Tutorial 3
Image Enhancement in the Spatial and Frequency Domain

COMP 4421: Image Processing

September 18, 2017

Outline

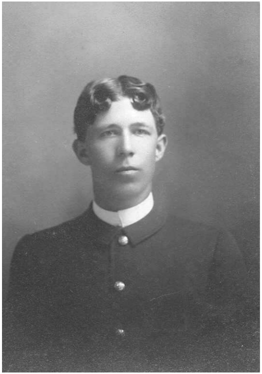
- Filter Operations
  - Smoothing
  - Sharpening
- Fourier Transform
  - Fourier Transform of 1D Signal
  - Fourier Transform of a Synthetic Image

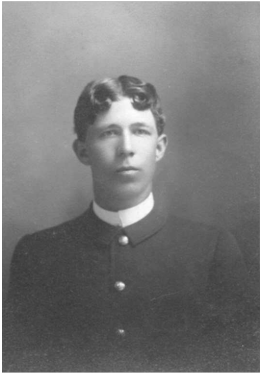
Outline

- Filter Operations
  - Smoothing
  - Sharpening
- Fourier Transform

Smoothing via an Average Mask (imfilter, fspecial)

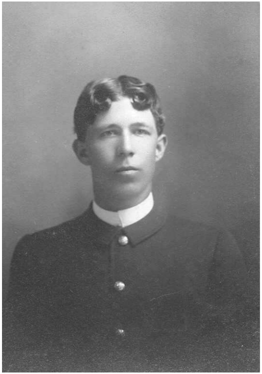
- mask =1/9*ones(3,3)
  g = imfilter(f,mask)
- mask 2= fspecial ('average',[3,3])
- 5×5

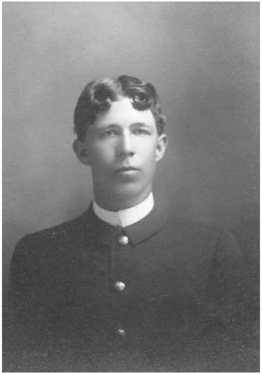




Smoothing via a Median Filter (medfilt2)

- g = medfilt2(f, [3,3])
- 3×3
- 5×5

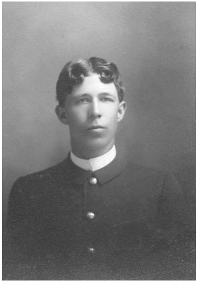




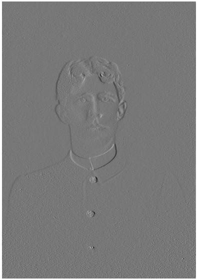
Gradients (gradient)

[Fx Fy] = gradient (double (f))

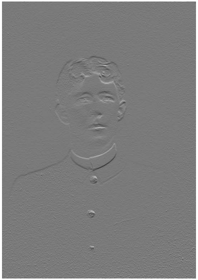
- Original



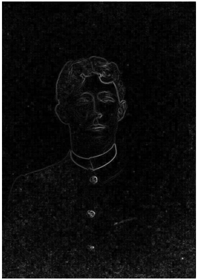
- df/dx



- df/dy

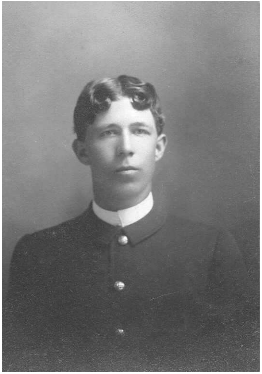


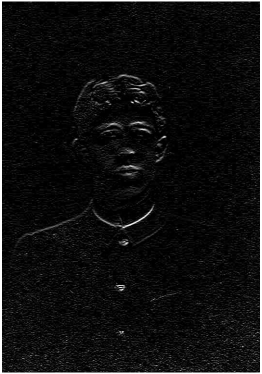
- magnitude

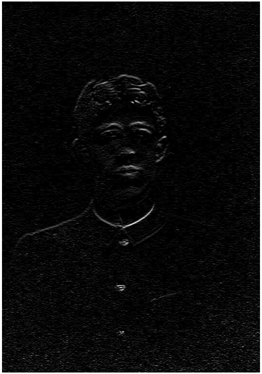


Sharpening via Approximated Derivative Filters (fspecial)

- input
- mask= fspecial ('sobel')
- mask= fspecial ('prewitt')







Recap

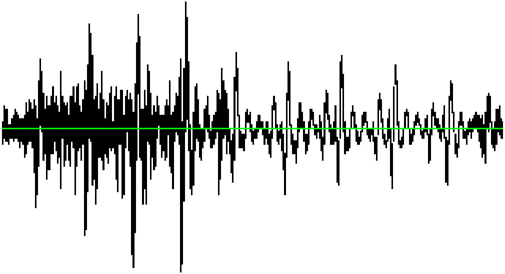
- The following built-in functions are important:
  - imshow
  - imhist
  - histeq
  - imfilter
  - medfilt2
  - gradient
  - fspecial
- Please explore other interesting functions!

Outline

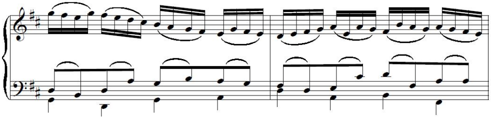
- Filter Operations
- Fourier Transform
  - Fourier Transform of 1D Signal
  - Fourier Transform of a Synthetic Image

Fourier Transform of 1D Signal

- Time Domain



- Frequency Domain

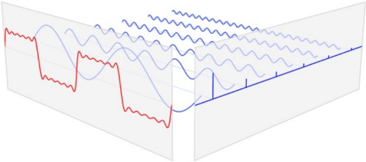


Fourier Transform of 1D Signal

- Any periodic signal can be decomposed to the sum of a set of sine functions with different magnitudes and phases.
- Any music can be decomposed to the combination of a set of keys pressed with various strengths and at different time points.

http://en.wikipedia.org/wiki/Fourier_transform
http://zhuanlan.zhihu.com/wille/19763358

Fourier Transform of 1D Signal



Fourier Transform of 1D Signal

```
M = 1000;
f = zeros(1, M);
l = 10;
f(M/2-l:M/2+l) = 1;
figure,plot(f);
F = fft(f);
figure, subplot(2,1,1), plot(abs(F));
Fc = fftshift(F);
subplot(2,1,2), plot(abs(Fc));
```

Create a simple rectangular 1D signal and examine its Fourier Transform.

Fourier Transform of 1D Signal

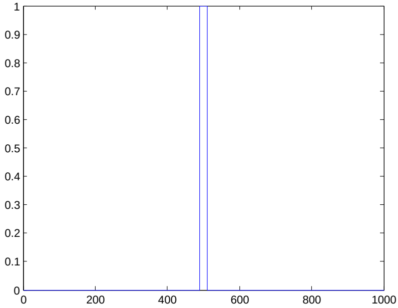


Figure: 1D Signal

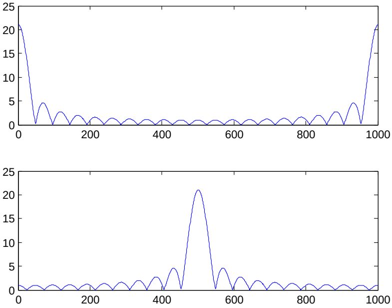
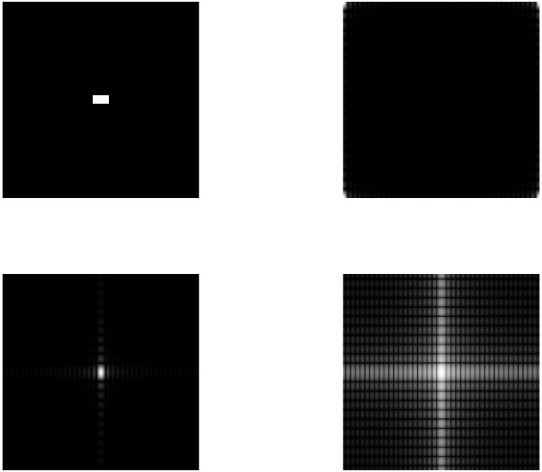


Figure: Spectrum

Fourier Transform of a Synthetic Image

```
f1 = zeros(500,500);
f1(240:260,230:270) = 1;
subplot(2,2,1);imshow(f1,[]);
F = fft2(f1);
S = abs(F);
subplot(2,2,2); imshow(S,[]);
Fc = fftshift(F);
S1 = abs(Fc);
subplot(2,2,3); imshow(S1,[]);
S2 = log(1+S1);
subplot(2,2,4);imshow(S2,[]);
```

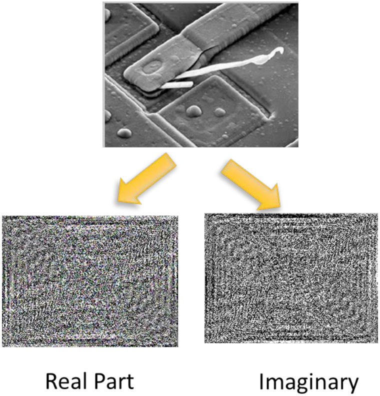
Fourier Transform of a Synthetic Image



Fourier Transform

Matlab Code

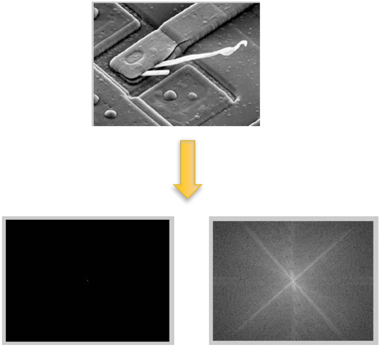
```
Im=imread ('example.bmp');
ft= fft2(Im);
figure,imshow(real(ft));
figure,imshow(imag(ft));
```



Fourier Transform

Matlab Code

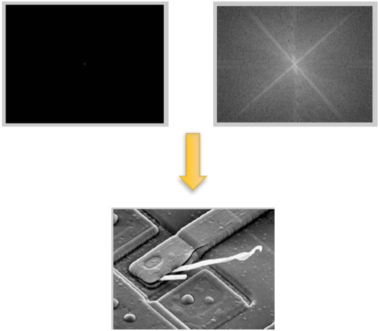
```
Im=imread('example.bmp');
ft= fft2(Im);
fts = fftshift(ft);
figure;imshow(abs(fts),[]);
figure;imshow(log(1+abs(fts)),[]);
```



Fourier Transform

Matlab Code

```
orift=ifftshift(fts);
oriIm=ifft2(orift);
figure;imshow(oriIm,[]);
```



Review of frequently-used funcions

- 2D Fourier transform: F = fft2(f);
- Spectrum shift: Fs=fftshift(F);
  Shift zero-frequency component to center of spectrum.
- Absolute value: Fm=abs(F);
  Return spectrum of F if it is complex
- Real or imaginary part of complex signal: real(F); imag(F);
- Demonstrating 2D signal(matrix): imshow(Fm, [])

Thank you!