

Optical imaging and image processing (VIII)

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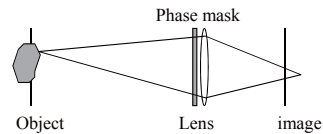
Limits on super-resolution and how to break them
IEEE Transactions on Pattern Analysis and Machine Intelligence, 24, 9 (2002) 1167-1183

Example-Based Super-Resolution

IEEE Computer Graphics, March/April 2002 (vol. 22 no. 2) pp. 56-65

Extended depth of field through wave-front coding

10 April 1995 / Vol. 34, No. 11 / APPLIED OPTICS 1859-1866



Phase mask

$$P(x) = \begin{cases} \frac{1}{\sqrt{2}} \exp[i\pi(x)^2] & \text{for } |x| \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

Optical Transfer Function (OTF) at the defocused plane

$$H(u, v) = \int |P(x + u/2) \exp[i\pi(x + u/2)^2 \phi]| \times |P^*(x - u/2) \exp[-i\pi(x - u/2)^2 \phi]| dx$$

$$\phi = \frac{\pi L^2}{4\lambda} \left(\frac{1}{f} - \frac{1}{d_o} - \frac{1}{d_i} \right) = \frac{2\pi}{\lambda} W_{20} = k W_{20}$$

Phase term by the defocus

New paradigm for imaging systems

APPLIED OPTICS / Vol. 41, No. 29 / 10 October 2002 / 6080-6092

Image filtering by convolution

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

$$G(u, v) = H(u, v) F(u, v)$$

$$g[m, n] = \sum_{k=0}^{M'-1} \sum_{l=0}^{N'-1} h[k, l] f[m-k, n-l]$$

– If it can be assumed that (circulant convolution)

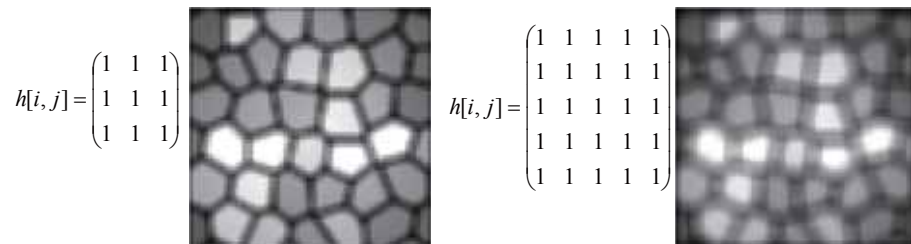
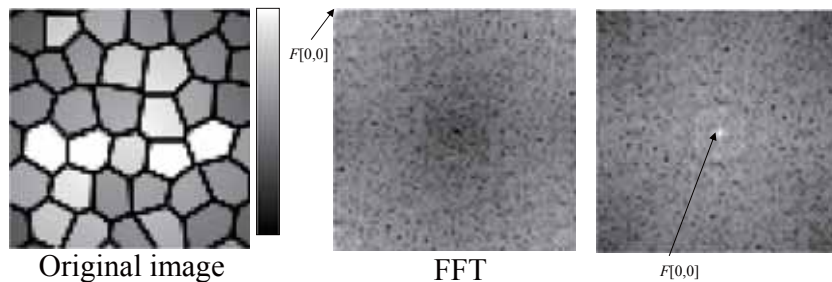
$$f[m+pM, n+qN] = f[m, n]$$

– where p and q are arbitrary integers, the convolution is expressed by DFT as,

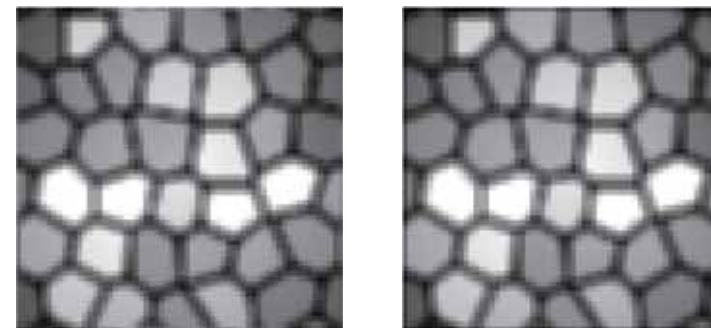
$$G[k, l] = H[k, l] F[k, l]$$

– Smoothing $h[i, j] = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$
• ex.

Smoothing



Filtered results



Filtered image by FFT

Filtered image by convolution

Matlab code

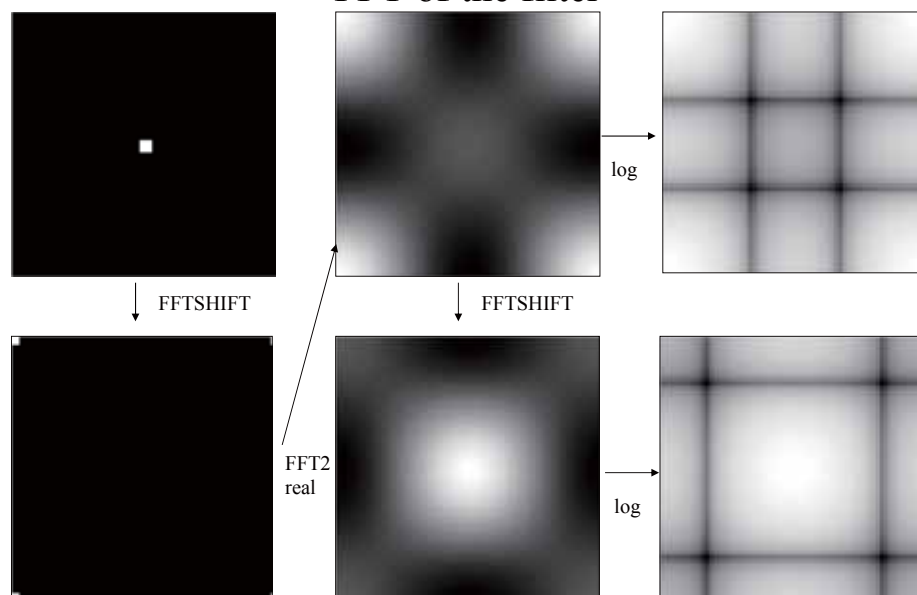
```
sim = imread('crystal64.bmp');
imagesc(sim);
axis('image');
a = zeros(64,64);
a([32:34],[32:34])=1;
imagesc(a);
axis('image');
sa = fftshift(a);

imagesc(sa);
axis('image');
fsa = fft2(sa);
imagesc(real(fsa));
axis('image');
mfsa = fsa .* fsm;
rec = ifft2(mfsa);

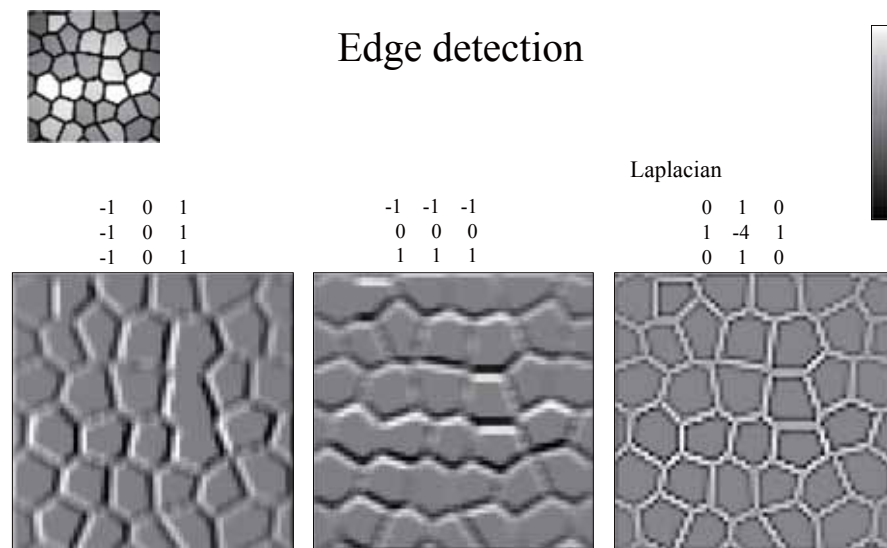
imagesc(real(rec));
axis('image');
a3([1:3],[1:3])=1;
ofilter = filter2(a3, sim);
imagesc(ofilter);
axis('image');
```

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FFT of the filter



Edge detection



Edge detection (Filtering + thresholding)

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