

Multiresolution Analysis of Rough Engineering / Tribological Surfaces

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1. Introduction

Multiresolution analysis (MRA) is a powerful mathematical tool based on wavelets leading to a quantitative and hence unambiguous model of tribological / engineering surfaces in terms of their roughness, waviness and profile (shape). Loosely speaking "wavelets are building blocks that can quickly decorrelate data". [1] More precisely, wavelets in general form a frame (basis) for most of the function spaces and therefore are used to expand (represent) functions in these spaces.

2. Computational framework

In particular, the lifting scheme, [2]

$$\left\{ \begin{array}{l} \{\lambda_j, \gamma_j\} := \text{Split}(\lambda_{j+1}) \\ \gamma_j - = \mathcal{P}(\lambda_j) \\ \lambda_j + = \mathcal{U}(\gamma_j) \end{array} \right. ,$$

i.e. , the second generation of wavelets, among other advantages allows one also to design wavelets closely related to the investigated data set $\{\lambda_n\}$ and hence to optimize both the analysis and reconstruction by just introducing a suitable prediction \mathcal{P} and update \mathcal{U} . Here $j = n-1, n-2, \dots, 0$ denotes the level of forward wavelet transform.

Having obtained all sets of $\{\lambda_j, \gamma_j\}$ for all higher levels than a given one $j = 0, 1, \dots, n-1$ a reconstruction and / or a decomposition of the original data, in fact, immediately follows by properly performing the inverse transform:

$$\left\{ \begin{array}{l} \lambda_j - = \mathcal{U}(\gamma_j) \\ \gamma_j + = \mathcal{P}(\lambda_j) \\ \lambda_{j+1} := \text{Join}(\lambda_j, \gamma_j) \end{array} \right. .$$

3. Results and discussions

In the present contribution, these features are vastly exploited to properly determine the roughness,

waviness and profile of, e.g., tribologically stressed surfaces. As it can be seen in Figs. 1 and 2 this decomposition properly works already when one uses cubic B-splines to analyze the surface of a standard HFRR-tested steel ball. In the right panel of Fig. 2, for example, one clearly observes different roughness on and besides of the wear scar. Furthermore the left panel of the same figure shows that similar feature holds for the waviness too.

Besides of further illustrative examples proving in details the usefulness of MRA in different tribological situations, the problem of directional (in)dependence of the MRA will be also addressed.

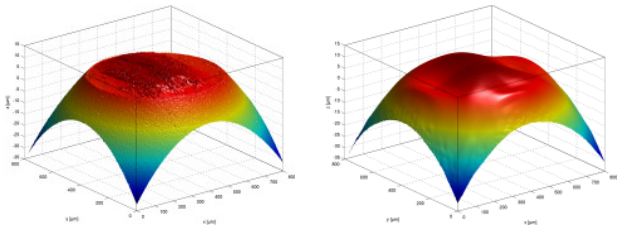


Fig. 1 Experimentally determined surface (left) of a steel ball after a standard HFRR-test and its calculated profile (right).

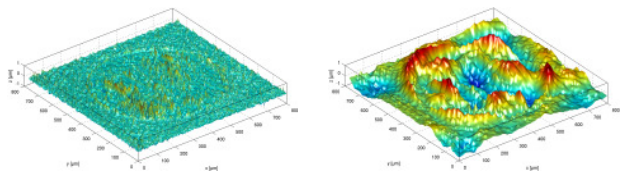


Fig. 2 Calculated roughness (left) and waviness (right) in the case of the steel ball from Fig. 1.

4. References

- [1] Sweldens, W., "The Lifting Scheme: A New Philosophy in Biorthogonal Wavelet Constructions", Proc. SPIE 2569, 1995, 68.
- [2] Sweldens, W., "Wavelets and the Lifting Scheme", Z. Angew. Math. Mech. 76, 1996, 41.