Eidgenössische Technische Hochschule Zürich
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Acoustics II: recording techniques

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stereo recording

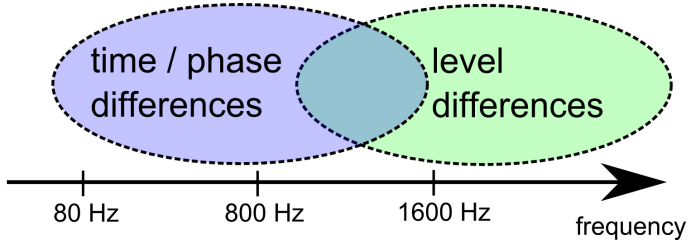
Stereo recording: Patent Blumlein, 1931

- in a real listening experience in a room, different contributions are perceived with directional information $\rightarrow$ 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

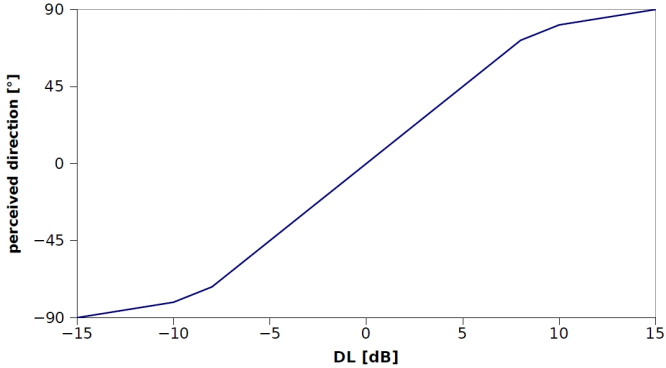
- evaluation of directional information by the ear:
  - level differences between left and right ear drum
  - time of arrival differences between left and right ear drum
- $\rightarrow$ frequency dependency?

Stereo recording: principle



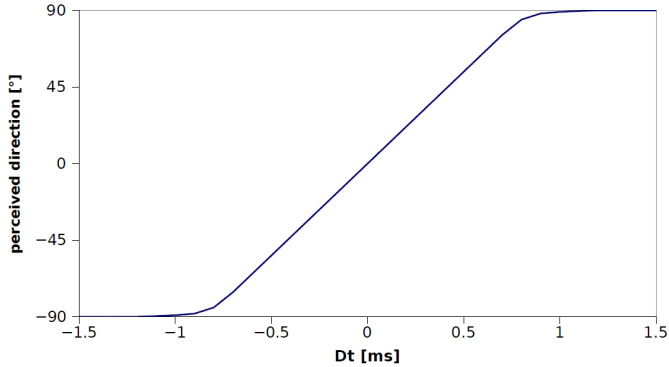
Stereo recording: principle

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 suitably mounted microphones:
    - intensity stereophony
    - time of arrival stereophony
    - mixed stereophony
- *indirect* stereo signal recording:
  - signals of several distributed microphones are summed up to left and right stereo channels

Stereo recording: principle

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  - two suitably mounted microphones:
    - intensity stereophony
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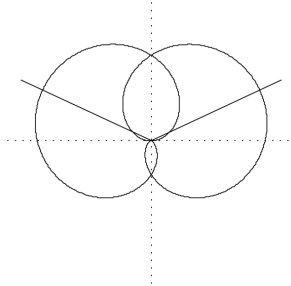
- *indirect* stereo signal recording:
  - signals of several distributed microphones are summed up to left and right stereo channels

intensity stereophony

XY arrangement

XY arrangement

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



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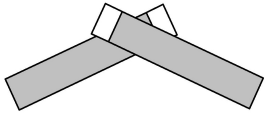
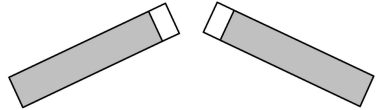


correct



wrong

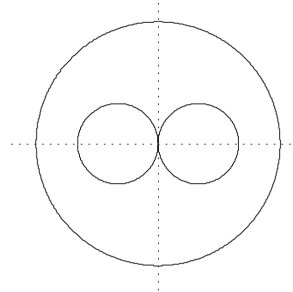
XY arrangement

- advantage:
  - substantial suppression of rear-side sources
- disadvantage:
  - frontal direction does not correspond to microphone axis $\rightarrow$ non ideal "off-axis" frequency response

MS arrangement

MS arrangement

- one omni (or a cardioid) and one figure of eight microphone
  - omni $\rightarrow$ *M*id signal
  - figure of eight $\rightarrow$ *S*ide signal
- capsules very close to each other



MS arrangement

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

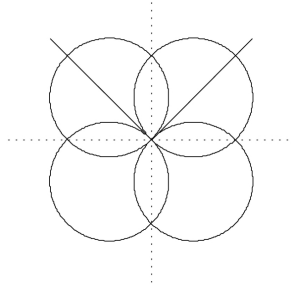
MS arrangement

- advantages:
  - opening angle can be adjusted electronically ($\rightarrow \beta$)
  - with high quality storage media, *M* and *S* can be recorded for subsequent formation of *left* and *right* (opening angle remains adjustable)
- disadvantage:
  - high sensitivity for rear-side sources

Blumlein arrangement

Blumlein arrangement

- two figure of eight microphones
- 90° differing orientation
- capsules very close to each other



Blumlein arrangement

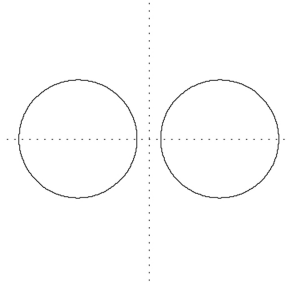
- advantages: -
- disadvantages:
  - high sensitivity for rear-side sources
  - low frequency weakness of figure of eight microphones

time of arrival stereophony

AB arrangement

AB arrangement

- two omnis
- laterally separated by typically 20 cm



AB arrangement

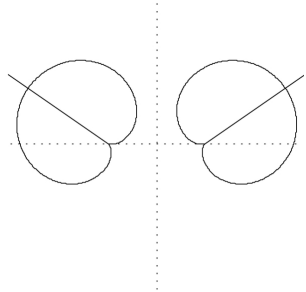
- increased lateral separation for larger distances to the source
- often used for recordings of classical music in churches and concert halls
- advantage:
  - omnidirectional microphones with excellent properties can be used
- disadvantage:
  - high sensitivity for rear-side sources

mixed stereophony

ORTF arrangement

ORTF arrangement

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



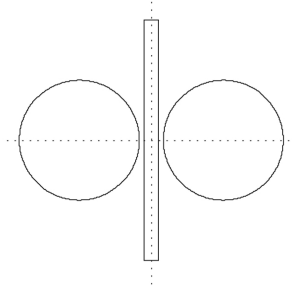
ORTF arrangement

- advantage:
  - phantom sources are distributed homogeneously on stereo basis
- disadvantage:
  - frontal direction does not correspond to microphone axis $\rightarrow$ non ideal "off-axis" frequency response

Jecklin disc

Jecklin disc

- two omnis
- laterally separated by 18 cm
- separating disc of 30 cm in diameter in between



Jecklin disc

Jecklin disc

- advantage:
  - usage of omnidirectional microphones with excellent properties
- disadvantages:
  - problem of comb filter in case of insufficient absorption of the disc
  - high sensitivity for rear-side 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 head, outer ear and ear canal (head related transfer function)
- suited for play-back by headphones, optimal if headphones are compensated for transfer function membrane $\rightarrow$ ear drum
- excellent reproduction of spacial impression
- however, front-back localization is not always perfect (visual information is missing, no information from head rotations)
- caution: can't be used for reproduction by loudspeakers (head related transfer function occurs twice)

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Binaural stereophony: localization test (JAES, vol. 47, p.83, 1999)

- experiment:
  - listener is sitting in a highly damped room, RT$\approx$ 0.3 sec
  - 19 visible loudspeakers arranged around listener
  - task: listener has to identify active speaker $\rightarrow$ localization accuracy
- procedure:
  - phase 1: reproduction by real speakers
  - phase 2: binaural recording with artificial head and reproduction by headphones

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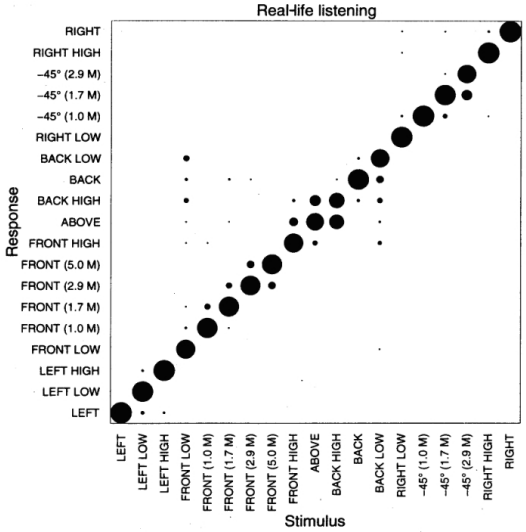
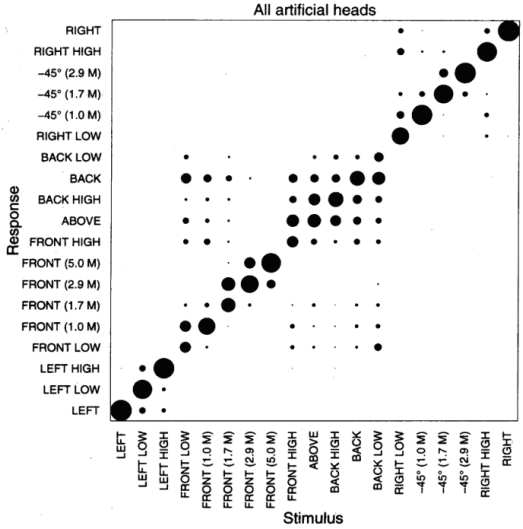
Binaural stereophony: localization test

results for loudspeaker reproduction:



Binaural stereophony: localization test

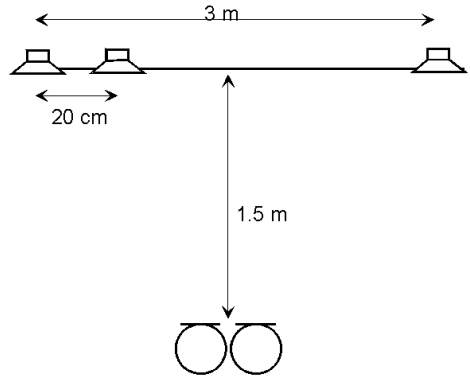
results for binaural recording and headphone reproduction:



sound demo: spacial mapping of various stereo microphones

demo: spacial mapping

(CD: Stereo Microphone Technique)



clicks radiated by one speaker after the other

Demo: spacial mapping

various stereo microphones:

A
B
C
D

Demo: spacial mapping

various stereo microphones:

A	XY
B	AB
C	MS
D	ORTF

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

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stereo microphone pair

- identify optimal distance to source
- if distance is too small:
  - recording too dry
  - extended source (orchestra) is mapped inhomogeneously
- if distance is too large:
  - recording too reverberant and too blurry
- optimal distance: strength direct sound $\approx$ strength diffuse sound
  - $\rightarrow$ critical distance
- caution: sources or microphones with pronounced directivity enlarge the critical distance

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stereo microphone pair + room microphone

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

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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)

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sound demo microphone arrangement and positioning

demo microphone arrangement and 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:

A	XY
B	Jecklin
C	distributed microphones

surround sound recordings

surround sound recordings

- capabilities of stereo:
  - generation of phantom sources within a listening angle of 60°
  - good direct sound reproduction of the sources on stage
- capabilities of surround:
  - listening angle: 360°
  - good direct sound reproduction of the sources on stage
  - reproduction of rear lateral reflections → more accurate room information

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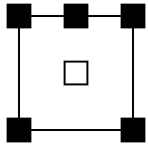
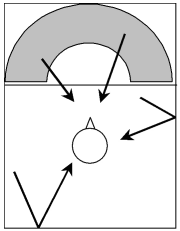
surround sound recordings: format

- 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

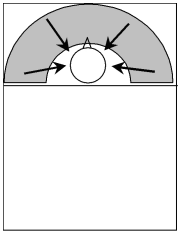
- direct/ambient
  - perspective of a listener in the audience area



- microphone arrangement:
  - front channels: stereo microphone pair
  - surround channels: more distant omnis or cardioids pointing to rear side

surround sound recordings: perspectives

- inside the band
  - musicians / conductor's 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 (*E*uropean *B*roadcasting *U*nion), 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 for 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 for criterion *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 for criterion *sound source definition*:
  - muddy
  - clear

assessment of recording quality

- sound balance (all sources appear with correct loudness):
  - loudness balance
  - dynamic range
- sound example for criterion *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 for criterion *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 for criterion *noise*:
  - noise by audience

eth-acoustics-2