Chapter 5
Insulator Fault Detection From UAV Images Using YOLOv5

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ABSTRACT

Identification of insulator defects is one of the most important goals of an intelligent examination of high-voltage transmission lines. Because they provide mechanical support for electric transmission lines as well as electrical insulation, insulators are essential to the secure and reliable operation of power networks. A fresh dataset is first built by collecting aerial pictures in various scenes that have one or more defects. A feature pyramid network and an enhanced loss function are used by the CSPD-YOLO model to increase the precision of insulator failure detection. The insulator defective data set, which has two classes (insulator, defect), is used by the suggested technique to train and test the model using the YOLOv5 object detection algorithm. The authors evaluate how well the YOLOv3, YOLOv5, and related families perform when trained on the insulator defective dataset. Practitioners can use this information to choose the appropriate technique based on the insulator defective dataset.

INTRODUCTION

When inspecting high-voltage transmission lines, a number of sensors are employed, and one crucial technique is the status detection of electrical equipment. Vision sensor-based techniques have advanced significantly over the past few decades, and various topics, including insulator identification, power line detection, and power tower detection, have been studied. The insulator string, which may offer both mechanical support and electrical insulation, is one of the high-voltage transmission line's most crucial

DOI: 10.4018/978-1-6684-8098-4.ch005

pieces of equipment, according to early research. However, insulator flaws typically manifest themselves after some amount of running time as a result of factors including lightning strikes, material aging, and overloading. Therefore, a crucial job for high-voltage transmission line inspection is the accurate detection of insulator failures. In a standard manual inspection, workers must traverse paths close to high-voltage transmission lines to examine the status of each insulator using a variety of tools, including cameras, ultraviolet imagers, infrared imagers, and audition sensors. However, because high-voltage transmission lines are typically erected in complicated environments with woods and lakes, the traditional manual method is ineffective and impractical in real-world applications. The study of aerial photographs taken by unmanned aerial vehicles (UAVs) has recently become more popular for insulator status inspection due to advancements in UAV handling and image processing techniques.

Multiple features, such as color, form, edge, gradient, texture, key-points, and their fusions, have been investigated in the man-made feature-based approaches. Some mathematical models, such the snake model, Hough transform, Active Contour Model, Fuzzy c-means, and Receptive field model, have also been used in the interim. AdaBoost, Sparse representation-based classifier, SVM, Cascade classifier, and KNN are used in machine learning-based approaches to identify insulator placements and identify insulator problems. The insulators in aerial photographs, however, are typically overlapped since the shooting angle and distance are constantly changing during UAV inspection, making it difficult to collect the spatial information of each insulator.

According to Liu et al. (2021), high-voltage transmission is essential because of the rising demand for electricity, particularly in relation to intelligent power grids. However, a defect will inevitably happen because the insulator spends a considerable amount of time outside. Unmanned aerial vehicle (UAV) patrols have gradually replaced typical manual patrol, which wastes resources and is ineffective. As a result, employees no longer need to use telescopes to find insulator defects along transmission lines. The automatic diagnosis of insulator failures has, however, been extremely difficult because to the complexity and diversity of application settings.

The accuracy of conventional image processing algorithms is lowered because the correlation properties of insulators in aerial photos are unknown. These techniques have various advantages over more conventional image processing techniques. With the widespread use of CNN suggested by Xiao and Sun (2021), deep learning techniques are able to surpass the constraints of conventional image processing methods, displaying outstanding performance and significantly enhancing object detection accuracy. With the advancement of hardware technology and deep learning theory, object detection has made significant strides over the last five years. Numerous exemplary deep convolutional networks, including RCNN, Fast-RCNN, Faster-RCNN, YOLOv1, YOLOv2, YOLOv3, and various variants, are proposed and confirmed on open datasets. These techniques use high-dimensional semantic attributes to represent objects.

In general, the majority of machine learning- and feature-based algorithms created by humans are extremely sensitive to complicated background interference. Additionally, the filming distance and angle typically reduce their performances. The majority of these techniques take a long time to complete and are not suitable for real-time applications. Since there aren't any insulator aerial picture datasets accessible from public sites, current deep learning techniques haven't been greatly improved. Most notably, none of the currently used machine learning, deep learning, or feature-based algorithms offer a systematic analysis that addresses the issue of insulator multi-fault detection. Therefore, it makes sense to provide a strategy that can address the issues with the current approaches.