Automated defect detection algorithm applied to shearography in composites

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Shearography for observing defects in composite materials

- Established technique for the detection of defects in composite materials
- Cheap, relatively robust and flexible, but requires special qualification to interprete the interference pattern

Figure 1: phase difference image

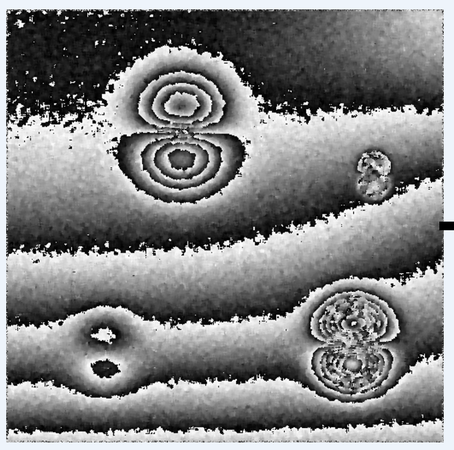
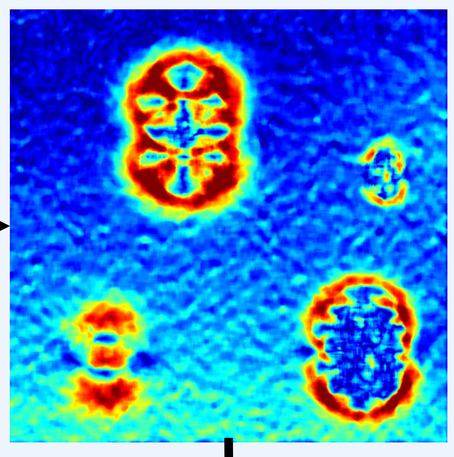


Figure 2: global gradient image



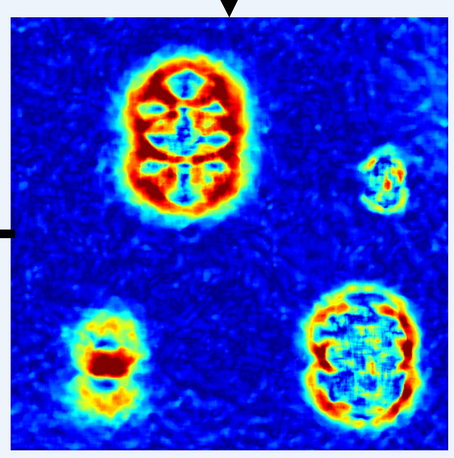


Figure 3: local gradient image

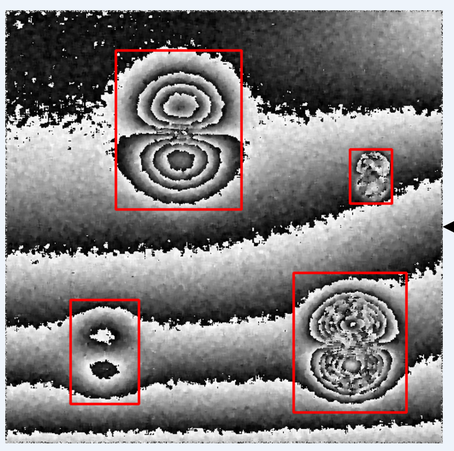


Figure 4: defects detected in the phase image

Automatically identify defects with shearography by the development of specific algorithms

— Detection of high local fringe densities

— Fringe density is correlated to phase difference slope
(i.e. the gradient of the phase difference)

Method implemented

— Computation of the gradient from the phase image
(fig. 1 & 2)

— Polynomial fit to remove global gradient and only observe local features
(fig. 2 & 3)

— Detection of the defects based on the value of the local gradient above a threshold
(fig. 3 & 4)

Improvements of the above method

× Material with structures can show local fringe density which are not defects. They are generally smaller in size than defects.

× Noise inherent to the speckle interferometry technique can also induce false positives, which are generally small. This noise can also make defects to be split in several smaller neighbor areas.

— To avoid these false positive, the method can be improved by setting a minimal size below which defects detected are rejected.

— To recompose the divided defects, the detected zone in contact or close vicinity are merged to recreate the real defect dimension.

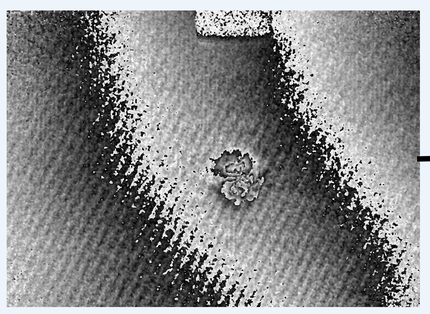


Figure 5: phase difference image

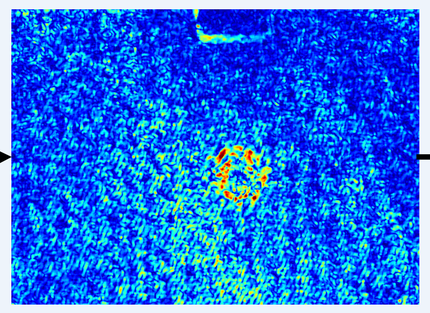


Figure 6: gradient image

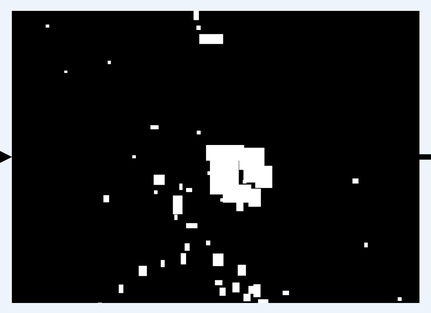


Figure 7: preliminary detection

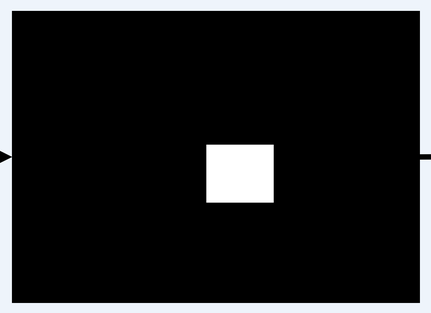


Figure 8: defects selected and merged

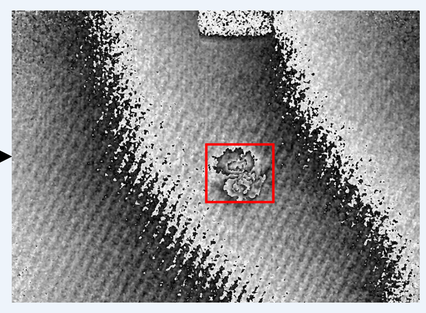
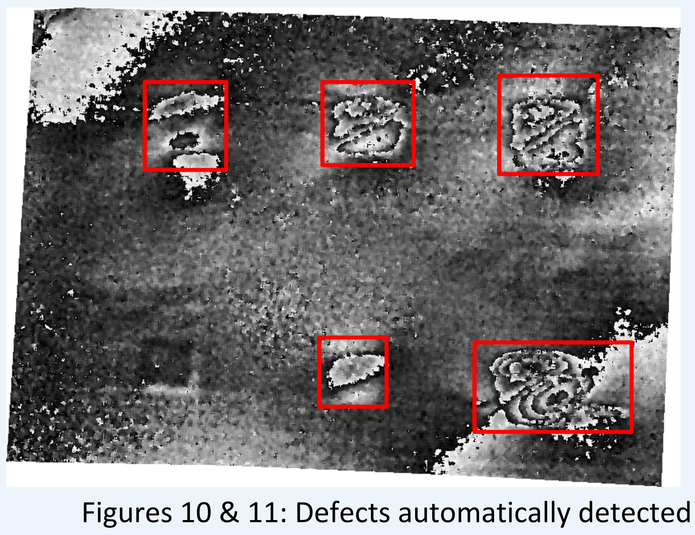
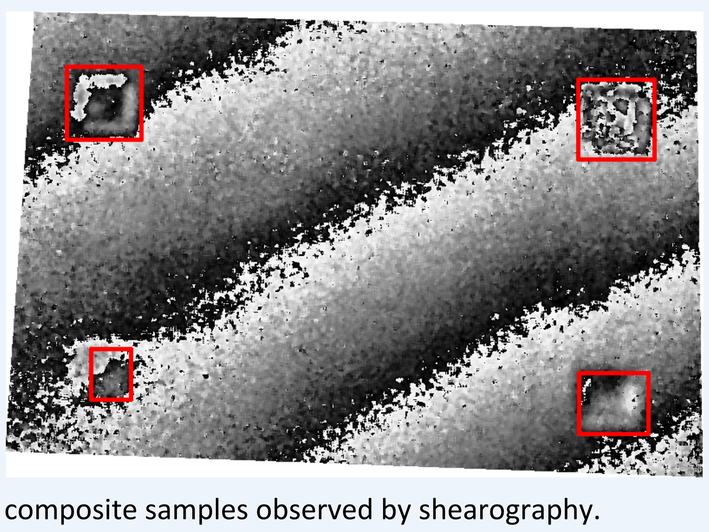


Figure 9: final output

Observation of representative samples in field conditions





Figures 10 & 11: Defects automatically detected on composite samples observed by shearography.

References

[1] Steinchen, W (2003) Digital Shearography: Theory and Application of Digital Speckle Pattern Shearing, SPIE-International Society for Optical Engineers

[2] Kalms, M, Osten, W(2003) Mobile shearography system for the inspection of aircraft and automotive components, Optical Engineering 42, 1188–1196

[3] Fantin, A, Willemann, D, Viotti, M, Albertazzi, A (2013) A computational tool to highkight anomalies on shearographic images in optical flaw detection, Proc. SPIE 8788, 8788-20

Acknowledgements

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