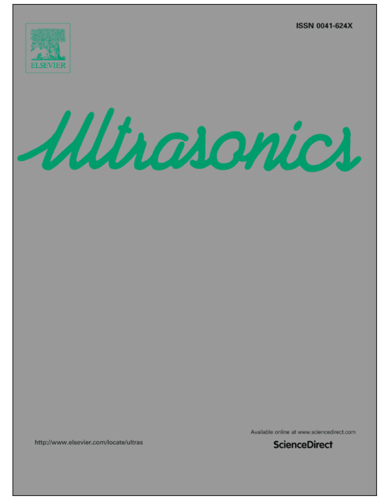
Accepted Manuscript



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PII: S0041-624X(17)30102-6
DOI: http://dx.doi.org/10.1016/j.ultras.2017.06.021
Reference: ULTRAS 5570

To appear in: *Ultrasonics*

Received Date: 3 February 2017
Revised Date: 8 June 2017
Accepted Date: 29 June 2017

Please cite this article as: Y. Yang, L. Xiao, W. Qu, Y. Lu, Passive Detection and Localization of Fatigue Cracking in Aluminum Plates Using Green's Function Reconstruction from Ambient Noise, *Ultrasonics* (2017), doi: http://dx.doi.org/10.1016/j.ultras.2017.06.021

Passive Detection and Localization of Fatigue Cracking in Aluminum Plates Using Green's Function Reconstruction from Ambient Noise

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Abstract: Recent theoretical and experimental studies have demonstrated that a local Green's function can be retrieved from the cross-correlation of ambient noise field. This technique can be used to detect fatigue cracking in metallic structures, owing to the fact that the presence of crack can lead to a change in Green's function. This paper presents a method of structural fatigue cracking characterization method by measuring Green's function reconstruction from noise excitation and verifies the feasibility of crack detection in poor noise source distribution. Fatigue cracks usually generate nonlinear effects, in which different wave amplitudes and frequency compositions can cause different nonlinear responses. This study also undertakes analysis of the capacity of the proposed approach to identify fatigue cracking under different noise amplitudes and frequency ranges. Experimental investigations of an aluminum plate are conducted to assess the cross-correlations of received noise between sensor pairs and finally to detect the introduced fatigue crack. A damage index is proposed according to the variation between cross-correlations obtained from the pristine crack closed state and the crack opening-closure state when sufficient noise amplitude is used to generate nonlinearity. A probability distribution map of damage is calculated based on damage indices. The fatigue crack introduced in the aluminum plate is successfully identified and oriented, verifying that a fatigue crack can be detected by reconstructing Green's functions from an imperfect diffuse field in which ambient noise sources exist locally.

Key words: fatigue crack; cross-correlation; Green's function reconstruction; PZT; damage image; ambient noise

1. Introduction

Plate-like metallic structures are widely used in aerospace structures such as fuselages and wings. Fatigue cracking is one of the main forms of failure in metallic structures. Under cyclic loading, fatigue cracks inevitably generate and propagate due to the decrease in structural strength. To prevent hazardous accidents caused by crack expansion, it is necessary to detect, assess, and locate such crack initiation and then promptly take necessary remedial measures.

Classical techniques for structural diagnostic purposes rely mainly on pitch-catch measurements of direct guided waves between an actuator and a receiver in the region to be measured. In traditional nondestructive testing of metallic structures, damage is usually identified by linear changes in the excitation signal and response signal, such as amplitude variation and phase shift [1]. Recently, fatigue cracking identification in plate-like metallic structures has mainly used nonlinear ultrasonic methods based on

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