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Image Processing and Recognition Technology of Transmission Line Icing Research

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This study is carried out with a view to understanding the processing and recognition technique of icing transmission line images. Methods: Based on the improvement of traditional simulated annealing algorithm combined with genetic algorithm, the two-dimensional OTSU's method is adopted to obtain the corresponding results. Results and analysis: This study mainly carries out the analysis of the segmentation results to obtain the accurate thickness of icing and then formulates the corresponding construction steps, which shows the correctness of this study. Conclusions: The results show the accuracy of this study.

1. Introduction

The transmission line engineering projects are extensively constructed in modern times, some will inevitably encounter the low-temperature environment, leading to transmission line icing, so that the transmission line operation is affected to a certain extent. To deal with the icing on transmission lines, it is necessary to distinguish the thickness of icing. The thin icing will not affect the transmission lines, thus sometimes to deal with it will only increase the burden of manual operation. Therefore, in order to accurately identify and determine the thickness of icing on transmission lines, this study mainly introduces a method for recognizing and calculating the thickness of icing on transmission lines based on remote digital video image processing technique and conducts an experiment to verify its practicability.

In this experiment, the digital images intercepted from the transmission line video stream transmitted to the monitoring center are mainly used as the research object in this study, and the images are pre-processed by the two-dimensional segmentation method. When the two-dimensional segmentation method is used to segment the images, the two-dimensional OTSU's method based on simulated annealing genetic algorithm is adopted in the process, which has achieved good segmentation effect and fast segmentation speed. Finally, the improved eight-connected region marking is adopted to mark the images of the transmission line, and the comparison of the image pixels before and after the icing of each transmission line is carried out to obtain an average ratio, and then the icing thickness is calculated.

2. Literature review

In foreign countries, the researchers of Russia, Canada, the United States, the United States, Japan, the UK, Finland and Iceland have carried out a great deal of research on the phenomenon of wire icing and dancing. A great number of theoretical results have been achieved in the mechanism of ice covering, the ice loading and so on, and a lot of research and research work have been carried out in various units, scientific research and operation units in China. Many fruitful results have been achieved. However, most of the researches at home and abroad are mainly about ice coating theory, ice scintillation mechanism and tower strength design (Papaioannou et al., 2017).

Ice observation is to set up ice observation stations in the icing area, install various test equipment, and record data in a long-term manner. Then, the statistical analysis of the observed data is carried out. Quarter draws the geographical area ice distribution map, which is used to guide the design and operation management of the line, that is, the experience of natural ice formation (Quarter et al., 2014). Internationally, countries in the forefront of research on ice cover are Canada, Japan, Russia, Finland, the United States, France and so on.

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These countries not only divide the line icing distribution map, the long-term observation of the ice cover, and study the icing mechanism in the laboratory, but also set up the test standard for icing and the design regulations of the ice resistance and take a series of effective measures and methods. For example, to study the mechanism of the condensation of the rime on the wire, the observation station and the open running natural cold cloud wind tunnel are established at the top of the top of the dome mountain province. This is the first ice coating laboratory under the world's natural environment (Legg et al., 2015). The American cold zone engineering and research laboratory built an analog transmission line at the top of Washington mountain in the early century and installed a variety of monitoring equipment to monitor various icing conditions. Ontario and Quebec, Canada are heavy ice zones. For this reason, the Quebec Hydropower Bureau established a remote monitoring system on one line. The ice rate table developed by it was installed on the insulator string to detect the ice load. At the same time, it can also record temperature, wind speed, direction, precipitation and so on. The data can be transmitted remotely. Park and others set up a nationwide reference database for the special wet snow and rime to improve the power supply quality to the year and put forward several criteria for the selection of data (Park et al., 2015). The Russians have long monitored the icing conditions of various high conductors. Bbu Censky studied various icing patterns in detail, including the shape of the cross section, the structure of ice products, and the features of the shape of the ice. A Russian company has jointly developed an ice wind load sensor with the technical improvement bureau, which can be used for early detection of wire and cable icing, and Nogales is trying to run on a transport line in Volgograd, currently in the Volga on main network in central Russia (Nogales, 2015).

China has also done a lot of work on ice cover observation, but due to insufficient investment in the construction of the observation station, backward equipment and unstable personnel, there is a lack of comprehensive, systematic and continuous work. The establishment of ice observation stations basically started in the early years. The Yunnan Electric Power Design Institute has set up three observational ice stations in Tai Huashan, Higashikawa Miko head and Zhaotong Dashan in Kunming. The Southwest Power Design Institute set up the Yellow Mau ridge view ice station in the Maicun County of Liangshan, Sichuan province. Yang has been observing and analysing the weather conditions of the transmission line ice covering for many years from 2014. The test lines are not uniform ice, ice overlying vibration, dance, de-icing, jumping, and the change of the wire icing with height (Yang et al., 2014). In addition, Jiangxi Mount Lu, Jinggangshan, Shaanxi Qinling Mountains, Hunan Chenzhou and other places have also established different types of ice - view stations, which have accumulated valuable historical data for the construction of the heavy ice area lines.

At present, in the on-line monitoring system of power transmission lines, the general method of identifying and calculating the icing thickness of the transmission lines by Nex and Remondino is based on the electrical characteristics of the transmission lines, such as the change of weight, the temperature, the humidity, the humidity, the rainfall, the wind speed, the wind direction, the air pressure and so on. The corresponding mathematical model is established and the icing condition of the line and the early warning signal of de-icing of the transmission conductance is analysed and calculated (Nex and Remondino, 2014). Although this method can basically grasp the icing condition of transmission lines and reduce the occurrence of accidents, the establishment of the model is difficult. Any small error will have a great influence on the calculation results, and its equipment is complex, the parameters need to be collected more, and the process is complex. Using digital video image processing and recognition technology to monitor the icing state of transmission lines is a very intuitive and simple method for identifying and calculating the ice cover thickness of transmission lines. Some scholars at home and abroad have already started the research in this field. There are literature reports based on digital signal processor. Kuijper uses the combination of edge detection and transformation to preprocess the ice-covered transmission line image, and the icing thickness of the transmission line is obtained according to a certain recognition algorithm. However, this method does not consider the icing condition of multiple transmission lines in the monitored transmission lines, and has some limitations (Kuijper et al., 2015).

To sum up, the ice cover of transmission lines can cause various accidents. China is one of the countries which have more accidents on the transmission line icing, which has seriously threatened the safe operation of the power system in China and caused huge economic losses. Therefore, based on the remote digital video image processing technology, the digital image intercepted in the transmission line video stream which is transmitted to the monitoring centre is used as the research object. The region marking algorithm is used to distinguish a lot of transmission lines in one image, and the automatic identification and calculation of the thickness of the ice cover of each transmission line is realized, so that it is in any one of the lines. Transmission line thickness can exceed the required safe range.

3. Methods

3.1 Simulated annealing algorithm

Simulated annealing, also known as Monte Carlo annealing, is a commonly used global optimization method that derives from the principle of solid annealing. The simulated annealing algorithm is an iteration of the stochastic optimization algorithm, which is often applied to the selection of the best problem, when the continuous gradient descent function does not exist, or the continuous gradient descent function is limited to a local minimum.

Physical annealing process

The core idea of the simulated annealing algorithm is very similar to the principle of thermodynamics, and is especially similar to the way of liquid flow and crystallization, and metal cooling and annealing. At high temperatures, a large number of molecules of the liquid move relatively freely with each other. If the liquid cools slowly, the heat mobility disappears, and a large number of atoms are often able to align to form a pure crystal. The crystal is arranged in a fully ordered manner within a few million times the distance of a single atom in all directions. For this system, the crystal state is the lowest energy state, and all slowly cooling systems can naturally reach this lowest energy state, which is surprising. In fact, if the liquid metal is rapidly cooled or quenched, it does not reach this state, but can only reach a polycrystal state with a higher energy or a non-crystalline state.

Improvement of simulated annealing algorithm

Both genetic algorithm (GA) and simulated annealing (SA) are global stochastic optimization algorithms. Although the genetic algorithm has a strong global search performance, it has weak mountain climbing ability, it is easy to produce premature convergence in practical applications, and its search efficiency is low in the later evolution. The simulated annealing algorithm has the ability to get rid of the local optima, and can effectively inhibit the prematurity of genetic algorithm. Therefore, the idea of simulated annealing is introduced into the genetic algorithm, which can achieve the purpose of alleviating the selection pressure of the genetic algorithm.

3.2 Two-dimensional OTSU’s method

The OTSU’s method is a one-dimensional image segmentation algorithm, which only considers the gray-scale characteristics of each image pixel without reflecting the spatial information between the image pixels, and which cannot obtain the good segmentation effect, when the contrast of the images is not obvious. The two-dimensional OTSU’s method is based on the two-dimensional histogram, which not only considers the gray information of the image, but also considers the relevant information of the neighborhood space. Therefore, the two-dimensional OTSU’s method has higher segmentation accuracy and robustness than the one-dimensional OTSU’s method, and is suitable for complex images with lower contrast.

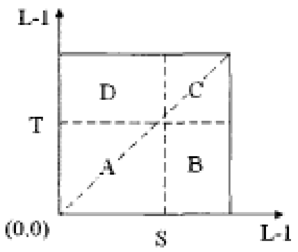

Figure 1: Two-dimensional histogram definition domain of image

The two-dimensional vector (S, T) in Figure 1 is the threshold value, which divides the two-dimensional histogram of the image into 4 regions, A, B, C and D (as shown in Figure 1). Since the gray value of the pixel is close to the average gray value of the neighborhood within the target and the background, and that the gray value of the pixel and the average gray value of the neighborhood are greatly different in the boundary neighborhood between the target and the background, the pixels in the target and background will therefore appear around the diagonal. Assuming that region A represents the background, and region C represents the target, B and D that are away from the diagonal represent possible edges and noise.

4. Results and Analysis

4.1 Segmentation results and analysis

This study writes the code in VC + + environment, and runs the program on the AMD3800 ten and 2. OGHZ microcomputer. Two gray scale images with a size of 2x288 of icing transmission lines are segmented by one-dimensional OTSU's method, two-dimensional OTSU's method and two-dimensional OTSU's method based on simulated annealing genetic algorithm respectively. The segmentation results are shown in Figures 2, 3 and 4 respectively.

Figure 2: One-dimensional OTSU's method

Figure 3: Two-dimensional OTSU's method

Figure 4: The proposed algorithm

4.2 Technical Scheme for identifying and calculating icing thickness of transmission lines

Based on the remote digital video image processing techniques, this study takes the digital images intercepted in the transmission line video stream transmitted to the monitoring center as the research object. In order to identify and calculate the icing thickness of transmission lines, a series of image processing and identification techniques are needed, including image pre-processing techniques introduced in Chapter 4 such as image gray scale and binary segmentation, as well as the image processing and recognition techniques, such as pixel calculation, ice flow identification and processing, and region marking, which will be introduced in the following part.

The specific steps for identifying and calculating the icing thickness of the transmission lines are as follows:

1) Collect the video signals of the transmission lines by the camera and transmit them back to the monitoring center in the form of video stream through the transmission channel by the video server.

2) Intercept digital images of the monitored transmission line from a video stream at the monitoring center to obtain the target monitoring images.

3) Image pre-processing such as gray scale and binary segmentation of color image is performed on the target images, and the number of target pixels in the whole image is calculated.

4) Determine whether the intercepted target images are the first intercepted icing-free transmission line images. If it is, mark the area, input the wire diameter parameter D of the transmission line, and store and mark the image. If not, then determine whether the number of pixels exceeds 15% of the corresponding image

of transmission lines without icing. If it does exceed, it is considered that the monitored transmission lines have icing and mark the image. Otherwise, returns to the Step 2.
5) Determine whether there is ice flow on the transmission lines in the images of icing transmission lines. If there is ice flow, deal with it, otherwise go to Step 6.
6) Mark the regions of images of icing transmission lines, and compare and calculate the pixels of images of transmission lines before and after icing. Calculate the icing thickness according to D, the known diameter of transmission line.
7) When the icing thickness of any one of the transmission lines exceeds the specified safety range, an alarm is given to enable the staff to take de-icing measures. Otherwise, go back to Step 2 and proceed.
This process can be visually represented by flow charts, as shown in Figures 5 and 6.

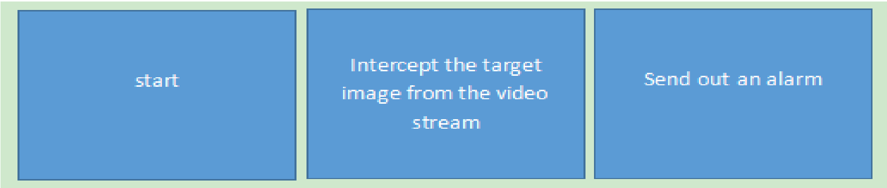

Figure 5: Flow chart of image processing and recognition technology for transmission line icing based on video monitoring (a)

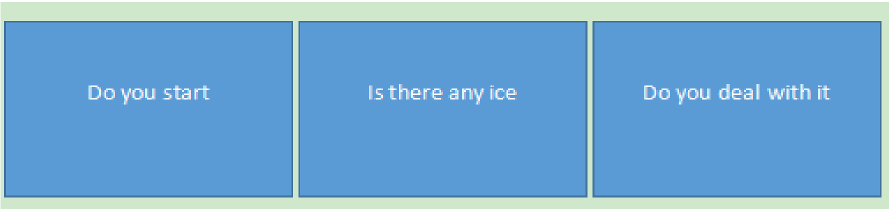

Figure 6: Flow chart of image processing and recognition technology for transmission line icing based on video monitoring (b)

4.3 Eight connected region marking

The implementation steps of the eight-connected region marking algorithm are as follows:
1) Read the original transmission line images, and store them in the buffer area, including pixel value of each point, width, height, and others of the original images.
2) Monitor the buffer and sequentially detect each pixel from left to right and from top to bottom. If it is found that the pixel value of a certain pixel is 0, then sequentially detect the pixel values of the four points in the upper right, upper, upper left and left front of the point. The connectivity is judged according to the following criteria:
a. If the pixel values of the upper left, upper, upper right and left front points of the point are not the recognition target. The number is incremented by 1, and it is marked with 1;
b. If a certain pixel is a recognition target, determine whether its upper right, upper, upper left and left front point is the target in turn. The top right priority is the highest, and the front left priority is the lowest;
c. If the upper right point is the recognition target, mark the current point with the value of the upper right point;
d. If the upper right point is the recognition target, then judge the upper right point;
e. Similarly, if the upper right point and the upper point of the current point are not the recognition targets, judge the upper left point sequentially by the same method. If the upper left point is not the recognition target, then judge the left front point;
f. If the upper right point, the upper point, the upper left point and the left front point of the current point are not recognition targets, then the value of the current point is added by 1 to the original mark, and the mark is used as a difference from another recognition target;
g. If the upper right point and the left front point of the current point have different marks, and the upper point and the upper left point are not recognition targets, then the current point is marked with the same value as that of the upper right point. At this point, scan the whole image, and mark all pixel values that are the same as the left front point mark with the same value as that of the upper right point. The statistics of arrays of pixel values (marked values) in the upper right point is added according to the number of the pixel points converted, while statistics of the arrays of pixel values (mark values) at the left front is set as 0.

5. Conclusions

The icing on transmission lines is not uncommon in China. Excessively thick icing may cause transmission lines to break, thus it is necessary to calculate the thickness of icing, in order to deal with this phenomenon appropriately and effectively. This study improves the traditional simulated annealing algorithm combining with the genetic algorithm; because both of these algorithms are global stochastic optimization algorithms, there exist the possibility of fusion. After the improvement, the two-dimensional OTSU's method is used to obtain the results. In order to verify the accuracy of the algorithm, the code is written in VC + + environment on the basis of the research results, and the program is run on AMD3800 ten and 2. OGHZ microcomputer. One-dimensional OTSU's method, two-dimensional OTSU's method and two-dimensional OTSUs method based on simulated annealing genetic algorithm are respectively used to segment two gray scale images of icing transmission lines. According to the segmentation results, the icing thickness can be determined through seven steps, and finally the eight connected region marking is used to identify the icing point, so as to strengthen the accuracy in dealing with icing.

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