LING 190 Lecture 0 - Introduction

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1 Speech Acoustics

1.1 Basic Terminology

- Transverse Waves: Not soundwaves
- Longitudinal Waves: Back and forth movement of particles, which is a transfer of energy from one particle to another. Motion is linear.
- Periodic sounds: Pressure wave of a specific shape is repeated (think tone)
- Aperiodic: No repeating pattern (think white noise)
- Transient Aperiodic Sounds: Aperiodic sounds that last for a short time.
  - Think the "ch" sound in "speech"

1.1.1 Some Lawful Relations

Wavelength (λ) is a measure of distance (in metres)
Period (P) is a measure of time (in seconds)
Frequency (f) is a measure of cycles per second (in Hz, s^{-1})

$$f = \frac{\text{speed of sound}}{\lambda}.$$

$$\lambda = \frac{\text{speed of sound}}{f}.$$

$$P = \frac{1}{f}.$$

1.1.2 Three kinds of information useful for describing periodic sound waves

1. Frequency: Cycles per second, or Hz, which we perceive as pitch
2. Amplitude: Displacement of the wave (not the same as intensity or loudness)
3. Phase: How a wave starts
   (a) Note: we do not perceive phase
   (b) Basically the offset or angle of the wave from the x-axis, at the start of the wave.

1.2 Frequency

- Lower frequency = lower pitch
- Higher frequency = higher pitch
- Humans hear a wide range of frequencies, roughly from 20 Hz to 20,000 Hz

1.3 Loudness

- Not the same thing as amplitude
- Frequency **and** amplitude affect loudness (total amount of "energy" in a wave)
- Measured in dB (decibels/decibel scale)
- deci = 1/10th of a Bel (Named after Alexander Graham Bell)

$$L_p = 20 \log_{10} \left(\frac{p_{\text{rms}}}{p_{\text{ref}}} \right) dB.$$

- This measure is a ratio of sound energy over area (Watts/Metre Squared) = "sound pressure level" (SPL).
- The Decibel Scale is a logarithmic scale.
- For human hearing of loudness, a "referencd" SPL is used (**i.e.** p_{ref} is the *lowest* threashold of human hearing)

1.3.1 Example

60dB SPL is 1,000 times louder than the threshold of human hearing.

Loudness (in dB SPL)

$$\begin{aligned} &= 20 \times \log_{10}(1000 p_{\text{rms}}/p_{\text{ref}}) \\ &= 20 \times \log_{10}(1000) \\ &= 20 \times 3 \\ &= 60\text{dB} \end{aligned}$$

2 Digitizing Sound

Sound is a continuous, analog signal, but we listen to digital sound all the time. Digital sound is ultimately coded as discrete units, or bits.

The sampling rate (in seconds) is how often you record information. The sampling rate should be faster than the period of the fastest frequency you would like to be able to measure (otherwise you will have **aliasing errors**).

The **Nyquist Limit** is the highest frequency without any aliasing, which is equal to $\frac{1}{2}$ of the sampling rate. Since humans can hear up to about 20,000 Hz (20 kHz), we set the industry-standard sampling rate to 44.1 kHz.