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Research on Construction Method of Underground Cable Path Network Based on GPS

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Abstract:

In view of the frequent excavation of underground cables in the city and the fact that the municipal management department does not update the underground cable path network in time, which leads to the chaos of urban underground cable management, a method for quickly constructing a cable path network is proposed. The method uses GPS positioning function and cable path detection technology, and combined with MATLAB image processing to quickly build an underground cable network of urban roads. The GPS data acquisition system is mainly responsible for cable positioning and data processing, using chain coding technology to process the data and extract effective feature points. Using MATLAB image processing can quickly generate feature scatter plots, at the same time generate all cable path networks as needed, or update the specified segment path network. The experimental results show that the formed path network reflects the real cable path better, and the research results provide great convenience for urban planning and construction.

Keywords: *Cable path, GPS positioning, Feature point extraction, Network construction.*

I. INTRODUCTION

The construction method of the underground cable path distribution network is to use the positioning function of GPS to mark the detected cable positions and directions, and then draw these marking information into an underground cable network distribution map, which can quickly and easily obtain the distribution information of underground cables.

With the progress and development of society, the urbanization process has been accelerating in recent years, urban spaces have become more and more crowded, and more transmission cables are laid underground, but its problems also ensue. During the construction process, because the existing underground cable path distribution map does not match the actual cable path, in order to shorten the construction time and reduce the amount of construction, the construction unit generally does not carry out the detection of the underground cable path, which results in the underground cable often being dug. The phenomenon. In addition, once the underground cable fails, the direction of the underground cable path is not clear, which brings great difficulties to the maintenance and management of the underground cable [1].

II. PROPOSED METHOD

2.1 Theoretical Basis of Path Detection

Under normal circumstances, there will be a 50Hz power frequency signal in the underground cable. At this time, according to the strength of the alternating signal generated around the underground cable, the closer to the cable, the greater the magnetic field strength. The equivalent model of the underground cable is shown in Fig 1. According to Biot-Savart-Laplace law, the magnetic field strength H of an infinitely long straight current can be expressed as:

$$H=\frac{\mu_0 I}{2\pi L} \quad (1)$$

In the formula, μ_0 is the magnetic permeability of the medium in vacuum ($\mu_0=4\pi\times10^{-7}$ H/m); I is the current intensity in the wire; L is the distance from the wire to any point.

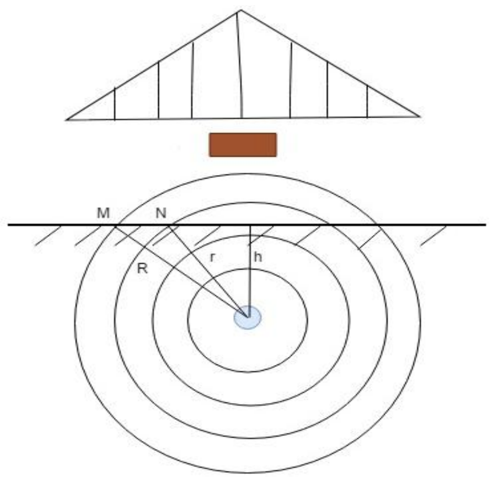

Fig 1: Underground cable equivalent model

Now suppose that the two points M and N are any two points on the ground, and the distance between them and the underground cable is R and r, respectively. According to equation (1), since r<R, the magnetic field strength at point N is greater than the magnetic field strength at point M, and the magnetic field strength at points M and N can be derived from the formula:

$$H_M=\frac{\mu_0 I}{2\pi R} \quad (2)$$

$$H_N=\frac{\mu_0 I}{2\pi r} \quad (3)$$

Since in the case of electromagnetic signals within the same frequency and the same cycle, the greater the rate of change of magnetic field strength of the magnetic field strength of greater

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magnitude, in accordance with Faraday's law, the greater the rate of change of magnetic field strength which is greater induced electromotive force. It follows that, the closer the inductive sensor cable, the detected voltage, the stronger the signal, as long as the signal peak can find the exact coordinates of the points to find the position of the cable [2-4].

2.2 GPS Data Acquisition System

2.2.1 GPS Module Hardware Interface

The GPS module data acquisition system is designed based on the single chip microcomputer. Other hardware mainly includes GPS module, active antenna circuit, data storage module, display module, etc., as shown in Fig 2.

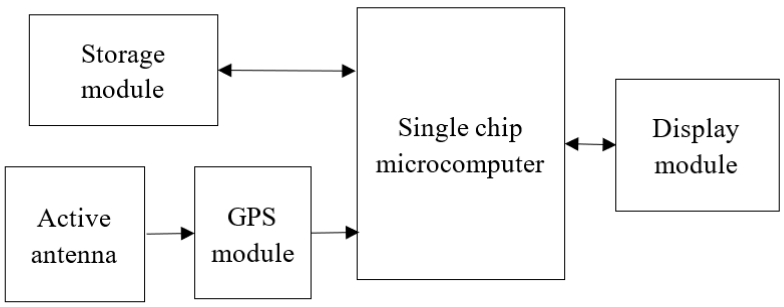

Fig 2: System structure diagram

As a data collection and logic control center, the single chip microcomputer is the control core of the GPS data collection system, and is responsible for the selection, analysis and storage of GPS data. First, the GPS receiver module receives satellite positioning data through an active antenna, and then uses the TXD of the GPS serial port to communicate with the RXD of the serial port of the single-chip microcomputer. After the single-chip microcomputer receives the serial data, the original GPS data is filtered, effective information is extracted, and stored in the storage In module 24C08, the main function of the display module is to show whether the current point has been positioned, as shown in Fig 3 [5].

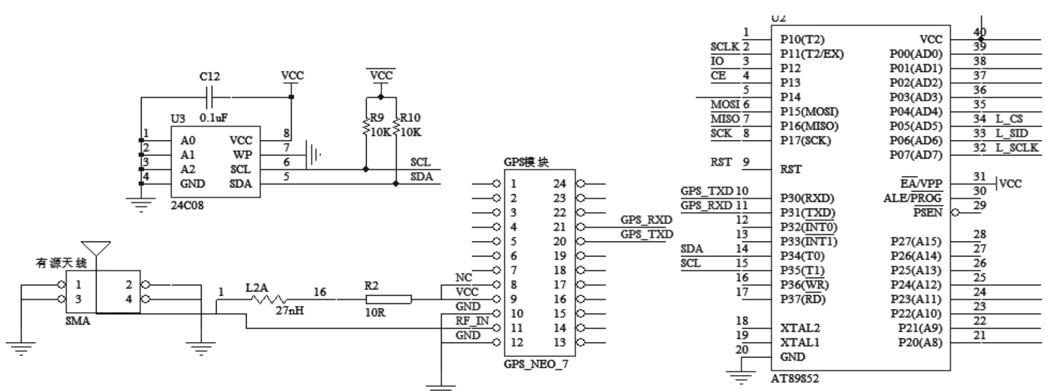

Fig 3: GPS hardware interface circuit

ISSN: 0011-9342
Issue: 11 | Pages: 705 - 713

2.2.2 GPS Data Transfer Protocol

In the GPS data collection process, data analysis is the key. The GPS receiver module uses the NMEA-0183 protocol, which was originally developed by the National Marine Electronics Association. The NMEA-0183 protocol defines the format standard of the output signal of the receiving module, also known as the data set. Each format is composed of a string of ASCII character data. The entire string of data is separated by commas to distinguish different information points. The length of the data string in each format is inconsistent, up to 100 characters. The data is usually selected for output at intervals per second. The datasets include $GPGGA, $GPGSA, $GPGSV, $GPRMC, $GPVTG, $GPGLL and so on. Because cable positioning does not require positioning information such as moving speed and altitude, the more commonly used $GPRMC format is selected here, which contains information such as latitude, longitude, UTC time, azimuth, and positioning status. Compared with other data set formats, the biggest feature of the $GPRMC format is to recommend the minimum positioning information, which has the advantages of shortness, convenient analysis, and easy storage. The example analysis of the $GPRMC data set is shown in TABLE I:

$GPRMC,093504.000, A,3862.7889, N,12418.6484, E,00.062,035.64 ,,,,A*50[6,7].

TABLE I. GLL data set analysis

Field	Resolution Meaning
Field 0: $GPRMC	RMC recommended minimum positioning information
Field 1: 093504.00	UTC time: 09:35:04
Field 2: A	Status, A=located, V=unlocated
Field 3: 3862.7889	Latitude: 38 degrees 62.788 minutes
Field 4: N	North Latitude (N North Latitude, N South Latitude)
Field 5 12418.6484	Longitude: 124 degrees 18.648 degrees
Field 6: E	East longitude (E east longitude, W west longitude)
Field 7: 00.062	Speed, 0.062 knots
Field 8: 035.64	Azimuth, 35.64 degrees
Field 16: A*50	Verify the data

2.2.3 GPS Data Processing

After the MCU reads the original information sent by the serial GPS module, it is necessary to scan the data text line by line to determine whether it contains the format data beginning with $GPRMC, and then start to read the valid information by changing the start address of the read data to the beginning of $GPRMC Data, and finally judge whether the reading is completed and return the reading result. The specific program flow is shown in Fig 4. The obtained positioning

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coordinate information is stored in the 24C08 storage module. After all the key position points of the cable are measured, the data is exported to the PC through the serial port for further processing.

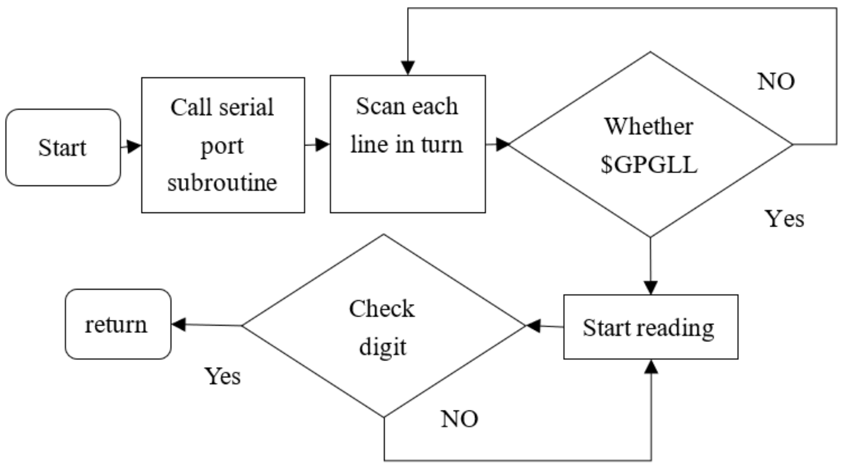

Fig 4: GPS data processing flow

III. EXPERIMENTS

The cable path position data obtained through the GPS data collection system contains a large number of independent point position data texts, which require special calculation processing algorithms to extract special points in the text data, called feature points. Then, the extracted feature points are generated by MATLAB to generate a scatterplot, and finally the cable path network distribution model is generated by fitting. The specific network construction method is divided into 2 steps: extracting feature points and generating cable path network [8].

3.1 Extract Feature Points

"Feature points" are geometric intersections where the path changes direction. Assuming that the cable path is a straight line within a certain distance, in theory, only two GPS positioning data points, namely the start point and the end point, need to be collected to represent the current cable path trajectory and direction. However, in real life, many underground cables are laid along both sides of the road, and the road is not an ideal straight line. Curved and irregular phenomena are very common.

In order to solve the problem of cable path bending and irregularity, a method similar to chain coding technology is adopted, as shown in Fig 5. First, by comparing the azimuths of continuous GPS positioning points A, B, C, D, and E, it is found that the azimuth difference between points A and B is $\Delta\alpha 1$, and the azimuth difference between points B and C is $\Delta\alpha 2$, and C The azimuth difference at point D is $\Delta\alpha 3$, as shown in Fig 5(a). Through experiments, it is found that the azimuth of continuous points is greater than 15° as a turning feature point, which is more in line with the actual situation, so point B can be extracted as a feature point. Although there is also a directional angle deviation between point B and point C, the deviation angle is less than 15°, so C Points are not characteristic points. By analogy, all valid feature points can

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be derived [9,10].

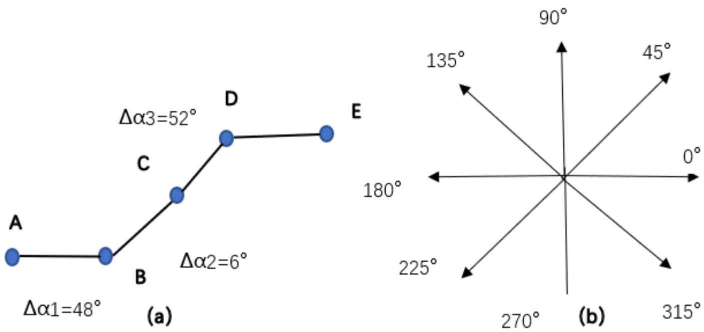


Fig 5: Feature point extraction principle

3.2 Generate a Cable Path Network

To generate a cable path network, you must first import the newly extracted effective feature points. Before importing this new set of data, you need to set a starting point as a reference. Importing new data is divided into two by comparing with the original cable path network. Cases: (1) The original path data is blank, a new path is directly generated; (2) The original path data exists, and the two sets of data are inconsistent, then update the existing feature point data, reconnect the feature points to generate a path, as shown in Fig 6.

In addition, it is necessary to pay attention to the problem of the intersection point of the cable path network, because the underground cable is intricate, and different cables will form an intersection point in the underground. Therefore, the chain coding technology is also used to solve this problem. After the reference starting point is set for the same cable, the subsequent feature points will be given unique codes to distinguish other cables, so that the direction of the cable path can be easily determined [11-14].

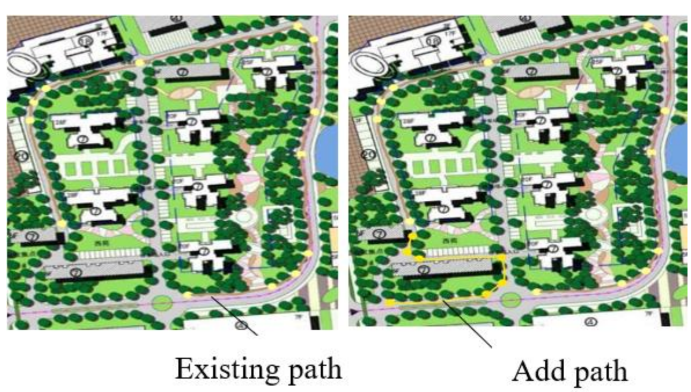


Fig 6: Example of generating a new cable path

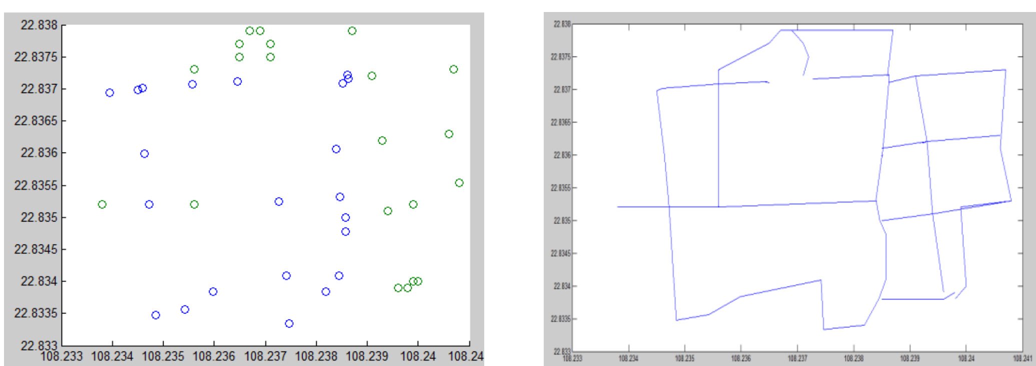
IV. DISCUSSION

Import the extracted effective feature data text into a PC and use MATLAB to generate a scatterplot of the feature points. Here we take a college campus as an example. The following is a high moral map of a college campus, as shown in Fig 7.

Fig 7: A college map

Using underground cable path detection equipment to detect and find that the roads on campus are mainly part of the main roads with buried cables. Detect the cable trajectory along the main road, and use GPS data acquisition system to locate the path to form the original cable trajectory GPS data, extract the feature points from the original data, and import MATLAB to form a scatter plot of the campus cable path feature points, as shown in Fig 8 (a).

Finally, use feature points to form a cable path network, as shown in Fig 8(b). The factors affecting the experimental results are as follows: (1) When extracting feature points, the smaller the azimuth change allowed, the more feature points are obtained, and the generated path network is smoother and closer to the real path; (2) Judgment of the direction of the cable cross point. In this experiment, the azimuth angle is 15° when extracting feature points, and the generated path network is basically consistent with the campus map.



(a) (b)

Fig 8: Cable path network

V. CONCLUSION

In this paper, through the GPS positioning function, the detected cable path position data is quickly obtained, and the chain coding technology is used to automatically extract the effective feature points according to the processing algorithm. At the same time, the algorithm for obtaining feature points is adjusted according to the bending of the path, and finally MATLAB is used to generate the cable path network. Experimental results show that this method can generate a local underground cable path network accurately and quickly compared with the traditional manual drawing of path maps, and can provide a solution for urban underground cable management. The shortcoming is that the instrument for detecting the position of the cable at this stage has a lot of room for improvement in terms of detection accuracy and convenience.

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