Methods for High Voltage Transmission Line Detection Based on Image Recognition

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Abstract. With the development of national economy, the demand for electric power from all walks of life is expanding. How to prevent and discover the natural disaster and accident that harm the transmission line in time has become an important basic work to guarantee the power supply. Image identification and automatic alarm system of transmission lines adopts image technology to monitor and analyze and process transmission lines, which can automatically identify and alarm the safe operation of transmission lines, provide basis for scientific decision-making of power enterprises, and improve response efficiency of natural disasters and accidents. Based on the research direction of identification and detection of transmission lines, this paper summarizes the commonly used methods of detection of transmission lines.

1. Introduction

Electric power system[1]is an important basis for economic advice and an important guarantee for people’s life. A complete power supply system includes a series of related equipment such as power distribution, power generation, power transmission, electricity consumption, etc. As the main part connecting the whole system, the normal operation of the transmission line affects the stability and security of the power system. Patrol inspection shall be carried out for transmission lines to discover the defect status of line equipment in time to ensure the safe and stable operation of power grid. At present, there are three main inspection methods of transmission lines: manual inspection[2], helicopter inspection[3] and uav inspection[4].Currently, the transmission line images taken by uavs are usually detected and identified manually to identify whether there are transmission line defects in the transmission line images. The existing manual identification of transmission line images is intensive, wasteful and inefficient. Transmission lines[5]are an important part of all parts of the power system. Together with power equipment such as transformers and circuit breakers, they are responsible for the transmission and distribution of electrical energy. However, the common transmission overhead lines are exposed to the natural environment for a long time, and often suffer from external disturbances such as line tension, ice, snow, strong winds, and bird nests. There are often many accidents such as line trips and disconnections, which are normal operation of the power system. Therefore, it is necessary to timely and effectively monitor the transmission line and provide early warning of the status of the transmission line. Various research institutions at home and abroad have conducted in-depth research on the problems and proposed various solutions. For example, Xi’an Jiaotong University analyzed the relationship between ice thickness and dip angle and established the mechanical model of transmission lines. South China University of Technology considered this. The influence of wind bias on the transmission line has modified the mechanical model of the transmission line to make it more accurate. Although the mechanical model can be used to analyze the ice and wind...
deviation of the transmission line, the model in the mechanical model method is more complicated and has higher requirements for the data collected by the sensor. When the sensor has a time deviation due to or transmission, a large error occurs in the judgment of the line condition. Later, with the development of image recognition technology, visual recognition has made great progress in the monitoring of transmission lines. Based on the basic image recognition technology of Chongqing University, an analysis algorithm for the icing of insulators in transmission lines is proposed.

2. Identify the Difficulties of Transmission Lines

Image recognition technology needs to process the original image to obtain relevant results, and generally has higher requirements for the original image. At present, the original image of the transmission line is often an image containing a transmission line taken by a camera device, which is generally a monitoring image. Due to the line itself, the camera angle and the weather, the following difficulties exist in the transmission line monitoring image recognition:

- The linear shape is obvious, the width is small in the picture, and the recognition difficulty is high;
- Generally distributed in a sag, some angles may be in a straight line (as viewed from above the power line), which is a visual error problem;
- The transmission line has a large span, which can generally span the whole picture and cannot be fully presented in one picture;
- The multiple lines of the same tower are generally in an approximately parallel relationship, and there is no intersection, but in some shooting angles, there may be cases where the influence overlaps and the lines intersect.

3. Optimization of Transmission Line Identification

In view of the above difficulties, most researchers generally use the following process to optimize transmission line identification:

- Grayscale processing. The original image is grayscaled, the color information in the image is removed, and the image data storage amount is reduced, so that the contour information of the object is processed.
- Filter enhancement processing. The processed image is first filtered to reduce noise pollution caused or generated by the initial imaging, transmission, and grayscale processing. After the enhancement processing, the image of the transmission line that we recognize is emphasized, so that the difference between the features and the background in the picture becomes more obvious, and the success rate of image recognition is improved.
- Extract edge contours and filter processing. By relying on the features enhanced in the previous step, the contour of the target in the image is identified, and then the identified contour is filtered to reduce the influence of the algorithm on the image, and a contour image of the pure transmission line is obtained.
- Identify the transmission line. The contour image of the transmission line obtained in the previous step is identified in the original image, and the original image of the original image is finally displayed.

4. Image Recognition Technology

Computer image recognition technology is the same as human image recognition, and their processes are similar. The process of image recognition technology is divided into the following steps: information acquisition, preprocessing, feature extraction and selection, classifier design and classification decision. The acquisition of information refers to the conversion of information such as light or sound into electrical information through a sensor. That is to obtain the basic information of the research object and transform it into information that the machine can recognize by some means. Preprocessing mainly refers to operations such as denoising, smoothing, and transforming in image processing, thereby enhancing important features of the
image. Feature extraction and selection means that in pattern recognition, feature extraction and selection are required. The simple understanding is that the images we study are various. If we want to distinguish them by some method, we must identify them by the characteristics of these images. The process of acquiring these features is feature extraction. Features obtained in feature extraction may not be useful for this recognition. At this time, useful features are extracted, which is the choice of features. Feature extraction and selection is one of the most critical techniques [25] in the image recognition process, so the understanding of this step is the focus of image recognition. The classifier design refers to a recognition rule obtained through training. Through this recognition rule, a feature classification can be obtained, so that the image recognition technology can obtain a high recognition rate. Classification decision-making refers to classifying the identified objects in the feature space to better identify which class the object under study belongs to.

4.1. Method Based on Aerial Photography of Drone Control
Some scholars have proposed a method for detecting and fault identification of aerial transmission line images in complex background environments. The method requires pre-processing [24] of the image of the UAV aerial [26]transmission line, including the use of median filtering and Gaussian filtering to de-twist the transmission line image, and the final stage of the pre-processing uses the histogram equalization method to enhance the image. After the pre-processing, the edge of the image is detected by using the improved Edge Drawing algorithm on the power line image. Then, the boundary of the transmission line is searched in the image according to the simplified model of the transmission line distribution, and the transmission line is detected by the random Hough transform in the transmission line area and the falsehood is utilized. The line decision mechanism rejects the pseudo line segment. The method effectively reduces the false detection rate and the missed detection rate of the transmission line, and enhances the recognition rate of the transmission line target detection. Finally, using the aerial transmission line image of the UAV inspection operation, the UAV aerial transmission line image database is established, and a transmission line fault identification model based on deep belief network is constructed. The DBN model is trained by a large number of samples and multiple iterations. The PReLU [27] activation function is introduced to replace the Sigmoid activation function, and the Softmax classification layer is added to the output layer. Experiments show that the proposed method has higher fault recognition rate than BPNN [28], SVM [29] and DBN-SVM [30] methods. In this paper, the UAV aerial transmission line image provided by the National Grid Nanrui Group is tested and verified. The experimental results show that the proposed method can accurately detect and identify the transmission line fault. Histogram [31] equalization is a slightly more complicated method for image gray transformation. Histogram equalization is an important application of gray scale transformation and widely used in image enhancement processing. It is a histogram correction method based on cumulative distribution function transformation, which can produce an image with uniform probability density of gray scale distribution and expand the dynamic value range of pixels. Histogram equalization is to transform the histogram of the original image into a uniform distribution form, so as to increase the dynamic range of gray value and enhance the image.

4.2. Infrared Image Processing Method
The accurate identification of transmission line faults in infrared images [32] has always been a problem that plagues inspectors. In this paper, the infrared imager is used to obtain the temperature rise image of the transmission line. From the analysis of the characteristics of the infrared image of the transmission line, by comparing the advantages and disadvantages of each color space, the HSI color space [33] conversion is used to obtain the image edge information, and the median filter [34] is used to maintain the edge information. Advantages, using improved median filtering to eliminate interference, using the gradient method to extract the highest temperature region, so as to quickly and accurately diagnose the temperature rise fault of the transmission line. Taking the infrared image of the transmission line as an example, the feasibility and effectiveness of the HSI spatial gradient [35] method to identify the highest temperature region are verified.
4.3. Network Camera Method

Using the network camera installed on the high-voltage transmission lines to high voltage transmission line of real-time video transmission to the server with a core of digital image processing algorithm, through the server at the core of the digital image processing algorithms to identify high voltage transmission line, the core algorithm of digital image processing steps are: (1) background extraction[36]: frame by frame difference method is used to establish the initial background; Background update: the background edge is used to identify the background information, and then the algorithm based on Canny edge detection is used for background update. (2) high-voltage [37] transmission line target extraction: using the algorithm based on the background difference method to extract high voltage transmission line target.

5. Discussion

Transmission lines are closely related to our lives. The safety of transmission lines is very important for us. Therefore, our analysis uses a variety of existing methods at home and abroad for analysis. Through analysis, the method commonly used in the State Grid is the aerial photographing method of unmanned aerial vehicles for monitoring, but this method is sensitive to time and needs a lot of financial support. Therefore, this method is not particularly good in the current technical situation, so we think that using deep learning methods for monitoring is a better method, because this method replaces manpower and the price is cheaper. However, there are few studies using deep learning methods.

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