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An N-Shortest-Paths Algorithm Implemented with Bidirectional Search

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Abstract To save the escaping time for the coal mine flood, improve the emergency rescue efficiency, an N-Shortest Paths algorithm utilized bidirectional search is presented, which is based on the classical Dijkstra algorithm. The algorithm was proposed roadway length equivalent weights to simulate the mine roadway length. Combined with GIS theory to extract topology structure of mine, an undirected weighted graph was constructed. With the above optimization algorithm, at the end of the paper, it was simulated using MATLAB. Simulation results demonstrate the feasibility and accuracy of the algorithm.
Keywords mine water-inrush, Dijkstra algorithm, N-Shortest Paths, bidirectional search

Introduction

Mine water inrush is one of the most serious and frequent disasters in the process of coal mining. It poses a serious threat to the mine safety production and the life safety of the workers. There are many types of mine water disasters in our country, according to the source of the water in general can be divided into surface water and aquifer water, water of old kiln, and fault etc. So it is particularly important that quickly launch the emergency rescue work in time to ensure the accuracy of the safety and the safety evacuation in the event of a mine flood. At home and abroad the researches about safety of mine disasters are mainly focused on the fire, gas, etc., while ignoring the disaster of water inrush. This paper not only puts forward a design on optimized escape route of mine water-inrush, but taking advantage of GIS spatial analysis and modeling function to design and fast optimization of mine safety route. Table 1 gives a disaster concept map combined with the practical situation of the coal mine.

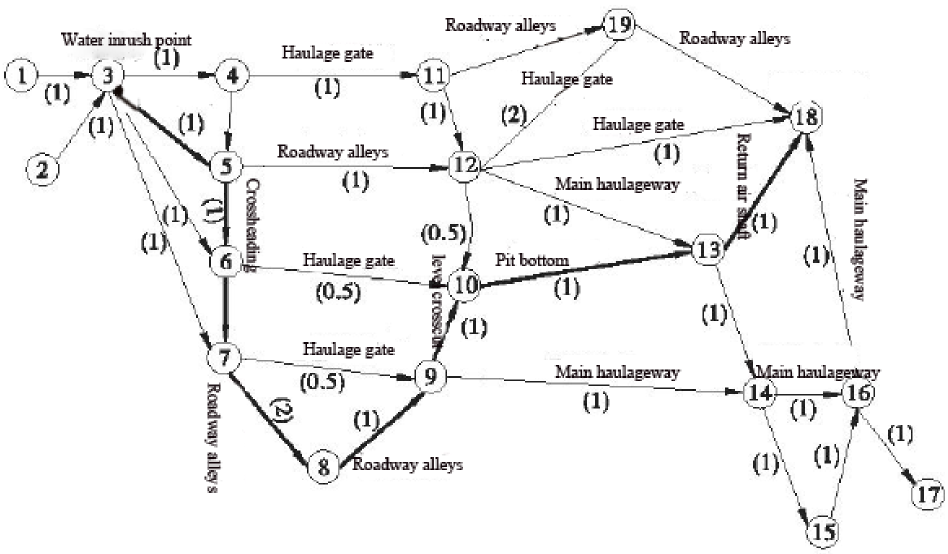

Fig. 1 *The display of the optimal paths in the network diagram in actual mine*

The best route of escaping and rescuing on the improved Dijkstra algorithm

Roadway equivalent weights

In view of the special down hole environment, whether following wind or contrary wind, the roadway can be used as an escape route. So a weighted undirected graph will be simulated to find the optimal path. And when the flood occurred, the biggest factor is the direction of water flow in escape. Under normal circumstances, staff should escape to higher ground, or bucking the trend. When we calculate to find the best path, not only the physical distance but the ease of access roadway flooding conditions also should be fully considered. Different roadway has different varying degrees of passage, even the same length of roadway, also due to the impact from the accident spot, the direction of water flow, among other factors have a greater gap between the passage of time. So there will be a variety of factors which influence the passage taken into account. With the impact factor to reflect the actual length of the roadway so that the coefficient multiplied by these factors, we get the equivalent weight of the roadway. Equivalent weights roadway can be more objective and true to response the time through roadway.

N-Shortest Paths

Optimized escape route is not simply meaning the one using the shortest time route. With the complex underground environment, it is more difficult to predict in the event of flooding. Water flow, wind speed and other factors also take great influence and unpredictability to predict. So this optimized escape route is likely to be destroyed, furthermore misleading emergency rescue. To prevent this from happening, on the basis of fully considering the roadway equivalent weight, it uses of optimization algorithms to get a number of alternative paths, namely N-Shortest Paths. N-Shortest Paths algorithm is more adapt to the dynamic changes in the underground environment.

Traditional shortest path algorithm for solving the former N paths is generally used to change-edge, this method of calculating the process is complex and the results obtained are not optimal. Therefore, this paper is using the bidirectional search strategy based on the direction optimization to get more efficiently and accuracy N-Shortest-Paths. Bidirectional search is the process of searching in two directions from the source node to destination node at the same time based on the above motioned direction optimization strategy.

Optimized escape route design on improved Dijkstra algorithm

There has a weighted undirected graph $G=(V,E,W)$, where V represents a collection of nodes, E represents the set of edges, W_{ij} represents the weight between edges i and j. $W_{ij}=(v_i,v_j)$, if v_i to v_j infinity or $v_i=v_j$, then let $W_{ij} = 0$. If the edge between v_i and v_j is blocked by flood, then $W_{ij} = \infty$.

The shortest path tree of taking starting point node as root is the positive sequence tree, taking end point node as root is called reverse tree. Extending the positive sequence tree, the adjacent nodes are out-degree nodes, while the adjacent nodes in the reverse are in-degree nodes. Generating principle of optimal path tree shows the need to save the out-degree and in-degree topological adjacency information of node, which ensures that the path stitched up with the intersection nodes is the path from the beginning to the end direction.

Simulation and analysis

The shortest path algorithm is one of the most important functions of GIS, this paper is to establish a network topology map using GIS theory. View under the mine roadway as edges in the graph topology, each roadway intersections as nodes in topology map. The uncertainty of the flow direction determines the isotropic of studied escape routes. The electronic mine map can be extracted into a more complex undirected topology. According to the actual situation of each mine tunnel and combined with periodic evacuation drills estimating experience to set equivalent weights for each section. Generally, N values of between 2 to 5.

In this paper, a relatively simple electronic map analog mine tunnel, establish topology of vector maps, then simulation tests in the MATLAB environment to achieve the quick search of N-shortest path, and compared with the traditional Dijkstra algorithm to verify the practicality and effectiveness of this improved algorithm.

By testing on the topology, it gets the optimal path from node 1 to node 27. Optimal paths optimized in this article are shown in fig. 2, where taking N = 2. Table 1 is a comparison of the two algorithms on the time complexity and search time. Obviously, the optimized algorithm is better than traditional Dijkstra algorithm.

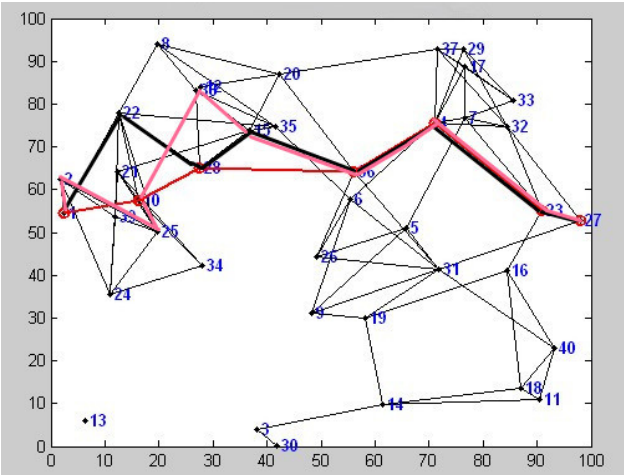

Fig. 2 *Optimal path diagram on improved algorithm*

The time complexity of optimization algorithm proposed in this paper is O (n log n). While the time complexity of traditional Dijkstra algorithm based on adjacency matrix is O (n^2). When the graph has a large number of nodes, or just switch to the adjacent table storage network data structures, it can not change the time complexity of the algorithm. Even the most commonly used K shortest paths algorithm of change-edge methods, whose worst-case time complexity is O ($e^{k-1} \times n^2$), where e is the average number of edges. The improved algorithm proposed in this paper can not only increase the number of alternative paths to improve the practicality, but also improve the time efficiency.

Conclusions

This paper proposes an improved Dijkstra algorithm based on GIS. It has high efficiency and practicality verified in the specific examples. However, due to the dynamic changes in flood, it needs to consider the equivalent length changes in real time. So the problem of accurate and detect the moment of impact factor timely, and applied to improve the algorithm to more accurately find the optimal path is urgent to be solved.

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