Sample 8-3

離散コサイン変換

画像符号化

画像処理特論

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動作確認: MATLAB R2023a

Discrete cosine transform

Image codec

Advanced Topics in Image Processing

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Verified: MATLAB R2023a

準備

(Preparation)

```
close all
```

単変量変換行列の定義

(Definition of univariate transform)

- 回転行列(rotation matrix)

$$\mathbf{A}_\theta = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}$$

```
Atheta = @(theta) [cos(theta) -sin(theta) ; sin(theta) cos(theta)];
```

ブロック毎の処理の定義

(Definition of patch processing)

順変換　→　量子化　→　逆量子化　→　逆変換

(Forward transform → Quantization → Inverse quantization → Inverse transform)

$$T(\mathbf{X}) = \mathbf{A}^{-1}(\mathbf{Q} \odot \mathrm{round}((\mathbf{A}\mathbf{X}\mathbf{A}^T) \oslash \mathbf{Q}))\mathbf{A}^{-T}$$

- $\odot$: 要素毎の掛け算 (Entry-wise multiplication)
- $\oslash$: 要素毎の割り算 (Entry-wise division)

```
mycodec = @(X,A,Q) inv(A)*(Q.*(round((A*double(X.data)*A.')./Q)))*inv(A).';
```

ブロックサイズ (Patch size)

```
blkSz = [2 2];
```

配列に対するブロック処理

品質制御パラメータ (Quality factor)

- 量子化ステップを制御 (Controls the quantization step)

```
Qfactor = 1;
```

入力配列の定義

(Definition of input array)

```
U = [
    2 2 3 1 ;
    2 2 3 1 ;
    3 3 2 0 ;
    1 1 0 2 ];
```

単位行列の場合

(For the indentity matrix case)

```
A0 = eye(blkSz) % or Atheta(0)
```

```
A0 = 2×2
     1     0
     0     1
```

量子化テーブル (Quantization table) $\mathbf{Q}$

```
Q0 = Qfactor*[ % Flat
    2 2 ;
    2 2 ];
```

符号化および復号(Coding and decoding)

```
% Definition of block processing
mycodec0 = @(x) mycodec(x,A0,Q0);

% Run codec
V0 = blockproc(U,blkSz,mycodec0)
```

```
V0 = 4×4
     2     2     4     2
     2     2     4     2
     4     4     2     0
```

```
     2     2     0     2
```

```
% Error
U-V0
```

```
ans = 4×4
     0     0    -1    -1
     0     0    -1    -1
    -1    -1     0     0
    -1    -1     0     0
```

ハール変換の場合

(For the Haar case)

```
Ah = Atheta(-pi/4)
```

```
Ah = 2×2
    0.7071    0.7071
   -0.7071    0.7071
```

量子化テーブル (Quantization table) $\mathbf{Q}$

```
Qh = Qfactor*[ % Manually weighted
    3 4 ;
    4 5 ]/2;
```

符号化および復号(Coding and decoding)

```
% Definition of block processing
mycodech = @(x) mycodec(x,Ah,Qh);
% Run codec
Vh = blockproc(U,blkSz,mycodech)
```

```
Vh = 4×4
    2.2500    2.2500    3.2500    1.2500
    2.2500    2.2500    3.2500    1.2500
    3.2500    3.2500    2.0000   -0.5000
    1.2500    1.2500   -0.5000    2.0000
```

```
% Error
U-Vh
```

```
ans = 4×4
   -0.2500   -0.2500   -0.2500   -0.2500
   -0.2500   -0.2500   -0.2500   -0.2500
   -0.2500   -0.2500         0    0.5000
   -0.2500   -0.2500    0.5000         0
```

品質評価

(Quality assesment)

$$\mathrm{PSNR}(\mathbf{U},\mathbf{V}) = 10\log_{10}\frac{\mathrm{peak}^2}{\mathrm{MSE}(\mathbf{U},\mathbf{V})}\ [\mathrm{dB}]$$

- PSNR が大きいほど誤差が小さい (Larger PSNR means smaller error.)

```
Qfactor
```

```
Qfactor = 1
```

```
fprintf('PSNR (theta=0): %6.2f [dB]',psnr(U,V0,max(U(:))))
```

```
PSNR (theta=0):  12.55 [dB]
```

```
fprintf('PSNR (theta=-π/4): %6.2f [dB]',psnr(U,Vh,max(U(:))))
```

```
PSNR (theta=-π/4):  20.61 [dB]
```

原画像の読込

(Read an image)

```
U = rgb2gray(imread('data/barbaraFaceRgb.tif'));
```

符号化および復号

(Coding and decoding)

単位行列の場合 (For the indentity matrix case)

```
% Run codec w/ θ = 0
V0 = cast(blockproc(U,blkSz,mycodec0),'like',U);
```

ハール変換の場合 (For the Haar case)

```
% Run codec w/ θ=-π/4
Vh = cast(blockproc(U,blkSz,mycodech),'like',U);
```

品質評価

(Quality assesment)

```
Qfactor
```

```
Qfactor = 1
```

```

fprintf('PSNR (theta=-π/4): %6.2f [dB]',psnr(U,Vh))
```

```
PSNR (theta=-π/4):  51.85 [dB]
```

画像表示

(Image show)

```
figure(1)
imshow(U)
```

```
title('Original picture')
```


```
figure(2)
imshow(V0)
title(['Decoded picture w/ \theta=0 (PSNR: ' num2str(psnr(U,V0)) ' dB)'])
```


```
figure(3)
imshow(Vh)
title(['Decoded picture w/ \theta=-\pi/4 (PSNR: ' num2str(psnr(U,Vh)) ' dB)'])
```