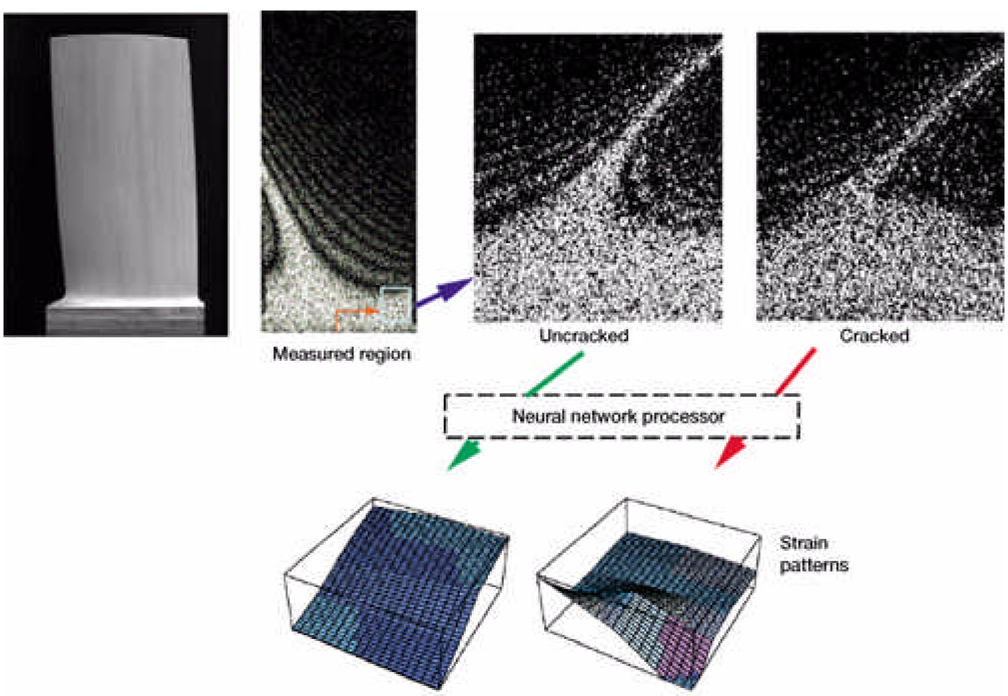
# Neural Networks Used to Compare Designed and Measured Time-Average Patterns

Electronic time-average holograms are convenient for comparing the measured vibration modes of fan blades with those calculated by finite-element models. At the NASA Lewis Research Center, neural networks recently were trained to perform what had been a simple visual comparison of the predictions of the design models with the measurements. Finite-element models were used to train neural networks to recognize damage and strain information encoded in subtle changes in the time-average patterns of cantilevers. But the design-grade finite element models were unable to train the neural networks to detect damage in complex blade shapes. The design-model-generated patterns simply did not agree well enough with the measured patterns. Instead, hybrid-training records, with measured time-average patterns as the input and model-generated strain information as the output, were used to effect successful training. One inspection process is outlined in the figure.




*Performance of a measured-input, model-output neural network*

A twisted blade appears at the top left. The full time-average or characteristic pattern of the first vibration mode is shown next. The third and fourth pictures at the top show measured-region time-average patterns for undamaged and cracked blades, where a crack was induced by high-cycle fatigue. These patterns were sampled on a nonuniform finite-element-model grid (not shown). The neural networks processed the samples as often as

30 times/sec. The outputs of the neural networks, in this case, were chordwise strains.

Three kinds of neural-net training have been implemented with software. These are listed in increasing order of effectiveness.

1. Neural networks can be model trained with model-generated time-average patterns and model-generated strain patterns. The effectiveness of this technique depends strongly on the accuracy of the models.

2. Neural networks can be trained with measured time-average patterns and model-generated strain patterns.

3. Neural networks can be trained very effectively to categorize measured time-average patterns. Categories can consist of damaged and undamaged fan blades, for example.

We plan to expand this work in the future from nonrotating to rotating fan blades.

# Bibliography

Decker, A.J., et al.: Comparison of Computational-Model and Experimental-Example Trained Neural Networks for Processing Speckled Fringe Patterns. NASA TM-1998-208814 (also International Conference on Optical Technology and Image Processing in Fluid, Thermal, and Combustion Flow, Proceedings of VSJ-SPIE98, Yokohama, Japan, Dec. 6-10, 1998, CD ROM format only), 1998.

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