Image Restoration

Image Processing
CSE 166
Lecture 8
Announcements

• Assignment 3 is due Apr 27, 11:59 PM
• Midterm exam is on May 4
• Reading
  – Chapter 5: Image Restoration and Reconstruction
Model of image degradation

- **Spatial domain**

\[ g(x, y) = h(x, y) \star f(x, y) + \eta(x, y) \]

<table>
<thead>
<tr>
<th>Degraded</th>
<th>Degradation</th>
<th>Original</th>
<th>Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>image</td>
<td>function</td>
<td>image</td>
<td>image</td>
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- **Frequency domain**

\[ G(u, v) = H(u, v)F(u, v) + N(u, v) \]

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Model of image degradation, then restoration

\[ g(x, y) = h(x, y) \ast f(x, y) + \eta(x, y) \]
Noise modeled as different probability density functions
Adding noise from different models

Free of noise

Gaussian
Rayleigh
Gamma
Adding noise from different models

Free of noise

Exponential

Uniform

Salt and pepper
Histograms of sample patches

Sample “flat” patches from images with noise

Identify closest probability density function (pdf) match:

Gaussian       Rayleigh       Uniform
Mean filters

X-ray image

Additive Gaussian noise

Arithmetic mean filtered

Geometric mean filtered
Mean filters

Additive pepper noise

Additive salt noise

Contraharmonic mean filtered

Contraharmonic mean filtered
Order-statistic filters

Additive salt and pepper noise

1x median filtered

2x median filtered

3x median filtered
Order-statistic filters

Max filtered

Min filtered
Comparing filters

Additive uniform + salt and pepper noise

Arithmetic mean filtered

Median filtered

Geometric mean filtered

Alpha-trimmed mean filtered
Adaptive filters

Additive Gaussian noise

Geometric mean filtered

Arithmetic mean filtered

Adaptive noise reduction filtered
Adaptive filters

Additive salt and pepper noise

Median filtered

Adaptive median filtered
Periodic noise

Additive sinusoidal noise

Conjugate impulses

DFT magnitude
Notch reject filters
Notch reject filter

Degraded image

Filter in frequency domain

Conjugate impulses

DFT magnitude

Conjugate impulses

Estimate of original image
Notch reject filter

Degraded image

DFT magnitude

Filter in frequency domain

Estimate of original image
Estimating the degradation function

• Methods
  – Observation
  – Experimentation
  – Mathematical modeling
Estimation of degradation function by experimentation

Impulse of light

Imaged (degraded) impulse
Estimation of degradation function by mathematical modeling
Estimation of degradation function by mathematical modeling

Motion blur model
Image restoration, inverse filtering

Full

Limited to radius of 40

Limited to radius of 70

Limited to radius of 85
Image restoration, Wiener filtering

Inverse filtering
Full

Wiener filtering
Radially limited
**Image restoration, constrained least squares filtering**

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<tr>
<th>Degraded image</th>
<th>Inverse filtering</th>
<th>Wiener filtering</th>
<th>Constrained least squares filtering</th>
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- **Motion blur and additive noise**
Next Lecture

• Color image processing
• Reading
  – Chapter 7: Color Image Processing