Sample 6-5

標本化
単変量アップサンプリング

画像処理特論

村松 正吾

動作確認: MATLAB R2020a

Sampling

Univariate upsampling

Advanced Topics in Image Processing

Shogo MURAMATSU

Verified: MATLAB R2020a

準備
(Preparation)

```
close all
```

補間率の設定
(Setting the upsampling factor)

- M: 補間率 (upsampling factor)

```
% Upsampling factor
uFactor = 2;
```

入力数列の設定
(Setting the input sequence)

- $\{u[n]\}_n$: 入力数列 (input sequence)

```
% Create a sequence from sound data
startIndex = 256;
nInputSamples = 16;
load gong;
inputSeq = y(startIndex:startIndex+nInputSamples-1);
load chirp;
inputSeq = inputSeq + y(startIndex:startIndex+nInputSamples-1);
```

出力数列の計算

(Computation of the output sequence)

- $\{v[m]\}_m$: 出力数列 (output sequence)

$$v[m] = \begin{cases} u[m/M] & m = 0, \pm M, \pm 2M, \cdots \\ 0 & \text{otherwise} \end{cases}$$

```matlab
% Downsampling
outputSeq = upsample(inputSeq,uFactor);
nOutputSamples = length(outputSeq);
```

入出力数列の表示

(Display of the input and output sequences)

```matlab
% Plot the input and output sequences
figure(1)
% Input sequence
subplot(2,1,1)
stem(0:nInputSamples-1,inputSeq,'filled')
hold on
plot(0:nInputSamples-1,inputSeq,':')
axis([0 nInputSamples -1 1])
title('Input sequence','FontSize',12)
xlabel('n','FontSize',12)
ylabel('u[n]','FontSize',12)
hold off

% Output sequence
subplot(2,1,2)
stem(0:nOutputSamples-1,outputSeq,'filled')
hold on
plot(0:uFactor:uFactor*nInputSamples-uFactor+1,inputSeq,':')
axis([0 uFactor*nInputSamples -1 1])
title(sprintf('Output sequence (uFactor = %d)',uFactor),'FontSize',12)
xlabel('m','FontSize',12)
ylabel('y[m]','FontSize',12)
hold off
```
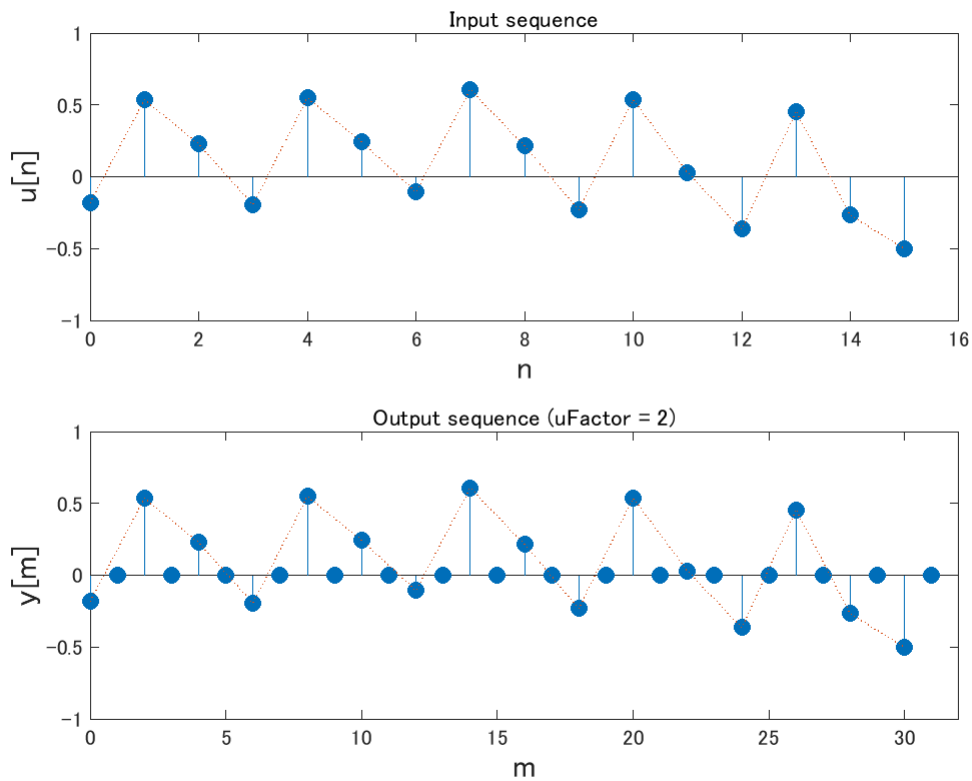
Input sequence

Output sequence (uFactor = 2)

入力数列の設定

(Setting the input sequence)

```
% Creation of a modulated Gaussian
w = 0; % Modulation frequency
nInputSamples = 128;
inputSeq = gausswin(nInputSamples);
inputSeq = inputSeq/sum(inputSeq);
inputSeq = inputSeq.*cos((0:(nInputSamples-1)).'*w);
```

出力数列の計算

(Computation of the output sequence)

$$V(e^{\jmath\omega}) = U(e^{\jmath M\omega})$$

```
% Downsampling
outputSeq = upsample(inputSeq,factor);
nOutputSamples = length(outputSeq);
```
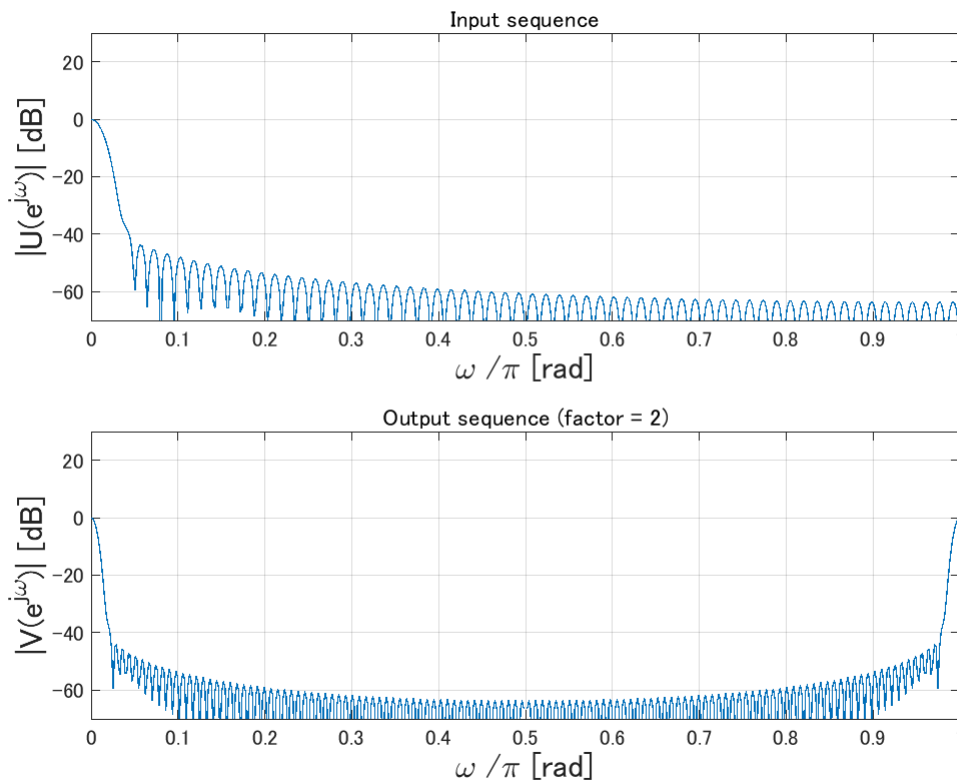
入出力スペクトルの表示

(Display of the input and output spectrum)

```
% Display spectra
figure(2)
```

3

```
% Input spectrum
subplot(2,1,1)
[H,W] = freqz(inputSeq);
plot(W/pi,20*log10(abs(H)))
title('Input sequence','FontSize',12)
xlabel('\omega /\pi [rad]','FontSize',12)
ylabel('|U(e^{j\omega})| [dB]','FontSize',12)
axis([ 0 1 -70 30 ])
grid on

% Output spectrum
subplot(2,1,2)
[H,W] = freqz(outputSeq);
plot(W/pi,20*log10(abs(H)))
title(sprintf('Output sequence (factor = %d)',factor),'FontSize',12)
xlabel('\omega /\pi [rad]','FontSize',12)
ylabel('|V(e^{j\omega})| [dB]','FontSize',12)
axis([ 0 1 -70 30 ])
grid on
```