The Detection Algorithm of Broken Wires in Power Lines Based on Grabcut Segmentation

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Abstract. Unmanned aerial vehicle (uav) has the advantage of rapid and efficient in power line fault detection. However, the background of power line image taken by uav is complex, and it is difficult to extract the foreground power line for fault detection.Aiming at this problem, we propose an algorithm based on Meanshift superpixel segmentation and Grabcut for further segmentation optimization. At the same time, the RANSAC algorithm is used for denoising to extract accurate power lines. Finally, the power lines are constrained based on their slender characteristics. Compare the width change on the same wire to detect the occurrence of strand breakage in the power line. The experimental results show that the algorithm has a good effect on the detection of broken strands in power lines.

1. Introduction

With the development of social economy, the importance of power system becomes more and more significant. In order to ensure the safety, order and efficiency of its operation, the inspection work of power lines has been paid high attention.Manual regular route inspection method not only labor intensity, time consuming, and low efficiency.Due to terrain factors, some line segments cannot be inspected manually [1].The development of uav technology provides a new mobile platform for aerial power line inspection.The use of unmanned aerial vehicles (uavs) equipped with inspection equipment for line inspection has incomparable advantages over the traditional way of line inspection.

Because the power line is exposed in the field, external factors such as mechanical tension, aging of materials, lightning strikes, pollution, etc., are prone to fatigue, oxidation and corrosion of power transmission lines, which can easily cause burrs, surface protrusions, and even broken strands. If it is not detected and eliminated in time, it will not only increase the power loss of the transmission line, but also seriously threaten the safety and stability of the power system [2]. After the broken wire of the transmission line, deformation and disconnection will occur, which will change the target edge. The position of broken strands can be detected by the edge information of the power line image.

At present, there are many researches on using digital images to detect transmission line faults. The main methods are ultraviolet imaging detection, infrared imaging detection and visible light detection [3,4]. The use of visible light for detection, in line with human visual characteristics, and more accurate detection, moderate price, with a wide range of applications [5]. However, for the UAV to conduct power line inspection to obtain images for visible light detection, the situation of the broken line of the power line is complicated. At the broken line of the power line, large deformations and
dropped lines are prone to occur, and the edge information of the broken line is complicated and easy. Due to the interference and influence of the background, it is difficult to extract specific edge information for the detection of broken wires in the wire.

In this paper, a new algorithm is proposed for the characteristics of power line images that are easily captured by drones, and accurate results are obtained on existing test data.

2. Algorithm and experimental analysis

The detection algorithm of broken strand of power line conductors based on super pixel segmentation is mainly divided into the following five steps:

1) The UAV image is firstly segmented by Meanshift in a super-pixel manner, and the initial segmentation map is obtained by coarse positioning of the wire (the wire area is relatively slender) according to the aspect ratio of the minimum bounding box in the segmented area.

2) According to the initial segmentation result as the background information, the image is segmented using Grabcut algorithm.

3) Ransac algorithm was adopted to extract straight line segments with the consistency of width (vertical direction) and filter out short lines. Then the collinear segment is extracted into a long straight line as the candidate of the conductor.

4) At the break point of a collinear wire, search the result of Grabcut binary graph for whether the width of the wire becomes smaller, and it is considered that if the width becomes smaller, there will be wire strand breakage.

5) For the detected wire, the wire strand breakage is detected according to the change of width and width. On the one hand, too wide wire is not detected; On the other hand, no matter the wire appears burr, or the wire breaks, its width will reduce, so this condition is used for detection to suppress false alarm caused by shielding, etc. (the width at the shielding will increase).

2.1. Meanshift algorithm for super pixel segmentation

In super division of pixels, each pixel area of all pixels with similar statistical properties, guarantees the pixel does not destroy the image of the main line structure, each super pixels can be regarded as an independent individual to participate in the process of clustering algorithm, after completion of each super pixel clustering, clustering result can be marked on the super pixels directly, the resulting image segmentation results will not destroy the image of the main structure, meet the central elements of the image, is helpful to distinguish the foreground.

Based on this, the Meanshift algorithm[6] is used to carry out super pixel segmentation, search the extreme points of probability density in the image feature space, and group the extreme points to smooth segmentation. The kernel density estimation method of nonparametric probability density estimation method is used to estimate the probability density.

2.2. Grabcut algorithm binary segmentation

The Grabcut algorithm is a method of image segmentation based on graph theory[7]. First, we need to define a Gibbs energy function, and then solve the min-cut of this function. This min-cut is the set of segmented pixels in the foreground and background. The Grabcut algorithm first needs to select foreground and background samples in a frame, build a GMM for the foreground and background areas, and initialize the GMM using the k-means algorithm, and calculate the distance from the node to the foreground or background and the distance between adjacent nodes. Then obtain segmentation energy weights, construct an s-t network graph for the unknown region, and then segment it using the maximum flow-minimum cut algorithm[8]. By iteratively updating and modifying GMM parameters, the algorithm tends to converge, and finally image segmentation is achieved.

2.3. RANSAC algorithm optimizes the segmentation results

RANSAC is the abbreviation of RANdom SAmple Consensus, which is a robust model parameter estimation algorithm[9]. According to a set of sample data sets containing abnormal data, the mathematical model parameters of the data are calculated to obtain valid sample data. The RANSAC
algorithm has a strong ability to exclude abnormal data\textsuperscript{[10]}. For the GrabCut segmentation results, first perform edge extraction, and then calculate the width of the foreground area of each edge point downward in the vertical direction. For these widths, this article first uses the RANSAC method to make a robust overall width It is estimated to obtain a reference width of the continuous edge, and then the width of each edge point is compared with this reference width. If it is less than a certain threshold, it is an abnormal broken strand area.

3. Experimental results and analysis

The experimental data used are aerial photography images of power lines in a certain place collected by the multi-rotor uav. The selected images include power line images with farmland, trees and houses as the background, which are resampled to 6000*4000 resolution and tested by the algorithm in this paper.

![Aerial Photography of Power Lines](image1)

**Figure 1. Aerial Photography of Power Lines**

(a) Meanshift super pixel segmentation result graph  (b) Grabcut fine binary segmentation result diagram  
(c) RANSAC algorithm line segment extraction result  (d) The collinear line segment is extracted as a long straight wire graph

**Figure 2. Algorithm Processing Diagram**
Figure 1 is the original power line image of the farmland in the background, including disturbance objects such as ridge, insulator and wire tower. To the original image by Meanshift algorithm for segmenting super pixels after filtered according to each super pixel aspect ratio obtained the figure 2 (a) as a result, chose the segmentation result as the initial frame Grabcut algorithm is used on the original binary segmentation, at the same time to modify the original input for maximum difference with RGB and figure of four-channel figure, figure 2 (b) results, in figure 2 (b), to edge extraction, and then calculate each edge point corresponding to the vertical width, according to the width of the edge of breaking into a series of lines, Use RANSAC for each line width and extract the line segment is figure 2 (c), the collinear line in long straight wire of the same color figure 2 (d), search collinear long straight wire truncation, and in the same position calculating straight direction, in figure 2 (b) in the same line and width of the same straight line set judgment in the middle for the width smaller. Finally, the smaller part of the width is marked in red to get figure 3.

Figure 3. Algorithm Detection Result Diagram

Figure 4. Power line image detection results with trees as background
Figure. 5 shows the detection results obtained by using the algorithm in this paper when the background is a complex tree. It can be clearly seen that the broken wire burr is clearly marked and recognized.

The test data set contains 40 power line aerial photography images, among which 10 are fault-free images and 35 are fault-broken images. After the test of the algorithm in this paper, the statistical results of the obfuscation matrix can be used to calculate the statistical results of the accuracy of the algorithm in this paper, as shown in table 1.

4. conclusion

This paper proposes a method for detecting broken strands in UAV power line images based on Meanshift superpixel segmentation. This method first performs Meanshift superpixel segmentation on the original image. Based on the aspect ratio of the minimum bounding box of the segmented area and the length of the short side, it is used as a screening template to initially locate the horizontally extending wires to obtain the initial segmentation map. Based on the initial segmentation results, the area left after filtering by the minimum bounding box is selected as a frame, and the Grabcut algorithm is used to perform fine binary segmentation on the image to further refine the segmentation of the traverse. The Grabcut results are constrained by the vertical width consistency. The RANSAC algorithm is used to extract straight line segments, and collinear conductors are selected as candidate conductors. Finally, by judging whether the binary image at the breakpoint of the collinear wire has a smaller width on the same collinear wire, if it is marked, it is determined that the broken wire has occurred. The experimental results show that the algorithm in this paper has a good effect in using UAVs to inspect broken power lines.

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