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Mosaic method for bridge surface imaging based on image correction and path optimization

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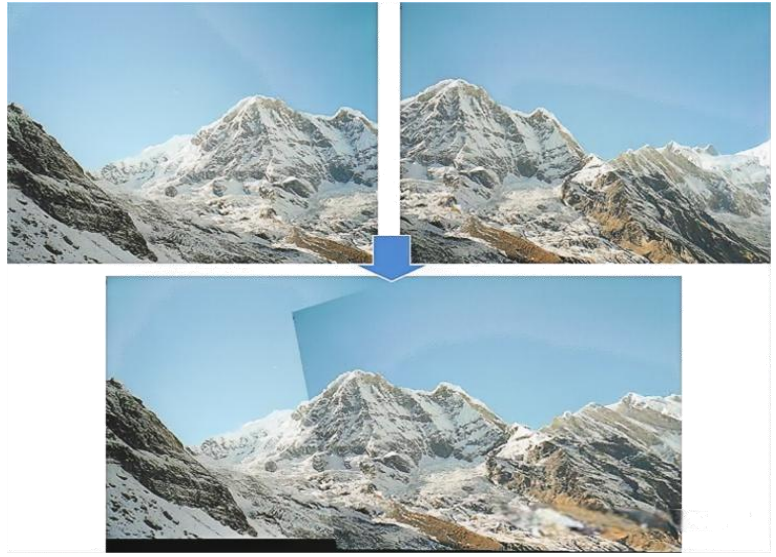
Introduction

- This study introduces an innovative bridge surface image stitching approach integrating image rectification with optimized shooting path planning, addressing challenges in capturing and fusing large-scale bridge images for accurate and efficient defect identification in bridge maintenance and inspection.



Research objectives

- Aiming at the challenges encountered in large-scale bridge image stitching, a new efficient and robust image stitching technology is developed to improve the image alignment accuracy and improve the accuracy and efficiency of subsequent bridge disease identification.
- A bridge surface image splicing method based on image correction and path optimization is proposed to meet the special needs of bridge maintenance inspection.

Methods

Image Rectification Method Based on Camera Pose Variation

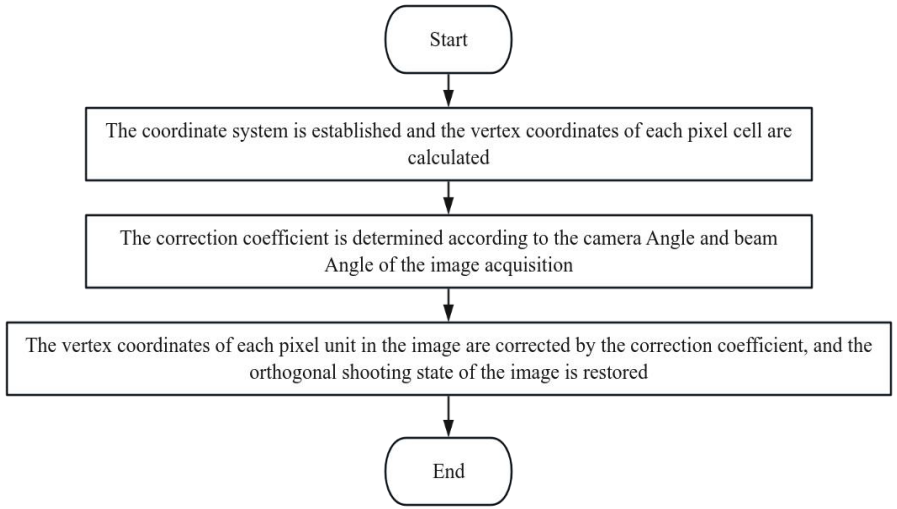


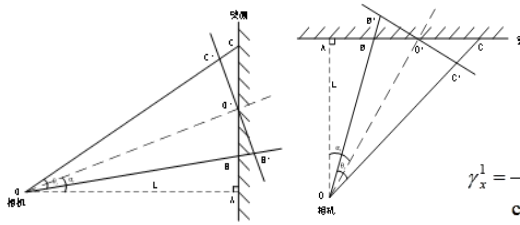
Figure 1. Flowchart of Image Correction Method Based on Camera Pose Changes

During bridge inspection using drones, maintaining a consistent orthogonal camera position is challenging, causing deviations in X and Y axes. Captured images thus require rectification to restore orthogonality. This involves establishing an image coordinate system, calculating pixel vertex coordinates based on shooting distance and camera specs, then determining rectification coefficients from shooting and view angles to correct the images.

Methods

Image Rectification Method Based on Camera Pose Variation

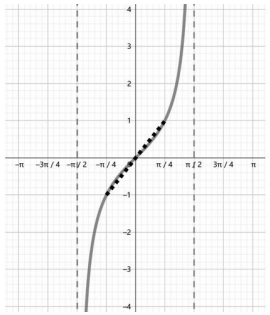
1



Calculation of Correction Coefficients

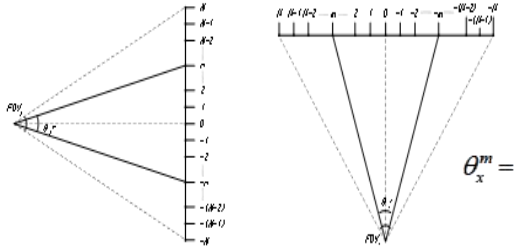
$$\gamma_x^1 = \frac{tg\frac{\theta_x}{2}}{\cos\alpha_x\left[tg\alpha_x - tg\left(\alpha_x - \frac{\theta_x}{2}\right)\right]};\quad \gamma_x^2 = \frac{tg\frac{\theta_x}{2}}{\cos\alpha_x\left[tg\left(\alpha_x + \frac{\theta_x}{2}\right) - tg\alpha_x\right]};$$

2



Schematic Diagram of Linearization Processing of Tangent Curve

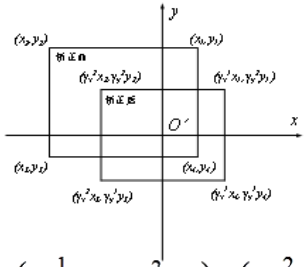
3



Determination of Beam Perspective

$$\theta_x^m = \frac{m \cdot FOV_x}{M},\quad \theta_y^n = \frac{n \cdot FOV_y}{N},\quad n = -N, \cdots, -1, 1, \cdots, N$$

4

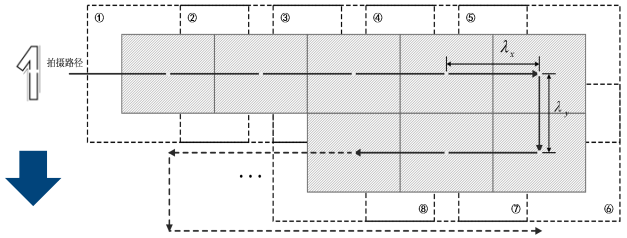


Schematic Diagram of Non-Orthogonal Image Correction

$(\gamma_x^1 x_1, \gamma_y^2 y_1)$, $(\gamma_x^2 x_2, \gamma_y^2 y_2)$, $(\gamma_x^2 x_3, \gamma_y^1 y_3)$, and $(\gamma_x^1 x_4, \gamma_y^1 y_4)$

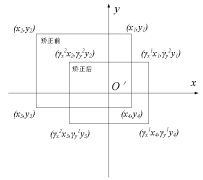
Stitching method based on shooting path optimization

1



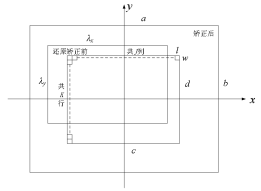
Determine the shooting Angle, shooting distance, cropping ratio, camera parame ters to calculate the shooting step

2



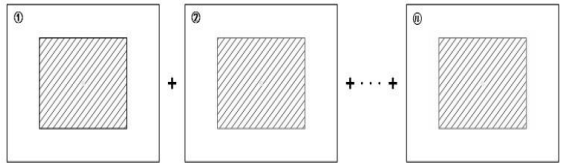
Set the shooting path and number the p hotos taken on the spot in combination with the shooting step

3



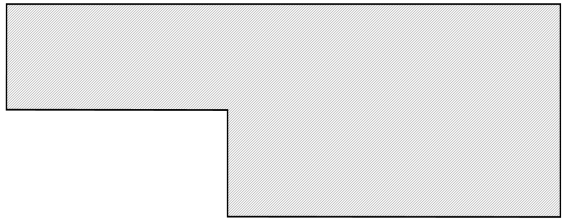
The correction parameters were calculat ed and corrected according to the photo number

4



Crop the corrected photos one by one u sing the photo number according to the cropping ratio

5



Set the shooting path and number the p hotos taken on the spot in combination with the shooting step

Test verification

Figure 10. Image Stitching Image Data Collection

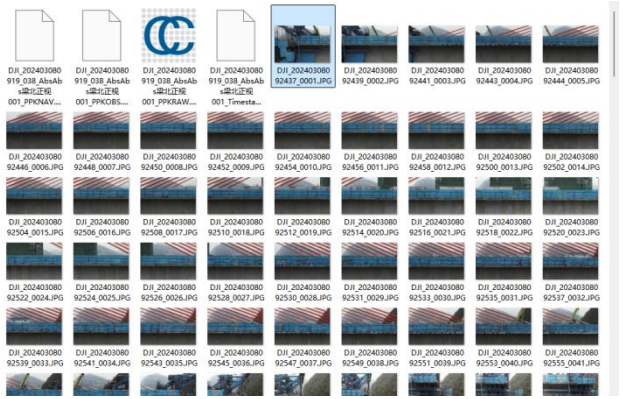


Figure 11. Image Stitching Image Data Collection

In order to verify the effectiveness of the image correction and image stitching techniques proposed in this paper, an experiment was carried out on the Mozhai Wujiang Bridge on the Yuxiang double line.

Figure 12. Full Image Stitching of the Main Beam of Mozhai Wujiang Grand Bridge

Figure 13. Detailed Image of the Main Beam of Mozhai Wujiang Grand Bridge

Figure 14. Splicing Diagram of the Main Beam of Mozhai Wujiang Super Major Bridge

For large-scale bridge splicing, the ability of traditional methods is quite limited, which greatly hinders our comprehensive understanding of the overall condition of the bridge.

Conclusions

- Aiming at the complexity and challenge of large-scale image stitching in bridge detection, an efficient and feature-free image stitching is realized by combining image correction with path optimization.
- The experimental results show that this method can generate a complete and high-quality bridge surface image, improve the efficiency and accuracy of image stitching significantly, and effectively overcome the problem of image distortion and discontinuity.
- The method in this study significantly reduces the consumption of computing resources, reduces manual intervention, and ensures the accuracy and reliability of the stitching results.

References

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[3]Huang Haixin, Wang Zheng, Cheng Shoushan, et al. Optimal Design of the Body Structure of a Negative Pressure Adsorption Wall-Climbing Robot for Bridge Inspection [J]. Journal of South China University of Technology (Natural Science Edition), 2023, 51(12): 21-33.