Infrared Image Recognition and Development of Management System for Electrical Equipment

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Infrared Image Recognition and Development of Management System for Electrical Equipment

H Zhong, X B Lin, F Hu, Y F Li and Z Yuan
State Grid Zaozhuang Electric Power Supply Company of Shandong Province Electric Power Company

Abstract. At present, infrared imaging technology has been widely used in the monitoring of the operating state of electrical equipment. In the operation and maintenance of substations, infrared imaging is often used to collect infrared images, and the health status of the equipment is judged by manual analysis. However, the management analysis of a large number of infrared images brings extra workload to the personnel. Aiming at this problem, this paper takes Visual Studio 2015 C# as development tool, Access 2010 as data management platform, and adopts C# and Matlab hybrid programming technology to realize the infrared image recognition and development of management system for electrical equipment. The system can accurately identify key information of infrared images, but also efficiently manage infrared images, and automatically generate diagnostic reports of electrical equipment based on infrared image recognition results and user needs.

1. Introduction
Many factors such as loose connection, bad contact, magnetic leakage, overcurrent and so on can cause equipment overheating that cause failure. Effective monitoring for electrical equipment of different types, and automatic analysis of electrical equipment failure, fault type, location and severity has become a research hotspot in the field. Infrared detection technology is widely used in power equipment fault detection because of its non-contact and high efficiency. Infrared radiation detection measures the thermal radiation of the equipment by thermo electrical conversion, in order to measure the intensity of infrared radiation of the equipment. It converts the received infrared radiation energy into a convenient electrical signal, and displays the temperature field distribution of the device surface in the form of two-dimensional thermal image by processing the electrical signal. The effective detection of electric power equipment by infrared thermal imaging technology can reduce the accident rate and maintenance cost of the equipment significantly [1].

At present, the application of infrared thermal imaging technology to fault detection of power equipment is very common at home and abroad. In China, infrared imaging technology has become an important basis for fault diagnosis in operation and maintenance of substations. The personnel responsible for the operation and maintenance use infrared thermal imager to do infrared photography of electrical equipment, get the infrared temperature information, and achieve the health judgement through thermal analysis of infrared images. Then the analysis results and infrared images are preserved and the infrared diagnosis report is generated. The analysis and sorting of infrared images is a complex and heavy work, adding a large amount of extra work to the personnel. In this paper, Visual Studio 2015 C# is used as development tool, Access 2010 as data management platform, C# and Matlab hybrid programming technology are applied to realize the infrared image recognition and development of management system for electrical equipment.
2. Structure design of integrated management system

In accordance with the functional requirements of the infrared image recognition and management system for electrical equipment, the block diagram of the program is designed, as shown in figure 1.

The system mainly includes system configuration, information management, infrared image recognition and infrared picture report generation and printing. Infrared image recognition is the core of the system development.

3. Information recognition of infrared image

The infrared imager in this paper has analysed the infrared characteristics of electrical equipment. Therefore, the main function of the module is to realize character recognition in infrared image, so as to extract the highest temperature and other information. The infrared image of the electrical equipment obtained by the infrared imager is shown in figure 2.
Before doing character recognition, infrared images are preprocessed first to eliminate the noise interference so as to improve the quality. In this paper, median filter is used to denoise the picture. Median filter is a nonlinear filter, and the basic idea is to use gray median value in the neighborhood instead of the gray value, which can effectively remove impulse noise and preserve the image edge details, for it does not depend on the values which are very different from the typical value in the neighborhood. The infrared image after noise reduction and ashing is shown in figure 4.

Figure 3. Character recognition process of infrared image

Figure 4. Infrared image after noise reduction and ashing
The gray image will use the binarization of the fixed threshold, which can realize the recognition of possible character area. The infrared image of the binary electrical equipment is shown in figure 5.

![Infrared image of electrical equipment with binarization](image)

Figure 5. Infrared image of electrical equipment with binarization

As can be seen from Figure 5, the characters in the infrared image of the electrical equipment are relatively obvious. Before character recognition, the character needs to be segmented. In this paper, the projection method is used to make vertical and horizontal projection of the images after binarization, and the wave valley after the projection is used as the dividing line. After the segmentation, the characters can be identified. In this paper, fuzzy matching is applied to character recognition, and the segmented characters are changed to match the same size of the template, and then the best match is selected as the result. A standard template $P_k$ is established for each of the possible characters in the infrared image by using binarization and gray scale. 0 represents a white background, and 1 represents a black character. Then the unidentified characters are matched with the template one by one, and the similarity $S_k$ is obtained.

$$S_k = \frac{\sum_{i=1}^{I} \sum_{j=1}^{J} (XP_k)}{\sum_{i=1}^{I} \sum_{j=1}^{J} P_k}$$

(1)

In equation (1), $X$ and $P_k$ are the matrices of the same dimension, and $XP_k$ means the multiplication of matrices. If $\max S_k > \lambda$, $X \in P_k$, the match is considered successful, otherwise the recognition is refused, and the maximum similarity result is used as the recognition result. $\lambda$ is the threshold derived of denial recognition from the experiment.

4. System development and programming implementation

The infrared images recognition and management system developed in this paper adopts the widely applied object oriented programming method, visualization technology and hybrid programming technology. Microsoft Visual Studio 2015 C# is used as the user interaction interface and information management module development tool. The Microsoft Access 2010 database is used as the data management platform, and the hybrid programming technology of C# and Matlab 2017a is used to realize the character recognition of the infrared image. This not only improves the friendliness and stability of the management system, but also improves the accuracy of the infrared thermometer images recognition of the electric power equipments, and shortens the cycle of the program development. In the program design, deployed convenience of the system has been taken into account, and it has strong extensibility and portability.

4.1. Development of user interface and information management module

The program development adopts the dynamic creation control technology, and realizes the design mode of the quasi full touch screen. This is not only convenient for the hand-held terminal to
transplant, but also to achieve a better user experience. When the picture content of the system is less, the system will automatically lean, and improve the speed and efficiency of the system. When the system pictures are increased, the system can automatically expand its capacity and realize the flexible management of a large number of pictures information. This module can realize the flexible and dynamic management of the two level directory. Users can make naming rules of information according to their usage habits, and create management information directory dynamically. The module also has simple and easy ways to use report management function.

4.2. Module of data access interface
The access of the database is the most important part of all programming languages, which directly affects the speed of the system access. This program uses the ADO. Net components provided by C# to access the database. Connection objects and Command objects in C# are adopted, and another object similar to RecordSet is called ADODataReader, which is responsible for processing and querying related RecordSet objects.

4.3. Character recognition module based on C# and Matlab hybrid programming technology
Matlab has a very professional function in image processing and computer vision processing, including: color space transformation, geometric transformation, feature extraction, super pixel segmentation, Quick shift, SLIC algorithm, advanced clustering algorithm and other functions, provides a powerful tool for infrared image processing. Compared with the C# program, the development of character recognition module with Matlab has the advantage of significantly shortening the development cycle and improving the accuracy of character recognition. However, the Matlab program also has some shortcomings, such as low execution efficiency and unfriendly user interface. The hybrid programming technology based on C# and Matlab can effectively avoid the disadvantages of long development cycle of C# and low efficiency of Matlab. Using Matlab to generate DLL format, the character recognition shared library is invoked by Visual C#, which significantly improves the operation efficiency and flexibility of the program, and shortens the development cycle.

5. Testing of software application
The system can manage the infrared images of all kinds of electrical equipment that have been stored and newly collected, the information extraction, the classification statistics and the automatic generation of the analysis reports. It can use different classification methods to achieve a variety of functions, such as the horizontal contrast of different types of electrical equipment, the comparison of the historical data of the same equipment, and so on. With the continuous storage, sorting and improvement of infrared images, a complete set of infrared images database of electrical equipment can be established, which will improve the effectiveness of infrared temperatures detection and promote the development of condition maintenance. Through "system configuration", the management information name and system capacity can be automatically configured according to users' management requirements. The "information management function" mainly includes the work area management. The work area is the highest management of the management system, and its main function is to realize the new and deletion of each management area. Within each workspace, we can customize the classified management objects, add and delete management objects, and realize the flexible setting of management objects. Infrared images management of management objects mainly realizes the infrared images to add, delete, in accordance with the infrared images temperature descending sort display, zoom display and so on. Figure 6 is the result of the lateral contrast of several transformers in a certain area.
Figure 6. Lateral contrast results of several transformers in a certain area

Through character recognition technology, all kinds of feature parameters can be automatically extracted, such as maximum temperature, reflection coefficient, reflection temperature, photo distance and so on, and the infrared images can be sorted according to the operation temperature. The automatic generation and printing of related infrared detection reports can also be realized through user operation.

6. Conclusion
Infrared detection technology is widely used in power equipment fault detection because of its non-contact and high efficiency. Based on the key technologies, such as C# and Matlab hybrid programming, the infrared image recognition and management system of electrical equipment is developed, which can realize convenient infrared image management and automatically generate the infrared image analysis report, effectively reducing the operation and management of the post infrared image processing and management of the operation and maintenance personnel.

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