Acoustics II: recording technique

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stereo recording
Stereo recording: Patent Blumlein, 1931

- in a real listening experience in a room, different contributions are perceived with directional information → allows for a separation of direct sound and reflections
- thus a suitable recording method has to provide directional information
- two channels are needed to offer different signals to the two ears
Stereo recording: principle

- evaluation of directional information by the ear:
  - level differences between the ear drums left and right
  - time of arrival differences between the ear drums left and right
Stereo recording: principle

directional information due to level differences at the ear drums
Stereo recording: principle

directional information due to time of arrival differences at the ear drums
Stereo recording: principle

- **direct** stereo signal recording:
  - two appropriately mounted microphones:
    - intensity stereophony
    - time of arrival stereophony
    - mixed stereophony

- **indirect** stereo signal recording:
  - signals of several distributed directional microphones summed up to left and right stereo channels
intensity stereophony
XY arrangement
**XY arrangement**

- two cardioid capsules
- orientation: 65° each, relative to frontal direction (opening angle: 130°)
- capsules close to each other
XY arrangement

correct

wrong
XY arrangement

- **advantage:**
  - good suppression of sources on the rear side

- **disadvantage:**
  - frontal direction does not correspond to microphone axis → non ideal "off-axis" frequency response
MS arrangement
MS arrangement

- one omni (or a cardioid) and one figure of eight microphone
  - omni → Mid
  - figure of eight → Side
- capsules close to each other
MS arrangement

- stereo signal is formed as:
  - left = M + $\beta \cdot S$
  - right = M - $\beta \cdot S$
- $\beta$ adjusts the opening angle
MS arrangement

- advantages:
  - opening angle can be adjusted electronically
  - with high quality storing media, recording of $M$ and $S$ for later formation of left and right (opening angle remains adjustable)

- disadvantage:
  - high sensitivity for rear sided sources
Blumlein arrangement
Blumlein arrangement

- two figure of eight microphones
- $90^\circ$ different orientation
- capsules close to each other
Blumlein arrangement

- advantages: -
- disadvantages:
  - high sensitivity for rear sided sources
  - low frequency weakness of figure of eight microphones
time of arrival stereophony
AB arrangement
AB arrangement

- two omnis
- laterally separated by typically 20 cm
AB arrangement

- increased lateral separation for larger distances to the source
- often used for recording of classical music in churches and concert halls
- advantage:
  - omnidirectional microphones with excellent properties available
- disadvantage:
  - high sensitivity for rear sided sources
mixed stereophony
ORTF arrangement
ORTF arrangement

- two cardioid microphones
- orientation: 55° each, relative to frontal direction (opening angle: 110°)
- laterally separated by 17 cm
ORTF arrangement

▶ advantage:
  ▶ phantom sources distributed homogeneously on stereo basis

▶ disadvantage:
  ▶ frontal direction does not correspond to microphone axis → non ideal "off-axis" frequency response
Jecklin disc
Jecklin disc

- two omnis
- laterally separated by 17 cm
- separating disc of 30 cm in diameter in between
Jecklin disc
Jecklin disc

- **advantage:**
  - omnidirectional microphones with excellent properties available

- **disadvantages:**
  - problem of comb filter in case of insufficient absorption of the disc
  - high sensitivity for rear sided sources
Binaural stereophony
Binaural stereophony

- two omnis
- mounted at position of ear drums in an artificial head
Binaural stereophony

- correct frequency response distortions due to outer ear and ear canal (head related transfer function)
- suitable for play-back by headphones, optimal if headphone is compensated for transfer function
- headphone-membrane → ear drum
- excellent reproduction of spacial impression
- however, front-back localization not always perfect (visual information is missing)
- caution: unsuitable for reproduction by loudspeakers (head related transfer function occurs two times)
Binaural stereophony: localization test
(JAES, vol. 47, p.83, 1999)

- experiment:
  - listener sitting in a highly damped room, RT about 0.3 sec
  - 19 visible loudspeakers arranged around listener
  - listener has to identify active speaker → localization accuracy

- procedure:
  - phase 1: reproduction by real speakers
  - phase 2: binaural recording with artificial head and reproduction by headphones
Binaural stereophony: localization test

results for loudspeaker reproduction:
Binaural stereophony: Ortungstest
results for binaural recording and headphone reproduction:
demo: spacial mapping of various recording arrangements
demo: spacial mapping

(CD: Stereo Microphone Technique)

<table>
<thead>
<tr>
<th>3 m</th>
<th>1.5 m</th>
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20 cm

clicks radiated by one speaker after the other
Demo: spatial mapping

various stereo microphone arrangements:

A  B  C  D
Demo: spacial mapping

various stereo microphone arrangements:

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microphone positioning
microphone positioning

- a recording aims at capturing:
  - the source signal
  - information about the room

- strategies:
  - stereo microphone pair
  - stereo microphone pair + room microphone
  - distributed microphones
Stereo microphone pair

▶ find optimal distance to source!
▶ if distance is too small:
  ▶ recording too dry
  ▶ extended source (orchestra) if mapped inhomogeneously
▶ if distance is too large:
  ▶ recording too reverberant and too blurry
▶ optimal distance for strength direct sound \( \approx \) strength diffuse sound
  ▶ \( \rightarrow \) critical distance
▶ caution: sources or microphones with pronounced directivity enlarge the critical distance
Stereo microphone pair + room microphone

- stereo microphone pair relatively close to the source
- room microphone (omni) in the diffuse field
- balance between direct and diffuse sound adjustable during mixing
Distributed microphones

- separate microphones for each instrument or group of instruments
- left-right mapping with help of panorama control
- distance mapping by adding artificial reverberation
- difficulties:
  - interferences between the signals of different microphones (large level differences between mics necessary)
  - early reflections at surfaces → comb-filter effects (solution: pressure zone microphones)
demo microphone positioning
demo microphone positioning

(CD: United Music of Marantz I)

different microphone arrangements:

A
B
C
demo microphone positioning

(CD: United Music of Marantz I)
different microphone arrangements:

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surround sound recordings
surround sound recordings

- capabilities of Stereo:
  - generation of phantom sources within a listening angle of $60^\circ$
  - good direct sound reproduction of the sources on stage

- capabilities of Surround:
  - listening angle: $360^\circ$
  - good direct sound reproduction of the sources on stage
  - reproduction of rear lateral reflections $\rightarrow$ accurate room information
surround sound recordings: format

- most common format: 5.1 (developed for movie theatres)
  - 6 discrete channels:
    - Front Left
    - Front Right
    - Front Middle
    - Rear (Surround) Left
    - Rear (surround) Right
    - LFE (low frequency effects: 20...120 Hz)
Surround sound recordings: perspectives

- direct/ambient
  - perspective of listener in the audience

microphone arrangement:
  - front channels: stereo microphone pair
  - surround channels: more distant omnis or cardioids oriented to rear side
Surround sound recordings: perspectives

- inside the band
  - musicians perspective

- microphone arrangement:
  - front channels: distributed microphones
  - surround channels: distributed microphones for each group of instruments
assessment of recording quality
assessment of recording quality

- Guideline: EBU (European Broadcasting Union), Tech. 3286, 1997
- assessment categories:
  - Spatial impression
  - Stereo impression
  - Transparency
  - Sound balance
  - Timbre
  - Freedom from noise and distortions
assessment of recording quality

- **Spatial Impression** (reproduction of plausible environment):
  - homogeneity of spatial sound
  - reverberance
  - acoustical balance
  - apparent room size
  - depth perspective
  - sound color of reverberation

- sound example criterion **reverberance**:
  - too dry
  - too reverberant
  - appropriate
assessment of recording quality

- **stereo impression** (reproduction of correct and plausible directions of the sources):
  - directional balance
  - stability
  - sound image width
  - location accuracy

- **sound example** *sound image width*:
  - too narrow
  - too wide
  - appropriate
assessment of recording quality

- **transparency** (reproduction can be heard in all its details):
  - sound source definition
  - time definition
  - intelligibility

- sound example: *sound source definition*:
  - muddy
  - clear
assessment of recording quality

- **sound balance** (all sources appear with comparable loudness):
  - loudness balance
  - dynamic range

- sound example: *loudness balance*:
  - trombone too weak
  - trombone too loud
  - trombone appropriate
assessment of recording quality

- **timbre** (correct reproduction of the characteristics of the sources):
  - sound colour
  - sound attack

- sound example: *sound attack*:
  - attacks are not precise
  - precise attacks
assessment of recording quality

- **freedom from noise and distortions** (no audible noise components or distortions):
  - sound example *noise*:
    - noise by audience