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A Method for Calculating the Normal Direction Width of Cracks Based on Machine Vision

XIONG Shaohui [a], AN Ran [b], GONG Yuanhao [a]

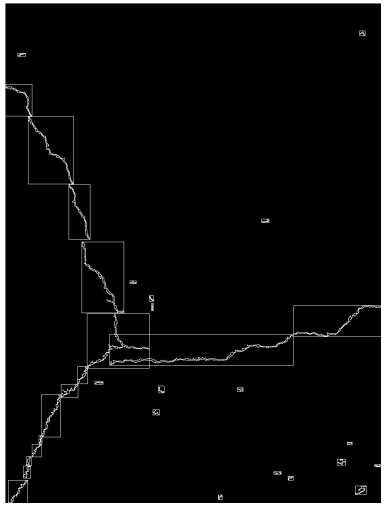
[a] State Key Laboratory of Bridge Safety and Resilience of China Merchants Chongqing Communications Research and Design Institute Co., Ltd., Nan'an District, Chongqing, China

b Cloud-based Intelligent Engineering Co., Ltd., Shenzhen, Guangdong, China

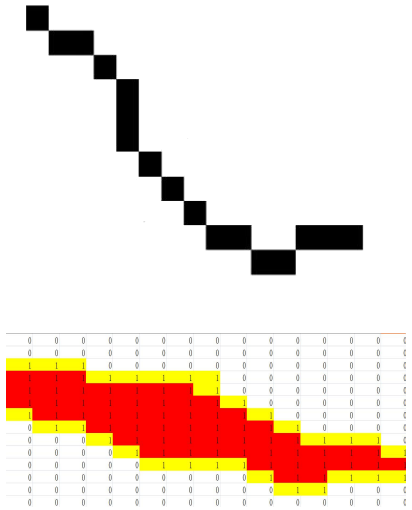
*Corresponding author's email: xiongshaohui@cmhk.cn

Introduction

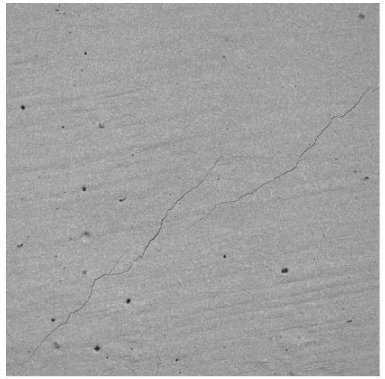
- At present, there are three main types of calculation methods for crack width:(1) "Grid Counting" Algorithm ;(2) Average Width Method;(3)Approximate Normal Method . But the calculation accuracy of these three methods is relatively low.

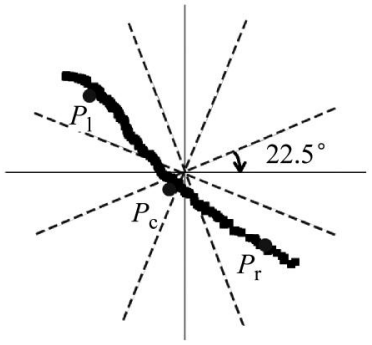


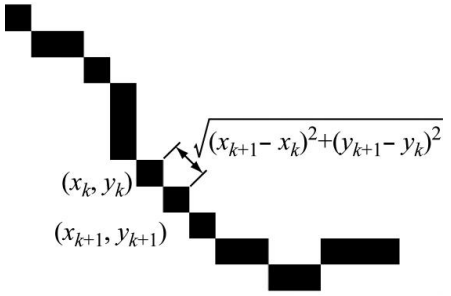
The binary crack image uses the minimum external rectangle to surround the connected domain

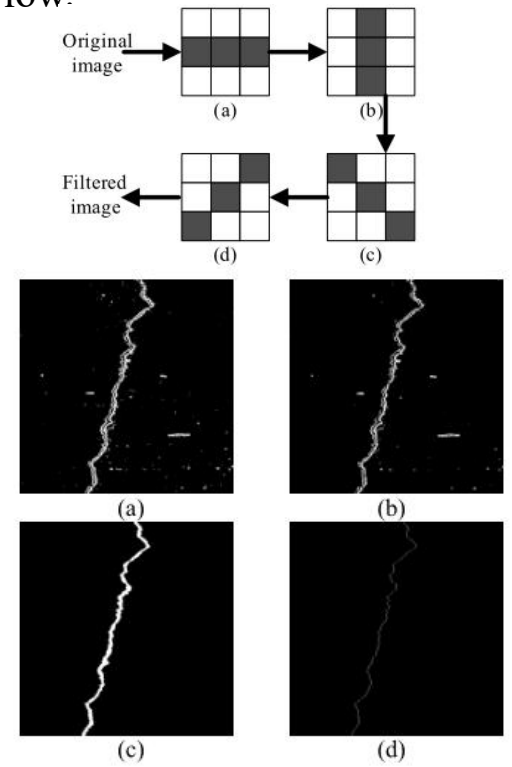


Fracture binary image corrosion schematic









Research objectives

- An innovative method for extracting single pixel width crack skeleton curve under the frame of coordinate system is developed.
- Ensure the continuity and integrity of the crack skeleton curve.

Methods

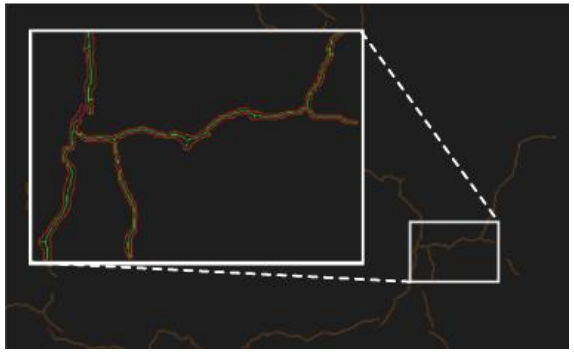
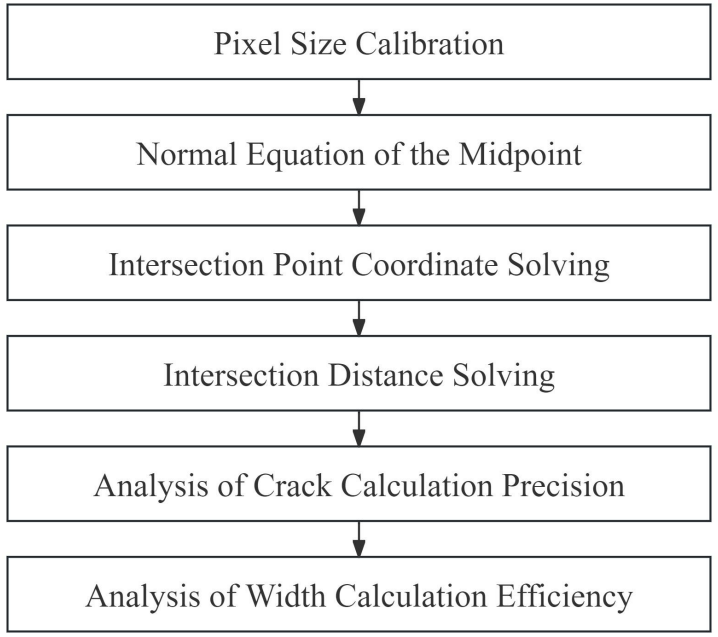


Figure 1. Key information of cracks

The resulting key information extracted is presented in Figure 1, where the red region signifies the crack edge curve, and the green region represents the crack skeleton curve.

Crack Width Calculation in the Normal Direction



$$\eta = \frac{B}{f}\sqrt{\frac{S_c}{R_I}}$$

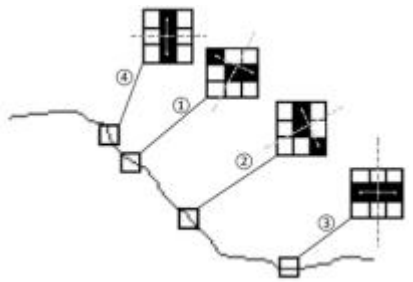


Figure 2. Schematic diagram of the crack trend

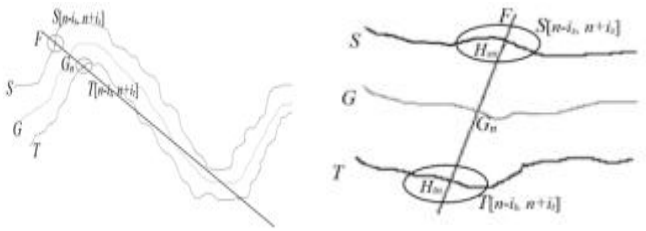


Figure 3-4. Schematic diagram of the crack trend

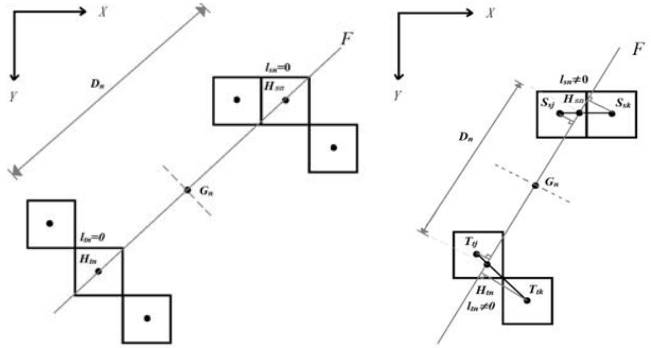


Figure 5. Schematic diagram of crack calculation

$$D_n = \sqrt{(y_{tn} - y_{sn})^2 + (x_{tn} - x_{sn})^2}$$

Pixel Size Calibration

The normal equation at the midpoint of the curve was derived by employing a three-point interpolation technique to fit the skeletal curve function.

By solving the corresponding equation of the fracture curve, the coordinates of the intersection points of the upper and lower edges of the fracture are determined.

As depicted in Figures 5 and 6, the intersection of the upper edge curve of the cracks with the normal line is computed for two distinct cases, both labeled as Case Hsn(xsn,ysn).

Intersection Distance Solving

Analysis

The actual measured values and calculated values of the maximum crack width were subjected to normality testing using both the Kolmogorov-Smirnov and Shapiro-Wilk methods, with the results detailed in Table 1.

Table 1. Test for data normality

Category	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	Degrees	Significance	Statistic	Degrees	Significance
Calculated Width Value	0.052	100	0.200	0.981	100	0.161
Measured Width Value	0.057	100	0.200	0.979	100	0.108

Some differences may cause changes in the results and may affect the accuracy of the test data, as shown in Figure 9.

As observed in Figure 10, the average return time is 9.468481s out of 100 crack image calculations.

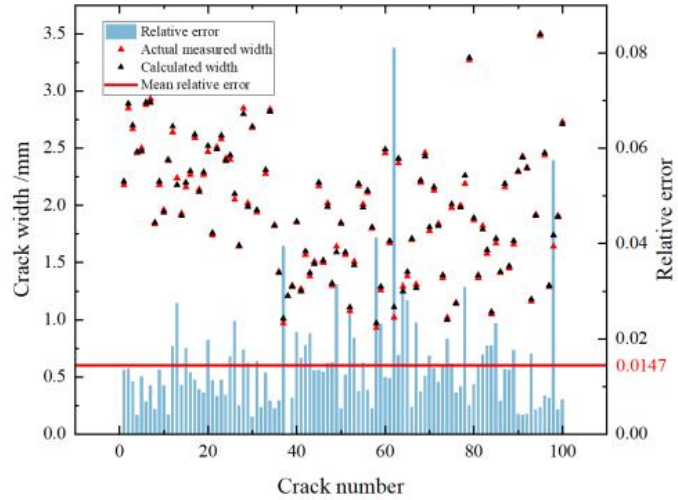


Figure 7. Comparison between the calculated maximum width of the crack and the measured value

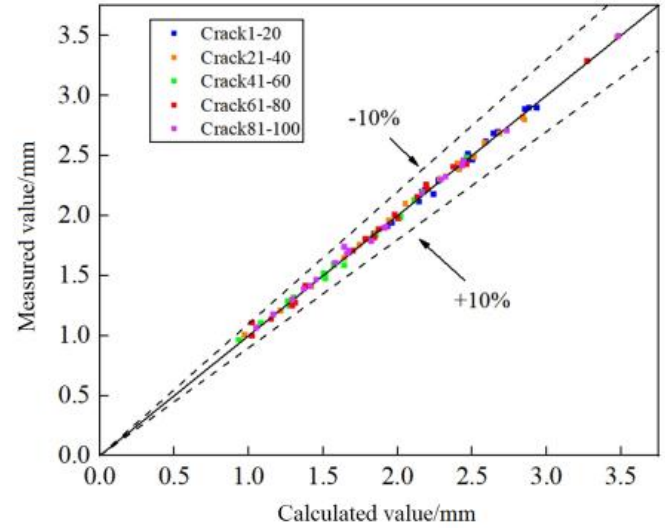


Figure 8. Analysis of the error between the calculated maximum width of the crack and the measured value

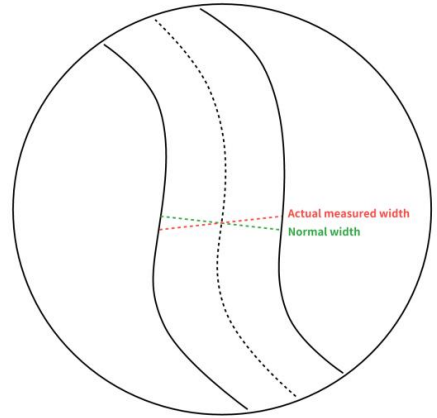


Figure 9. Schematic diagram

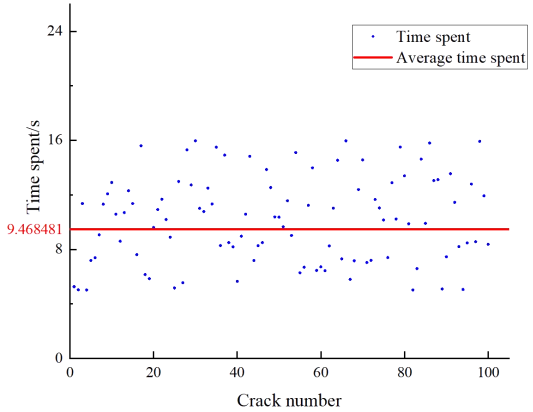


Figure 10. Returns the time statistics

Conclusions

- This article models crack skeleton curves using a three-point interpolation, deriving the legal line equation. The algorithm finds closest points to crack edges, calculates fracture width, and systematically identifies max crack width. The approach enhances accuracy and efficiency through purely mathematical methods, avoiding simplifications.
- The research offers practical value for intelligent crack identification, addressing interpolation function challenges. Its approach achieves high computational accuracy, setting a benchmark for future work in this field.

References

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