UWSNs Deployment Method Based on Sink Node Gravitational Pull and Dynamic Communication Radius

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Abstract

Underwater wireless sensor networks (UWSNs) are an underwater monitoring system consisting of nodes with sensing, computing and acoustic communication capabilities. Node deployment is not only closely related with monitoring quality, but also the basic of other subsequent protocols.

This paper proposes a non-uniform deployment scheme for UWSNs based on the sink node 's gravitational pull and dynamic communication radius, integrating improved virtual force algorithms with particle swarm optimization for iterative deployment optimization.

System Models

Sink node is responsible for aggregating data, and normal nodes equipped with various sensors to detect environmental information. After the network is deployed, regular nodes collect data and transmit it to the surface sink node via underwater acoustic channels. The sink node then utilizes electromagnetic waves for long-distance transmission.

This scheme employs a spherical sensing model based on Boolean perception, assuming that the detection region of an underwater sensor node is a three-dimensional sphere.

Methods

Improved Virtual Force (IVF):

Sink Node Gravitational Pull: Nodes are attracted to the sink node based on a gravitational force, optimizing deployment and reducing the hotspot issue.

Dynamic Communication Radius: The communication radius of nodes is adjusted based on their current depth. The interaction force thresholds between the nodes also vary with the communication radius. Shallow nodes have a higher density, improving connectivity and efficiency.

Particle Swarm Optimization Algorithm Based on IVF(IVF-PSO):

Improves the particle velocity update in the PSO using the enhanced virtual force algorithm. Reduce search randomness, enabling faster convergence to the global optimum.

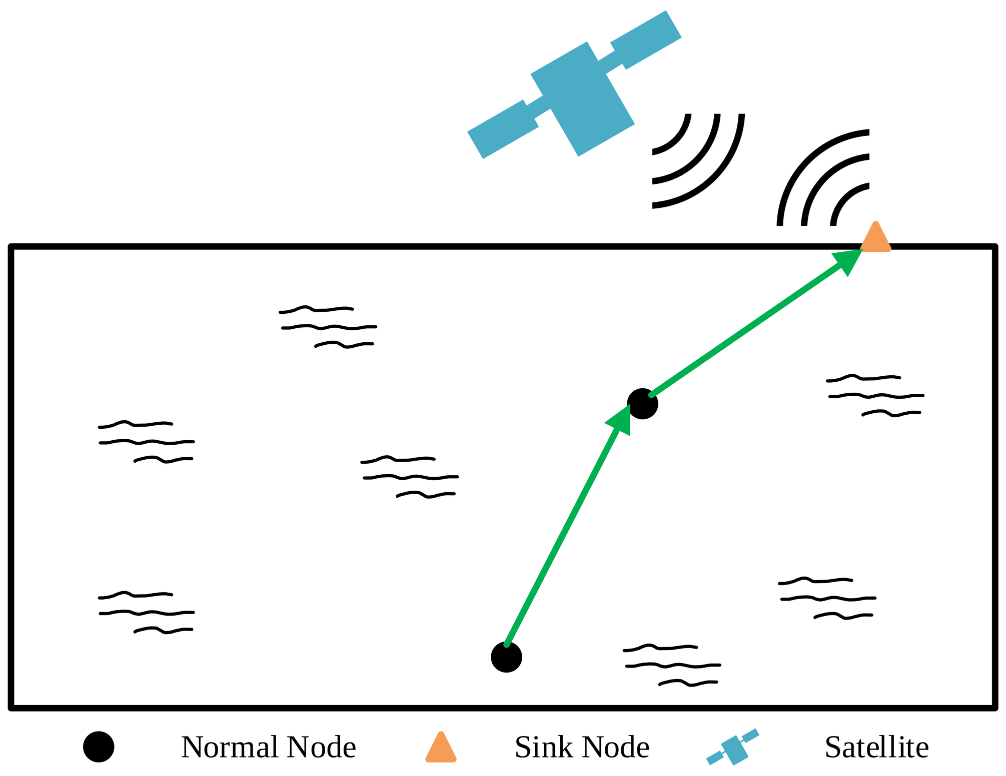

Fig. 1 System Model

Results

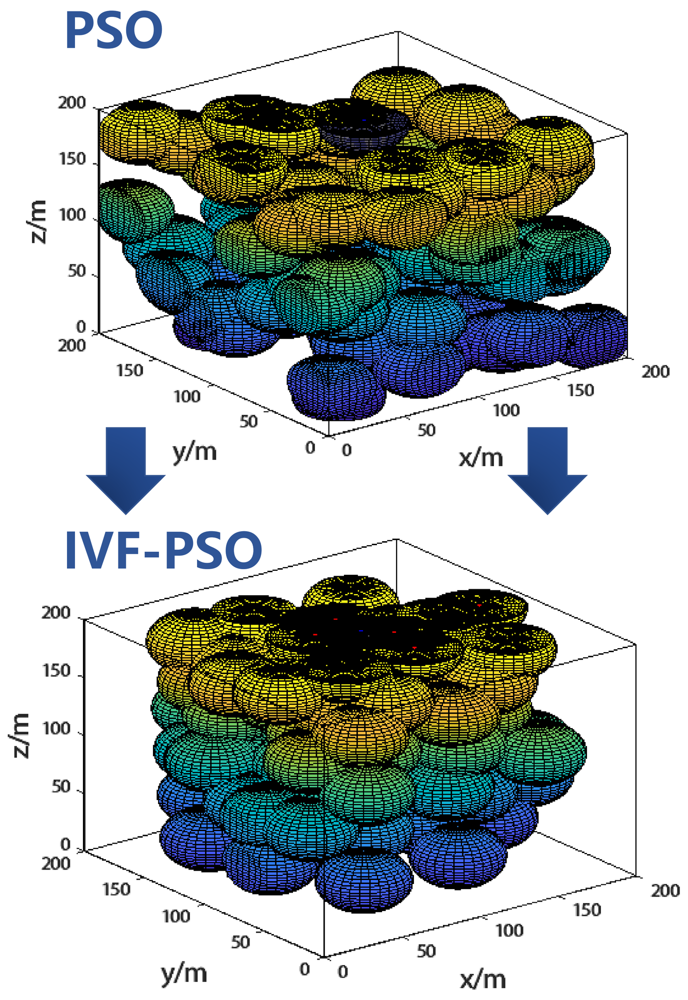

Fig. 2 Deployment Effect Diagram

Fig.2 illustrates the deployment effect diagram before and after the application of the algorithm. It is evident that the overall deployment effect of the IVF-PSO algorithm tends to cluster towards the center, with the number of nodes increasing as the depth decreases, effectively mitigating the hotspot issue.

Fig.3, Fig.4, and Fig.5 can be observed that the IVF-PSO algorithm demonstrates improvements in all aspects compared to the PSO algorithm. In networks with fewer nodes, the average number of disconnected nodes is less than 1, indicating that the network maintains good connectivity.

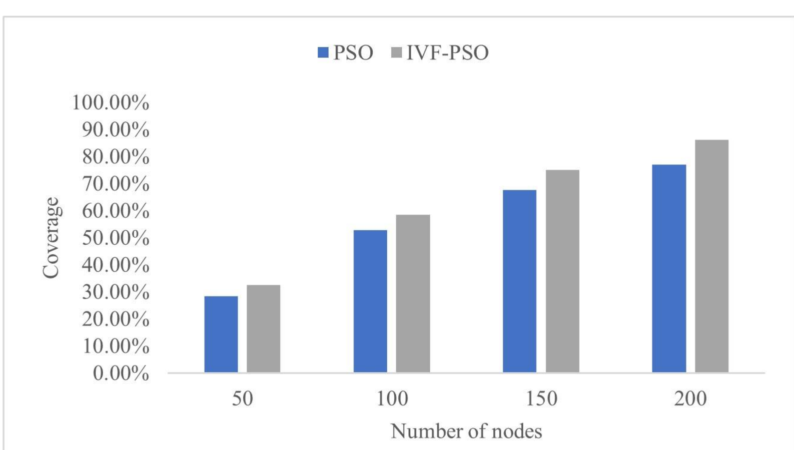

Fig. 3 Coverage Rate under Different Numbers of Nodes

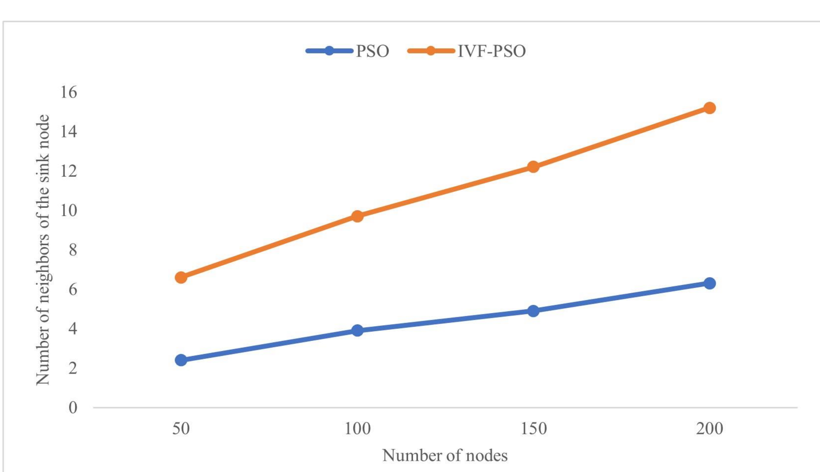

Fig. 4 Neighbors of Sink under Different Numbers of Nodes

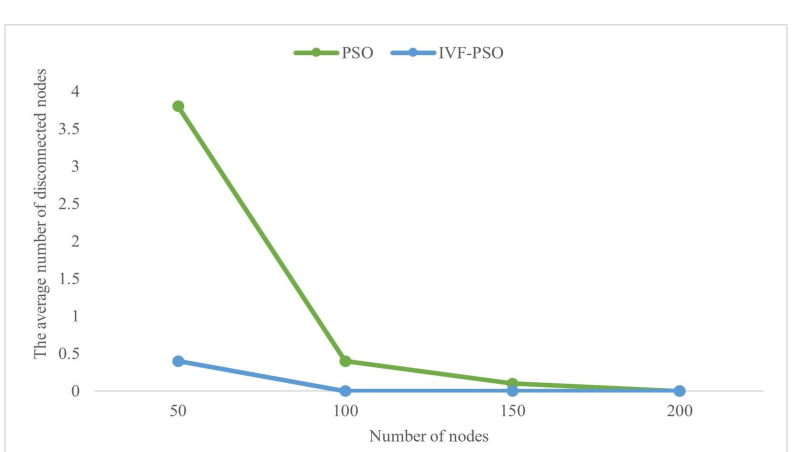

Fig. 5 Disconnected Nodes under Different Numbers of Nodes

Conclusion

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To address the issues of low coverage and poor network connectivity in the deployment of UWSNs, this paper proposes a particle swarm optimization algorithm based on improved virtual force. Simulation results show that the proposed IVF-PSO successfully increases network coverage and connectivity in UWSNs while increasing the density of nodes in shallow regions, effectively mitigating the hotspot issue encountered during subsequent network operations.