency by 33.29% as compared to previous model. In future scholar can perform this work in under water situations.

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