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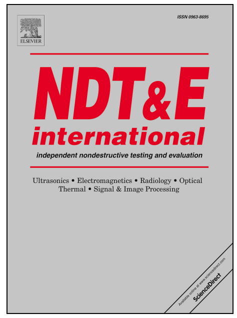

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Wonjae Choi, Fan Shi, Michael J.S. Lowe, Elizabeth A. Skelton, Richard V. Craster, William L. Daniels

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Rough surface reconstruction of real surfaces for numerical simulations of ultrasonic wave scattering

Wonjae Choi[a,*], Fan Shi[b], Michael J.S. Lowe[b], Elizabeth A. Skelton[c], Richard V. Craster[c], William L. Daniels[d]

[a] *Center for Safety Measurement, Korea Research Institute of Standard and Science, Republic of Korea*

[b] *Department of Mechanical Engineering, Imperial College London, U.K.*

[c] *Department of Mathematics, Imperial College London, U.K.*

[d] *Wood plc., U.K.*

Abstract

The scattering of waves by rough surfaces plays a significant role in many fields of physical sciences including ultrasonics where failure surfaces are often rough and their accurate identification is critical. The prediction of the strength of scattering can be hampered when the roughness is not adequately characterised and this is a particular issue when the surface roughness is within an order of the incident wavelength. Here we develop a methodology to reconstruct, and accurately represent, rough surfaces using an AutoRegressive (AR) process that then allows for rapid numerical simulations of ultrasonic wave rough surface scattering in three dimensions. Gaussian, exponential and AR surfaces are reconstructed based on real surface data and the statistics of the surfaces are compared with each other. The statistics from the AR surfaces agree well with those from actual rough surfaces, taken from experimental samples, in terms of the heights as well as the gradients, which are the two main factors in accurately predicting the wave scattering intensities. Ultrasonic rough surface scattering is simulated numerically using the Kirchhoff approximation, and comparisons with Gaussian, exponential, AR and real sample surfaces are performed; scattering intensities found using AR surfaces show the best agreement with the real sample surfaces.

Keywords:
Ultrasonic wave scattering, Rough surface, Surface reconstruction, Numerical simulation

1. Introduction

Rough surface scattering is important across a broad spectrum of research fields in the physical sciences including optics, electromagnetism, and acoustics, and thus considerable research effort has been devoted to it [1, 2, 3]. The scattered field naturally depends on the incident wave, the medium and the scatterer; typically for smooth planar scatterers the scattering energy is concentrated at the specular angle, however roughness can often have a profound effect with the directivity of the scattered signal spreading to other angles. Roughness is often regarded as decreasing the energy available from the incident waves, since it decreases the reflected, i.e. measured, signal at the specular angle, although conversely the signal increases at other angles;