Intelligent Multi-drive Inspection and Positioning Method for Water Environment of Cable Pipe Corridor Based on Artificial Intelligence

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Abstract. The running environment of underground power cables is hidden, and it is difficult to identify the cables in the parallel cable trench, which is not conducive to the rapid troubleshooting and accurate positioning of faults. However, the traditional manual inspection method has some defects, such as difficulty in finding, recording, low efficiency and inconvenient re-use of inspection information. Based on the above background, the purpose of this study is to explore the intelligent multi drive inspection and positioning method for water environment of cable pipe gallery based on artificial intelligence. Based on the analysis of the existing cable tunnel water environment inspection technology, this paper introduces the basic theory of machine vision and artificial intelligence to analyze the requirements of the water environment inspection and positioning method of the cable pipe gallery. Firstly, an intelligent multi drive inspection and positioning overall structure is designed. Secondly, aiming at the problem of unattended cable tunnel water environment inspection and navigation positioning, A monocular vision navigation scheme based on guide line is developed, which includes two parts: walking along the line and detecting the fixed point. Through the intelligent multi drive inspection and positioning method, the work efficiency of the water environment inspection of the cable tunnel is greatly improved. The reference error of the identification method is less than 1.8%. At the same time, the inspection data can be completely saved, which is conducive to the early warning of cable equipment defects and the analysis of the development trend, and the reliable and stable operation level of the field equipment and power grid of the cable tunnel is improved.

Keywords: Artificial Intelligence, Intelligent Inspection, Machine Vision, Navigation and Positioning
1. Introduction

With the application and innovation of new technologies such as artificial intelligence and big data in the intelligent construction of hydropower plants, the construction of intelligent power plants from automation to intelligence and from artificial decision to machine decision-making has become the development requirements of the times[1-2]. In the process of intelligent construction of hydropower plant, how to make the operation and management of power generation equipment more safe, effective, convenient and controllable; how to improve the inspection quality of power generation equipment, at the same time reduce the work intensity of employees; how to provide a reliable basis for the operation and management of production equipment status assessment, maintenance forecast, decision-making planning, are still practical problems to be studied and solved[3-4]. At present, there is no inspection robot that can meet the special inspection requirements of such complex production occasions as hydropower plants. For example, it lacks intelligent state inspection ability for large and complex rotating equipment such as generators and turbines in hydropower plants, and it lacks open self-learning inspection ability for oil, water, gas, electricity and other multi-media production occasions[5].

The inspection system integrating mobile Internet, database development, embedded development, GIS and Internet of things has important application significance in underground cable inspection work[6-7]. Overseas underground cable inspection system is mainly used in underground cable operation monitoring (including auxiliary emergency command of outburst accident, remote monitoring and alarm of underground cable, and entrance and exit pipe of cable tunnel) Monitoring of tunnel covers, monitoring of dynamic current carrying capacity and load of underground cables, PDA mobile operation, etc., expansion of cable operation status monitoring (such as grounding current monitoring of underground cables, gas monitoring of cable tunnels, etc.), cable expert diagnosis[8-9]. Although the intelligent inspection of underground cables in China started late, there are already mature products. For example, Huawei intelligent inspection system based on GPRS, GPS, Pocket PC and other technologies has the functions of cable inspection, defect report and production management system docking[10].

This research is to solve the problem of intelligent multi-drive inspection and positioning method of cable duct gallery. Based on the research of existing cable tunnel inspection technology and the basic theoretical analysis of machine vision, digital image processing and artificial intelligence, the appropriate visual navigation scheme is formulated, and the corresponding image processing algorithm is studied. Finally, the feasibility and reliability of the algorithm itself is verified.

2. Intelligent Inspection of Cable Duct Corridor

2.1. Intelligent Multi Drive Inspection Operation Library for Water Environment of Cable Tunnel

A variety of operation documents with different contents will be generated in the process of underground cable inspection, and managers need to spend a lot of time and energy to standardize and compile them. Therefore, the system builds the underground cable intelligent inspection operation library to meet the requirements of rapid and intelligent preparation of management personnel and the editing and approval process requirements of operation documents. Specifically speaking, the functions of underground cable intelligent inspection operation library are as follows:
(1) Standardized operation model of underground cable. As the basis of the implementation of the underground cable intelligent inspection operation library, the underground cable standardized operation model includes the preliminary preparation model, technical measures model, special equipment model at dangerous points, common use model of dangerous points, implementation scheme model, typical safety measures card model, etc., which are integrated according to working steps by means of collective mode.

(2) Intelligent analysis of documents. The responsibilities of document intelligent analysis include: according to the requirements of underground cable standardization operation text involving equipment, equipment type and inspection type, and the habits of management personnel in the preparation of operation documents, the corresponding keywords are constructed and analyzed for each cable standardization operation text by standardizing the prepared cable standardization operation text; According to the type of the cable management personnel, the selection of the cable management personnel will be simplified according to the text type of the new equipment management personnel, The reusable equipment, personnel and safety requirements in the inspection work shall be combined, and the operation contents will be automatically separated according to different equipment in the field operation.

2.2. Intelligent Multi Drive Inspection and Positioning Technology

(1) Intelligent sensor technology

According to the needs of the on-site monitoring objects, the advanced sensitive measuring elements are selected in the front-end of the system and packaged into intelligent sensors as the measurement and diagnosis means of patrol inspection. Through these front-end intelligent sensors, the required data will be connected to the big data background to complete the required monitoring and analysis. When the intelligent sensor data is connected to the system, the data itself describes what it is, what state it is in, what actions need to be triggered to drive the relevant actions of the database, so as to greatly improve the working efficiency of the whole database, enhance the value of the whole database, and make better use of the database to complete data fusion and cognition.

(2) Big data analysis technology based on multimodal fusion sensing

Through intelligent data access, we have the ability to put a large number of multimodal data together to build a big data platform for unified analysis and learning. By training its parameter matrix, deep learning neural network can learn without relying on human knowledge, optimize its learning process and effect, and discover laws and phenomena previously unknown. In this platform, there is no garbage data, all data is useful, so as to really play the value of data. Big data intelligent fusion sensing system is not only intelligent collection and monitoring, but also the learning, discovery and cognition of laws on the basis of monitoring.

(3) Intelligent image recognition and processing technology

Image coordinate system includes image physical coordinate system and image pixel coordinate system. The image obtained by the camera is transformed into digital signal and input into the computer by the acquisition card. Each image is stored in the form of Mn array. In the image of m row and n column, each element (i.e. pixel) stores an array of bits. When the array is three values of red,
green and blue (RGB), it is a color image. However, we usually use grayscale image, that is, there is only one element in the array. Represents the gray level of the pixel, which can be simply regarded as brightness. Plane image can be represented by rectangular coordinate system $u$ and $v$, that is, the number of columns and rows of pixels in the array $(u, v)$ represents its coordinates, so $(u, v)$ is the coordinates of image coordinate system with pixel as the unit.

The origin coordinates of the physical coordinate system are $(u_0, v_0)$, and the physical dimensions of each pixel on the x-axis and y-axis are $d_x$ and $d_y$, respectively:

$$
\begin{bmatrix}
  u \\
  v \\
  1
\end{bmatrix} = \begin{bmatrix}
  \frac{1}{dx} & 0 & u_0 \\
  0 & \frac{1}{dy} & v_0 \\
  0 & 0 & 1
\end{bmatrix} \begin{bmatrix}
  x \\
  y \\
  1
\end{bmatrix}
$$

(1)

The inverse transformation is as follows:

$$
\begin{bmatrix}
  x \\
  y \\
  1
\end{bmatrix} = \begin{bmatrix}
  dx & 0 & -u_0dx \\
  0 & dy & -v_0dy \\
  0 & 0 & 1
\end{bmatrix} \begin{bmatrix}
  u \\
  v \\
  1
\end{bmatrix}
$$

(2)

3. Design of Intelligent Inspection Experiment

3.1. Design of Intelligent Inspection and Tracking for Experiment

The intelligent multi drive patrol inspection carries infrared and visible cameras to collect images of equipment to be inspected along the way, and carries tracking camera to collect the guide line signs taken on the road. If only the road navigation signs are encountered, the motion control subroutine of four side detection can be executed. At this time, when the robot arrives at the parking point, the robot will detect the black mark when it arrives at the parking spot, and then the robot will detect the black mark when it arrives at the parking spot. The collected data are shown in Table 1.

| Serial number | Pixel coordinates | Visual inspection | Actual distance | Error rate | Visual measurement declination | Actual measurement declination | Error rate |
|---------------|--------------------|-------------------|----------------|------------|-------------------------------|-------------------------------|------------|
| 1             | (42,74)            | 2.886             | 2.841          | 1.58       | -26.1                         | -26.5                         | 1.51       |
| 2             | (77,74)            | 2.587             | 2.612          | 0.96       | -18.5                         | -18.7                         | 1.07       |
| 3             | (57,81)            | 2.901             | 2.932          | 1.06       | -20.7                         | -21.1                         | 1.89       |
| 4             | (57,66)            | 2.491             | 2.522          | 1.23       | -23.6                         | -23.3                         | 1.29       |
| 5             | (57,74)            | 2.705             | 2.721          | 0.59       | -22.1                         | -22.4                         | 1.34       |
In fact, the intelligent multi drive inspection and positioning system is very complex, so we need to choose a suitable operating system. Considering the popularity, reliability and real-time of the system, we choose the windows 7 operating system. For the choice of programming language, this project is realized by using the IMAQ Vision module provided by LabVIEW virtual instrument software platform and MATLAB. Among them, LabVIEW uses graphical programming language g, and the generated program is in the form of block diagram and data flow. The data flow direction between nodes in the program block diagram determines the execution order of VI and functions, which is intuitive and simple. Its IMAQ Vision is a good image processing module, providing almost all basic image preprocessing operations, The processing program can also be embedded in the overall flow chart in the form of sub VI. Matlab is a combination of Matrix & Laboratory, which means matrix factory (Matrix Laboratory). Its data processing ability is very strong. When designing the motion control algorithm based on the prior template for four side detection, it needs to process the four boundary data of the image taken by the robot. MATLAB has obvious advantages. Therefore, in this paper, matlab calibration toolbox and MATLAB programming are mainly used to realize the motion control subroutine of four side detection in monocular vision navigation based on guide line, and matlab program can be embedded into LabVIEW.

3.2. Safety Design of Intelligent Multi Drive Inspection and Positioning for Water Environment of Cable Pipe Gallery Based on Artificial Intelligence

The security design of intelligent multi drive inspection and positioning for water environment of cable pipe gallery based on artificial intelligence mainly adopts the following measures: it has the security management function combined with organization management, adopts the identity authentication method based on user name / password and the access control mechanism based on role to solve the security management problems in Wan, Its basic security management principle is "determine the post by responsibility and determine the person by post"; based on Java application and web service mechanism, the system access security management is carried out, and the system functions are applied through HTTP basic authentication and Java authentication rules; the overall network and information security protection strategy of electric power company is divided into different regions, domains and levels, The security design of all kinds of data and corresponding storage, application and sharing in the system is formulated; the data management log is automatically created in normal work, and the operation information such as user login, data access, search and edit are recorded in real time, so as to track the operation of login users.

4. Position Analysis of Intelligent Multi-Drive Inspection

4.1. Analysis of Experimental Simulation Results

In this study, SURF, SIFT, FAST, MSER, ORB feature points are used for image registration, and the differences of different feature points detection and matching effect are compared. The experimental results are shown in Figure 1.
**Figure 1.** Comparison of image registration results of different types of feature points

The experimental results show that: (1) in terms of time efficiency, orb feature points have the best time efficiency, SIFT feature points have the worst time efficiency, SURF, FAST and MSER time efficiency difference is not big; (2) from the registration results, SURF and SIFT can accurately match the instrument image, FAST, MSER, ORB can not match the instrument image when the template image size is small, SIFT and SURF matching success rate is the highest, The results show that fast has the lowest processing time and processing efficiency; (3) it is not suitable to deal with a large number of features in fast environment. Although ORB feature points have great time advantage, the registration results are not ideal when the template image size is small. Generally speaking, SURF feature points are the most suitable for this study.

4.2. Monitoring and Management Analysis of The Whole Process of Patrol Inspection

(1) General location of inspection points.

The position of working cable, cable direction, longitude and latitude of working well can be transmitted to PDA through the background monitoring platform. The position of inspection personnel can be located in real time by GPS. The absolute distance value can be obtained by comparing the position of working cable with that of inspection personnel, and then arranged according to the absolute distance value. When the calculated absolute distance value is less than the warning value set by the system, it means that the patrol personnel will go to the place to perform the task. At this time, the road topology of the geographic information layer will be called, and then the shortest path to the working cable position of the patrol personnel will be calculated, and pictures and voice prompts will be given to help the patrol personnel to find the general location of the designated well, So as to lay the foundation for the next step of accurate positioning.

(2) Accurate positioning of inspection points.

The global positioning technology used in the system depends on the longitude and latitude information of the positioning points provided. At the same time, the global positioning of PDA is affected by weather factors and the number of satellites above the location, which results in positioning error of 3 ~ 5m. Therefore, when the patrol personnel find the general location of the designated well, they use the PDA artificial intelligence technology to read the video identification card information within the scope, so as to accurately find the inspection point.

(3) Inspection personnel control.
When the inspection personnel carry PDA to carry out tasks, the real-time location information, equipment information and inspection task information on PDA will be recorded in the monitoring management background, so as to ensure that the inspection personnel are under the management of the monitoring platform.

(4) Inspection personnel on duty monitoring.

Through mobile Internet, PDA inspection function and other technologies, the tag ID information, longitude and latitude information of each key position on the inspection line will be collected and transmitted to the background monitoring platform for storage. In addition, the inspection track of the patrol personnel can also be visually displayed on the background interface through the map matching algorithm. When the background monitoring platform finds that there is a difference between the patrol route and the task requirements (that is, the patrol personnel deviates from the established inspection route), it will send an audible and visual alarm to the management personnel, and the management personnel will send an alarm to the patrol personnel according to the actual situation.

5. Conclusion

To sum up, the underground cable intelligent inspection system, which is composed of field operation PDA and background monitoring platform, realizes the closed-loop control of the whole operation process of underground cable inspection, which not only uses the standardized operation information base to realize the standardization and standardization of field operation, In addition, artificial intelligence technology is used to cooperate with inspectors to master the information of underground cables, trenches, wells and other related equipment and environmental information.

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