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A Visual Detection Method for Foreign Objects in Power Lines Based on Mask R-CNN

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ABSTRACT

The high-voltage power lines and transmission towers are large in volume, large in number, and wide in coverage, so they are easily attached to foreign objects, which may cause failure of the transmission line. The existing object detection methods are susceptible to weather and environmental factors, and the use of neural networks for target detection can achieve good results. Therefore, this article uses MASK R-CNN as the basic network detection method for detecting foreign objects in the transmission network. The experimental results show that compared with the traditional target detection method, the method adopted in this article has achieved good results in the speed, efficiency, and recognition precision of foreign object detection. In the future, image processing operations can be performed for complex backgrounds of transmission lines to improve recognition effect.

KEYWORDS

Equipment Failure, Foreign Object Detection, Mask R-CNN, Power Line, Transmission Tower

INTRODUCTION

With the rapid development of society, the adequate supply of electricity is an indispensable part of ensuring people's normal life. High-voltage transmission lines are the most basic part of the supply of electrical energy. The safe operation of the transmission line is the key to ensuring the stability of the entire power grid from the power generation side to the transmission side, because the high-voltage transmission line and the distribution line are the link between the power plant, the substation and the user (Wang, 2012). High-voltage power line towers are a very important part of the entire power grid. For power companies, it is very important to carry out long-term and serious scientific transmission line inspection work, because the transmission line is exposed to the harsh natural environment such as mountains, long-term wind and sun make the equipment on the transmission line very It is prone to aging, oxidation and corrosion (Qi, 2017).

Motivation

In recent years, security incidents caused by foreign objects such as bird nests, hanging balloons, kites, etc. on transmission lines have occurred frequently. Winding foreign objects on the wires may cause three-phase short-circuit (Pei & Kang, 2012), as well as ground discharge (Wu, Chen, & Zhou, 2003). At present, the common transmission line inspection methods include manual inspection,

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drone inspection (Bo, W., Wu & Xu, 2014) and image morphology (Wang, Wang, & Shao, 2017; Baker, Mills, & Langlotz, 2016).

The manual line inspection method takes a long time, is inefficient, and is prone to omission. Line survey personnel need to spend a lot of time on the transmission line to observe the transmission facilities using auxiliary equipment such as telescopes. Transmission lines exist in abundance in harsh environments such as mountains and forests, and are a huge hidden danger to the personal safety of line-patents. The manual inspection method will also lead to the omission of some transmission equipment due to the negligence of employees.

Drones have also been used to inspect high-voltage lines, and drones can quickly perform tasks in accordance with the instructions of the inspectors. However, the inspection of drones is easily affected by extreme weather such as rain, snow, hail and strong winds, which interrupts the inspection mission. In addition, the operation of the drone is complicated, and the requirements of the operator are high, and the returned image also needs to manually judge the foreign object.

The use of robots for transmission line inspection is also a widely used method. This method relies on sensors such as eddy currents, infrared and ultrasonic waves carried by the robot to complete the task of detecting foreign objects and fault recognition, but the robot inspection method also has the disadvantages of slow speed, poor timeliness and low efficiency. With the deep learning and computer vision development in recent years, the patrol robot gradually began to apply computer vision to the detection system, so that the robot has the visual ability to improve the intelligence and controllability of the patrol robot. However, the application of the vision system to the robot has the problems of poor adaptability and weak anti-interference ability (Zhu, 2017).

In this paper, online imaging equipment and drones are used to obtain photos, analyze the characteristics of foreign objects on the transmission line, train by neural network method, and finally obtain empirical prediction models. The foreign object detection model can guide the inspection work and reduce the intensity of workers' work, which has important practical significance.

Deep Learning Algorithm for Target Detection

With the application of increasingly high-powered GPU arrays to model training, deep learning has developed faster and faster in recent years. Neural network algorithms are a kind of representative algorithms in deep learning, including deep belief network (Bengio, & Yoshua, 2007) and Convolution Neural Network (CNN) (LeCun, & Yann, 1998). At present, there are two different approaches to the deep learning method applied to target recognition. The performance of the neural network algorithm in the current mainstream target detection is shown in Figure 1. The first category is based on the candidate region's target detection method, which is representative from the R-CNN generated in 2013 (Girshick, 2014) to the later Fast R-CNN (Girshick, 2015), Faster R-CNN (Ren, He, & Girshick, 2015), and Mask R-CNN (Kaiming, Georgia, & Piotr, 2018) used in this paper. The second category is a single detection method, representative methods include YOLO (Redmon, Divvala, & Girshick, 2015), SSD (Liu, Anguelov, & Erhan, 2015), etc.

Related Work

Existing edge detection algorithms often have poor noise suppression capabilities, and the problem of extracting edge features of images from aerial images using only their grayscale gradients. In (Wu, 2012), based on the difference of texture between transmission line and background in aerial transmission line image, a threshold detection method based on texture feature is proposed by using threshold noise reduction technique and edge denoising method. The analysis of the experimental results shows that the algorithm has stronger noise suppression ability, can effectively retain the specific information of the transmission line break, and can more completely extract the edge information of the equipment in the transmission line.

Aiming at the contradiction between edge location and noise suppression in Canny edge detection algorithm, the edge detection function adopts the modified Γ density function and introduces the edge