Introduction to Audio Signal Processing for Music Applications

Xavier Serra
Music Technology Group
Universitat Pompeu Fabra, Barcelona
http://mtg.upf.edu

Index

- What is audio signal processing?
- Applications areas: storage, level compression, data compression, enhancement, effects and transformations, synthesis, description
-

What is audio signal processing?

- Definition: Intentional alteration of sound.

- As audio signals may be electronically represented in either digital or analog format, signal processing may occur in either domain. Analog processors operate directly on the electrical signal, while digital processors operate mathematically on the binary representation of that signal.

Analog versus digital signals

- An analog representation is usually electrical; a voltage level represents the air pressure waveform of the sound.

- A digital representation expresses the pressure waveform as binary numbers. This permits signal processing using microprocessors and computers. Although such a conversion can be prone to loss, most modern audio systems use this approach as the techniques of digital signal processing are much more powerful and efficient than analog domain signal processing.

Application areas

- Storage
- Level compression
- Data compression
- Enhancement
- Effects and transformations
- Synthesis
- Description

Application: Storage

- Sound recording and reproduction is an electrical or mechanical inscription and re-creation of sound waves.
- The two main classes of sound recording technologies are analog recording and digital recording.

Application: Level compression

- Dynamic range compression, also called DRC or simply compression, is a process that reduces the dynamic range of an audio signal, that is, narrows the difference between high and low audio levels or volumes.

- Compression is commonly used during sound recording, live sound reinforcement, and broadcasting.

Application: Data compression

- Designed to reduce the transmission bandwidth requirement of digital audio streams and the storage size of audio files.
- Optimized audio lossless and lossy algorithms have been created. Lossy algorithms provide greater compression rates and are used in mainstream consumer audio devices.
- In both lossy and lossless compression, information redundancy is reduced, using methods such as coding, pattern recognition and linear prediction to reduce the amount of information used to represent the uncompressed data.

Application: Enhancement

- Filtering
- Equalization
- Noise cancellation
- Echo or reverb removal
- …

Application: Transformations

- Echo, Reverb
- Flanger, Phaser, Chorus
- Pitch shift
- Time stretching
- Voice effects
- 3D audio effects
- Morphing

Application: Synthesis

- Additive synthesis
- Subtractive synthesis
- Granular synthesis
- Non-linear synthesis: FM, Waveshaping
- Sampling and Spectral synthesis
- Physical modeling

Application: Description

- Low-level: loudness, timbre, pitch, ..
- Mid-level: rhythm, harmony, melody, …
- High-level: genre, emotions, similarity, …

References

- https://en.wikipedia.org/wiki/Audio_signal_processing
- Davide Rocchesso, 2003. *Introduction to Sound Processing.* http://www.theassayer.org/cgi-bin/asbook.cgi?book=522

Credits