Automated labeling method for direction detection of objects inside X-ray image

Jungi Lee, HyunYong Lee, Nac-Woo Kim, Yumin Hwang, and Seok-Kap Ko
Honam Research Center (HRC)
Electronics and Telecommunications Research Institute (ETRI)
Gwangju, Korea
{jungi, hyunyonglee, nwkim, yumin, softgear}@etri.re.kr

***Abstract*—To utilize image datasets for deep learning models, high-quality labeling data is required for good performance. In the case of acquiring a dataset, there are difficulties such as making an annotation by manpower. Many studies or software are provided to increase the convenience of such labeling. In this paper, YOLOX-based object detection, Canny edge detection, and Hough transformation-based linear component extraction techniques are applied to automatically label the position of a linear structure inside an X-ray image. To verify this method, actually acquired X-ray images of wind turbine blades were used in this experiment.**

Keywords—Data labeling, Object detection, Image classification, Canny edge detection, Hough transform

I. Introduction

As the utilization of deep learning-based image classification models is applied in various fields, building a high-quality dataset is important for learning a good artificial intelligence model. Numerous open datasets have already been released so that they can be used for training for image classification models, so various deep learning models are being developed using these datasets. Widely used datasets such as ImageNet [1] and COCO [2] have well-organized labeling for images to facilitate the training of classification models. Labeling of image datasets provides the coordinates of the bounding box where objects inside the image are located, or furthermore, provides segmentation information.

However, unlike these datasets, datasets for building deep learning models for special purposes must be used by methods such as building your own. In this paper, we propose an automated algorithm for object orientation labeling inside X-ray image data. The proposed method is an algorithm that can assist a human to perform labeling individually.

The reason for devising this task is to predict the shape of the internal structure through techniques such as X-ray when there is no information on the internal structure. Inside the blade for wind turbine operation, there is a lightning cable for preventing from damaged by lightning. However, these internal lightning cables may be destroyed or damaged due to factors such as lightning strikes or external shocks, and it is difficult to detect them with the exterior appearance. In order to solve this problem, in the previous study, after labeling the direction of the object inside the X-ray image in 8 directions, a study was conducted to predict the direction in which the structures are connected based on the deep learning model [3]. However, this research had a disadvantage in that the direction in which the objects were connected moved in the form of a two-dimensional lattice representing one of eight directions, rather than a direction subdivided into 360 degrees, resulting in lower accuracy. In order to improve this problem, we want to devise a method that can automatically calculate the position and angle of the lightning cable inside the X-ray image.

To verify this, a dataset of X-ray images of wind turbine blades acquired directly was constructed, and a YOLOX [4] model was used to extract only ROIs (region of interest) with objects from the dataset. And after extracting only edge information from the extracted ROI image by Canny edge detection [5], only linear components were extracted through Hough transformation [6] to acquire the direction of the lightning protection line inside the image. And the possibility of using the labeling based on the method was considered.

II. Dataset Information

The dataset used in this paper is X-ray image data taken to observe the inside of a specific object that cannot be observed from the outside, the X-ray images of blade of a wind turbine are taken. In order to understand the structure of a lightning cable inside a random wind turbine blade, it is necessary to take an X-ray image of the location where the lightning cable is located and stitch several x-ray images to estimate the shape of cable. In order to proceed with data labeling required to train a deep learning model that can perform these tasks, the direction in which the lightning cable inside the X-ray image is connected must be labeled. The difficulty with this problem is that the direction of the lightning cable inside the X-ray image is different, and it is difficult to distinguish the lightning cable from the other objects in the blade. Figure 1 below is an example of an actually acquired X-ray image. In the four pictures, a white lightning cable is observed, and a disconnection can be seen in the lightning cable in the lower right picture.

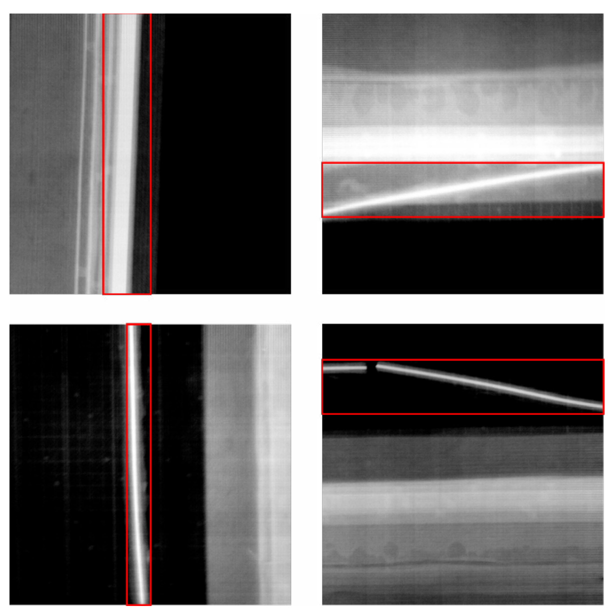

Fig. 1. Examples of X-ray image of wind turbine blade

To solve the problem of finding the where lightning cable is from the X-ray image, the coordinate of bounding box where the lightning cable is located was directly labeled in the X-ray image data by human, and a labeling database was built by extracting only the area with the lightning cable. Figure 2 below is an example of a dataset obtained by detecting only the part with lightning cables based on YOLOX based on actual X-ray image data and cropping it. The application of the direction detection algorithm proposed in this paper tests 1,461 cropped datasets so as not to be confused with other structures as much as possible.

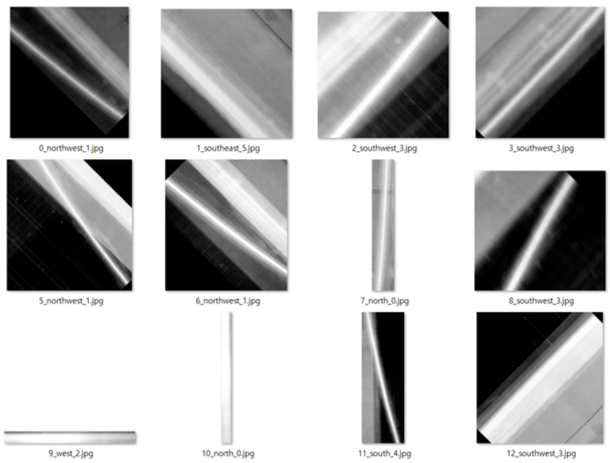

Fig. 2. Examples of cropped X-ray image of lightning cable

III. Algorithm for Labeling

In order to detect the direction of the cable in the X-ray image of the lightning cable, Canny edge detection is applied. By applying Canny edge detection to image, it is possible to extract prominent edge information from an X-ray image. After extracting edges from the image based on Kenny edge detection, Hough transform is applied to estimate the position of the lightning cable by extracting straight line components. Since almost lightning cables have straight shape, it can be helpful to find the cable in the image.

Figure 3 below shows an example of the whole experiment process. This is a figure of detecting a lightning cable based on YOLOX for arbitrary X-ray image data, cropping the corresponding range, and then detecting a straight line based on Canny edge detection and Hough transform.

In order to verify the validity of the proposed labeling method, the corresponding work was performed on 1,461 pieces of X-ray image data. Table 1 below is a table summarizing the experimental results. As a result, a straight line was obtained for 674 of the 1461 acquired data. And it was confirmed that 354 images of the straight line labeled data were accurately labeled. This enabled successful labeling of 24.2% of the total data.

TABLE I. Labeling Result of Proposed Method

Dataset	Unlabeled	Labeled		Total
		Successful	Failed	
X-ray Dataset of Wind blade	787	354	320	1,461

Figure 4 below is an example of the labeling result. The pictures on the left in the figure are examples of successful labeling, and you can see that a straight line is well marked in red where the lightning cable is located inside the image. On the other hand, the image on the right is an example of failing to find the lightning cable. Analyzing the cause of the failure, first of all, there is a point that the color of the lightning cable and the surroundings are not very different, or that the lightning cable and other structures have a similar shape, so all straight lines are labeled. In addition, there is a case where noise such as a line is generated in the image itself, and the noise is judged as a straight line.

Although the corresponding labeling method is not applied to all X-ray data, it is expected that it will be of great help to labeling if first automated labeling is performed and then only erroneous labeling is corrected. In addition, it is expected that the labeling success rate will be improved if used after improvement through various pre-processing of the image.

Figure 5 below is a flow chart representation of the labeling process. Before labeling X-ray images, we apply YOLOX-based lightning cable detection proposed in this paper, and proceed with labeling through Canny edge detection and Hough transform. And if people label only those with bad labeling results, the labeling process that requires a lot of labor can be reduced.

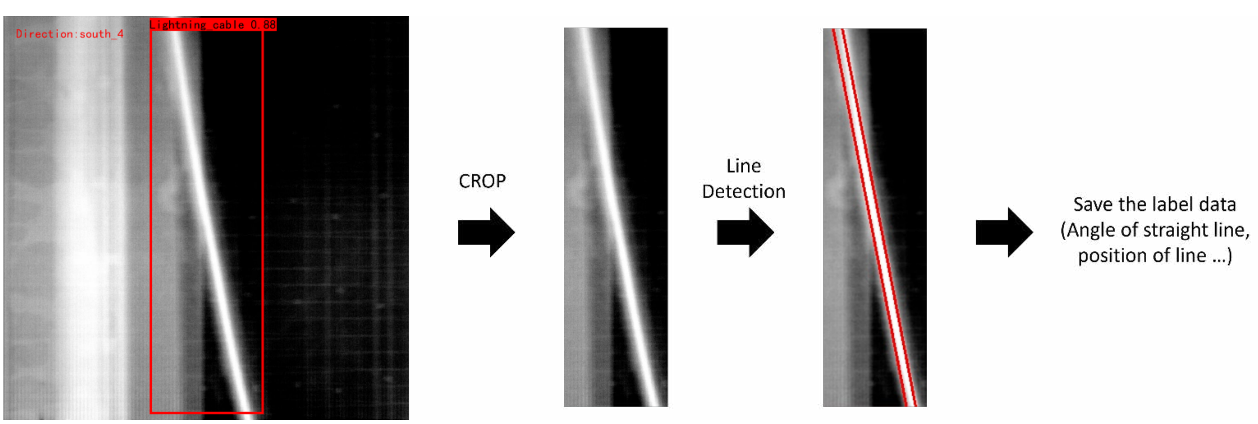

Fig. 3. Whole process of automated labeling method of X-ray image

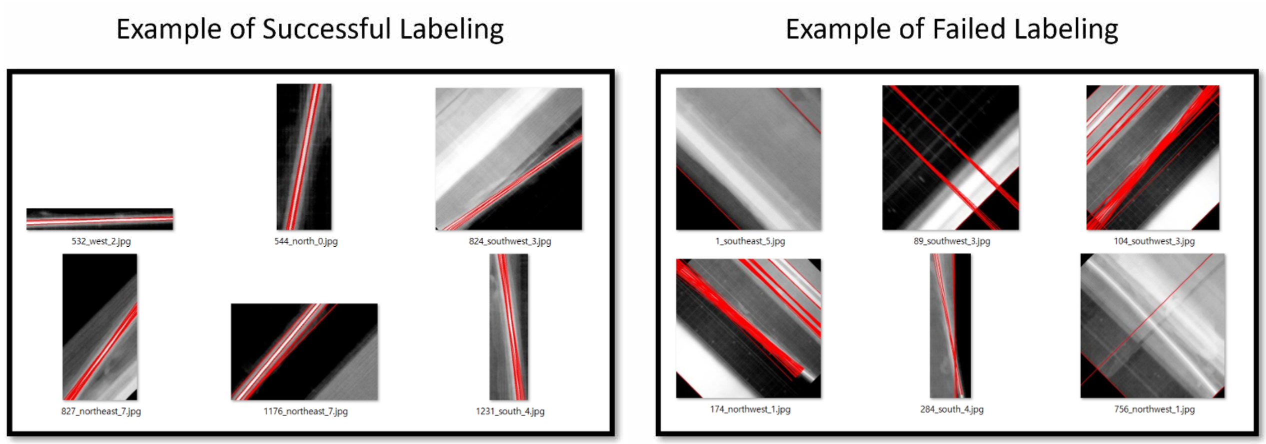

Fig. 4. Examples of labeled data; (Left) Successful, (Right) Failed labeling of X-ray image

In the future, if a sufficiently large number of labeling values are generated in this way, a deep learning-based labeling technique may be implemented through a technique such as image segmentation based on the corresponding labeling data.

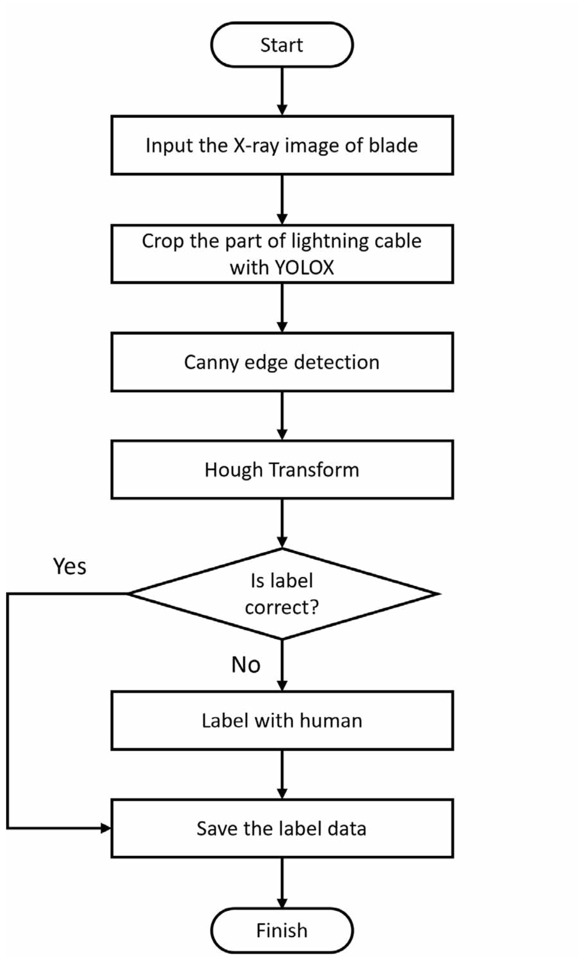

Fig. 5. Flow chart of suggested labeling method of X-ray image

IV. Conclusion

In this paper, it was confirmed that labeling can be performed for some images by using a labeling technique using Canny edge detection when labeling data of X-ray images does not exist. Through the labeling data obtained through this method, when inspecting the inside of a huge structure, it is possible to use it for efficient X-ray shooting by identifying the direction in which it is connected without taking X-ray images of unnecessary parts. In this way, it is expected to reduce the cost of data acquisition and labeling by dozens of percent, resulting in time and economic benefits.

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