Sample 5-4

周波数解析

画像スペクトル

画像処理特論

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動作確認: MATLAB R2023a

Fourier analysis

Spectrum of images

Advanced Topics in Image Processing

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Verified: MATLAB R2023a

準備

(Preparation)

```
close all
```

サンプル画像の準備

(Preparation of sample image)

```
% Reading original image
u = im2double(imread('cameraman.tif'));
figure(1)
imshow(u)
title('Original')
```

画像（2 変量信号） のスペクトル

(Spectrum of an image (bivariate signal))

ただし， は画像のサポート領域を意味する． (where denotes the support region of the image.)

DFT(FFT)による DSFT の周波数サンプル計算 (Frequency sampling of DSFT by DFT (FFT))

以下では周期行列 を対角行列 (In the following, the periodic matrix is set to a diagonal matrix)

に設定する．すなわち，(That is,)

ただし，は基本周期内の整数ベクトル集合 (where denotes a set of interger vectors in the fundamental pallalelpiped as)

である．ここでは， を仮定する．(Here, let us assume .)

```
% Setting the number of frequency sample points in [0,2π)
nPoints1 = 256; % N_1
nPoints2 = 256; % N_2

% Spectrum of u[n]
U = fft2(u,nPoints1,nPoints2);
```

表示のための係数シフト

(Coefficient shift for display)

直流(DC)成分を配列の中心にシフト (Shift the direct current (DC) component to the center of the array)

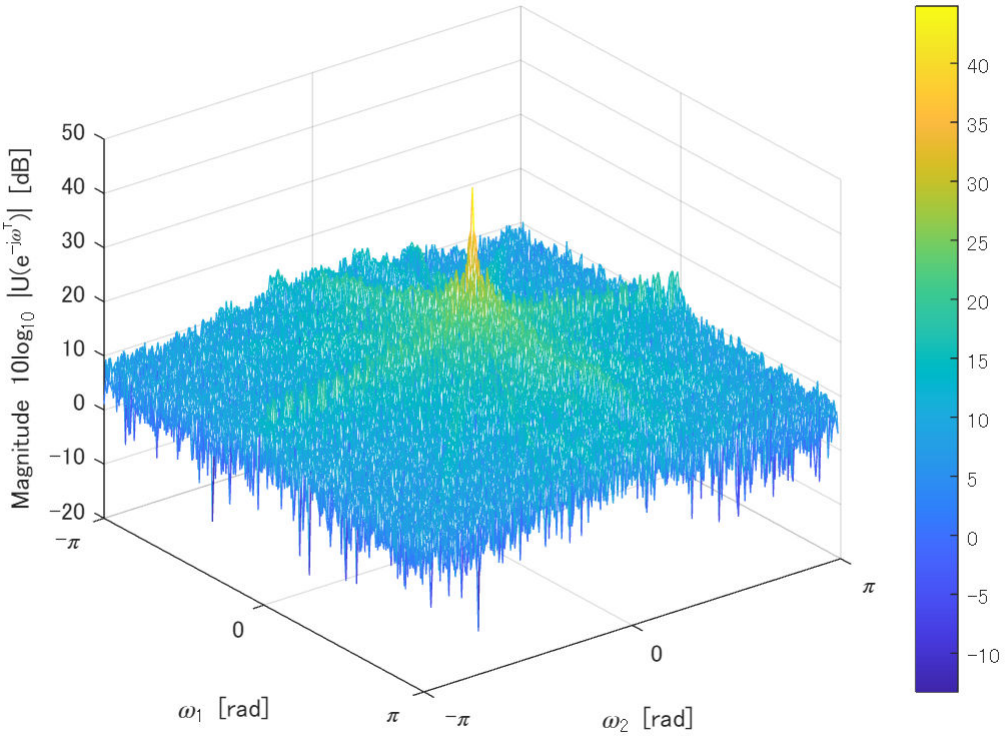
```
% Shift the DC Coef. to the center
Usft = fftshift(U);

% Frequency sampling points
[w2,w1] = meshgrid(-pi:2*pi/nPoints2:pi-2*pi/nPoints2,-pi:2*pi/nPoints1:pi-2*pi/
nPoints1);
```

振幅スペクトル の表示

Display of magnitude spectrum

```
% Calculation of the magnitude spectrum
Umag = abs(Usft);
```

```
% Display the magnitude spectrum
figure(2)
mesh(w1,w2,10*log10(Umag))
ax = gca;
xlabel('\omega_2 [rad]')
ylabel('\omega_1 [rad]')
zlabel('Magnitude 10log_{10} |U(e^{-j\omega^T})| [dB]')
axis ij
ax.XLim = [-pi pi];
ax.XTick = [ -pi 0 pi ];
ax.XTickLabel = { '-\pi', '0', '\pi'};
ax.YLim = [-pi pi];
ax.YTick = [ -pi 0 pi ];
ax.YTickLabel = { '-\pi', '0', '\pi'};
colorbar(ax)
```

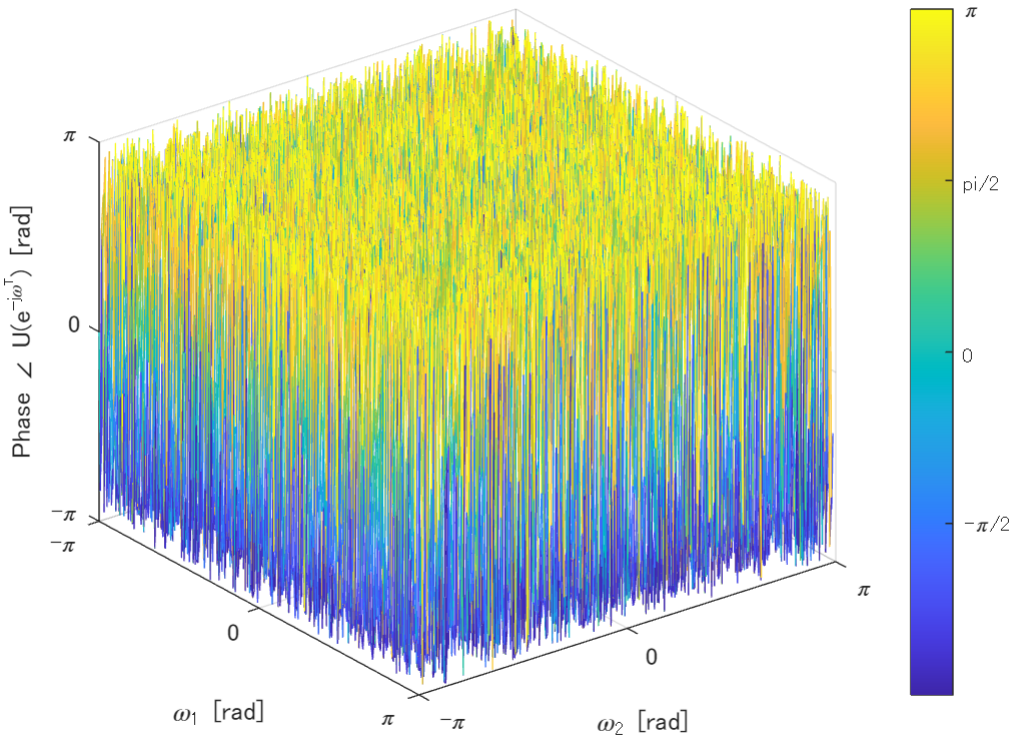


位相スペクトル の表示

(Display of phase spectrum)

```
% Calculation of the magnitude spectrum
Uphs = angle(Usft);

% Display the magnitude spectrum
```

```
figure(3)
mesh(w1,w2,Uphs)
ax = gca;
xlabel('\omega_2 [rad]')
ylabel('\omega_1 [rad]')
zlabel('Phase \angle U(e^{-j\omega^T}) [rad]')
axis ij
ax.XLim = [-pi pi];
ax.XTick = [ -pi 0 pi ];
ax.XTickLabel = { '-\pi', '0', '\pi'};
ax.YLim = [-pi pi];
ax.YTick = [ -pi 0 pi ];
ax.YTickLabel = { '-\pi', '0', '\pi'};
ax.ZLim = [-pi pi];
ax.ZTick = [ -pi 0 pi ];
ax.ZTickLabel = { '-\pi', '0', '\pi'};
colorbar(ax,'Ticks',[ -pi -pi/2 0 pi/2 pi],'TickLabels', { '-\pi', '-\pi/2', '0',
'pi/2', '\pi'})
```



スペクトルからの画像再構成

(Reconstruction from the spectrum)

IDFT(IFFT)による再構成 (Reconstruction by IDFT (IFFT))

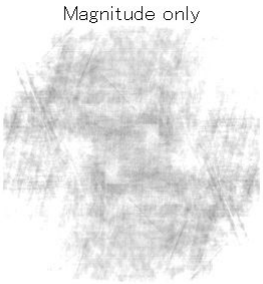
```
% Reconstruction from the spectrum
r = ifft2(U,nPoints1,nPoints2);

% Clipping to the support region Ω
urec = r(1:size(u,1),1:size(u,2));
figure(4)
imshow(urec)
% MSE
mymse = @(x,y) mean((double(x)-double(y)).^2,'all');
title(['Reconstruction MSE: ' num2str(mymse(u,urec))])
```

振幅スペクトルからの画像再構成

(Reconstruction from the spectrum)

IDFT(IFFT)による計算 (Calculation by IDFT (IFFT))

```
% Reconstruction from the spectrum
rmag = ifft2(ifftshift(Umag),nPoints1,nPoints2);

% Clipping to the support region Ω
umag = rmag(1:size(u,1),1:size(u,2));
figure(5)
imshow(umag+.5)
title('Magnitude only')
```



位相スペクトルからの画像再構成

(Reconstruction from the spectrum)

IDFT(IFFT)による計算 (Calculation by IDFT (IFFT))

```
% Reconstruction from the spectrum
rphs = ifft2(exp(1j*ifftshift(Uphs)),nPoints1,nPoints2);

% Clipping to the suppor region Ω
uphs = rphs(1:size(u,1),1:size(u,2));
figure(6)
imshow(nPoints1*nPoints2*real(uphs)+.5)
title('Phase only')
```