Lec 19

Image Restoration

Degraded Images:

Cause of blur
- Camera [translation
- Environment
- Device noise
- Quantisation noise

Optical Blur → Caused due to limited depth of field → Solution:
- → Light field camera
- → Multifocus Image Fusion

Motion Blur

Spatial Quantisation (Discrete pixels)

Additive intensity noise

Restoration from camera shake:

$$B = K * L + N$$

- B → Blurred Image
- K → Blur Kernel
- L → Blur-Free Image
- N → Sensor Noise

Consider blurred image as convolution with degradation

Deconvolution is done to restore img.

Image enhancement is subjective but image restoration is objective

Degradation Model

Model ⊛ convolution with shift-invariant filter $h(x,y)$

$$f(x,y) * h(x,y) = g(x,y)$$

↓ Gaussian is preferred

$$\frac{1}{2\pi\sigma^2} e^{-x^2/2\sigma^2}$$

Loss of info (blurring attenuates high spatial frequency) and noise

→ Out of focus is modelled as gaussian

Limitations

Loss of info (blurring attenuates high spatial freq.) & noise

Degradation model:

Observed Image

$f(x,y) \rightarrow$ [Degradation] $\rightarrow g(x,y) \rightarrow$ [Restoration] $\rightarrow \hat{f}(x,y)$

True Image

$h(x,y)$ ↑ Deg. filter

$n(x,y)$ ↑ Additive noise

Estimate of $f(x,y)$ from $g(x,y)$

$$g(x,y) = h(x,y) * f(x,y) + n(x,y)$$

$$\Updownarrow$$

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

Assumptions:

Noise
- → Ind. of spatial location
  - ↳ Except periodic noise
- → Uncorrelated with image

→ Degradation function (H)
- ↳ Linear
- ↳ Position-invariance

→ Doesn't depend on pixel coordinate but rather on functional value

Noise Models:

→ Gaussian
  ↳ Sensor Noise
  ↳ Low/high tem

→ Uniform Noise
  Random Num Generator

→ Rayleigh Noise
  ↳ Noise in range image

→ Gama Noise
  Laser Images

→ Exponential Noise
  Laser Imaging

→ Impulse Noise
  (salt & pepper)
  Quick Transients
  (faulty switching

→ How to study system noise
  ↳ Case I: Imaging system available
    ↳ Noise calibration [Capture set of "flat image"]
    ↳ Select model with better statistical test score

Case 2:

Only images available

↳ Estimate parameters of pdf from patch of constant bg intensity

↳ Compute variance & mean from intensity levels

Restoration: (In presence of noise)

↳ Use spatial filtering techniques

Mean filters: → Geometric mean filter

Salt & gaussian [Bad for pepper]

Harmonic filter:

Contraharmonic mean filter

↳ salt-pepper noise

$Q<0$ → salt

$Q>0$ → Pepper

$Q=-1$ → harmonic mean filt

$Q=0$ → arth. mean filt

Midpoint filter: → Alpha trimmed filter

Remove $d/2$ lowest & highest intensities

$d=0$ [Arit. Mean]

$d=mn-1$ [Median]

Adaptive Local Noise Reduction → Variance of overall noise

$$f(x,y) = g(x,y) - \frac{\sigma_n^2}{\sigma_L^2}[g(x,y) - m_L]$$

↳ Local Mean

↳ Local Variance

$\sigma_L^2 > \sigma_n^2$ → Edge, preserve it

$\sigma_L^2 = \sigma_n^2$ → Return mean. local area

Periodic noise:

↳ Band pass / band reject

Estimation of degradations

3 ways

- ↳ Observation
- ↳ Experimentation
- ↳ Modelling

$$H_s(u,v) = \frac{G_s(u,v)}{\hat{F}_s(u,v)}$$

$$H(u,v) = \frac{G(u,v)}{A}$$

↳ strength of impulse

Motion blur:

→ Amt of light hitting sensor changes fast

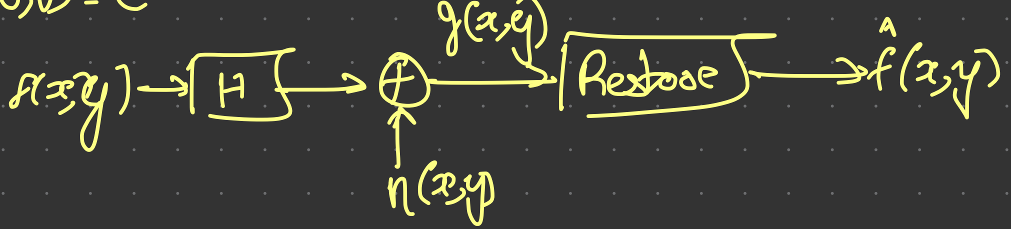
→ Camera motion

$$g(x,y) = \int_0^T f(x - x_0(t), y - y_0(t))\, dt$$

$x_0(t) = \frac{at}{T}$, $y_0(t) = \frac{bt}{T}$ → Linear motion

Modelling Atmospheric turbulence

$$H(u,v) = e^{-k^2(u^2+v^2)^{5/6}}$$



Direct Inverse filtering

Assume H is known,

$$\hat{F}(u,v) = \frac{G(u,v)}{H(u,v)} = F(u,v) + \frac{N(u,v)}{H(u,v)}$$

→ Limit Noise upto certain radius