L. Yaroslavsky

Introduction to Digital Holography

Synopsis

The course is intended to provide an introduction into tasks and methods of computer synthesis and analysis of wave fields, unified under the name “Digital holography”. It covers the following topics:

- Evolution of imaging techniques: direct imaging, holographic imaging, computational imaging, digital holography
- Holographic transforms and their representation in digital computers: principles
- Discrete Fourier Transforms: Canonical, Shifted, Scaled, Rotated DFTs; invertibility of DFTs and sincd- function
- Discrete Fresnel transforms: Canonical, Shifted, Focal Plane Invariant, Convolutional, Scaled and Rotated DFrTs; invertibility of DFrTs and frincd- function
- Digital recording of holograms: “off-axis” and “on-axis” methods
- Numerical reconstruction of Fourier holograms: point spread function, resolving power and reconstruction artifacts
- Numerical reconstruction of Fresnel holograms: Fourier and convolution reconstruction methods; point spread function, resolving power and reconstruction artifacts
- Computer Generated Holograms (CGH): principles and mathematical models; digital-to-analog conversion problem of recording CGHs; devices and spatial light modulators for recording CGHs
- Methods for encoding CGH for Recording on Physical Media: binary holograms and phase-detour encoding method; gray-scale methods for hologram recording on amplitude media; gray-scale methods for hologram recording on phase media; kinoform; color CGH
- Optical Reconstruction of CGHs: optical setups for reconstruction of CGHs; CGHs as diffraction elements; sampling artifacts in optical reconstruction of CGHs; point-spread functions of optical reconstruction of CGHs
- CHGs and optical Information Processing: lens as a Fourier transformer and Chirp-modulator; optical systems for image processing; optical correlators for target location and recognition; optimal adaptive correlator; opto-electronic Joint Transform Correlators (JTC); optimal adaptive JTCs
- CGHs and 3D Visual Communication: CGH based 3D video communication paradigm; limitations of human visual system relevant to holographic 3D visualization; computer generated display holograms
- Image processing methods in digital holography: image perfection methods; automatic diagnostics of noise and other distortions of holograms and interferograms; correcting of linear and non-linear distortions of digitally recorded holograms and interferograms; image preprocessing for computer generated display holograms and diffraction optical elements; synthesis of kinoform optical diffraction elements; reconstruction of interferograms and fringe patterns

Recommended readings:

1. L. Yaroslavsky, Digital Holography and Digital Image Processing, Kluwer Academic Publishers, Boston, 2004
2. L. Yaroslavsky, Discrete Transforms, Fast Algorithms and Point Spread Functions of Numerical Reconstruction of Digitally Recorded Holograms, in: J. Astola, L. Yaroslavsky, Eds., "Advances in Signal Transforms. Theory and Applications", EURASIP Book Series on Signal Processing and Communications, Hindawi, 2007
3. L. Yaroslavsky, M. Eden, Fundamentals of Digital Optics, Birkhauser, Boston, 1996
4. L. Yaroslavskii, N. S. Merzlyakov, Methods of Digital Holography, Consultence Bureau, N. Y. 1980
5. J. W. Goodman, Introduction to Fourier Optics, McGraw-Hill, N.Y., 1996