National Institute of Information and Communications Technology

Near 3D Sound Field Reproduction System Using Directional Loudspeakers and Wave Field Synthesis

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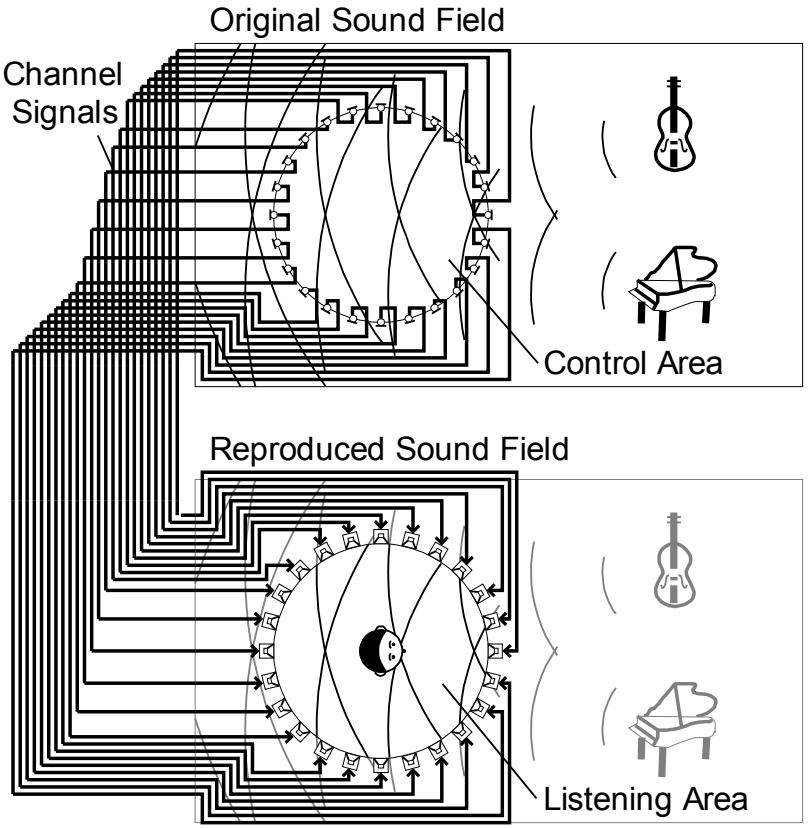
Ultra-Realistic Communication

- Future 3D television
  - 3D video and audio appear in a 3D space
  - People view an object anywhere in its vicinity
    - Without glasses
  - 3D sound field reproduction systems without headphones must be developed

Wave Field Synthesis (WFS) System

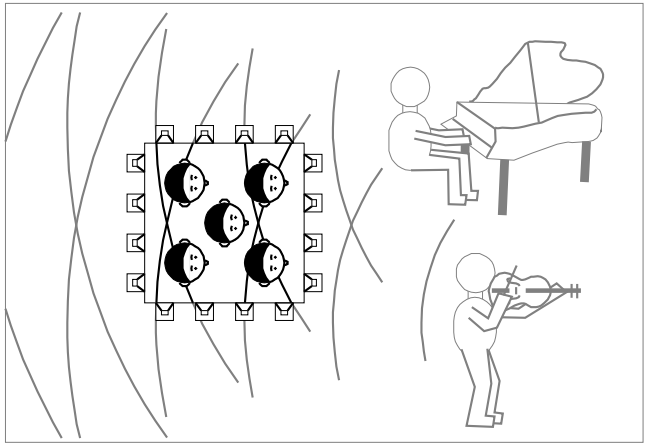
- Multiple listeners can listen to a sound without headphones
- Original sound field
  - Sound is recorded by the microphone array
- Reproduced sound field
  - Recorded sound is played by the loudspeaker array
  - 3D sound field is reproduced based on Kirchhoff-Helmholtz integral equation



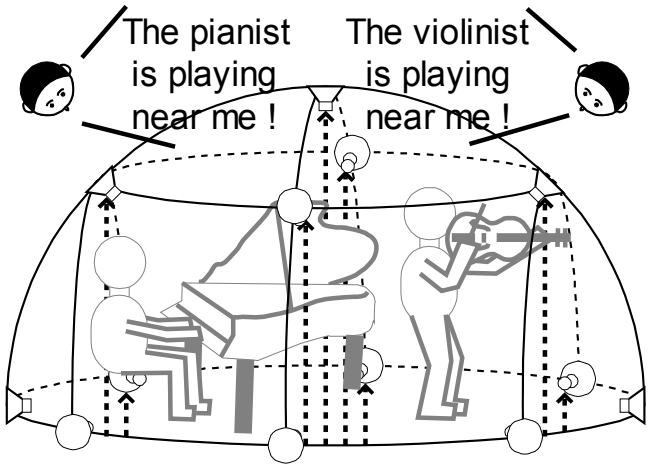
WFS System for Future 3DTV

- Conventional WFS system
  - Loudspeakers are placed around the listeners
  - Sound scene is reproduced
- Proposed WFS system
  - Loudspeakers are placed around sound sources
  - Near 3D Radiated sound field is reproduced

Conventional System



Proposed System

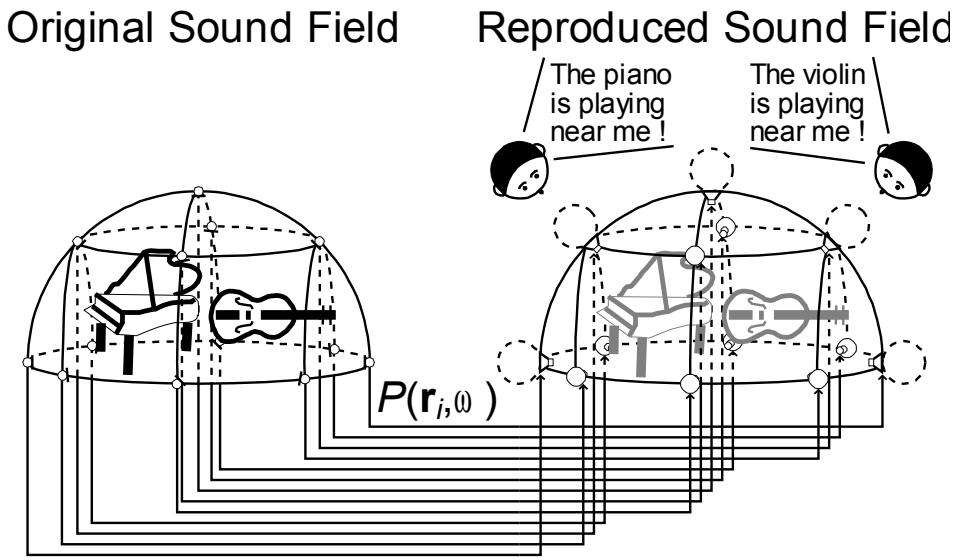


Aim of Talk

- Introduction of proposed WFS system
  - Near 3D sound field reproduction system using directional loudspeakers and wave field synthesis
  - Diagram of proposed system
  - Specification of developed prototype system
  - Display of string quartet by the developed system

Diagram of Proposed System

- Original sound field
  - Sound is recorded by microphones placed around sound sources
- Reproduced sound field
  - Recorded sound is played by directional loudspeakers
  - 3D sound field is reproduced
- Listeners feel that sound sources are playing in the array

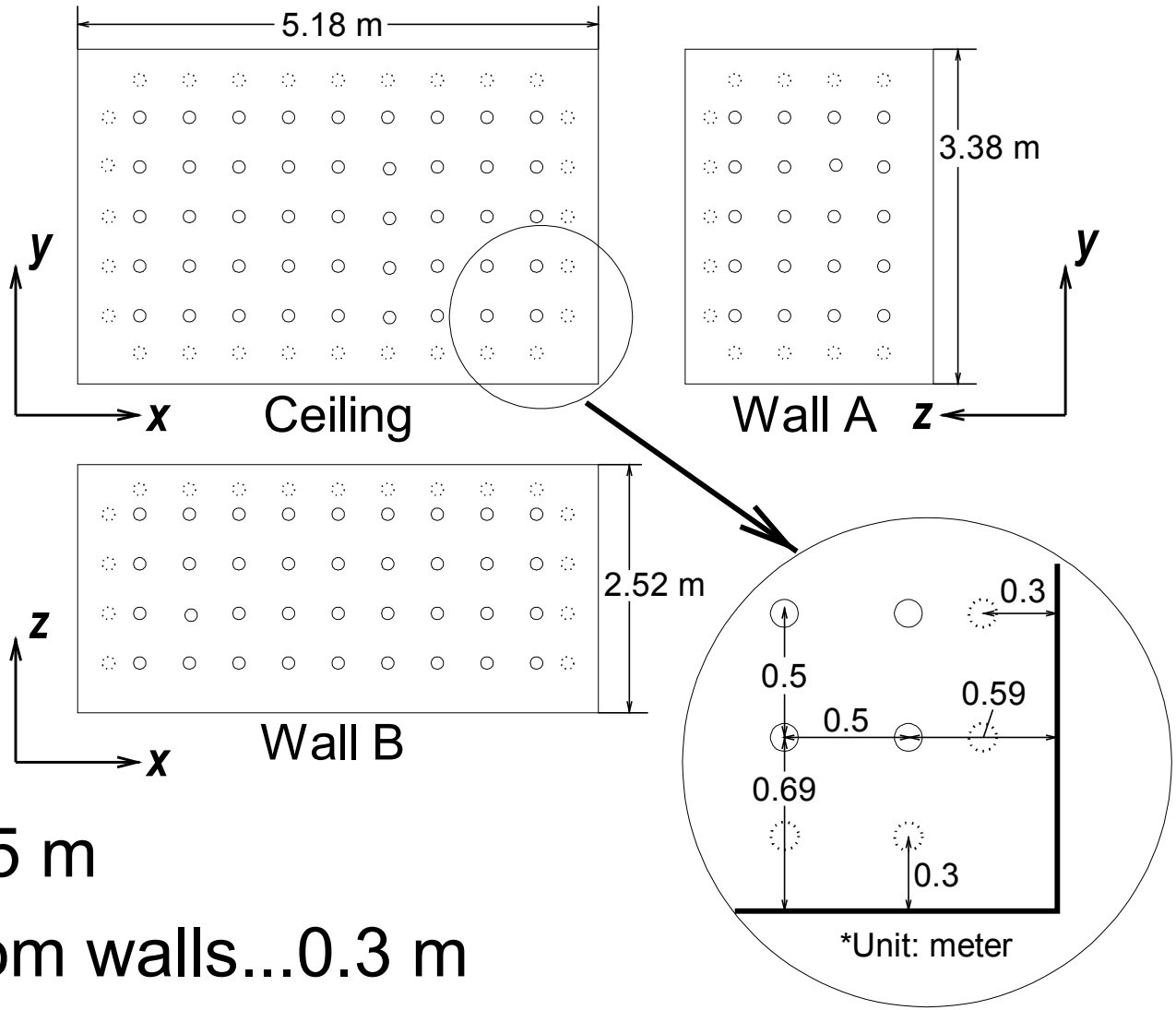


Surrounding Microphone Array

- Surrounding microphone array room
  - Equipped in Suzuki Lab. (RIEC, Tohoku Univ.)
  - Reverberation time...about 150 ms
- 157 omnidirectional microphones
  - B&K: Type 4951
  - Placed on 5 planes
  - Mainly record the direct sound from sound sources
- 10 Amplifiers
  - B&K: Type 2694

Arrangement of Microphones

- Wall A
  - 2 planes
  - 20 (=5×4)
- Wall B
  - 2 planes
  - 36 (=9×4)
- Ceiling
  - 1 plane
  - 45 (=9×5)
- Interval...0.5 m
- Distance from walls...0.3 m

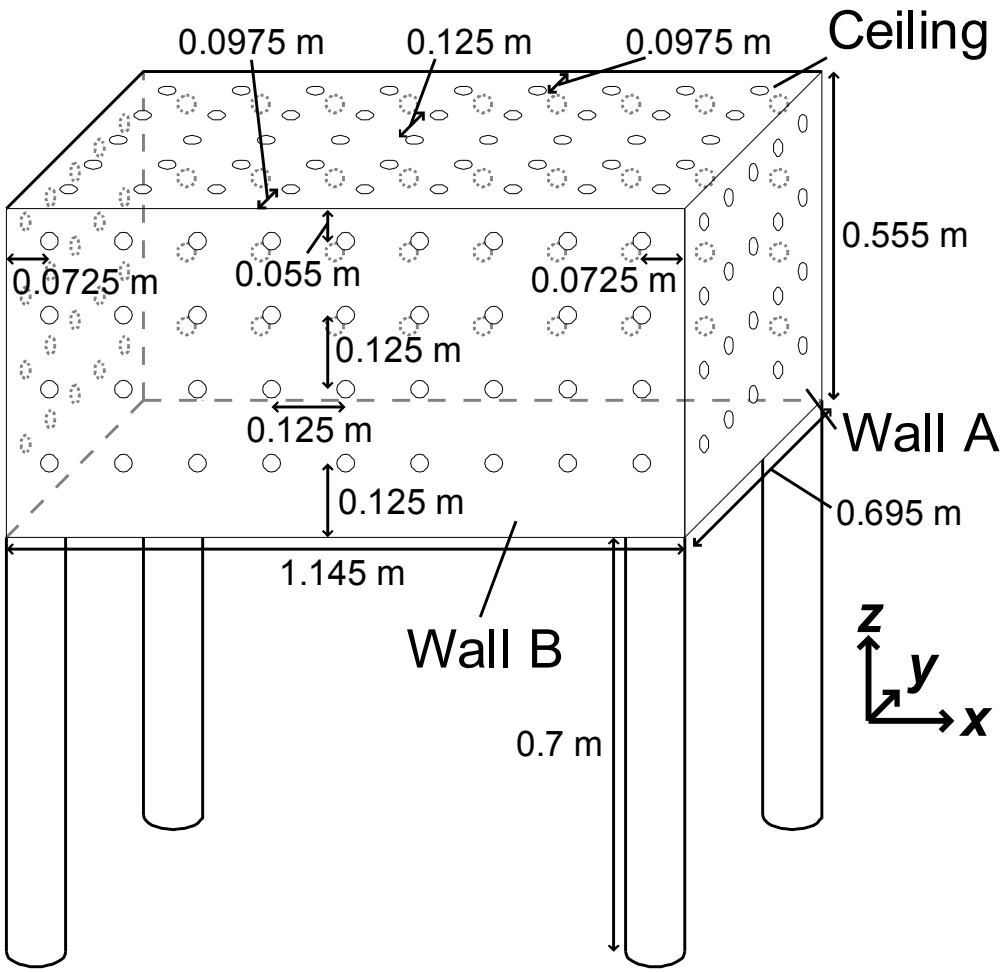


Radiated Loudspeaker Array

- Rectangular enclosure
  - Size...1/4 of surrounding microphone array
  - Material...Plywood and aluminum panels
- 157 loudspeaker units
  - AURASOUND:
    - NSW1-205-8A suitable
  - Attached to 5 planes
  - Size...1 inch
  - Directivity
    - Towards outside
- Amplifier
  - Custom-made (157ch)

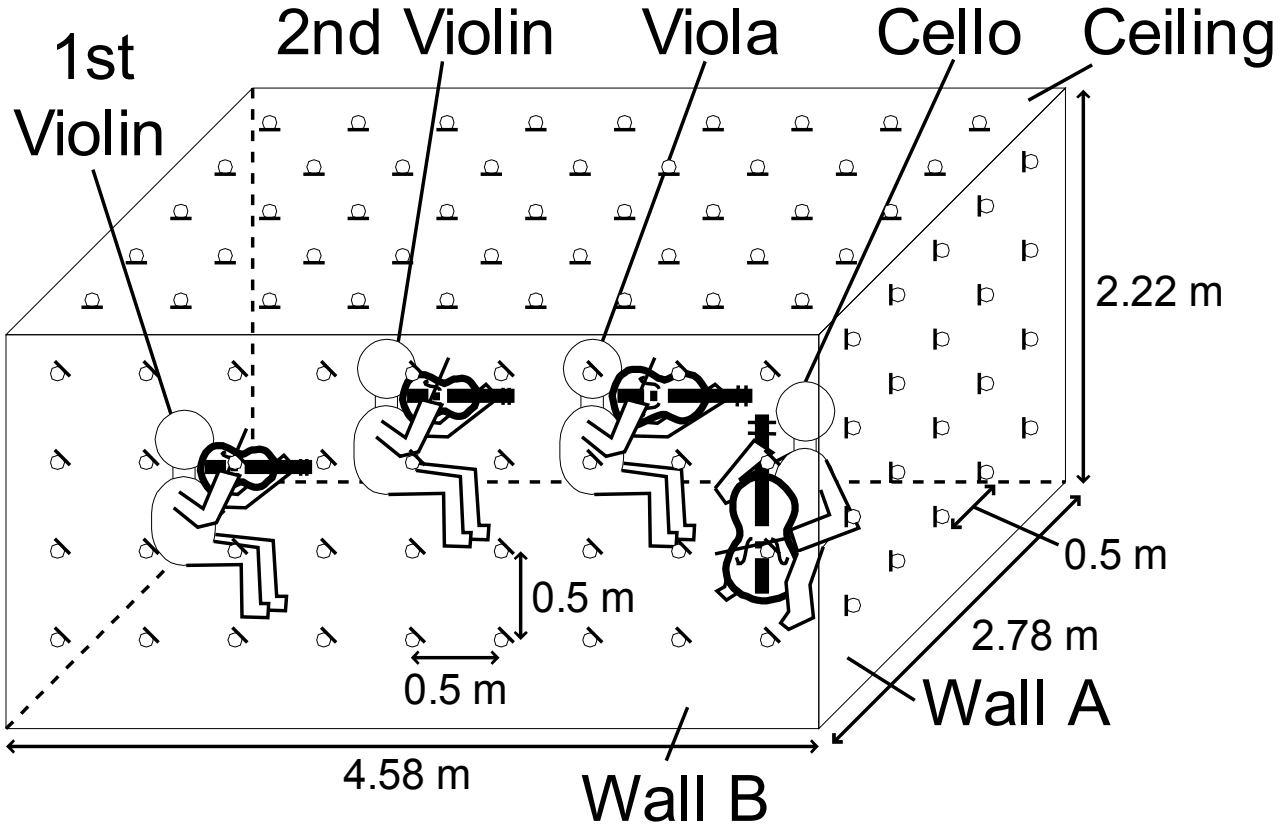
Arrangement of Loudspeaker Units

- Interval...0.125 m
- Wall A
  - 2 planes
  - 20 (=5×4)
- Wall B
  - 2 planes
  - 36 (=9×4)
- Ceiling
  - 1 plane
  - 45 (=9×5)
- Elevated by 0.7 m



Recording of String Quartet

- The 157-ch audio signals were recorded
  - First movement of Mozart's thirteenth serenade “Eine kleine Nachtmusik“



Recording Equipment

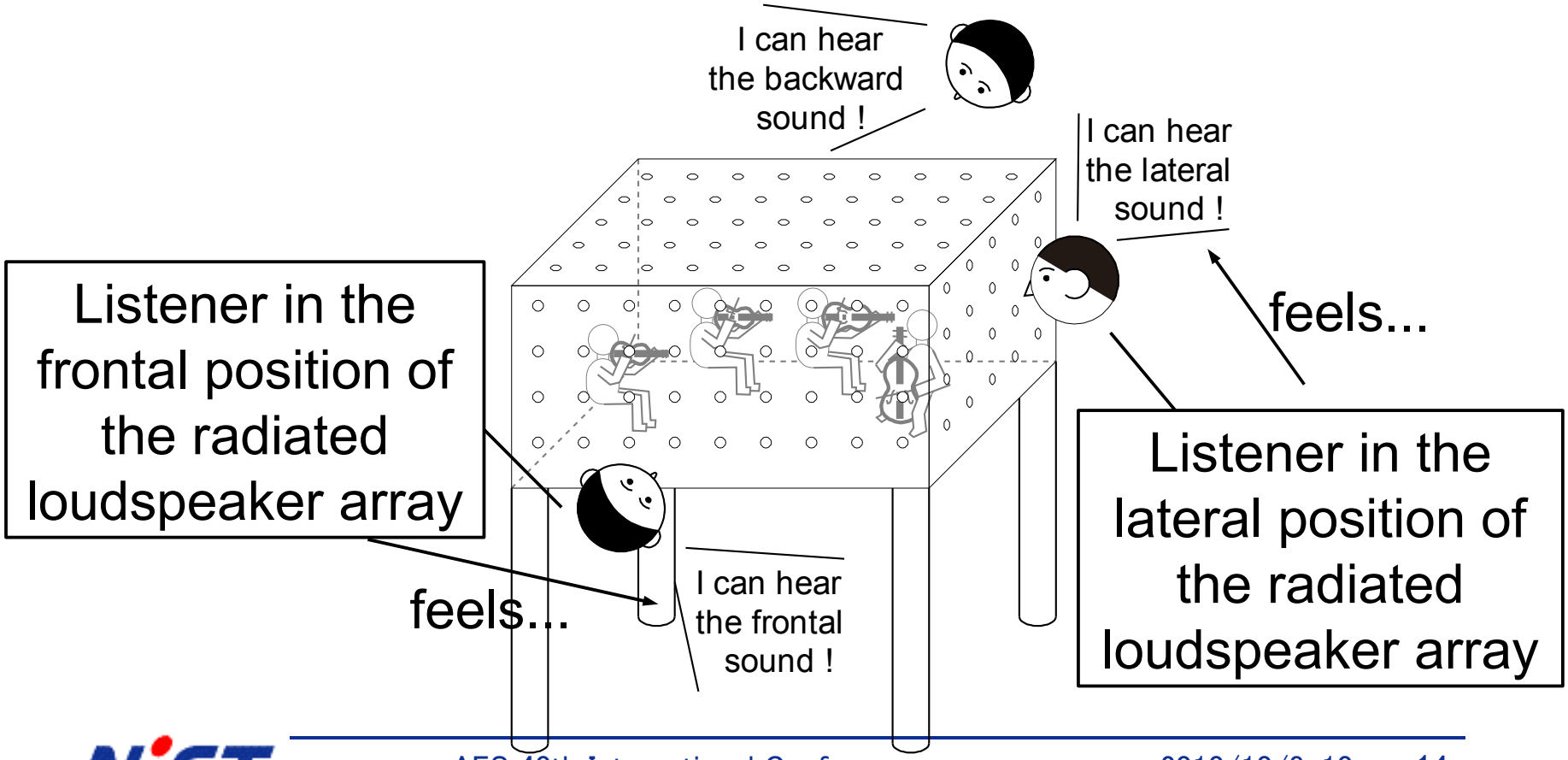
- 10 microphone pre-amplifiers (16 ch)
  - Brüel & Kjær: Type 2694
- 14 audio devices
  - Mark Of The Unicorn: HD192
- 4 recording softwares
  - Steinberg: Nuendo 3
  - Installed on four PCs
    - Apple: Power Mac G5
- Recording format
  - Sampling frequency...48 kHz
  - Quantization bit...16 bits

Playing Equipment

- The recorded 157-ch audio signals were directly replayed
- 157-ch preamplifiers
  - Custom-made
- Playing device & software
  - Digidesign: Pro Tools HD
  - Installed on a PC
    - Apple: Mac Pro
- Playing format
  - Sampling frequency...48 kHz
  - Quantization bit...16 bits

Playing of 157-ch Audio Signals

- 3D sound field was generated
  - Several listeners felt as if they could listen to the sound at any position around the string quartet



Display of Developed System

- CEATEC JAPAN 2008
  - Date
    - 2008/9/30-2008/10/4
  - Place
    - Makuhari Messe (Chiba, Japan)
  - Visitor
    - About several tens of thousands
  - Impression
    - Most of visitors felt that there were four musical players and the string quartet was played in the radiated loudspeaker array

Conclusion

- Introduction of proposed WFS system
  - Near 3D sound field reproduction systems using directional loudspeakers and wave field synthesis
  - Display of the string quartet by developed system
- Further Study
  - Evaluation of the performance of the developed system
    - Talk in IUCS 2010
    - (International Universal Communication Symposium)
      - 2010/10/18-19
      - Beijing, China

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Thank You For Your Attention