Tutorial 4 Image Restoration and Filtering

COMP 4421: Image Processing

September 30, 2019

Outline

- More about filtering in the frequency domain
- Noise Models
- Restoration in the Presence of Noise Only-Spatial Filtering

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Properties of DFT

- Periodicity:
  - $F(u,v) = F(u+M,v) = F(u,v+N) = F(u+M,v+N)$
- Conjugate Symmetry:
  - $F(u,v) = F^*(-u,-v)$
  - $|F(u,v)| = |F^*(-u,-v)|$
- Translation

Translation in the image plane

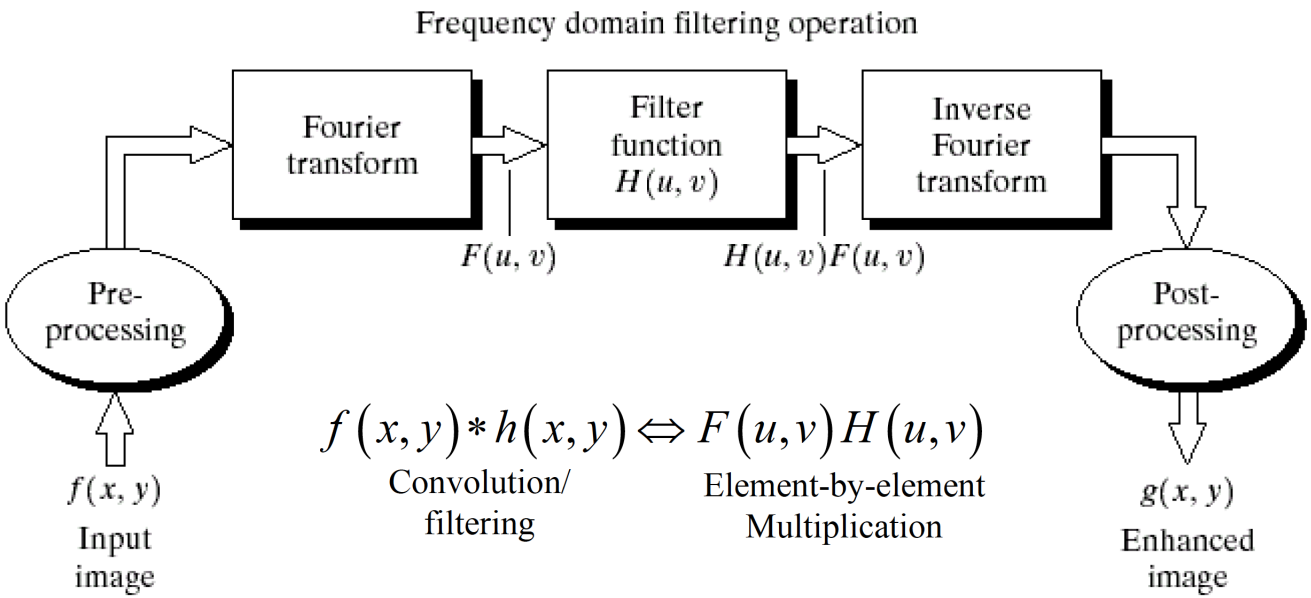
$$f(x-x_0, y-y_0) \Leftrightarrow F(u,v)\, e^{-j2\pi(u_0 x/M + v_0 y/N)}$$

Translation in the frequency plane

$$f(x,y)\, e^{j2\pi(u_0 x/M + v_0 y/N)} \Leftrightarrow F(u-u_0, v-v_0)$$

Another Idea for Filtering in Frequency Domain

- Based on Convolution Theory



- Padding Problems: Zero(black boundries), Periodic, No-padding
- Wraparound Error

Wraparound Error

- Multiplication in the frequency domain corresponds with circular convolution in the spatial domain.
- Without padding, results from one side of the image will wrap around to the other side of the image
- Zero padding:

$$f_p(x,y) = \begin{cases} f(x,y) & 0 \leq x \leq A-1 \text{ and } 0 \leq y \leq B-1 \\ 0 & A \leq x \leq P \text{ or } B \leq y \leq Q \end{cases} \tag{1}$$

$$h_p(x,y) = \begin{cases} h(x,y) & 0 \leq x \leq C-1 \text{ and } 0 \leq y \leq D-1 \\ 0 & C \leq x \leq P \text{ or } D \leq y \leq Q \end{cases} \tag{2}$$

where $P \geq A + C - 1$ and $Q \geq B + D - 1$.

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Noise Models

- Gaussian Noise
- Rayleigh Noise
- Gamma Noise
- Exponential Noise
- Uniform Noise
- Impulse (Salt & Pepper) Noise

Noise Models

Matlab Code (add noise to image)

```
x=imread('camera.ras');
figure,imshow(x);
% salt & pepper noise added to image
y1=imnoise(x,'salt & pepper');
figure,imshow(y1);
y2=imnoise(x,'salt & pepper',0.2);
figure,imshow(y2);
g = imnoise(x, 'gaussian', 0, 0.01);
figure, imshow(g);
g = imnoise(x, 'gaussian', 0, 0.1);
figure, imshow(g);
```

Function imnoise( )

Function r = imnoise(f, type, parameters)

- Corrupt image f with noise specified in type and parameters
- Results returned in r
- Type include:

Value	Description
`'gaussian'`	Gaussian white noise with constant mean and variance
`'localvar'`	Zero-mean Gaussian white noise with an intensity-dependent variance
`'poisson'`	Poisson noise
`'salt & pepper'`	On and off pixels
`'speckle'`	Multiplicative noise

Salt & Pepper



Gaussian



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Restoration in the Presence of Noise Only-Spatial Filtering

- Mean Filters
  - Arithmetic mean filter
  - Geometric mean filter
  - Harmonic mean filter
  - Contraharmonic mean filter
- Order-Statistics Filters
  - Median filter
  - Max and min filters
  - Midpoint filter
  - Alpha-trimmed mean filter
- Adaptive Spatial Filters
  - Adaptive, local noise reduction filter
  - Adaptive median filter

Restoration in the Presence of Noise Only-Spatial Filtering

Function f = spfilt(g, type, m, n, parameter)

- Performs spatial filtering
- Type include:
  - Mean Filters
    amean, gmean, hmean, chmean
  - Order-Statistics Filters
    median, max, min, midpoint, artimmed

Reference: Gonzalez R C, Woods R E, Eddins S L. Digital image processing using MATLAB[M]. Knoxville: Gatesmark Publishing, 2009.

Restoration in the Presence of Noise Only-Spatial Filtering

- Creating a pepper noise image

```
f = imread('lenna.jpg');
R = imnoise2('salt & pepper', M, N, 0.1, 0);
c = find(R == 0);
gp = f;
gp(c) = 0;
figure, imshow(gp);
```

- Filtering

```
fp = spfilt(gp, 'amean', 5, 5);
fpm = spfilt(gp, 'median', 5, 5);
fpmax = spfilt(gp, 'max',2,2);
figure,imshow(fp);
figure,imshow(fpm);
figure,imshow(fpmax);
```

Function imnoise2( )

Function R = imnoise2(type, M,N,a,b);

- Generates R of size M-by-N
- ‘a‘ and ‘b‘ are parameters
- Type include:
  Gaussian Noise; Rayleigh Noise; Gamma Noise; Exponential Noise; Uniform Noise; Salt & Pepper Noise; Lognormal Noise

Reference: Gonzalez R C, Woods R E, Eddins S L. Digital image processing using MATLAB[M]. Knoxville: Gatesmark Publishing, 2009.

Example

Image corrupted by pepper noise with probability 0.1. Result images with arithmetic mean filter, median filter, max filter respectively.

Thank you!