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Research Article

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Position prediction in mine personnel RFID positioning system based on shortest path principle

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ABSTRACT

The RFID-based positioning equipment, which is widely used in mine operation such as coal mine, has the advantages of low cost and maturity. It can locate human effectively so that it could improve the production safety situation and provide guarantee for disaster prevention and relief. However, the traditional RFID technology has the drawbacks of small monitoring range and no orientation which cause larger deviations and blind area in personnel locating. In this paper, we design the coal mine personnel positioning system based RFID. The system could track the underground person and draw the movements between the RFID base stations by the shortest path principle and algorithm. Combining the factors of time and experience data, the system can also predict the person position in blind area of the base stations. That improves the localization ability of RFID system.

Key words: RFID; Positioning system; Shortest path

INTRODUCTION

With the ever increasing attention to the coal mine safety of government, the coal mine enterprises have also equipped corresponding production monitoring system to improve production safety situation and provide guarantee for disaster prevention and relief. In those systems, the personnel positioning system based on RFID technology is easy to use and is cheap on hardware cost. The RFID system can draw the distribution of personnel on the monitoring computer, so that the managers can master the distribution of mine personnel and equipment and can also track every person underground. That could help the managers to make more reasonable scheduling management. When the accident happened, it can help rescue workers to locate the relevant person and take rescue measures timely based on the data and graphics provided by the positioning system. That can improve the efficiency of emergency rescue work [1][2].

Determining the real-time position of an underground mining vehicle relative to a global map is a veryimportant problem facing the mining industry. Unfortunately, techniques such as Global Positioning System (GPS) cannot be used in underground mines. [3] The RFID technology becomes a better alternative. RFID (Radio Frequency Identification), also known as electronic label, is a technology using Radio Frequency signal for automatically identify target and obtain information. Basic RFID system includes tag, RFID reader and support application software. Tag is composed of chip and antenna. Every tag has a unique electronic code and is attached on object for identify. The RFID reader control the RF module to send reading signal to the tag, receive the tag's response and decode the label object identity information. After identity, it transmits the identity information and its relevant information to the host for further processing. The RFID applications include filter, collection and calculation process of the tag data. With the development of the technology, RFID has been widely used in many fields, including object locating and tracking [4-5].

1. PERSONNEL POSITIONING SYSTEM BASED ON RFID

The hardware of system includes three parts: data center, RFID base stations and radio frequency identification cards. The overview of system is showed in Figure 1. Data center includes communication computer, monitor computer and the database server. It controls the communication positioning system. Combining the mine map, personnel information and the location information, it can monitor the mine personnel in real time and display the personnel position. Base stations are the key part of the system. By regularly checking the radio frequency cards in the detection range, the system can confirm the personnel information within a certain area. After receiving the radio frequency card data, the system decodes the data and checks the validity at first, and then transfer data through RS232 and RS422, RS485 or wireless way to the computer network[6]. Finally, the data is transferred to the data center and in which the ID of radio frequency card and the personnel will be one to one correspondence and record in the data center database. This data can be used to locate and manage the mine personnel.

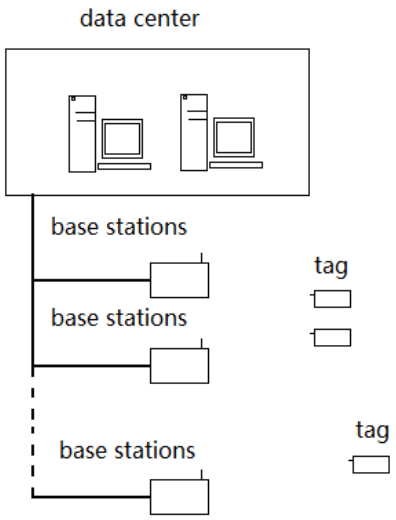

Figure 1 Overview of the Personnel Positioning System Based on RFID

In the system software design, we should extend the functionality of the software with the data provided by the positioning system as possible as we can except for the basic positioning function, so that to improve the technological content of products and level of competition. Software design should comply with the regulations of coal mine enterprise's management, business process and people's habits. The entire location monitoring system based on RFID in 'head lamps' has many other applications. Such a solution can create a core base of an intelligent security management system for miners[7].

2. PERSONNEL Position Prediction in Blind Area

3.1 limitation of the RFID

The RFID equipment has the advantages of low cost and maturity, but it also has the drawbacks of small monitoring range and no orientation which cause larger deviations and blind area in personnel locating. Because of the complex terrain of the mine, the system needs a large number of the base stations if the signal covers all of the area. That would increase the cost. In practice, we only acquire signal at key points to determine the personal position.

As a result, the RFID positioning system is not perfect. It can determine the underground personnel position in the cover area of the base stations and cannot determine the personnel position out of the scope of the base stations. There is a considerable blind area which causes the positioning information incompletely. That should be resolved in the system.

3.2 Prediction of the Personal Position in Blind Area

We cannot get the personal position in blind area directly. Therefore, we predict the position with the collected information. According to special terrain of mine which mainly includes channels and intersection, we can predict the tunnel of mine he had moved by the personnel's direction of movement (the next positioning base station location). If known his movement speed, we can calculate the moving distance by the time of leaving the base station and predict the personal position. In our system, the shortest distance method is chosen to predict the moving path, which determines the shortest path between two base stations as personnel moving path. This method conforms to the actual situation of most.

3.3 The Shortest Path Method

The shortest path problem has much important significance in operational research and is also one of the important contents of GIS network analysis. In the shortest path methods for resolving network diagram problem, Dijkstra and Floyd algorithm is considered as the best algorithm. In these algorithms, network is abstracted as a directed graph or undirected graph, and the correlation information between points are recorded as node adjacency matrix. In graph traversal, distinguish the minimum based on the matrix to find the shortest path until getting the final path [8].

The representation of vector map and construction of network topology in Traffic network are the indispensable basic work to realize the shortest path analysis system, and efficient implementation of shortest path algorithm is the core of the shortest path analysis system [9].

Referring to the application background of shortest path analysis, the shortest path algorithm we discussed is mainly designed for the planar directed graph which all the weights of arc are positive. The main problem is how to quickly find the shortest path between two specified nodes.

In the mine map, intersections of pathways are defined as nodes of the graph.

For the convenience of the followed discussion, the relevant definition of the directed graph and shortest path algorithm are defined as follows:

Definition 1: directed map G={N,A}, where N is nodes set and A is arc set, the number of nodes n = [N], the number of arcs m=[A], s is source node, t is target node.

Definition 2: d(i) represents the weighted distance of the source node s to node i; l(i, j) represents the arc weights between node i and j; S(j) represents the state of node j, which has three status: unreached labeled, temporarily labeled and permanently labeled node.

Labeling Method is the core of most of the shortest path algorithm process. The output result of labeling method is a spanning tree whose root node is the source node s. The tree is generated by iteration. At the end of the iteration process, the spanning tree becomes a shortest path tree, the path from s to any node i on the tree is the shortest path from s to i.

In the process of iteration, there are three markers of each node i: distance label, l(i); parent node, p (i); node status, S(i). Where d (i) represents weighted distance between the node i and source node s. At the end of algorithm, the d (i) represents the minimum weighted distance between s and i: p (i) represents the current shortest cost path. Node distance label follows the following rules: for the temporarily labeled node, d (i) represents the source node s to node i in the upper bound of the weighted distance; for permanently labeled node, d (i) is most final and optimal weighted distance from the source node s to node i [10].

3.4 Improvement of the Shortest Path Algorithm in RFID Mine Personnel Positioning System

At practice, we found that the movement of personnel in the mine should consider the walk convenience of pathways, the transport and the tunnel environment except for the shortest path. It is not enough to predict the path by simply consider the distance factor. In order to improve the predict accuracy, we must improve the algorithm.

In the algorithm, we take the length of each path of mine as the weight between nodes, and build the corresponding spanning tree. But in practical applications, the path length factor is not the only reason when personnel choose the path. There are other factors which affect the weight. So we can set up a number of factors to build the weights for path chosen. We use the path length as the primary basis of a weight value and set up some correction parameters R whose basic values are 1 to modify the path values. By this method we can obtain the same optimal value of the path approximately to the personnel selection scheme. The original formula is below:

$l(i,j)=S(i,j)$

the adjusted formula is

$l(i,j)=S(i,j)*R1*R2 \cdots\cdots *Rn$

By using these revised in each tunnel, we can solve the problem of weights very well.

3.5 Personnel Position Prediction

To predict the personnel position in blind area, we must use the known conditions. There are three information can be used: (1) the time that the personnel leaving the position of the base station; (2) personnel movement speed; (3) personnel route. By the movement speed and the difference between current time and leaving time, we can calculate the distance that personnel moved from the base station. Then we can analyze the path of personnel in the blind area by the shortest path algorithm and predict the exact position of personnel.

If exists intersection, branch will occur in personnel movement trajectory. According to this situation, we use the history data of personnel movement in the positioning system to predict the moving direction by analyze the discipline of the movement, and then identify the next station of the personnel. That can increase prediction accuracy.

CONCLUSION

Mine personnel positioning system can improve the production safety situation and provide guarantee for disaster prevention and relief. Because of the complex of tunnels, positioning system based on RFID technology in mine has many problems, such as how to predict in blind area. We use the shortest path algorithm and history data to calculate the next base station and the movement trajectory, and then predict the personnel's position in the blind area. The method can solve the problem and can be applied to other positioning devices whose line is relatively simple and movement speed is constant, such as rail transit.

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