Fundamental of Digital Media Design

Introduction to Audio

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Chapter Description

- Aims
  - To understand the concept and characteristic of audio
  - To know about audio format and the usage of audio in multimedia
- Expected Outcomes
  - Able to understand the theory of audio
  - Able to produce and edit audio
- References

  - Nigel &Jenny Chapman, Digital Multimedia, John Wiley & Sons Ltd, 2004, England.
  - Prof. Jeffrey Hass, Chapter Five: Digital Audio, 2013
    http://www.indiana.edu/~emusic/etext/digital_audio/chapter5_digital.shtml
  - Prathima,SlideShare Lecture Note: Sound, 2014

What is Sound?

- Sound is a continuous wave that travels through the air
- The wave is made up of pressure differences
- Sound is detected by measuring the pressure level at al location
- Sound waves have normal wave properties (reflection, refraction, diffraction, etc.)

What is Sound?

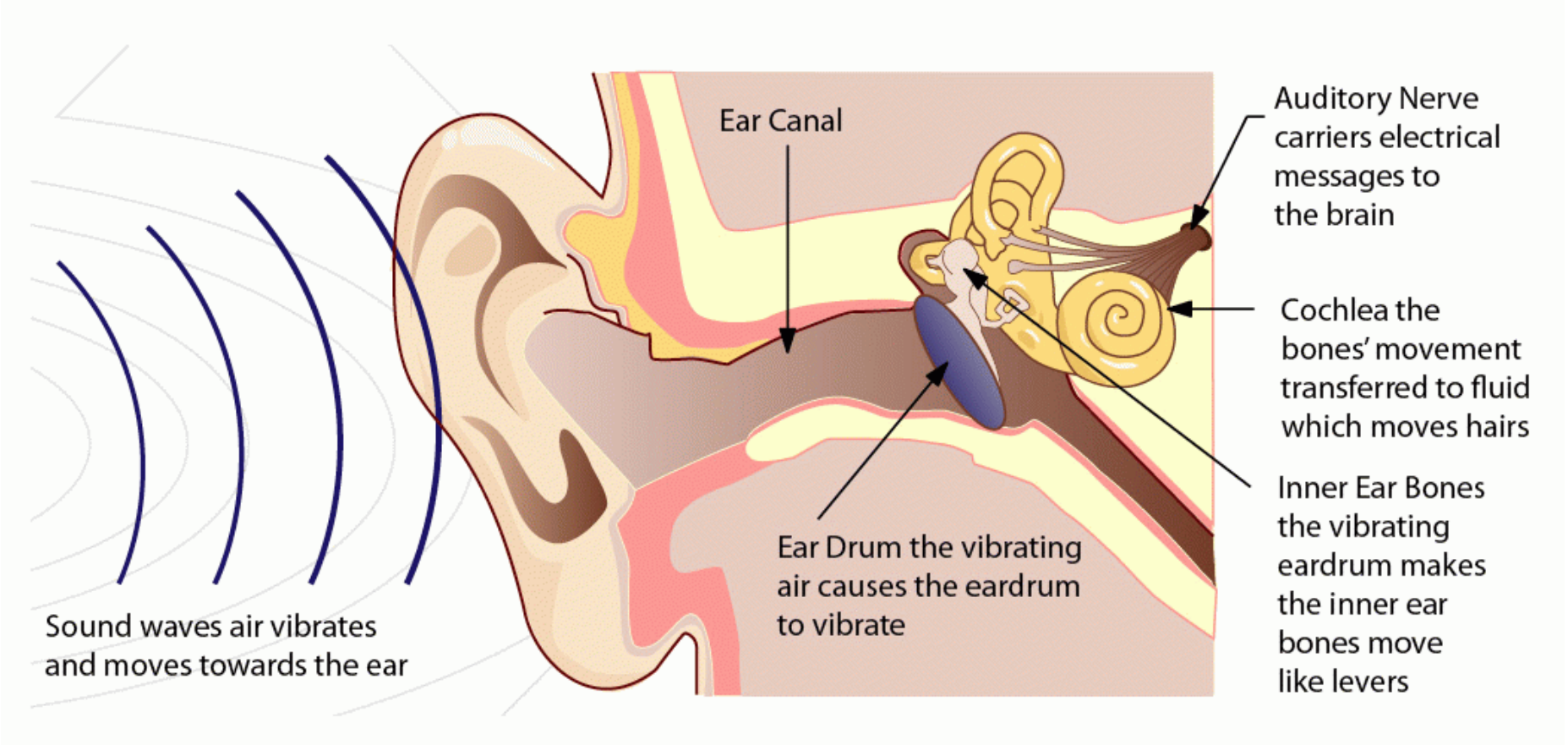


Image source: http://www.soundproofingcompany.com/wp-content/uploads/2011/06/ear_drum_frame-e1447285427283.gif

Wave Characteristics

Frequency

- Represents the number of periods in a second and is measured in hertz (Hz) or cycles per second. Human hearing frequency range: 20Hz to 20kHz (audio)

Amplitude

- The measure of displacement of the air pressure wave from its mean. Related to but not the same as loudness

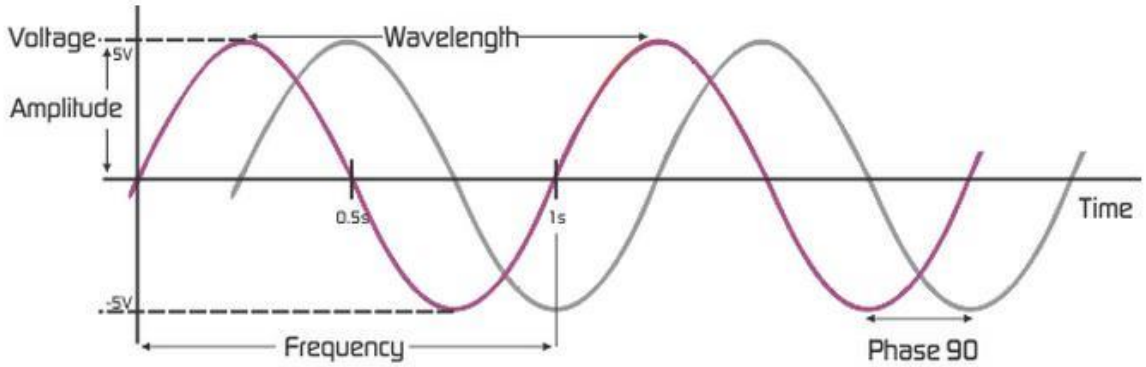


Image source: http://fiberbit.com.tw/wp-content/uploads/2013/07/amplitude-frequency-wavelenght-phase.jpg

Sound in Multimedia

Sound/Audio can be used in multimedia as:

1. Voice over or narration
2. Background music
3. Music
4. Sound effects

The power of Sound

- Sounds can closely ‘touch’ our emotion or feelings.
- Different intonations represent different messages even for the same sentences.
- Some feel-good music powerfully fills the heart, generating emotions of love, etc.
- Animation or video would not seems ‘alive’ without sounds.

Musical Instrument Digital Interface (MIDI)

Musical Instrument Digital Interface (MIDI)

- is a communications standard developed in the 1980's for electronic instruments and computers.
- It allows instruments from different manufacturers to communicate.
- But MIDI data is not digitized, its only music data stored in numeric form.
- Digital Audio is recording where as MIDI is a score.
- Device Independent.

Musical Instrument Digital Interface (MIDI)

- A MIDI file is a list of time stamped commands that are recordings of musical actions.
- Using MIDI, we can easily and quickly compose our own original score.
- The process of creating MIDI is quite different from digitizing a recorded audio.
- For digitized audio we simple need to play the recording through a computer device that can digitally record the sound.
- To make MIDI, we need :
  - Notation Software
  - Sequencer Software
  - Synthesizer
  - MIDI Keyboard

Musical Instrument Digital Interface (MIDI)

- MIDI software creates data about each note as it has been played on a MIDI keyboard
- Which note, how much pressure was put on each key, how much time the sound sustained…….
- This information, when played back through MIDI device , allows the same to be reproduced exactly.

Musical Instrument Digital Interface (MIDI)

Advantages :

- MIDI files are more compact than audio files.
- MIDI is small , can be easily embedded into the web pages.
- If the MIDI sound source is of high quality, this sounds better than audio files.
- MIDI data is completely editable.
- MIDI data can be easily converted to musical notations and vice versa.

Musical Instrument Digital Interface (MIDI)

Disadvantages :

- MIDI does not represent sound, there fore cannot be used for sound production.
- MIDI cannot be easily used to playback a spoken dialog, although expensive and technically tricky digital samplers are available.

Digitising Audio

- Computers cannot understand analog information.
- In order for an analog signal to be understood by a digital device (such as a computer CD or DVD player), it first needs to be digitized or converted into a digital signal by a device called an Analog to Digital Converter or ADC.
- Then for the human ear to be able to hear a digital signal, it needs to be converted back to an analog signal. This is achieved using a Digital to Analog Converter or DAC.

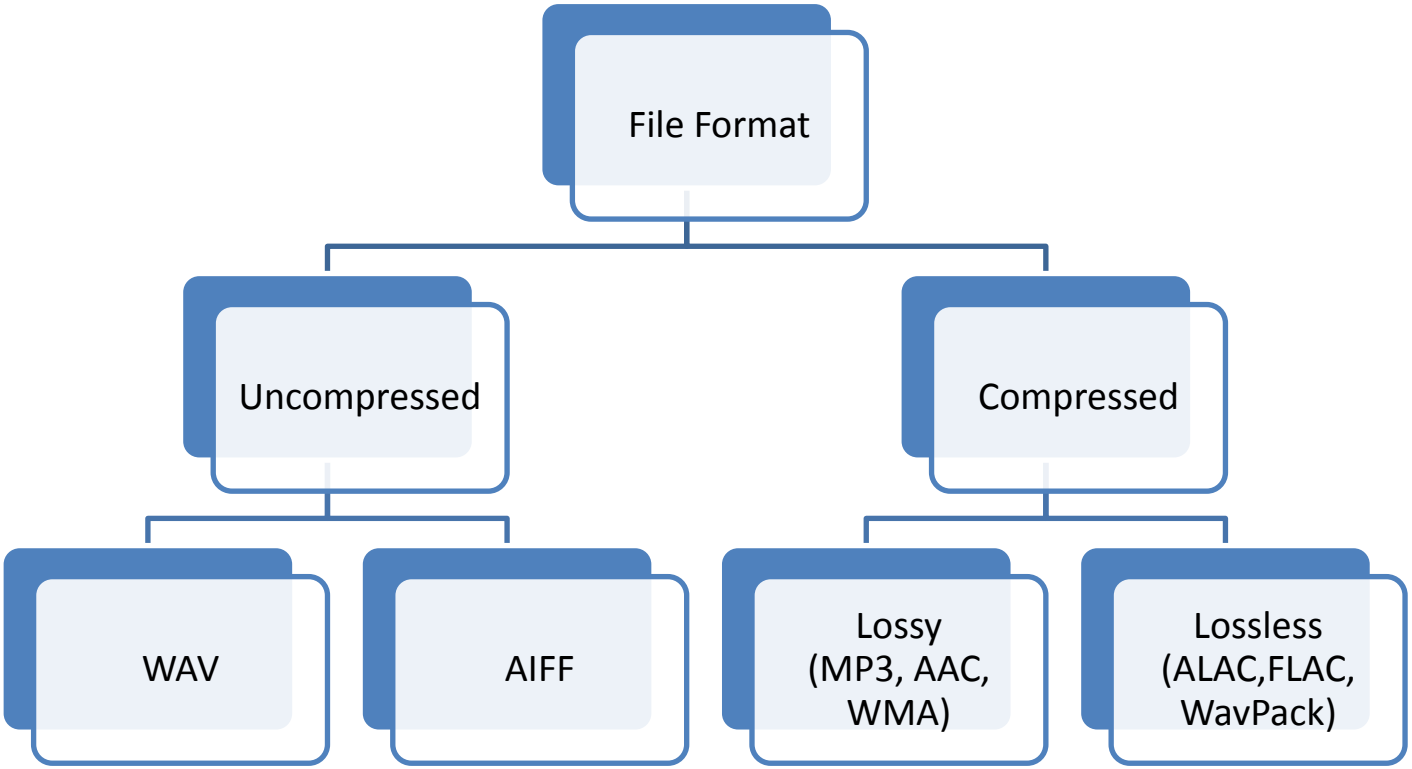
Digital Audio

- Digital audio is created when you represent the characteristics of sound wave using numbers
  - a process referred to as Digitizing.
- We can digitize any sound.(i.e: microphone, synthesizer).
- Digitized sound is sampled sound.
- Every n^{th} fraction of a second, a sample of a sound is taken and stored as digital information in bits and bytes.
- The quality of digital recording depends on the how often the samples are taken:
  - higher the sampling rate better is the quality of sound.

Digital Audio

- Sampling rate is measured in KiloHertz (KHz).
- Three sampling rates are normally used in Multimedia :
  i. 44.1k Hz (CD- Quality)
  ii. 22.05 kHz
  iii. 11.025 kHz.
- Larger the sample size , more accurate data will describe the recorded sound.
- The value of each sample is rounded off to the nearest integer, called Quantization.
- Digital audio uses *pulse-code modulation* (PCM) to represent sampled signals

Audio File Format



Audio File Format

Uncompressed Audio Formats

- Real sound waves that have been captured and converted to digital format without any further processing.
- As a result, uncompressed audio files tend to be the most accurate but take up a LOT of disk space about 34 MB per minute for 24-bit 96 KHz stereo.

Audio File Format

WAV

- WAV stands for Waveform Audio File Format (also called Audio for Windows at some point but not anymore).
- It's a standard that was developed by Microsoft and IBM back in 1991.
- WAV is actually just a Windows container for audio formats
- Most WAV files contain uncompressed audio in PCM format.
- The WAV file is just a wrapper for the PCM encoding, making it more suitable for use on Windows systems.
- However, Mac systems can usually open WAV files without any issues.

Audio File Format

AIFF

- AIFF stands for Audio Interchange File Format.
- Similar to how Microsoft and IBM developed WAV for Windows, AIFF is a format that was developed by Apple for Mac systems back in 1988.
- Most AIFF files contain uncompressed audio in PCM format.
- The AIFF file is just a wrapper for the PCM encoding, making it more suitable for use on Mac systems.
- However, Windows systems can usually open AIFF files without any issues.

Audio File Format

Lossy Compression

- Lossy compression is a form of compression that loses data during the compression process.
- In the context of audio, that means sacrificing quality and fidelity for file size.
- The good news is that, in most cases, you won’t be able to hear the difference.

Audio File Format

Lossy Compression - MP3

- MP3 stands for MPEG-1 Audio Layer 3.
- It was released back in 1993 and quickly exploded in popularity, eventually becoming the most popular audio format in the world for music files
- Nearly every digital device in the world with audio playback can read and play MP3 files, whether we're talking about PCs, Macs, Androids, iPhones, Smart TVs, or whatever else

Audio File Format

Lossy Compression - AAC

- AC stands for Advanced Audio Coding. It was developed in 1997 as the successor to MP3, and while it did catch on as a popular format to use, it never really overtook MP3 as the most popular for everyday music and recording.
- It’s the standard audio compression method used by YouTube, Android, iOS, iTunes, later Nintendo portables, and later PlayStations.

Audio File Format

Lossy Compression - WMA

- WMA stands for Windows Media Audio.
- It was first released in 1999 and has gone through several evolutions since then, all while keeping the same WMA name and extension.
- As you might expect, it’s a proprietary format created by Microsoft

Audio File Format

Lossless Compression

- On the other side of the coin is lossless compression, which is a method that reduces file size without any loss in quality between the original source file and the resulting file.
- The downside is that lossless compression isn’t as efficient as lossy compression, meaning equivalent files can be 2x to 5x larger.

Audio File Format

Lossless Compression - ALAC

- ALAC stands for Apple Lossless Audio Codec.
- It was developed and launched in 2004 as a proprietary format but eventually became open source and royalty-free in 2011.
- ALAC is sometimes referred to as Apple Lossless.
- While ALAC is good, it’s slightly less efficient than FLAC when it comes to compression

Audio File Format

Lossless Compression - FLAC

- FLAC stands for Free Lossless Audio Codec.
- A bit on the nose maybe, but it has quickly become one of the most popular lossless formats available since its introduction in 2001.
- What's nice is that FLAC can compress an original source file by up to 60% without losing a single bit of data.
- What's even nicer is that FLAC is an open source and royalty-free format rather than a proprietary one, so it doesn't impose any intellectual property constraints.

Audio File Format

So Which Format Should You Use?

- If you're capturing and editing raw audio,
  - use an uncompressed format. This way you're working with the truest quality of audio possible. When you're done, you can export to a compressed format.
- If you're listening to music and want faithful audio representation,
  - use lossless audio compression. This is why audiophiles always scramble for FLAC albums over MP3 albums. Note that you'll need more storage space for these

Audio File Format

So Which Format Should You Use?

- If you're okay with "good enough" music quality, if your audio file doesn't have any music, or if you need to conserve disk space,
  - use lossy audio compression. Most people actually can't hear the difference between lossy and lossless compression.

Audio File Size

- File size (in bytes) = a * b * c * d

  a = sampling rate (44.1 KHz, 11 KHz, etc.)

  b = duration or recording in seconds

  c = bit resolution

  d = channel (stereo = 2, mono = 1)

Audio File Size

Calculate file size for → Stereo 48K at 16bit, duration: 36 seconds

Stereo Audio File Size:

= (Sample Rate x Sample Size x Time) x 2

= (48,000Hz x 16 bits x 36 seconds) x 2

= 27,648,000 bits

$$\frac{27,648,000}{8} = 3,456,000 \text{ bytes} \rightarrow \frac{3,456,000}{1024} = 3,375 \text{ KB} \rightarrow$$

$$= \frac{3,375 \text{ KB}}{1024} = 3.29 \text{ MB}$$

Conclusion of The Chapter

- Sound is a continuous wave that travels through the air that made up of pressure differences.
- Sound can be used as narration, music and sound effect in multimedia.
- There various types of audio format thats suits different purpose of the audio.