IAT 380: Sound Design

Sound Spatialisation

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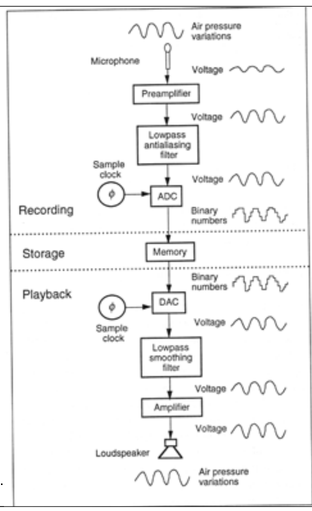
Digitalising sound

- **Overview of the audio digital recording and playback chain**



Sound Design for Moving Images

- **Sound design for moving images can be divided into three domains:**
  - **Speech:**
    - **Naration: Direct, Indirect, Contrapunctual**
    - **Dialogue**
  - **Sound effects:**
    - **Contextual**
    - **Narrative**
  - **Music:**
    - **Production source music**
    - **Source music**
    - **Underscore music**

Sound Design for Moving Images

- The creation of sounds for moving images can be:
  - Synchrone:
    - Foley: create the sound effects in synchronisation with the picture.
    - ADR (Automated Dialogue Replacement): record the dialogue in synchronisation with the picture. Tips: play short loops (in the recording mode) to synchronise the lips with the image
  - Asynchrone:
    - Narration: voice-over (mostly non diegetic, interpreted by a voice actor)
    - Underscores music
    - Sound effects from library

Mixing Techniques

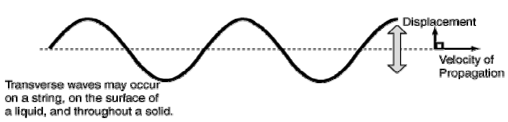
- Mixing music, speech and sound effects:
  - In a mix for radio, TV, film, multimedia, it is frequent that these three elements are simultaneously present
  - A typical spot (radio, TV, …) may call for:
    - Attention getting music at the beginning
    - Faded under during announcement, or narration
    - Re-established to conclude

    A donut
  - Create a hole for the voice over:
    - A change in volume
    - Filtering the frequency range of the voice
- It is also important to position the sounds properly to improve clarity.

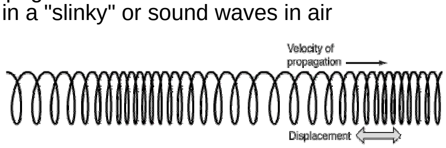
⇒ Sound spatialisation

Sound Spatialisation

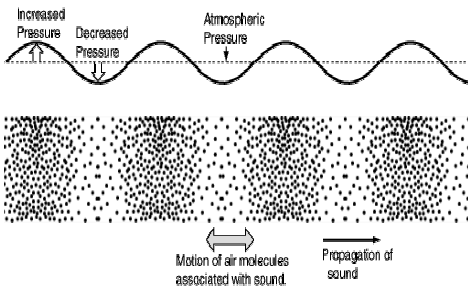
For transverse waves, the displacement of the medium is perpendicular to the direction of propagation of the wave.
Examples: A ripple on a pond and a wave on a string



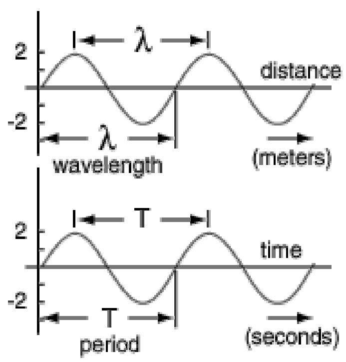
In longitudinal waves the displacement of the medium is parallel to the propagation of the wave.
Examples: wave in a "slinky" or sound waves in air



Sound Spatialisation

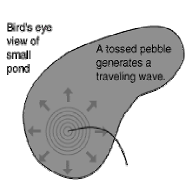


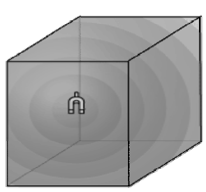
Sound Spatialisation



Spatial Sound

- **A disturbance of the air pressure at a single point produces a spherical traveling pressure wave (sound). A sound wave in air is a longitudinal wave.**





Sound is spatial, sound is 3D

Spatial Sound Perception

- The main cues to determine the angle of afference of a sound:
- Temporal cues:
  - The wavefront is not arriving at both hears at the same time
  - The difference in the time of arrival of the wavefront allows calculating the angle (in fact, the brain is reasoning in term of phase)
  - This is known as the Interaural Time Delay (ITD)
  - The precedence effect
- Amplitude cues:
  - Extra distance travelled plus screening effect of the head.
  - This is known as the Interaural Level Difference (ILD)

Spatial Sound Perception

- Spectral cues:
  - The shape of your head and your ears are filtering the sound (especially the high frequencies).
  - This is known as Head related Frequency Response (HRFR)
  - This is the main mechanism when ILD and ITD give ambiguous results (e.g. for signals in the median plan)
  - Help for front-back positioning and azimuth
  - Note that trebles are always perceived as “light” and coming from the top while the basses are “heavy” and close to the ground.
- Head movement:
  - Check if ITD and ILD are increasing or decreasing
  - This is mainly how we distinguish front and back

Spatial Sound Perception

- Main cues for the perception of distance:
  - The fall of loudness with distance
  - Ratio of direct to reverberant sound
  - Pattern and directions of early delays
  - Higher frequencies drop with distance (due to the absorption of moisture by the air)
- These are all dependant on the knowledge of both the spectra and loudness of the sound source.
- This is true in general for sound spatialisation:
  - Foot steps would generally be more precisely located than abstract sounds
- Visual cues: no matter what you do, the voice of a visible character will be associated to him.

Techniques of Sound Spatialisation

- The various types of spatial sound reproduction techniques developed over the years can be classified as either:
  - Perception simulation:
    - Aim to reproduction of what the ears would hear in a natural situation
    - Examples: Binaural sound, n-channel stereophony, Dolby surround, etc.
  - Sound-field simulation:
    - Aims to reproduce the actual sound field.
    - Examples: Beam forming, wave field synthesis, Ambisonic surround, etc.

Techniques of Sound Spatialisation

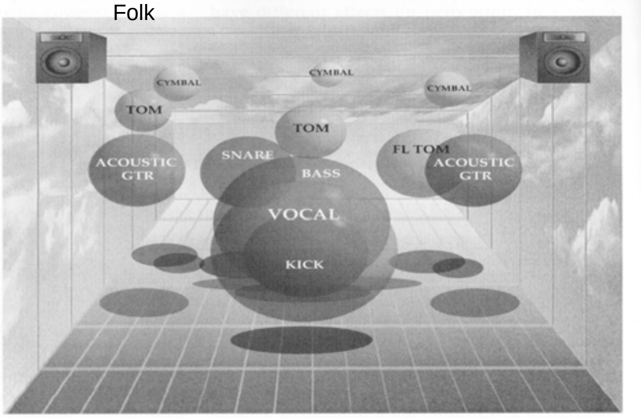
- Monophony:
  - Telephone, radio AM
- Stereophony:
  - CD, Tv, radio FM, ...
  - Dolby stereo (LR): introduced for film in 1976
- Multiphony:
  - 4.1: quadriphony (concert, ...)
  - 5.1: Home cinema, DVD
  - 7.1: DVD
  - 9.1
  - 24.2: electroacoustic concerts
  - Acousmonium: electroacoustic concerts

Techniques of Sound Spatialisation

- 2-stereo signal (LR):
  - Covers a sound stage (usually in front of the listener)
  - Defines an horizontal plan between the speakers
  - Panning (intensity control) can be used to “position” sounds
  - Phase can also be used
  - Limited to a speakers' separation of about 60 degree, otherwise you start loosing the central phantom image
- Increasingly poor performances as the listener moves off the central axis
- Difficulty with image stability when the listener head or body is moving

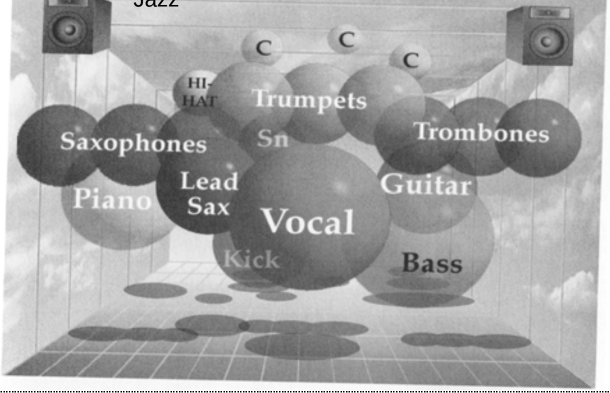
Techniques of Sound Spatialisation

Folk

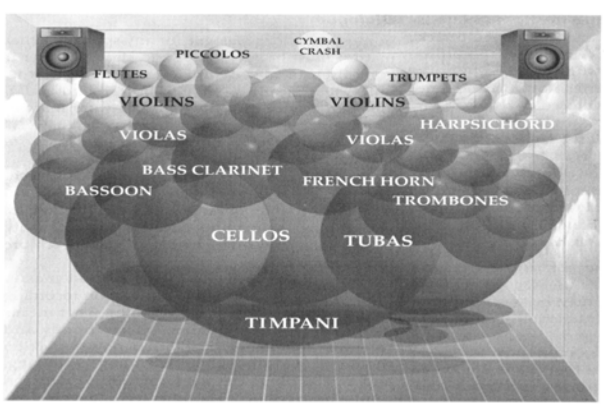


Techniques of Sound Spatialisation

Jazz



Techniques of Sound Spatialisation



Techniques of Sound Spatialisation

- **3-stereo (LCR, left, center, right):**
  - **The central image is not a phantom anymore (so it is more stable)**
- **5.1 (Cinema surround, Dolby surround, ...):**
  - **The central channel is used to lock the dialogues to the screen and improve performance for off-centre listeners (it also improves intelligibility when compared to stereo presentation)**
  - **Surround speakers: diffuse ambient sounds and sound effects and are meant to fool perception by making the listener believe that there are sound all around her**
  - **Low frequency effects: many sound effects have substantial low frequency components**
- **N-stereo: generalisation**

Techniques of Sound Spatialisation

- **Binaural**:
  - Reproduction of what the ears would hear in a natural situation
  - Better with headphones but can also be done with loudspeakers
  - Recordings are done with a dummy head with microphones in its ears
  - Or playback is using head related transfer functions HRTF (one per ear) to simulate:
    - Individuals (synthetic or natural)
    - Averaged for many listeners
  - Sometimes complemented with head tracking (help to correct front-back reversal errors)

Can be very convincing

Techniques of Sound Spatialisation

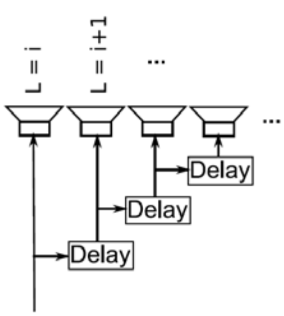
- Computationally intense if one want a realistic result:
  - With speakers it is less efficient because of:
    - Crosstalk (the too signals are not isolated as in a headset)
    - The position of the listener is important
- Still it has been applied industrially (sound cards, ...)
  - You can search the web to listen to a number of examples (with your headphones)

Techniques of Sound Spatialisation

- **Ambisonic surround sound:**
  - Special format (quite controversial)
  - Try to simulate the sound field
  - Unlike stereo, all the speakers are working together
  - The most common configurations use either 4 (plan) or 8 (3D) speakers.
  - In the 3D, each sound is encoded/decoded as a set of:
    - Overall pressure levels
    - Up-down velovity
    - Front-back Velocity
    - Left Right Velocity

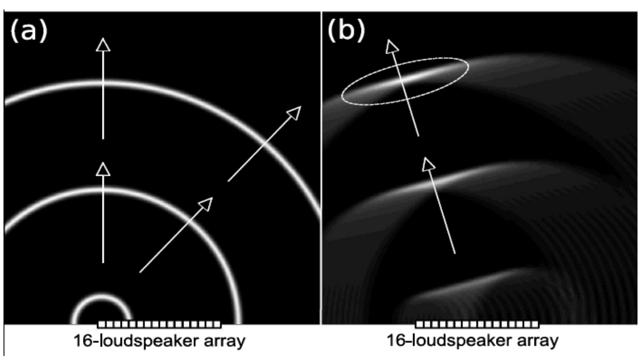
Techniques of Sound Spatialisation

- **Beamforming**

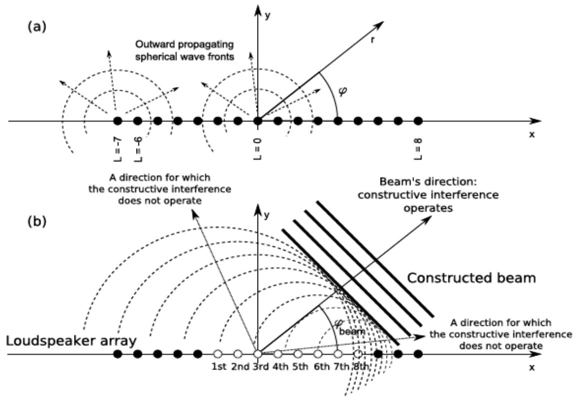


Techniques of Sound Spatialisation

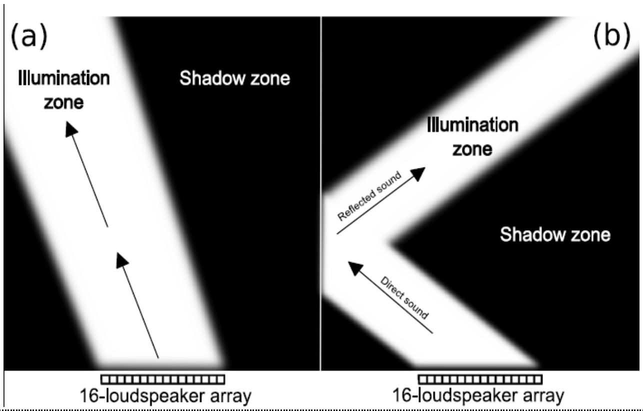
- **Beamforming**



Techniques of Sound Spatialisation

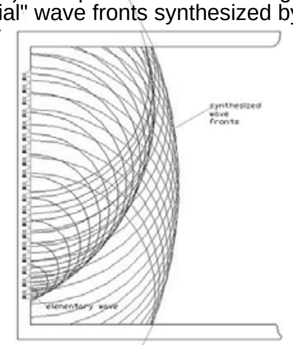


Techniques of Sound Spatialisation



Techniques of Sound Spatialisation

Wave field synthesis (WFS) is a spatial audio rendering technique producing "artificial" wave fronts synthesized by a large number of individually driven speakers.



Contrary to traditional spatialization techniques such as stereo, the localization of virtual sources in WFS does not depend on or change with the listener's position.

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“Music is the poetry of the air.”

Jean Paul Friedrich Richter