Eng. 100: Music Signal Processing

DSP Lecture 6 (addendum)

Aliasing

Curiosity:

- aliasing video!

Announcements:

- Needed for HW 3 !

Sampling rates and maximum frequency

Q0.1 What is the highest frequency we could find by arccos method? (HW1 "challenge" problem.)

??

Q0.2 What is the highest frequency we can find by the FFT method?

`plot((2/N)*abs.(fft(x)))` gives:

$$[2c_0 \underbrace{c_1\ c_2\ \ldots\ c_{N/2-2}\ c_{N/2-1}}\ c_{N/2}\ \underbrace{c_{N/2-1}\ c_{N/2-2}\ \ldots\ c_2\ c_1}]$$

??

Q0.3 What is the maximum frequency we can find "by eye" from a digital signal $x[n]$, assuming no aliasing has occurred?

??

Q0.4 What is the maximum frequency we can find "by eye" from an analog periodic signal $x(t) = x(t+T)$?

??

Why $S > 2B$ is crucial to avoid aliasing

- Consider $x(t) = \cos(2\pi f t)$ with $f = S/2$
  Plot its samples $x[n]$
  ??

- Consider $y(t) = \sin(2\pi f t) = \cos(2\pi f t - \pi/2)$ with $f = S/2$
  Plot its samples $y[n]$
  ??

Q0.5 Would $S \geq 2B$ suffice to avoid aliasing?
??

- For FFT approach, the highest *reliable* frequency is really for $k = \frac{N}{2} - 1$,
  i.e., $f = \frac{(N/2-1)}{N} S = \left(\frac{1}{2} - \frac{1}{N}\right) S < S/2$

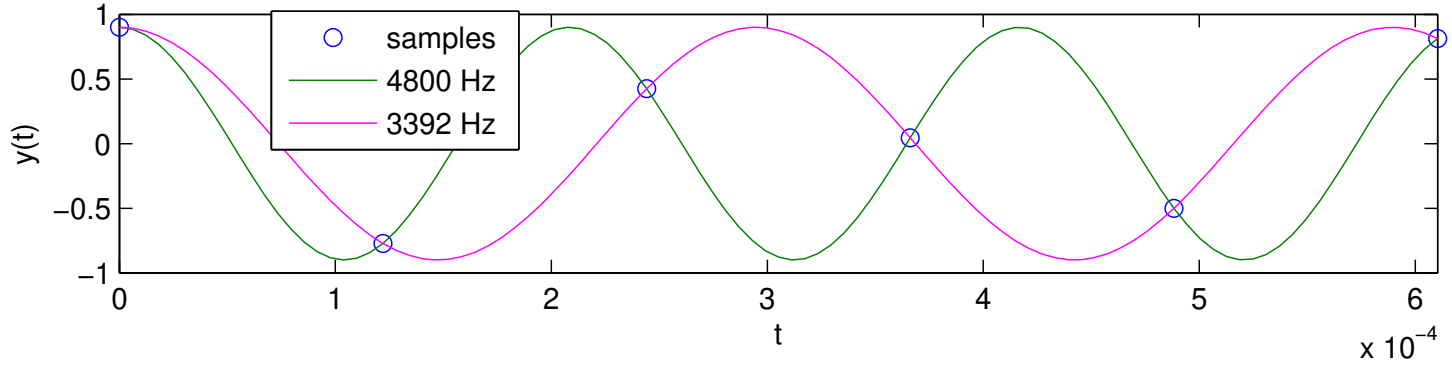
Aliasing: audio example

```
S = 8192; t = 0:1/S:0.3
x = 0.9*[cos.(2pi*2800*t); cos.(2pi*3800*t)]
```

play

```
y = 0.9*[cos.(2pi*3800*t); cos.(2pi*4800*t)]
```

play



arccos method says 3392 Hz, not 4800 Hz for last part of this example

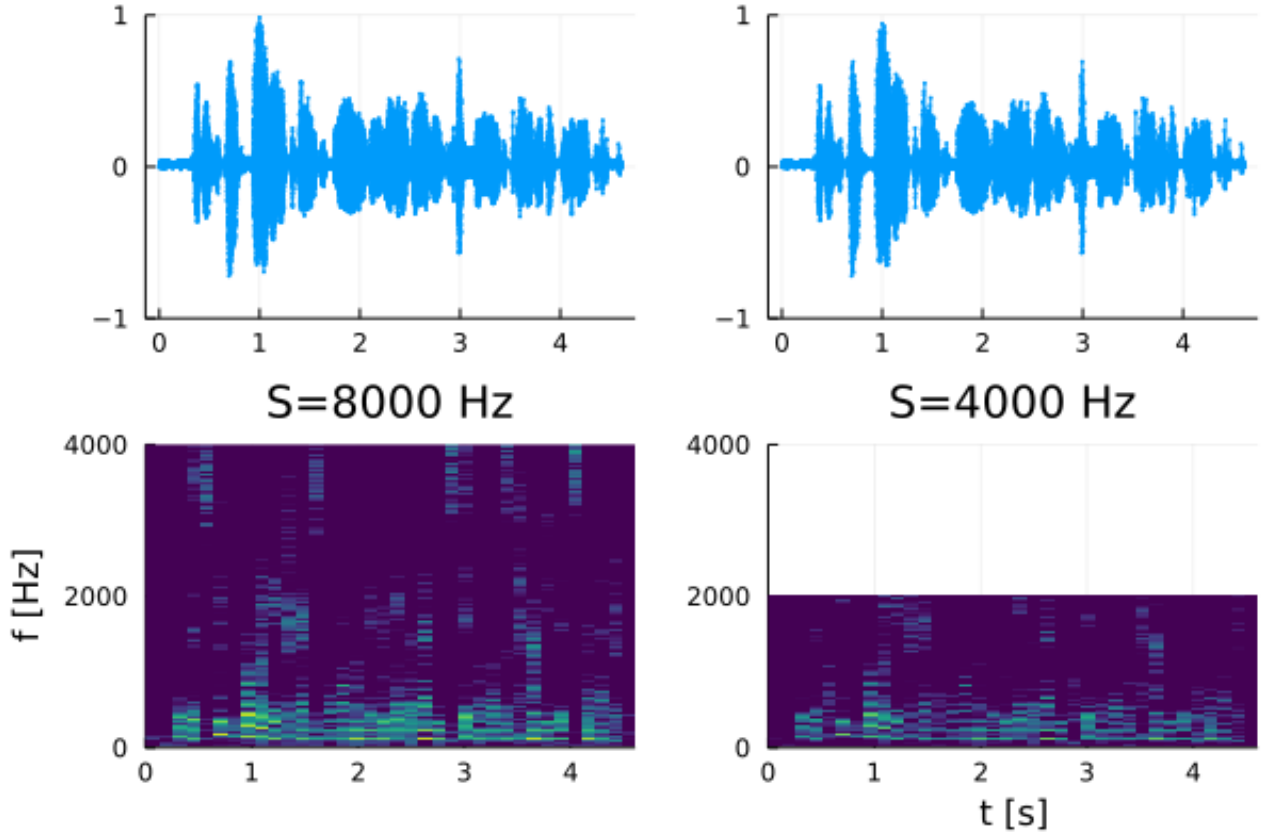
Q0.6 Is $S > 2B$ here?

A: Yes B: No ??

Aliasing: speech example

play Original $x[n]$ with $S_1 = 8000 \frac{\text{Sample}}{\text{Second}}$

play Down-sampled $y[n] = x[2n]$ via `y = x[1:2:end]` with $S_2 = S_1/2 = 4000 \frac{\text{Sample}}{\text{Second}}$



Is $S_2 > 2B$ here? ??