HIGH-RESOLUTION FDOCT FROM LOW-RESOLUTION ACQUISITION

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1. Introduction: Frequency-domain optical coherence tomography (FDOCT) is an important tool to efficiently and accurately characterize thin multilayered structures such as the layers of photocells and foils. As the resolution of the tomogram is directly proportional to the spectral width of the probing light source, to resolve thin layers, a broadband light source is required. Light sources for OCT, in general, get increasingly expensive with increasing bandwidth. In this work, we propose a signal processing solution to improve the resolution by using an inexpensive light source.

2. Problem Formulation: For a L-layered specimen the normalized spectrogram measurements in wavenumber domain are written as $I(k)/|A_0(k)|^2 = \left|1 + \sum_{\ell=1}^{L} a_\ell \, e^{\mathrm{j}\,2\,\pi\, b_\ell\, k}\right|^2$, $k \in \mathbb{N}$. In this model, $A_0(k)$ is a known power-spectrum of the light source; a_ℓ is the reflection coefficient and b_ℓ accounts for the optical path length of the ℓ^{th} layer from the reference plane. In case of a narrowband spectrum, the division of $I(k)$ by the source magnitude spectrum $|A_0(k)|^2$ results in enhancement of noise due to small values of $|A_0(k)|^2$. To control noise boosting, we propose to consider samples $\frac{I(k)}{|A_0(k)|^2}$ for the spectral indices for which $|A_0(k)|^2$ is relatively large, which correspond to the effective bandwidth and high signal-to-noise ratio regions of the light source. The resolution achieved by the conventional Fourier method is reduced, whereas, by applying high-resolution method such as estimation of signal parameter by rotational invariance technique (ESPRIT) [2] one could achieve high-resolution reconstruction from low-resolution data.

3. Results: To validate the proposed technique, we consider multilayer foil specimen which is used in the food packaging industry. The figure below shows the reconstruction of high-resolution tomogram from low-resolution data measured from a narrowband light source. The reconstruction from low-resolution data is comparable to that achieved by high-resolution data measured using a broadband light source. Moreover, by using ESPRIT, a high-resolution tomogram is reconstructed compared with the Fourier-based reconstruction.

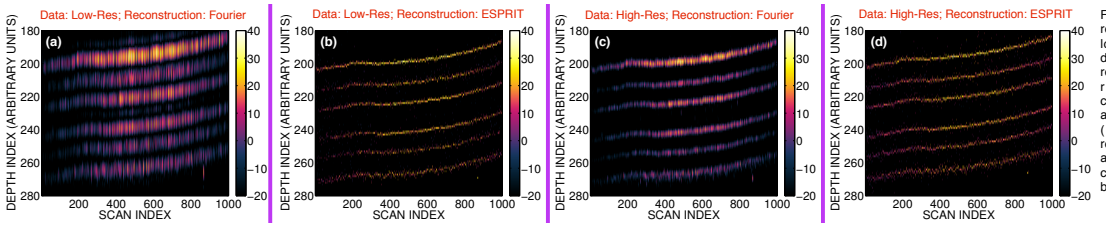

Fig: High-resolution (high-res) reconstruction from low-resolution (low-res) data; the tomogram reconstructed from low-res data in (b) is comparable to that achieved by high-res data (d). The tomograms reconstructed by ESPRIT are highly resolved compared with Fourier-based reconstruction.

References:

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