Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

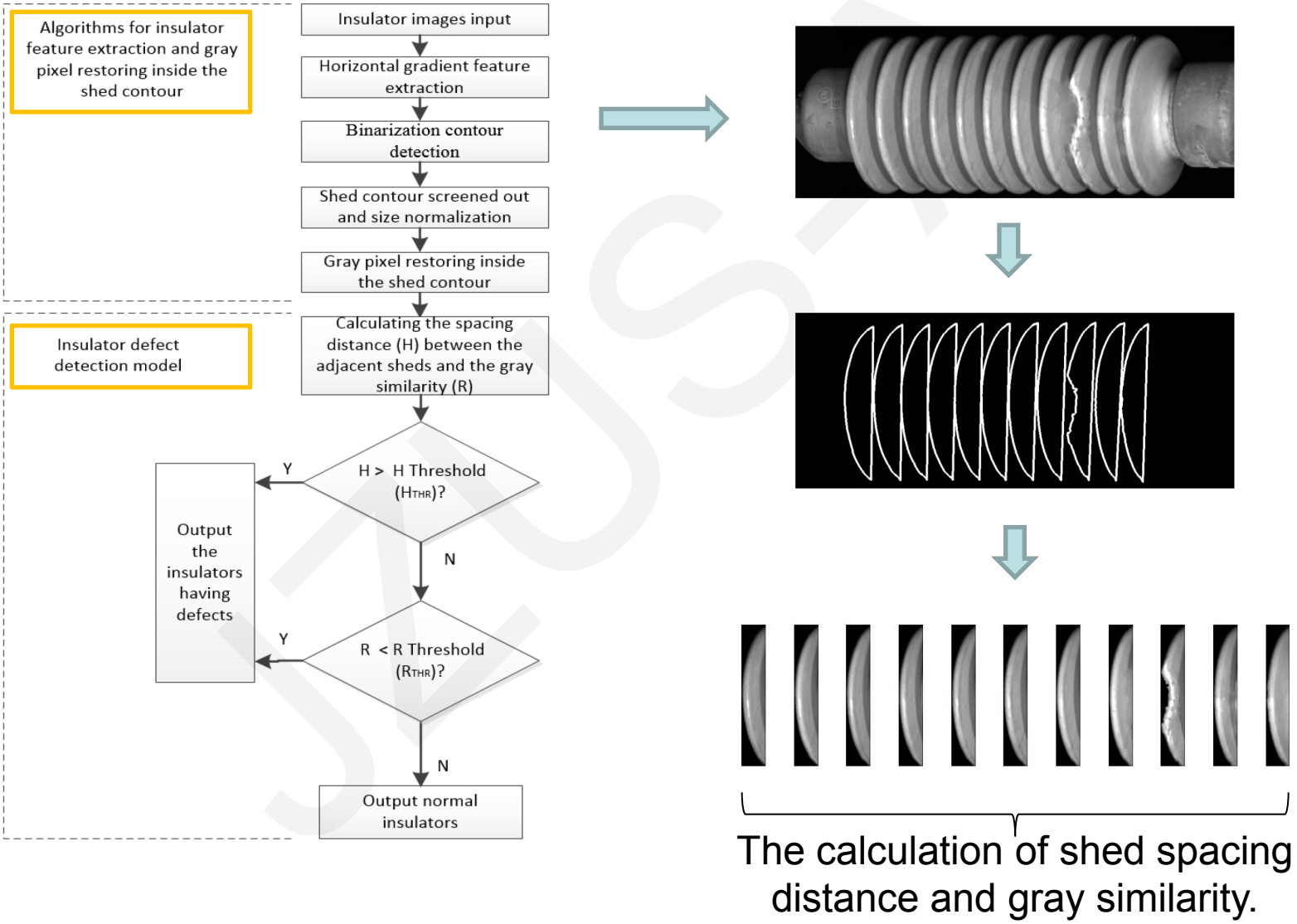
Catenary insulator defect detection based on contour features and gray similarity matching

Ping TAN, Xu-feng LI, Jin-mei XU, Ji-en MA, Fei-jie WANG,
Jin DING, You-tong FANG, Yong NING

Cite this as: Ping Tan, Xu-feng Li, Jin-mei Xu, Ji-en Ma , Fei-jie Wang, Jin Ding, You-tong Fang, Yong Ning, 2020. Catenary insulator defect detection based on contour features and gray similarity matching. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 21(1):64-73.
https://doi.org/10.1631/jzus.A1900341

The Overall Algorithm Model

Fig. 1. Overall model of insulator defect detection.



Insulator feature extraction and pixel restoration algorithm of sheds

- Gradient feature extraction
  - The effective detection method for insulator shed contour can be designed based on the insulator characteristic analysis result, combined with Sobel operator and binarization edge detection.
- Contour extraction of insulator sheds
  - The horizontal gradient feature map of the insulator is converted into a binary image.
  - Extract the contour information and unify the contour size of the sheds.
- Pixel restoration of insulator sheds

JZUSA

Insulator defect detection model

- Spacing distance calculation of insulator sheds
  - The spacing distance threshold is set, the shed defect can be detected by comparing with the spacing distance threshold.
- Similarity detection algorithm of insulator sheds
  - The gray-based matching algorithm is selected in this article (Normalized Cross Correlation (NCC) algorithm).

- Major innovations
  - Spacing distance and gray similarity comparison of adjacent insulator sheds
  - Improved contour extraction method

JZUSA

Experimental testing and analysis

Insulator shed contour extraction comparison:

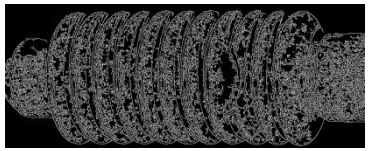


Fig. 2. Canny edge detection.

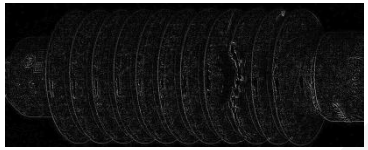


Fig. 3. Laplace edge detection.



Fig. 4. Sobel edge detection.

The contour information of each shed is accurately and effectively extracted.

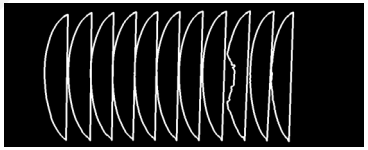
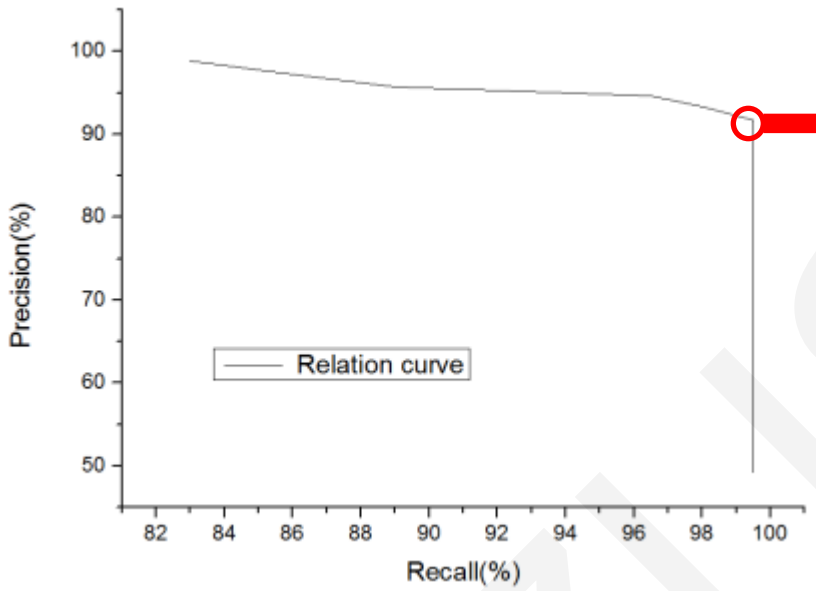


Fig. 5. This article edge detection.

Strong edge information of the shed edge can be obtained by Sobel. Therefor, this article extracts contours based on the improvement of Sobel.

Insulator defect detection model evaluation



The insulator defect detection model of this article has better performance. The point where the Recall and the Precision are superior is selected.

Fig. 6. The relationship curve between Recall and Precision.

Table 1 Insulator defect detection result

Image Item	The total number of insulator images	The number of defect images detected	The number of defect images correctly recognized	Recall (%)	Precision (%)	MR (%)	FR (%)
Insulator	400+200	217	199	99.5	91.71	0.5	4.5

Conclusions

- In this article, based on the structural features of the insulator, a detection model based on the contour and gray similarity of the shed is proposed. By accurately extracting the insulator shed contour features, the model separates the insulator sheds, and adopts the method of calculating the spacing distance and gray similarity of each shed. This can achieve the accurate detection of insulator defects with high reliability even when the insulator images consistency is poor. It provides a reliable and accurate solution for defect detection of high speed railway catenary insulators.

Published articles

- Ping TAN, Xu-feng LI, et al. Multialgorithm Fusion Image Processing for High Speed Railway Dropper Failure-Defect Detection [J]. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 2019: 1-13. http://dx.doi.org/10.1109/TSMC.2019.2938684
- Ping TAN, Ji-en MA, et al. Sustainability Development Strategy of China's High Speed Rail [J]. Journal of Zhejiang University-SCIENCE A, 17(12): 923-932. http://dx.doi.org/10.1631/jzus.A1600747