

Image Processing for Physicists

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Summary

1. Spatial Domain
2. Fourier Domain
3. Sampling & Interpolation
4. Image Representations
5. Characterization Of Detection Systems
6. Wave Propagation & Image formation
7. Interferometric Imaging And Imaging with Far-Field Fourier Amplitudes
8. Tomography
9. Least Squares Optimization
10. Maximum Likelihood and Maximum a Posteriori

1. Spatial domain

Digitization

Sampling

Intensity mapping

Color spaces

Morphological operations

Digitization

Dynamic range

Affine transformations

Signal & Contrast

Segmentation

Quantization

2. Fourier domain

- Fourier Transform definitions & properties
- Discrete Fourier transform
- Sampling & aliasing
- Linear filters:
 - low/high pass, derivative, gaussian, ...

3. Sampling and interpolation

- Nyquist theorem
- Sampling & aliasing
- Resampling, zero-padding
- Interpolation (bilinear, sinc, ...)

4. Image representations

- Direct space, reciprocal space basis
- Discrete Cosine Transform
- Windowed Fourier transform
- Continuous/discrete wavelet transform

5. Linear imaging system

- Linear transfer model
 - PSF, OTF, MTF,
- Noise models
 - Uniform, gaussian, Poisson distributions
- Noise power spectrum
- Noise reduction by spatial filtering

6. Propagation & imaging systems

- Propagation modeling
- Wave propagation in paraxial approximation
- Near-field vs far-field
- Lenses, numerical aperture
- Scanning systems

7. Interferometric methods

- The phase problem
- Holography (in-line / off-axis)
- Grating interferometry
- Imaging with far-field diffraction
 - Fourier holography, ptychography,
crystallography

8. Tomography

- Physics and geometry of tomography
- Analytic formulation, Fourier slice theorem
Radon transform, filtered back-projection
- Algebraic formulation
ART, SART, ...

9. Least-squares

- Optimization & least-square principle
- General least squares, pseudo-inverse
- Applications
 - Linear regressions
 - Deconvolution
 - Image registration
 - Tomography

10. Likelihood

- Maximum Likelihood, Maximum a posteriori
- Applications
 - Classification
 - Deconvolution
 - Image stacking