

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)

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

- \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 identity matrix case)

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

```
A0 = 2x2
    1    0
    0    1
```

量子化テーブル (Quantization table) 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 = 4x4
    2    2    4    2
    2    2    4    2
    4    4    2    0
```

2 2 0 2

% Error

U-V0

ans = 4x4

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 = 2x2

0.7071	0.7071
-0.7071	0.7071

量子化テーブル (Quantization table) 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 = 4x4

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 = 4x4

-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)

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

- 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 identity matrix case)

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

ハール変換の場合 (For the Haar case)

```
% Run codec w/  $\theta = -\pi/4$   
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)'])
```

Decoded picture w/ $\theta=0$ (PSNR: 51.1546 dB)



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

Decoded picture w/ $\theta=-\pi/4$ (PSNR: 51.848 dB)

