



Identification of Sensitive Regions for Power Equipment Based on Fast R-CNN

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Abstract. Electricity is an indispensable resource in the daily life of people. However, the inspection of power equipment is still in the artificial stage. This way of work is inefficient, consumes a lot of manpower and material resources, and is not accurate enough. In order to realize the intellectualization of patrol inspection system, this paper uses a fast R-CNN technology based on Google LeNet V2, which brings a more efficient and advanced supervisory technology for power equipment. Experimental results of this paper show that the average accuracy rate of the scheme reaches 92.0%, and the average recall rate reaches 79.7%, with good results..

Keywords: GoogLeNet V2 · Fast R-CNN · Electric power equipment · Target detection

1 Introduction

Electricity is an indispensable resource in our life, so the inspection of power equipment is a task related to people's livelihood. Nowadays, the way of power plant monitoring is mostly to send the collected images or videos of power equipment to the monitoring personnel through video equipment. The disadvantages of this way are low stability, labor negligence, low efficiency, and high cost. Deep learning research has grow rapidly for the past few years in image recognition and target detection, and other algorithms have been applied in more and more fields. If these technologies can be used to identify power equipment in monitoring pictures, it will undoubtedly further improve the power system's intelligent level and brings about a kind of unprecedented and advanced detection technology. This will greatly liberate human resources and make the whole power system more stable and secure.

This paper is to apply the faster R-CNN algorithm of object detection [1] to the identification of power equipment. Compared with ordinary objects, the number of electrical equipment is relatively small, but the light is mostly dark, and the color difference is relatively small. At the same time, because it is related to people's daily life, the precision requirement of the algorithm is very high. In foreign countries, image processing and recognition technology has been applied to the field of power system through infrared image detection and other technologies since 1997. In China, image recognition technology has also been widely used in power system research. In traditional target detection algorithm, feature extraction and classification decision are carried out separately, so the requirement of feature selection is more strict, and it is difficult to obtain ideal results in the face of complex scenes [2]. Since Professor Hinton put forward the theory of deep learning, more and more researchers have found that applying deep learning in the area of power system can effectively improve the application effect and system performance. Therefore, deep learning methods has been extensively applied in the process of research of power system.

For the sake of enhance application status of neural network in partial discharge pattern recognition, Yu Yang studied introducing the deep learning mechanism to realize partial discharge pattern recognition [3]. Gan Weitao uses convolutional neural network (CNN) to realize the recognition of transformers and insulators [4]. As for the accurate detection of thermal faults of electrical equipment in substations, Jia Xin proposed an infrared fault identification method of electrical equipment based on double supervised signal convolutional neural network [5]. Li Yunhao combines infrared thermal imager with visible light camera, through the research of image processing and depth learning algorithm, and combines embedded system to realize automatic location and diagnosis of power transformer faults [6]. Zhu Xuliang et al. proposed an intelligent identification method of partial discharge atlas of electric power equipment based on image processing technology and deep sparse data denoising, and realized intelligent classification and recognition of partial discharge by using the extreme learning machine (ELM) network.

2 Related Work

In this paper, the faster R-CNN model is gradually improved from the R-CNN [7] model. CNN is the foundation of most deep neural networks. In 2014, R-CNN algorithm was first proposed by Professor Girshick. The steps of R-CNN are briefly described as follows. Firstly, candidate regions are identified, and the recall rate is guaranteed by utilizing the information of edge, color difference, and color value of pixels in the image. However, an important shortcoming of R-CNN is that each different candidate box will be computed separately. This leads in the training process which has a mass of calculation, which means that the speed is very slow. KH et al. [8] put forward the use of spatial pyramid pooling (SSP) to solve the problem of long computation time of RCNBN. The model proposed by combining SSP theory is fast R-CNN. However, despite solving the huge computation problem, fast R-CNN still has an important problem, which is that it costs lots of time to find all the candidate boxes. This also makes the speed of fast R-CNN reached a bottleneck. Therefore, researchers think of adding a neural network to fast R-CNN that can extract edges to help us identify edges more quickly. This is faster

R-CNN that will be used in this paper. It is a model that can be trained quickly and identified steadily. Therefore, this paper decides to apply faster R-CNN technology in power equipment identification.

3 Feature Extraction

Feature extraction is an important basis of image recognition. The feature extraction based on DLN can solve the shortage of generalization ability of manual features. This paper will use the classical deep convolution network GoogLeNet V2 [9] for feature extraction.

The Google LeNet series network is a deep convolution neural network developed by Google. The traditional convolutional neural network deepens the network depth by stacking convolutional layers continuously. However, deeper network means more parameters, which will increase the computation amount. In addition, it is easy to lead to the phenomenon of over-fitting. The main idea of Google LeNet is to increase the same amount of computation through elaborate manual design. The greatest feature of Google LeNet is that it builds a network by stacking inception modules. The network structure of Inception v1 is shown Fig. 1.

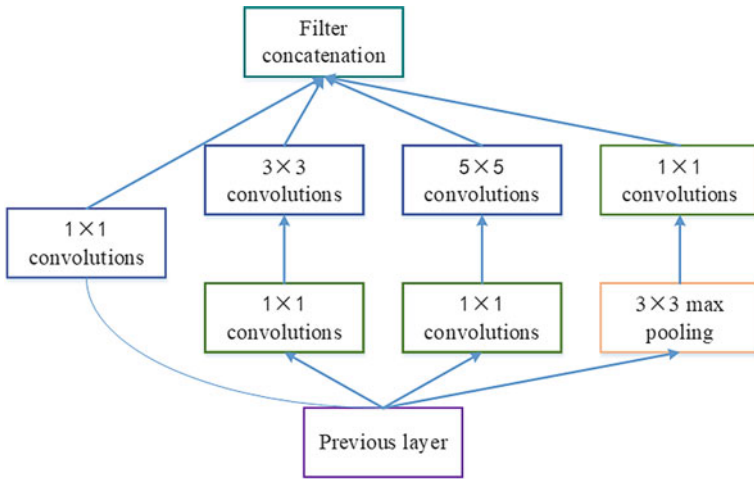


Fig. 1 Network structure of Inception v1

This paper will use Google LeNet V2 to extract features. On the basis of v1, Inception V2 mainly makes two improvements. The first uses two convolution layers with 3 * 3 kernels, which can accelerate the calculation and reduce a mass of parameters. Secondly, add batch standardization layer, which accelerates the training speed, reduces the internal covariate transfer, and improves the classification accuracy.

4 Fast R-CNN Model Based on Deep Learning Network Framework

The most advanced object detection network relies on region generation algorithm to assume the location of objects. In the further exploration, researchers have introduced regional generation networks (RPN). RPN and detection network share the whole image convolution feature, thus achieving region generation at almost no time. Region generation network is a fully convoluted network. The simple alternative optimization is proposed. Its concrete structure is shown in Fig. 2.

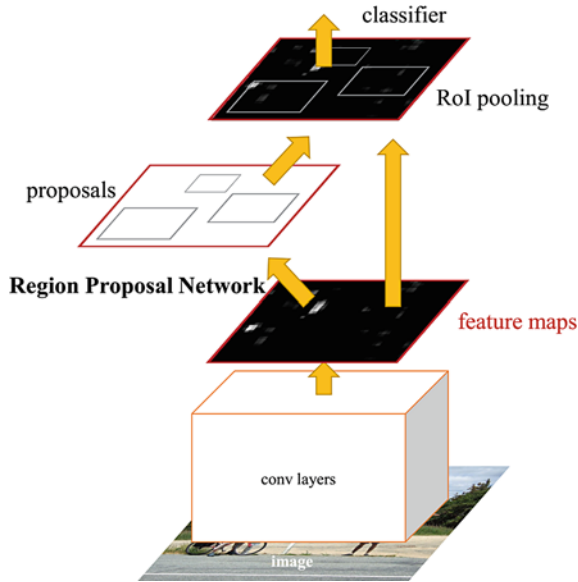


Fig. 2 Fast R-CNN structural diagram

Fast R-CNN consists of four parts: convolution layer, RPN network, RoI pooling, and classifier. The advantage or difference of this and the previous model refers to it is RPN. RRN network is specially used to recommend candidate areas. It inputs an picture of any size and outputs several interrelated matrices. For an input picture, it is actually considered as a large matrix. Then, RPN generates several anchors. So-called anchors are boxes that are preset in size. By default, each slide position will produce nine anchors. The most important characteristic of anchor points is translation invariance.

5 Experiment and Analysis

5.1 Data Introduction

In this paper, the dataset contains a total of 3241 pictures, including transformer radiator, transformer bushing, transformer oil pillow, transformer body, circuit breaker capacitor, isolating switch, transformer wall bushing, and other common equipment in power

system. For each device, different parts, different angles, and different illumination are collected. This paper randomly divided the dataset into two categories, the proportion of training data is 90%, and the other is test dataset.

5.2 The Experiment Platform

The operating system of this experiment is Ubuntu1.18.0.04, the GPU is NVIDIA1080ti, the deep learning framework is tensorflow1.13.1, and the programming language is python.

5.3 Experimental Results and Analysis

This paper chooses COCO Data Centralization Evaluation Index published by Microsoft, which is commonly used in target detection, to analyze the experimental results (Table 1).

Table 1 Experimental results

Evaluation index	Measure way		The model in this paper
Average accuracy	Overlapping degree	0.5:0.05:0.95	0.728
		0.5	0.920
		0.75	0.851
Average recall rate	Number of detection results	1	0.620
		10	0.797

This paper randomly selected two pictures to show the recognition effect. As shown in Figs. 3 and 4, we find that the strong light has a certain impact on the recognition effect, but it still maintains a high recognition effect, and the recognition effect is also affected by the number of samples. This is also the direction of our future improvement.

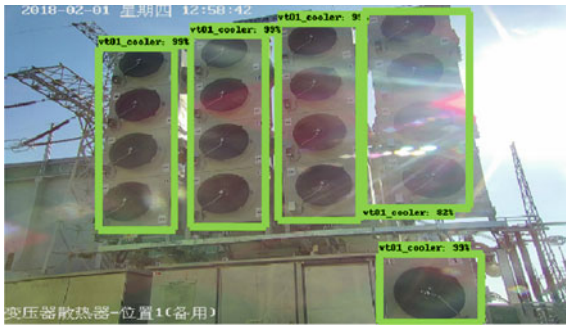


Fig. 3 Recognition effect of transformer radiator

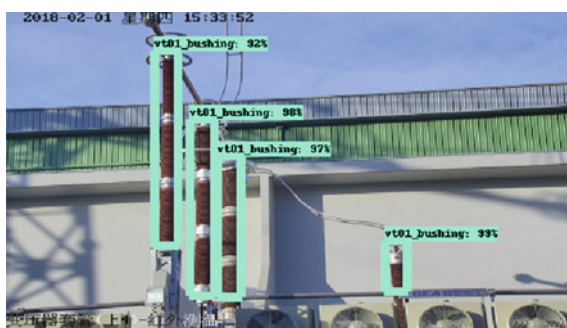


Fig. 4 Recognition effect of transformer bushing

6 Conclusion

The Fast R-CNN power equipment identification scheme based on GoogLeNet V2 has a high accuracy and recall rate in this paper. In order to realize intelligent patrol inspection of power equipment, an effective scheme is proposed, which will be applied in the actual patrol inspection system in the future.

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