Immersive Psycho-Acoustic Design and Evaluation Workflow (i-PADEW)

Di Liu | College of Architecture
Yung-Hsin Tung | College of Engineering
Current Acoustic Design & Research:

◈ Building acoustic performance has a great impact on occupants well-being.
◈ Current architecture acoustic design methods emphasis on numeric report which is difficult to communicate between multiple parties and lack of the integration with user feedback in the early design stage.

We propose Immersive Psycho-acoustic Design and Evaluation Workflow (i-PADEW) that allows architects, engineers, and clients to:

◈ test various acoustic design parameters, including:
   □ building materials with acoustic properties
   □ room sizes
   □ room shapes
   □ environmental context, such as social or work context
◈ obtain the instant user feedback
◈ improve design scheme efficiently and collaboratively
Methodology

- We proposed an Immersive Psycho-acoustic Design and Evaluation Workflow (i-PADEW)
- We conducted a validation test by using classic acoustic simulation method.

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Psycho-Acoustic Design and Evaluation Workflow

Classic Acoustic Simulation Method

Reverberation Time (RT)

SABINE EQUATION

\[ RT = \frac{0.16}{A} \]

\[ RT = \frac{0.16}{[A_{\text{air}} - S_r \log_e (1 - \alpha_{\text{avg}})]} \]

where:

- \( V \) - Volume (m\(^3\))
- \( A \) - Total Absorption (m\(^2\))
- \( A_{\text{air}} \) - Air Absorption (m\(^2\))

RT - Expected Reverberation Time (s);
\( \alpha_{\text{avg}} \) - Absorption Coefficient (avg. all surfaces);
\( S_r \) - Surfaces Total Area (m\(^2\)).

EYRING EQUATION

Visual and audio cues

User-based Design Optimization

User-centered Performance Assessment

user test

Multi-sensor feedback integration
Experiment Design

Auralization

Case 1 Perforated Board

Case 2 Carpet

Case 3 Concrete

Auralization Case 1

Auralization Case 2

Auralization Case 3

VR Modeling

3m x 3m x 3m Single Office

Interactive Scene: Proofreading Task
Task accuracy + User survey

- The virtual space felt realistic.
- The controller was easy to use.
- I could focus when performing the task.
- The virtual acoustic environment was comfortable.

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User Test
Results and Conclusion

i-PADEW is validated by the classical method. The best material is Perforated Board in both methods.
Contribution to Knowledge

- i-PADEW can be implemented in every stage through the whole building life-cycle.
- Encourage human-centered, adaptive, and intelligent design.

Future Works

- Human factors:
  - attention, stress, perception
  - Physiological factors
- Other acoustic design parameters:
  - room size, room shape, room layout
  - environment context: social-place, workplace, education, etc..
- User population:
  - Large population size
  - Multiple user groups based on profession: designers, engineers, clients, etc..
- The relation between visual cues and audio cues.

“Enhance the humanity in the age of digital simulation within AEC industry.”
Appreciation

TAMU Innovation [X] Project
https://innovation-x-tamu.netlify.app/#ourteam

Intelligent Psychoacoustic Spaces for Health and Well-Being

A disciplinary project in collaboration between School of Engineering, Liberal Arts, and Architecture.

Team Leaders:
Dr. Winfred Arthur, Jr., Department of Psychological & Brain Sciences
Dr. Theodora Chaspari, Department of Computer Science & Engineering
Dr. James E. Hubbard, Jr., Department of Computer Science & Engineering
Dr. Anastasia Muliana, Department of Mechanical Engineering
Dr. Youngjib Ham, Department of Construction Science

Team Contributors:
Ellen Hagen, Ph.D. Student in Psychological & Brain Sciences
Zaryab Shahid, Ph.D. Student in Mechanical Engineering
Reference


Maffei et al., 2016. Immersive virtual reality in community planning: Acoustic and visual congruence of simulated vs real world.

