

Compression and Decompression of Audio Data via FFT

1. MOTIVATION: to compress audio data, reduce transmission bandwidth requirements and reduce memory storage requirement; to filter out the dominant noise in certain range.
2. REQUIREMENTS:
 - (a) efficiency : real-time compression on the one side and real-time decompression on the other side
 - (b) accuracy: loss control
 - (c) filtering: noise reduction or removal
3. EXISTING STANDARDS include MPEG, GSM (in Europe), VSELP , CELP
4. TRANSFORM-BASED DATA COMPRESSION TECHNIQUES
 - (a) Fast Fourier Transforms (FFT), including fast Cosine transforms (DCTs) and fast Sine transforms (FSTs),
 - (b) Fast Wavelet Transform (FWT).

5. DATA IN THE PROCESS

- (a) original audio signal of length L

$$v = [v(n), | n = 0 : L - 1],$$

provided in MATLAB files.

- (b) data segments of length $N < L$,

$$v_m = [v(m \cdot N + n), | m = 0 : \lceil L/N \rceil - 1, n = 0 : N - 1].$$

- (c) transformed and compressed data segments of length $D < N$ via FFT

$$s_m = [s(m \cdot D + d), | m = 0 : M - 1, d = 0 : D - 1], \quad M = \lceil L/N \rceil,$$

- (d) reconstructed signal of length L

$$\hat{v} = [\hat{v}(n) | n = 0 : L - 1.]$$

6. Performance measurement

- (a) the signal-to-noise ratio (SNR)

$$SNR = 10 \cdot \log \left(\frac{\|v\|_2^2}{\|e\|_2^2} \right) dB, \quad e = v - \hat{v},$$

and

$$SNRSG(m) = 10 \cdot \log \left(\frac{\|v_m\|_2^2}{\|e_m\|_2^2} \right) dB, \quad e_m = v_m - \hat{v}_m.$$

- (b) the average segmental signal-to-noise ratio (AVSNRSG).

$$AVSNRSG = \frac{1}{M} \sum_{m=0}^{M-1} SNRSG(m) dB.$$

- (c) compression ratio.

7. Implementation, Investigation and Presentation

- (a) Describe the compression ratio in terms of D and N .
- (b) Provide a compression policy for selecting D among N spectrum values, for a given D .
- (c) Provide a criterium for selecting D and N with respect to a given threshold on SNR.
- (d) Give a complexity analysis for compression and decompression using FFT.
- (e) For each provided audio data, present a performance evaluation table with different values of D and two or three different compression strategies.
- (f) ref. script file `AudioCompression.m`