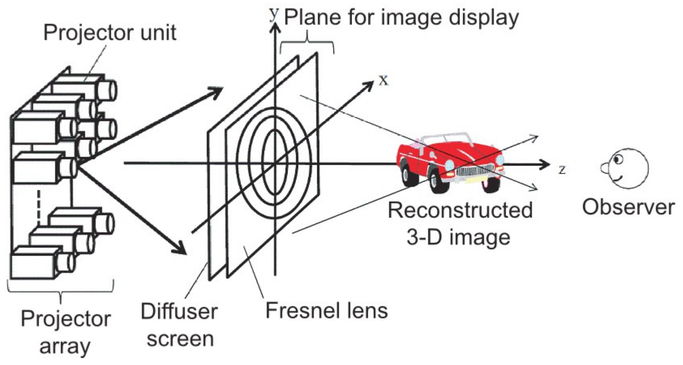
Effect of Horizontal Panning in 3D Audio System Based on Multiple Vertical Panning

Toshiyuki Kimura (Tohoku Gakuin Univ.) and Hiroshi Ando (NICT)

1. INTRODUCTION

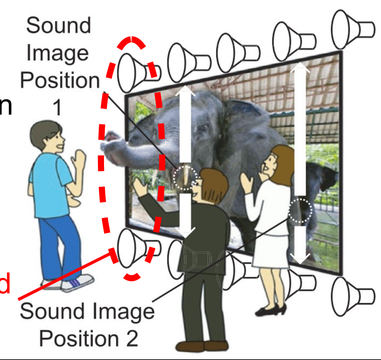
Multi-view 3D video display system

- Projector array makes parallax videos
- Several viewers can view natural 3D objects without special glasses



Multiple vertical panning (MVP) method

- Multiple "vertically panned loudspeakers" are placed at the upper and lower sides of the screen
  + 2 loudspeakers are placed at upper and lower sides of sound image positions
- Sound is played by the "vertical panning"
  + Viewers perceive a sound image between vertically panned loudspeakers
  + Multiple viewers can simultaneously feel the sound images at the position of the 3D objects regardless of the viewing position



Aim of Study

- Previous study
  + Microphones: neighborhood of sound sources
- Teleconference system
  + Microphones can't be placed at the neighborhood of sound sources
  + Hyperdirectional microphone array is applied
  + Horizontal panning is added since neighboring microphones simultaneously record a sound

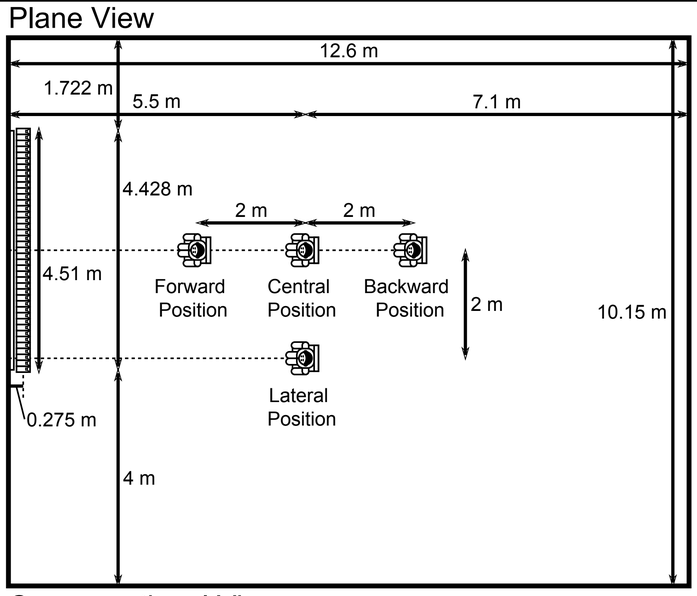
The effect of horizontal panning is evaluated by audio-visual experiment

2. AUDIO-VISUAL EXPERIMENT

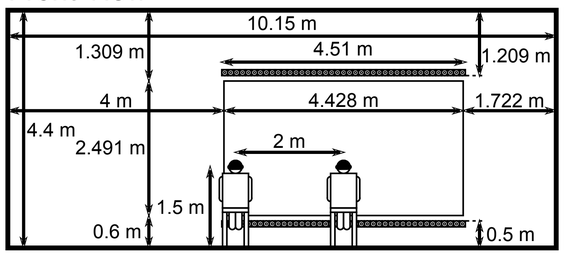
Experimental Environment

- Conference room
  + Reverberation time: 402 ms
  + Background noise level: 38 dBA
  + Viewing position: 4 positions
    + Central position (5.5 m distance)
    + Forward position (3.5 m distance)
    + Backward position (7.5m distance)
    + Lateral position (5.5 m distance)
      + Lateral distance: 2 m (Left)
  + 82 Loudspeakers
    + 41 at upper side
    + 41 at lower side
  + Sound pressure level: about 70 dBA
    + At the central viewing position

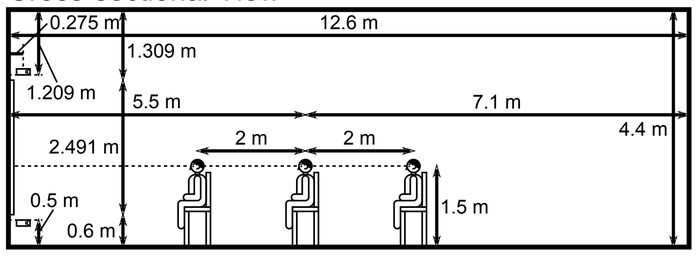
Plane View



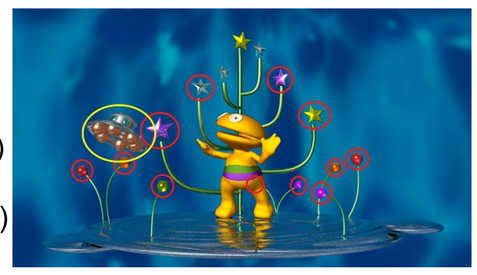
Front View



Cross-sectional View

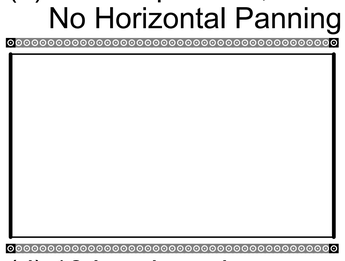


Experimental Condition

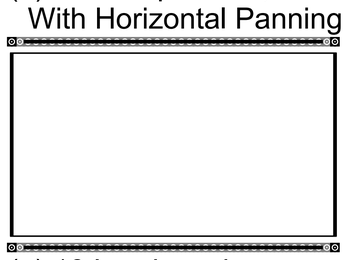


- 3D video (5 seconds)
  + UFO that plays a sound is moving about the screen (Yellow oval)
  + The sound of stars and balls is played when UFO touches them (Red circles)
- Sound condition
  + Reference conditions: (a), (e) and (f) (No horizontal panning)

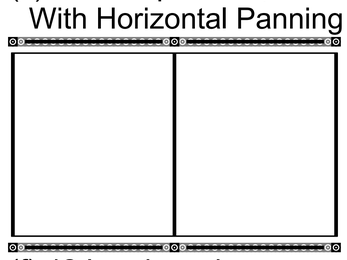
(a) 4 Loudspeakers, No Horizontal Panning



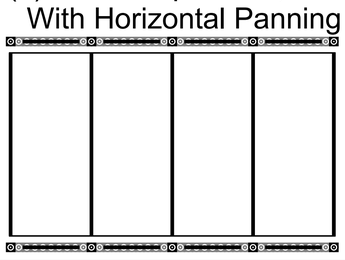
(b) 4 Loudspeakers, With Horizontal Panning



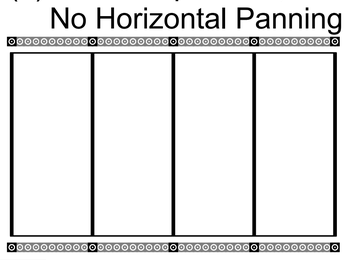
(c) 6 Loudspeakers, With Horizontal Panning



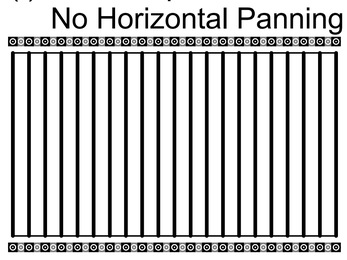
(d) 10 Loudspeakers, With Horizontal Panning



(e) 10 Loudspeakers, No Horizontal Panning



(f) 42 Loudspeakers No Horizontal Panning

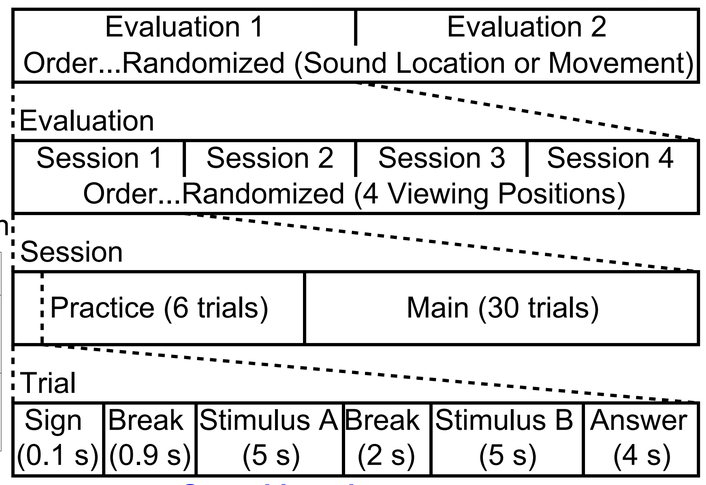


Experimental Design

- Viewer
  + 9 persons
    + 5 males
    + 4 females
  + Age: 27-38
  + Stereoscopic view: Possible
  + Audibility: Normal in daily life
- Method
  + Scheffe's paired comparison
- Evaluation criterion
  + The degree of coincidence
    + Sound location of stars and balls
    + Sound movement of UFO
- Trial
  + Order is randomized in each session

	Element	Note
Practice (6)	Permutation of 3 conditions	Condition (a), (c) & (f)
Main (30)	Permutation of 6 conditions	Condition (a)-(f)

Test



Experimental Procedure

- Instruction
  + Grade the degree of the coincidence of stimulus B
  + Reference: Stimulus A
  + Grade index: 7 steps
  + Be allowed to move their head and upper body freely while listening to a sound

Grade	Judgment
3	Very good
2	Fairly good
1	Little good
0	The same
-1	Little bad
-2	Fairly bad
-3	Very bad

Experimental Results

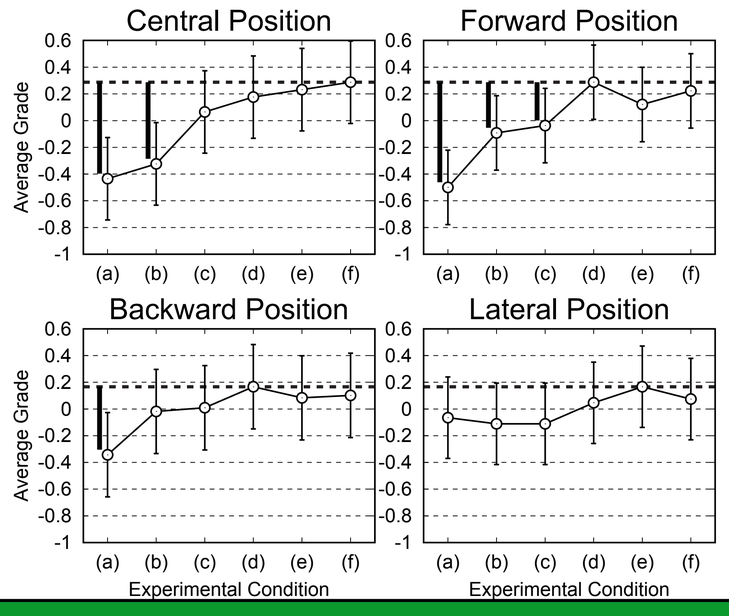
- Sound conditions (d)-(f)
  + There are no significant differences among the basic sound conditions in all the sessions
  + Basic sound condition: The highest average grade

Viewers cannot discriminate the differences even if the horizontal panning is added

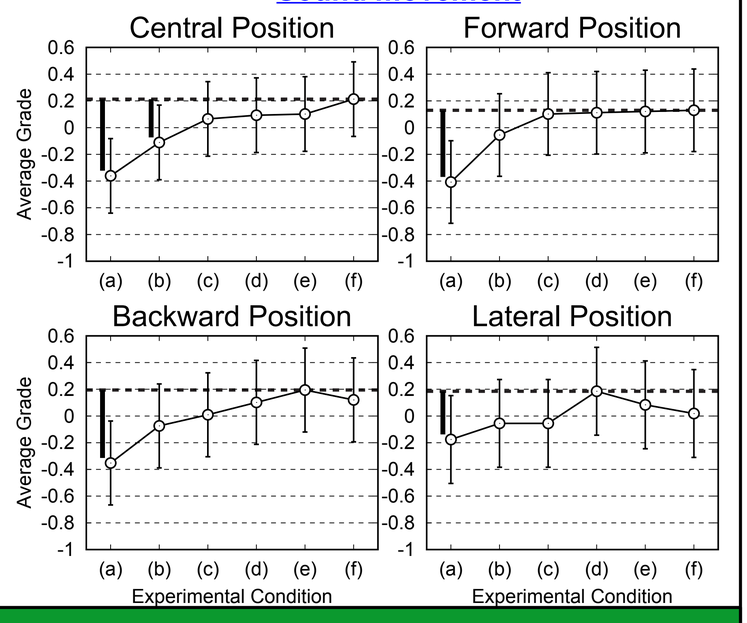
- Sound conditions (b) and (c)
  + Average grades are significantly lower than the basic sound condition in a subset of sessions

The number of loudspeakers is not reduced even if the horizontal panning is applied

Sound location



Sound movement



3. CONCLUSION

- Audio-visual experiment was performed to evaluate the effect of the horizontal panning in our proposed 3D audio system
  + **3D audio system based on multiple vertical panning (MVP)**
- Viewers could not discriminate the difference of the sense of presence even if the horizontal panning is added
  + **The performance is maintained even if the hyperdirectional microphone array is applied when the teleconference system is constructed based on our system**
- Future work: Reduction of the number of loudspeakers
  + **Study of the placement of loudspeakers**