Research on Fault Location and Intelligent Inspection Based on Gps + Gis Transmission Line

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Abstract. Transmission line inspection management is to ensure the safe and reliable operation of the power grid of a basic work. Through the line inspection workers could find that the potential risk factors, the necessary maintenance. So as to ensure the safe and reliable operation of the entire power system, this article designed an intelligent inspection system. The inspection system integrates the global positioning system, geographic information system, computer network communication technology. It can minimize the leakage detection system, the wrong test, saving costs, increase business efficiency and ensure safe and stable operation of transmission lines. In addition, the system can effectively supervise and manage the inspectors to ensure that the inspection is in place record, store and position reminders of incident data such as faults, accidents and equipment defects during the inspection process, and command personnel. But it makes it easier to pay close attention to the operating staff, so that it can grasp the safety of field staff in a timely manner, when an emergency situation can quickly locate the staff, and according to the system to provide navigation guidance to give the appropriate support or organization to rescue, And effectively put the “people-oriented, safety first” concept to implement.

1. Introduction
Transmission lines are important part of the power system. In recent years, China's power grid construction has developed rapidly, especially the formation of ultra-high voltage long distance transmission network, making the transmission line size and equipment volume and so on are significantly increased, thus increasing the line construction and operation and management of the difficulty. Still taking the traditional manual management has been far from being able to meet the power grid construction and line safety, feasible operation requirements [1]. Therefore, how to use advanced technical means to improve and improve the power grid construction, operation and management level is particularly important.

The research on electric power inspection system based on GIS is relatively long, the technology has been relatively mature, and the results have been widely applied to the power companies and the transmission and distribution line, and have obtained the rich economy [1, 2]. Many software developers in the implementation of the power project in the process of acting as a software provider role, has accumulated a wealth of experience in project, and constantly upgrade the product. And they have a considerable customer resources, the domestic market on the one hand hardware technology immature, resulting in PDA. The use of limited scope; the other hand, the domestic system R & D started late. The corresponding mobile GIS research and development in the beginning of the stage, so the domestic mobile inspection technology and foreign information there is a big gap.
At present, most of the domestic power system, the commonly used is the traditional way, mainly using manual paper media records work, there are many human factors. But it is difficult to manage and supervise the spot in place and other defects. Inspection personnel on-site fill in the defect records, but also need to return to the office input power transmission and production management system, time-consuming and filling the content is not standardized, defect reporting is not timely and not conducive to line defects summary analysis. And lack of management affects the line tour check the effect of work [3]. Therefore, it is necessary to introduce new technologies to solve the inspection is not in place, the information is not correct, the defect is not standardized, information exchange lag and other issues, improve the level of line inspection management. In the traditional inspection mode, the transmission line inspection staff hand-held paper standardized work instructions to the scene for inspection work. This inspection mode there is a certain degree of randomness and blindness, whether the work content can be timed. Quantitative completion can’t be guaranteed, the manager of the operation process can’t be effectively managed and supervised.

2. Relevant Theory of Power Line Inspection System

2.1 Gps
The GPS system consists of three separate parts:
The space part of a satellite constellation is composed of satellite satellites and stars on the rail spare satellite composed of GPS satellite constellation, recorded as \((21 + 3)\) constellation. 24 satellites are evenly distributed in the 6 orbital plane, the satellite orbital plane relative to the equatorial plane of the tilt angle of about 60 degrees, each orbital plane degree of 90 degrees. The angle of intersection between the satellites in each orbital plane is 30 degrees, and the satellite advance on the adjacent orbital plane on either side of the satellite wall. The average height of the orbit is about 20200 km. When the earth rotates for a week, they run around the earth for two weeks, that is, around the earth for 12 stars a week. In this way, for the observers on the same observatory on the ground, the satellite distribution pattern will appear the same every day, just 4 minutes ahead of each day [3, 4]. The number of GPS satellites above the horizon varies with time and place, with a maximum of 11. In the signal navigation and positioning, in order to the results of the three-dimensional coordinates of the station, we must observe 4GPS satellite, known as positioning constellation.

![Figure 1 the System Frame of Gps.](image-url)
satellite-launched ephemeris, which describes the parameters of the satellite movement and its orbit. The ephemeris played by each GP satellite is provided by the ground monitoring system. Whether the equipment on the satellite is working properly, and whether the satellite has been running along the intended orbit, must be monitored and controlled by the ground equipment. Another important role of the ground monitoring system is to keep the satellites at the same time standard, that is, GP time system, which requires the ground station to monitor the time of each satellite, and find the clock is poor, and then sent by the ground into the satellite station, The satellite is then sent by the navigation message to the user equipment.

![Figure 2 Positioning Method Of Gps](image)

The user equipment receives the GPS satellite transmission signal to obtain the necessary navigation and positioning information, through various data processing, complete the navigation and positioning work. User equipment mainly consists of GPS receiver hardware, data processing software, microprocessor and its terminal equipment. The hardware of the receiver generally includes the host, antenna and power supply, the main function is to receive the satellite to send the signal to obtain navigation and positioning information, and simple data processing and real-time navigation and positioning software. GPS part refers to a variety of post-processing software package, its main role is to observe the data processing, in order to obtain precision positioning results.

2.2 Gis Technology
The premise of GIS work is the need for a related computer system, including the corresponding application of hardware and software [6, 7]. The function of this system is to use the spatial data related display, analysis, acquisition and ultimately to manage, in order to solve complex planning and management issues.

The basic principles of geographic information systems:
It is based on the geospatial database, which contains data on the geographical distribution of the Earth's surface and space. Through the cooperation of the computer, it can carry out the analysis of the relevant data of the surface and space of the earth, including display, roaming, operation, acquisition, management, simulation and so on. And at the same time provide dynamic information of space, and finally formed a unified space research system. In short, the integrated computer science, software engineering, economic management, systems engineering and other disciplines are in support of the plan, with the geographical analysis and real-time spatial positioning of the foundation, forming a complete, intuitive spatial data management system. We live in this three-dimensional material world, people's lives, work and study, eating and drinking are inseparable from the geographical information to accompany. And providing an intuitive geographic information system that elevates a grade for the level of our lives. With the development of science and technology and information technology reform, making the status is also more and more important [8]. At present to use in a wide range of areas, such as with the cooperation, making the current information age has been more far-reaching impact.
From a different point of view, we can see that there are different uses. From the basic function point of view has the ability to obtain spatial data, and can carry out simple data processing, including the display of pictures, editing and analysis [8, 9]. From a variety of disciplinary point of view, but also a computer science, mapping, geography are combined with the application of independent disciplines. And then froming the application of technical point of view is used to solve the key problems of space technology, because it has a complete system structure and a relatively complete application layer function.

![Figure 3 the Composition Of Geographic Information Systems](image)

### 2.3 Line Patrol
The main purpose of visiting the power overhead line is to always grasp the operation of the line equipment and the surrounding environment, the timely detection of equipment defects, and eliminate the impact of power supply security risks to prevent accidents [10]. At the same time, through the inspection and inspection, the details of line maintenance could be found. So the defects found in the tour to could be carefully recorded. According to the different purpose and nature of the line tour, it can be divided into regular visits, special inspection, inspection tour, fault inspection and other four categories.

**Regular inspections**: regular inspections are the main day-to-day work of inspectors. Patrolmen rely on regular inspections to keep abreast of and grasp the line components and equipment, running around the situation, the evolution of defects. Special inspections: special inspections are a kind of inspection that must be carried out immediately when the climate is abnormally changing or along the area where the natural disaster seriously affects the safety of the transmission and distribution lines. Monitoring Inspections: Inspectors are the leaders and supervisors in order to identify the defects of line components and equipment, determine the maintenance of the next line, inspect the quality of inspectors and the training of personnel to improve their technical level and carried out The Trouble patrol: fault inspection is the power overhead line failure caused by switching off the gate, the tour line along the line to visit, to find the fault location and fault content [11]. In addition to inspecting lines and equipment, the operating personnel carry out regular inspections and preventive tests on poles, wires, various electrical equipment and other ancillary components. It mainly includes the inspection of the decaying condition of the rod pole, the measurement of the contact condition of the wire connector card, the measurement of the voltage distribution of the insulator string, the measurement of the leakage current of the insulator, the measurement of the clearance distance of the lightning protection device, the secondary of the distribution transformer Voltage and load measurement, as well as the grounding device inspection and grounding resistance measurement. The period of inspection and measurement of these items shall be clearly defined in the on-site procedures in accordance with typical procedures [12].
2.4 Gps Data Processing Technology

2.4.1 System Cluster Analysis

System clustering is one of the most widely used methods in cluster analysis. Its basic principle is to first consider a certain number of data or indicators as one class, and then according to the degree of data, merge. And then people consider the merged class and other classes between the degrees of affinity, and then merge. Repeating this process until all the data is merged into one class. Distance and similarity coefficients: There are two types of indicators that measure the degree of affection between data, namely distance and similarity. The distance is to see each data as a point in the m-dimensional space corresponding to the m variable, and then the closer the distance is defined in the space, the higher the degree of intimacy. When the similarity coefficient is close to 1 or -1, it is considered that the data are irrelevant when it is considered that the properties between the data are close to the similarity coefficient close to zero. Here are some of the commonly used distance and similarity coefficient and its definition method.

Euclidean distance:
\[ d_{ij} = \sqrt{\sum_{j=1}^{p}(x_{ij} - x_{jq})^2} \quad (i, j = 1, 2, ..., n) \]  

Standardized Euclidean distance:
\[ d_{rs}^2 = (x_r - x_s)D^{-1}(x_r - x_s) \]

Mahyagra distance:
\[ d_{rs}^2 = (x_r - x_s)V^{-1}(x_r - x_s) \]

Bullock distance:
\[ d_{rs} = \sum_{j=1}^{n}|x_{rj} - x_{sj}| \]

Chebyshev distance:
\[ d_{\infty} = \max |x_{rj} - x_{sj}| \]

Minkowski distance:
\[ d_{pq} = \left( \sum_{j=1}^{n}|x_{rj} - x_{sj}|^p \right)^{\frac{1}{p}} \]

When P = 1, is the Brooke distance. When P = 2, the Euclidean distance.

Common clustering method:

The shortest distance method: The algorithm defines the distance between two classes as the smallest of the distance between all individuals of a class and all individuals of another class, so:
\[ D_{pq} = \min d_{ij} \quad x_i \in G_p, x_j \in G_q \]

The longest distance method: In contrast to the shortest distance method, the method defines the distance between the class and the distance from the distance between individuals:
\[ D_j = \max \{ d_{ij} \} \quad x_k \in G_i, x_j \in G_j \]

Intermediate distance method: This method uses the distance between the shortest distance and the longest distance when defining the distance between the class and the class.
\[ D_v = \sqrt{\frac{1}{2}D_{pq}^2 + \frac{1}{2}D_{pq}^2 + \frac{1}{4}D_{pq}^2} \]

\[ D_{pq}, D_{pq}, D_{pq} \] is the distance between \( G_i, G_p, G_q \).

Method of core of Gravity: This method defines the distance between two classes as the distance between two categories of core of gravity. It takes into account the number of data contained in each
class, and the core of gravity of each category is the mean of the data. Assuming that classes \( G_p \) and \( G_q \) are merged into \( G_r \), three categories, their data numbers are \( n_p, n_q \) and \( n_r = n_p + n_q \), respectively. The distance from the other class is

\[
D_{ir}^2 = \frac{n_p}{n_r} D_{ip}^2 + \frac{n_q}{n_r} D_{iq}^2 - \frac{n_p}{n_r} \frac{n_q}{n_r} D_{pq}^2
\]

(10)

Average join method: the previous description is the use of the minimum distance between the classes, the maximum distance and the distance between the class methods, you can also use the average method to join the class. The average association method is divided into two kinds, namely the average between the group method and the average group method. The averaging method between groups is used as the distance between classes in all pairs of cases, and the distance is minimized. It takes advantage of all the pairs of cases in the class. The purpose of the average join method in the group is to make the average distance between all cases of the generated class as small as possible.

2.4.2 Use the Arithmetic Mean Method to Improve Accuracy

After the clustering and elimination of gross errors are complete, the arithmetic mean is obtained for the data in each cluster. The following is an overview of the arithmetic mean principle. If the same amount of measurement is the same as the standard deviation of each measurement, the \( n \) measurement data \( x_1, x_2, ..., x_n \) are obtained. The best estimate of the measured \( X \) should be the arithmetic mean of all the measured data.

\[
\bar{x} = \frac{1}{n} (x_1 + x_2 + ... + x_n) = \frac{1}{n} \sum_{i=1}^{n} x_i
\]

(11)

This is the arithmetic mean principle. The arithmetic mean \( x_i \) of the multiple measurement results \( x \) is the same as the estimated value \( X \) of the \( x \), and has the same and unbiasedness.

Consistency: Let the measured error be \( \delta_i \) \( (i = 1, 2, ..., n) \)

There should be:

\[
\delta_i = x_i - X
\]

\[
x_i = X + \delta_i
\]

So

\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i = X + \frac{1}{n} \sum_{i=1}^{n} \delta_i = X + \bar{\delta}_x
\]

(14)

Where \( \bar{\delta}_x \) is the mean error.

\[
\bar{\delta}_x = \frac{1}{n} \sum_{i=1}^{n} \delta_i
\]

(15)

While \( n \to \infty \), with the arithmetic mean as \( \bar{x} \) of the estimated amount of \( X \) is consistent, we have to find the minimum error when the best value \( n \).

Unbiased: It can be seen from the following equation that the error \( \delta_i \) of the arithmetic mean is the linear sum of each measurement error \( \delta_i \), and thus \( \bar{\delta}_x \) is also a random variable of normal distribution and has paired, and the mathematical expectation is zero.

\[
E(\bar{x}) = E(X + \bar{\delta}_x) = X
\]

(16)

We can see that \( \bar{x} \) is an unbiased estimate of \( x \).
Optimality: It can be shown that when the measurement error obeys the normal distribution, the variance of the arithmetic mean is exactly the lower bound of the variance of the estimate:

\[
E(\delta) = \frac{1}{nE\left[\left(\frac{\partial}{\partial X} \ln f(x, X) \right)^2\right]} = \frac{\delta}{n}
\]

(17)

3. Transmission Line Fault Location and Intelligent Inspection Design Based on Gps/Gis

3.1 Gps Data Acquisition and Analysis Module

The main function of the communication module is to complete the data transmission with the management core. Communication module sub-transmission and receive two functions. Upload function is the management core of the inspection tasks, fault handling measures, etc. to the scene inspection staff. Inspection staff according to these equipment inspection work. Receiving function is to receive handheld device positioning data and on-site inspection situation. And use the geographic information system to analysis and store the positioning data.

Data analysis module is to upload the data statistics, generate various types of charts, support chart browsing, printing and so on including any two parameters of the curve, the trend of changes in parameters, timing parameters of the highest curve, the parameters of the average curve. This module mainly includes patrol situation analysis function and data analysis function. Patrol situation analysis module for inspection work, a large part of the work is to inspect the line and the equipment is running normally. In order to provide more information to the inspectors, the system create a library of equipment and equipment defect picture library. The library contains a variety of equipment on the side of the normal work of the pictures and equipment defects for the operation of management personnel and technical staff decision-making reference. Using these pictures will be able to carry out the operation of equipment analysis, and can browse, query, edit and other operations. Data analysis module is mainly used to upload the original data, the accident processing expert system data, the use of data mining ideas and technology for a variety of data analysis. For example, each distribution transformer in a certain period of time the relevant parameters of the comparison and analysis of the user can arbitrarily specify the need to analysis the data. The data analysis module also provides powerful graphical analysis capabilities. Chart operation can be specified by the user to run the data statistics, generate various types of charts, graphs, histograms and other different expressions for the user to choose. For example, you can generate any two parameters of the relationship between the curve, parameter change trend, timing parameters of the maximum and minimum, the average curve, histogram and so on. A variety of data analysis are given at the same time the data table and the specified requirements generated by the chart, the two control each other, so that the results more intuitive and clear. In addition, the analysis results include statistical results and the generation of various types of charts can be saved as historical records, operation managers can always query, browse, modify and print, very convenient.

3.2 Fault Diagnosis Module

Expert system and database combination: fault diagnosis is mainly using the collected data, combined with the rule base to carry out routine fault judgment. The key technology is the use of the expert database of a ‘thinking. We often have both database management functions and deductive capabilities, but also provide some of the expert system performance of the database system, known as the expert database. The basic idea of the expert database is to solve the problem-solving system of knowledge-based, knowledge-based and knowledge-based exclusive information. At present, the combination of expert system and database structure as shown in the figure, according to the close degree of the two can be divided into three kinds to achieve.
Rules and database design: Generative rules which are general form of a model rule is a prerequisite conclusion that it represents the credibility of the conclusion when the current formulation is established. Where the premise is the form of fact or assertion.

3.3 Intelligent Inspection System in the Transmission Line Fault Location Application

3.3.1 Fault Detection Principle
In the event of a single-phase earth fault, the signal source injects a special low-frequency signal into the feeders via the bus. In addition to the capacitive current and the induced current of the arc suppression coil, there is a special low frequency injected signal flow between the neutral point and the ground point of the small current grounded distribution network, and in the non-ground phase. Non-grounded lines, and ungrounded portions of the grounded lines do not flow through this particular low-frequency injected signal. The fault indicator detects and locates the single-phase ground by detecting this special low-frequency injection signal. The fault indicator detects this special low frequency signal and turns it red, indicating a single phase ground fault in this circuit.

3.3.2 System Structure Function
The diagram is a structural diagram of the whole system fault indicator, which has a detection phase, an infinite communication network and a faulty system master. The address information of each detection point is unified and encoded, and each detection node will contain the encoded information in the information coverage of the fault. So, when a problem occurs in the middle of the point, the detector on it immediately detected the fault information, while the lower and other test lines by the score line did not detect any problems. The fault automatic positioning system starts to use the matrix algorithm to calculate the fault information after receiving the information reported by the detection node, and finally determines the fault point and the interval, which gives the accurate area of the fault.
3.3.3 Use Trend Graph for Fault Analysis

A prominent feature of the inspection management system is to be able to predict the micro-variables for the equipment to provide the basis for pre-maintenance work. It is typical to use trend graphs to analysis. For example, the voltage distribution curve of the insulator string, the voltage distribution curve of the insulator string, because the insulator on the wire and the stray capacitance of the ground caused its generally high at both ends, the lower low saddle-shaped, after the entire string of insulator stray current After the accumulation, the voltage on the first insulator on the wire side is much higher than the voltage of the last insulator on the ground side. Factors affecting their voltage distribution. Taking the insulator as an example, the voltage distribution curves of the normal and non-normal conditions are compared, and the voltage distribution curves in four cases are plotted respectively.

![Voltage distribution graph](image)

**Figure 6 Overlap Insulator String Voltage Distribution**

In non-normal curves, icing information about the insulator can be obtained and the possible faults are analyzed. So that inspectors can focus on the insulator to check, remove the hidden trouble. Other equipment can also make such a trend of the situation on the equipment for comparative analysis of the situation, real-time access to the operation of the equipment, in time to eliminate the risk of failure.

4. Conclusion

On the basis of the research, this paper analysis the present situation of the current transmission line inspection, and finally designs and develops the intelligent inspection system based on the transmission line. This system integrates the three technologies of mobile application platform, geographic information system and global positioning system. Based on this, the system has been researched so that the system can be successfully applied to the inspection work of transmission network. From the economic point of view, the system cost-effective, low cost. From the work to consider, the system is easy to operate, they manage, greatly reducing the inspection staff and management staff workload, improve work efficiency. From the technical considerations, the system
has a relatively accurate positioning accuracy, data transmission and interactive equipment to improve and convenient, it is suitable for transmission line inspection tasks and strength requirements. Not only that, the system can also be widely used in agriculture, coal mining, natural gas extraction and other outdoor management entities need to patrol, so that the effective reduction of operating costs to promote economic growth.

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