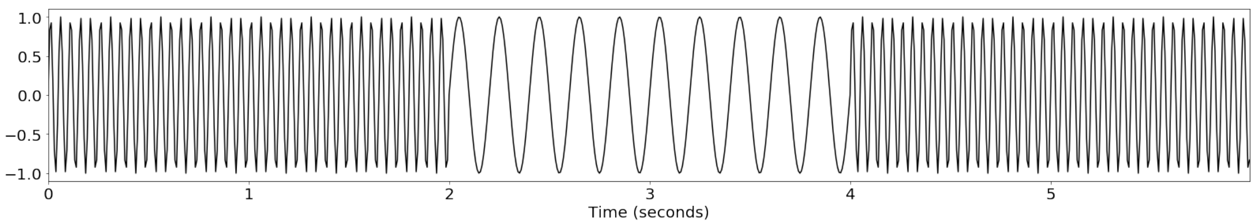
ECS7006 Music Informatics

# Tutorial - Time–Frequency Representations

1. Consider the below signal:




   Sketch the STFT spectrogram for the above signal.

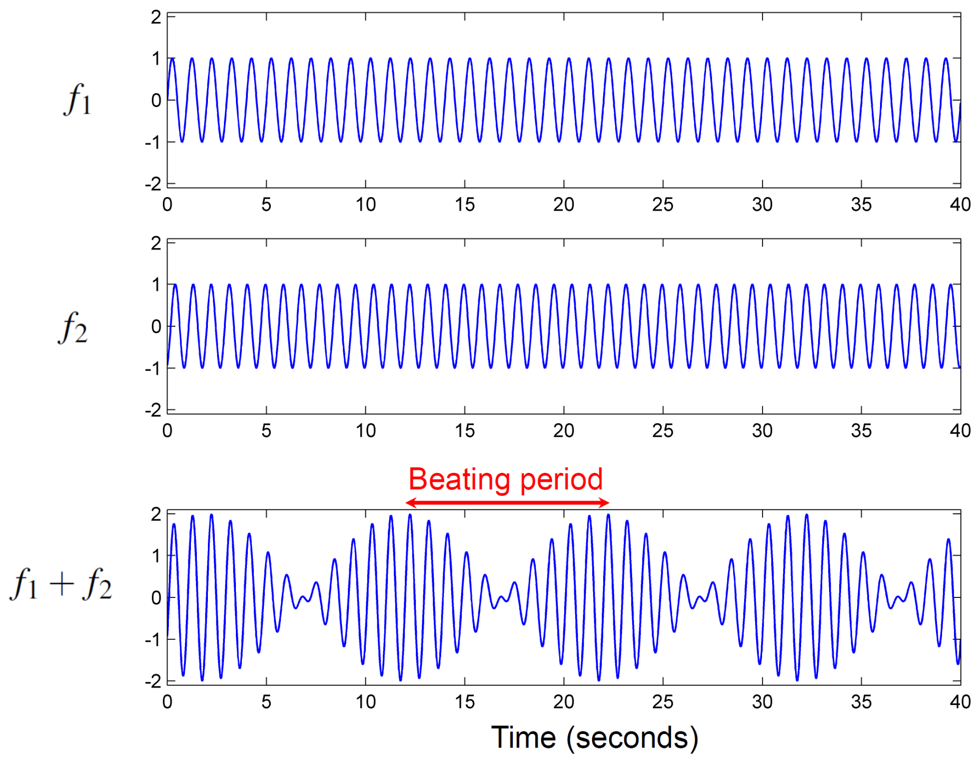
2. Compute the time resolution in msec, frequency resolution in Hz, and the Nyquist frequency of a discrete STFT based on the following parameter settings: $F_s = 44100$ Hz, $N = 2048$, and $H = 512$.

3. Let $F_s = 48000$ Hz, $N = 2048$ and $H = 512$ for a discrete STFT. What is the physical meaning of STFT coefficients $\mathcal{X}(1000, 500)$ and $\mathcal{X}(16, 1024)$? Why is the coefficient $\mathcal{X}(16, 1024)$ problematic?

4. Assume that the STFT of exercise 3 is used as input to a mel filterbank with 128 coefficients using the mel scale proposed by Fant: $m = 1000 \cdot \log_2\left(1 + \frac{f}{1000}\right)$. What is the physical meaning of the mel spectrogram bin $\mathcal{X}_{mel}(30, 64)$ and to which unit in the mel scale does the frequency correspond to?

5. **Beating** - Two sinusoids of similar frequency may add up (constructive interference) or cancel out (destructive interference). Let $f_1(t) = \sin(2\pi\omega_1 t)$ and $f_2(t) = \sin(2\pi\omega_2 t)$ be two such sinusoids with distinct but nearby frequencies $\omega_1 \approx \omega_2$. In the following figure, for example, $\omega_1 = 1$ and $\omega_2 = 1.1$ is used.

   The figure also shows that the superposition $f_1 + f_2$ of these two sinusoids results in a function that looks like a single sine wave with a slowly varying amplitude, a phenomenon also known as *beating*. Determine the rate (reciprocal of the period) of the beating in dependency on $\omega_1$ and $\omega_2$. Compare this result with the plot of $f_1 + f_2$ in the figure.
   **Hint**: Use the trigonometric identity $\sin(a) + \sin(b) = 2\cos\left(\frac{a-b}{2}\right)\sin\left(\frac{a+b}{2}\right)$ for $a, b \in \mathbb{R}$.




6. In the below spectrogram one can notice vertical stripes at $t = 0$ and $t = 1$. Why?