



National Centre for Computer Animation

Sound Speech and Music 1

If a tree falls down in the woods, does it make a sound if no one is there to hear?



ES Overview

- Introduction to ES
- 2D Graphics in Entertainment Systems
- **Sound, Speech & Music**
- 3D Graphics in Entertainment Systems



Image Perception & 2D Images

- What is Sound?
- Sound Perception
- Sound Analysis



Sound

Sound is created through vibration, causing waves within the medium of air.

Like all waves, sound has three attributes:

- Period
- Frequency
- Amplitude

The speed of sound through air at room temperature (20°C) is 343.4 m/s.



Period

- Period is the interval of time between the recurrence of phases in a sound wave (*wavelength*).
- Periods are usually cyclic (*repeating*), i.e. once one period ends the next begins.

The measure of periodicity is the frequency.



Frequency

Frequency (*measured per second in hertz - Hz*) measures the number of times that a repeated event (*here: the oscillations*) occurs per unit of time.

The longer the wavelength, the lower the frequency, and the lower the sound.



Amplitude

Amplitude is the measure of a wave's magnitude of oscillation (*difference of the extremes*) during one wave cycle (*loudness of sound*).

- For sound waves it refers to the air pressure generated.
- The logarithm of the square of the amplitude is measured in dB

The bigger the difference in the highs and lows of the waves, the louder the sound.



Doppler-Effect

A source of sound moving towards appears to be pitched higher than a source of sound moving away from you

- sound waves moving towards you are more compressed through partial overlap of the signal
- named after Christian Doppler who predicted it in 1842 in regards to colour shifts of stellar objects in astronomy (*movement of stars*)



Human Hearing

1. sound waves “hit” the ear drum
2. the ear bones transfer (& *amplify*) the resulting vibration to the inner ear
3. this stimulates the fluid filled ducts of the cochlea
4. this moves the hair cells inside these ducts, the movement of which causes the auditory nerve to be stimulated



Sound Perception

The human ear can perceive sound waves between 17 Hz and 20 KHz.

Auditory information is processed by the brain.

- direction is extrapolated from the loudness of a sound perceived by both ears
- sound waves arriving in a harmonious series of pitches and ordered rhythmically is often perceived as music



Harmonies

Harmonies are generated by chords, i.e. several sounds of different pitch, sounding simultaneously.

- Harmonies form the basis of music.
- The musical unit for pitch is the octave. The distance between one octave to the next is the doubling/halving of the frequency.
- In music theory, there are several rules for the generation of harmonies, chord sequence etc.
- While usually harmony requires several sounds to sound simultaneously, it can be implied by a quick sequence of linear sounds.



Resonance

Resonance of an acoustic device is its tendency to oscillate if energy of a specific frequency is applied to it.

- This frequency is called the „natural frequency of vibration“ of the device or „resonant frequency“.
- Devices often have more than one resonant frequency.
- This forms the basis for musical instruments, microphones and loudspeakers.



Sound Representation

For entertainment systems the analogue sound waves have to be digitised into a discrete signal.

1. The sound is sampled in fixed intervals (*making a continuous signal discontinuous*).
2. The analogue signal becomes discrete by adding a horizontal raster on top of the sampled values, only allowing certain amplitudes (*quantisation*). This is called the **resolution** of the signal (*which is often expressed as the number of bits that are available for this*).
3. This can be stored in a file (*obviously there will be some data loss*).



Sound Representation

Different sampling rates during digitisation result in different file sizes:

sampling rate (KHz)	resolution	data rate (<i>stereo, Kb/s</i>)	memory requirement / minute
44.1	16	1411	10.6 MB
37.8	8	604.8	4.33 MB
22.05	8	352.8	2.64MB

This explains why a 700 MB CD can hold just over 1 hour of music.



Sound Analysis

When sound is analysed its components are examined:

- period ↔ tempo/speed
- frequency ↔ pitch
- amplitude ↔ volume/loudness

From this we can extrapolate:

- rhythmic patterns
- different sound sources
(*channels/layers*)

