Avatar360: Emulating 6-Dof Perception in 360° Panoramas through Avatar-Assisted Navigation

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360° Panoramas

Lippman 1980 (Credit: MIT Architecture Machine Group and computerhistory.org)

IEEE VR 2024
ORLANDO, FL USA

360° Panoramas

Lippman 1980

Anguelov et al. 2010

360° Panoramas

- Expansive view of environment
- Immersive
- First person, egocentric perspective

Limited to 3-DoF (rotation)
No translational movement
Cannot walk around environment

Related Work – 6-DoF Movement

Pre-recorded Movement
Lippman 1980

No autonomy - not truly 6-DoF

Can invoke simulator sickness

Teleport/Blur between Panoramas
Ripley 1989
Chen 1995
Anguelov et al. 2010

Requires changing the 360 image to a different nearby location to gain a sense of movement

Visual artefacts

3D Reconstruction
Zhao *et al. 1998*
Gunadi *et al. 2002*
Asai et al. 2005

Visual artifacts

Specialized equipment

Movement range

Sophisticated algorithms

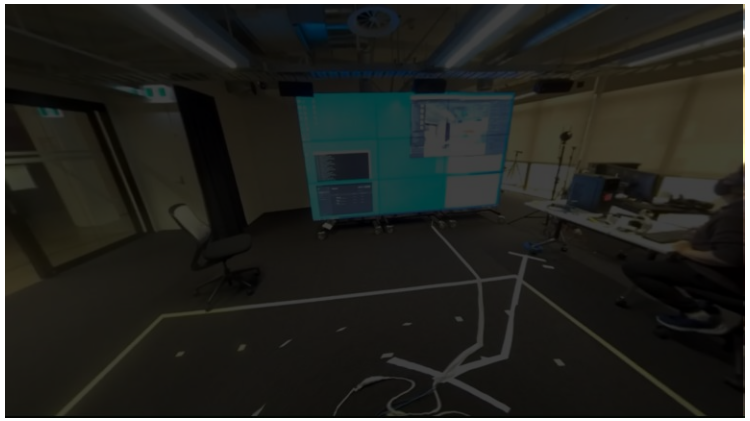

Image-based Modeling
Mildenhall et al. 2021 (NeRF)
Kerbl et al. 2023 (Gaussian Splatting)
Chen et al. 2022

Visual artifacts

Specialized equipment

Movement range

Sophisticated algorithms

Solution - Avatar360

- Changing from **egocentric** to **exocentric** perspective of 360 panorama
- Avatar-assisted navigation
  - Emulates 6-DoF perception
  - No specialized hardware
- Exploration of View Control and Transition Techniques in this new setup

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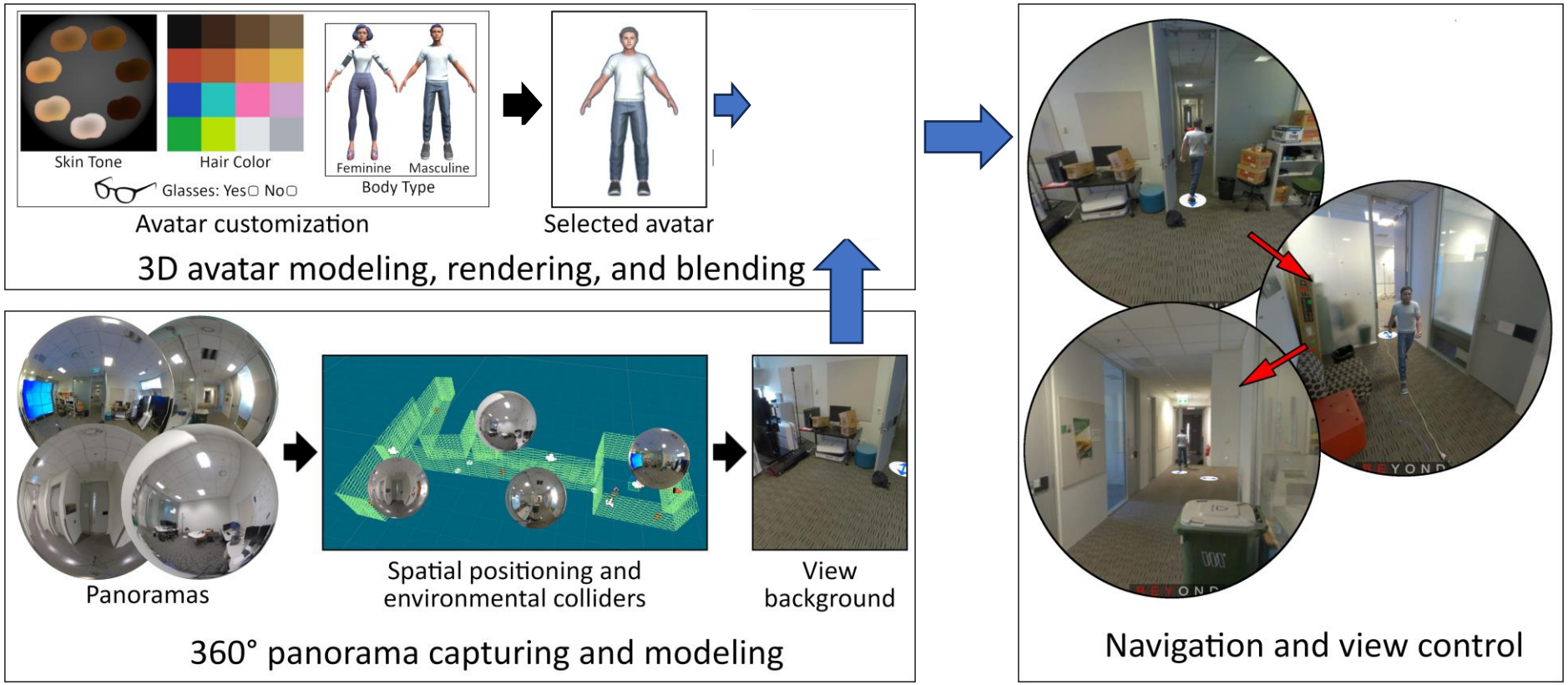
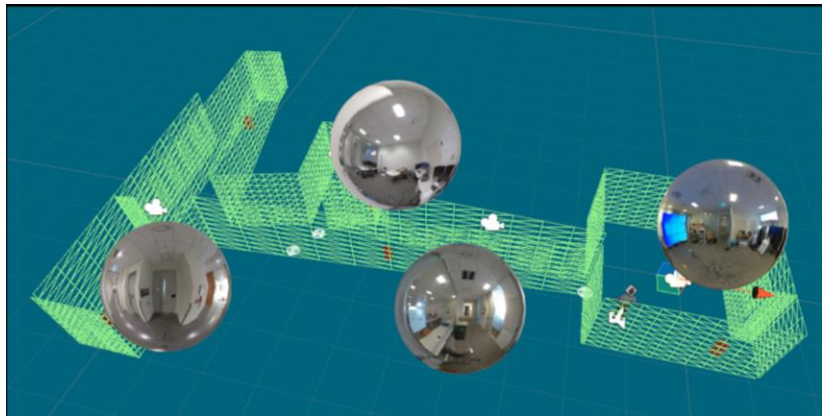
System

Avatar360 System Overview

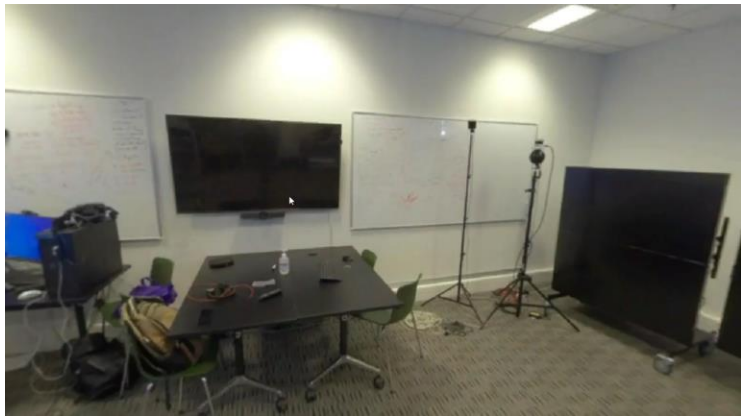


360° Panorama Capturing and Modeling

Panoramas



Spatial positioning and environmental colliders



View background

3D Avatar Modeling, Rendering, and Blending

Avatar customization

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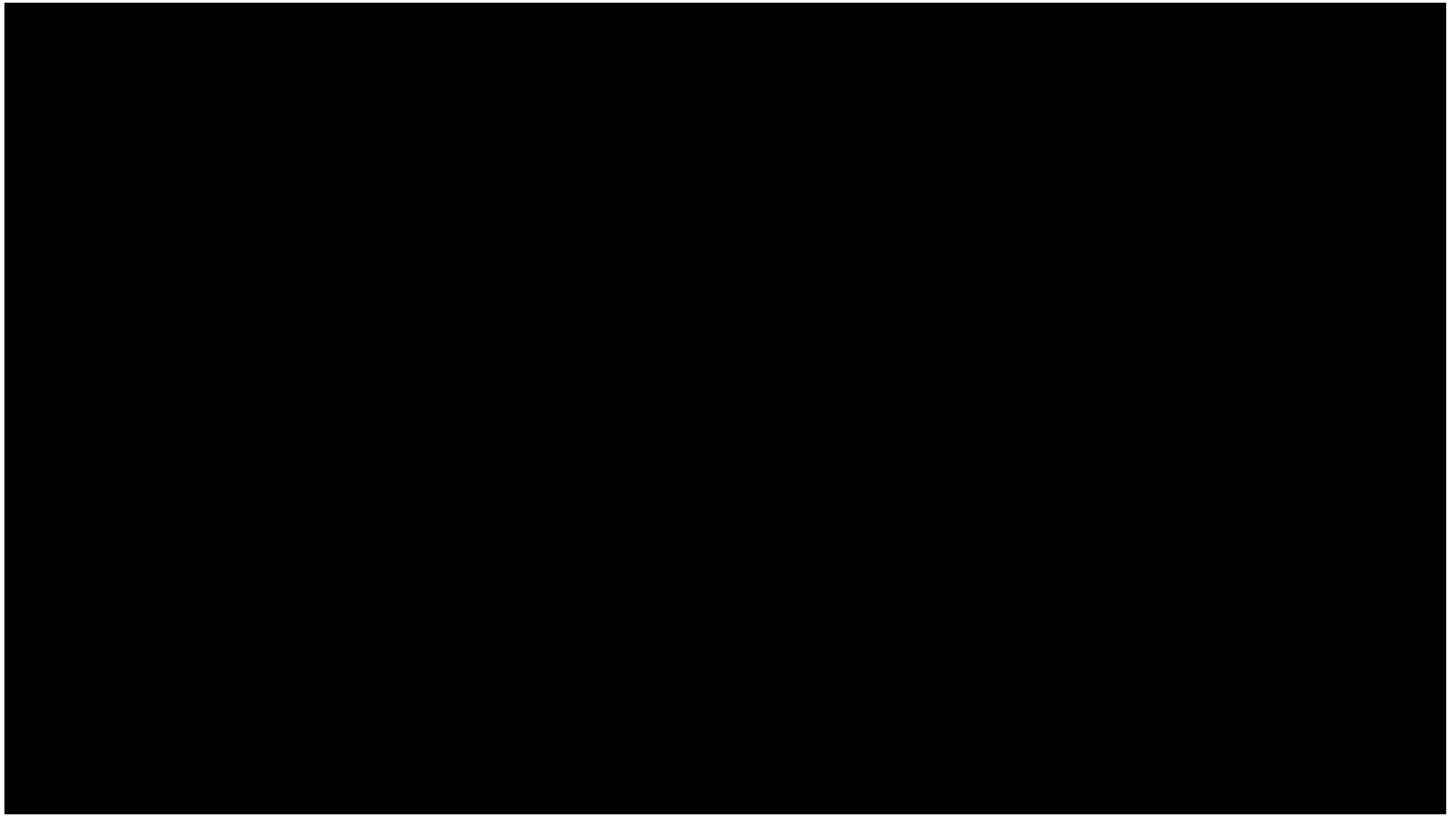
Avatar-Assisted Navigation

View Control

View Transition



User Study

Research Questions

- Primary question:
  - *Does avatar-assisted navigation elicit the sensation of 6-DoF movement?*

    "It seemed as if I was moving in the captured environment"

- Secondary questions:
  - *What are the effects of view control?*
  - *What are the effects of view transitions?*

Variables, Design, Participants

Independent Variable	Possible States		
Avatar	Off	On	
View control	Coupled	Decoupled	Static
View transition	Zoom	Cut	Fade

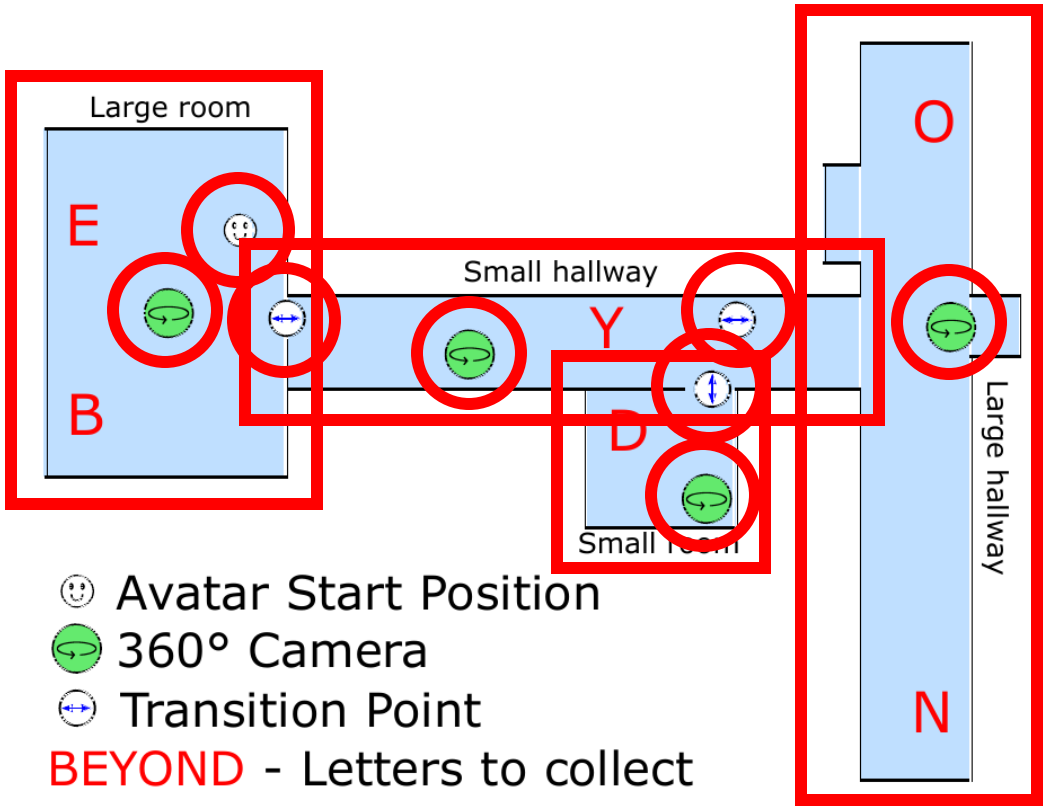
- Within-subjects 2×3×3 mixed factorial design
- Dependant Variables:
  - Sense of movement
  - Disorientation
  - Spatial Presence
  - Preference
- Participants:
  - 20 participants (15 male, 5 female)
  - Aged between 18-49 (M=28.28, SD=8.06)
  - All reported normal or corrected-to-normal vision

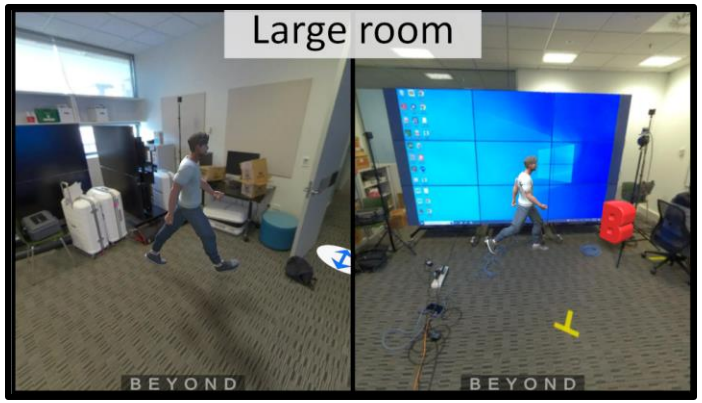
Conditions

	Avatar	View control	View transition
C1	Off	Decoupled	Zoom
C2	On	Coupled	Zoom
C3	On	Decoupled	Zoom
C4	On	Static	Zoom
C5	On	Coupled	Cut
C6	On	Coupled	Fade

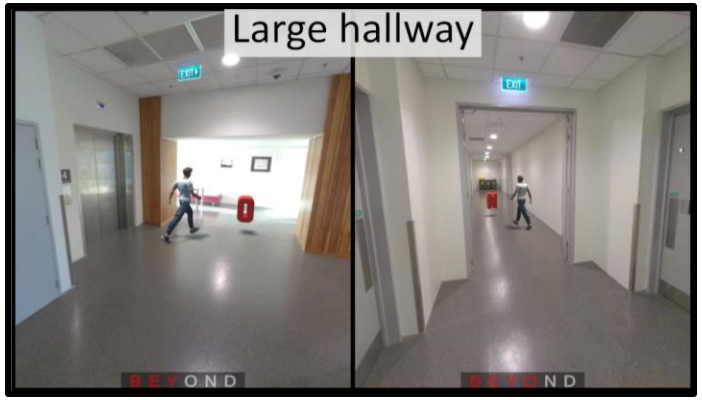
- C1 acts as our baseline (similar to Google Street View)
- C2-C6 are variations of the Avatar360 System
- C3/C4 compare view control
- C5/C6 compare view transition

Task Design


Large room
E
B
Small hallway
Y
D
Small room
O
N
Large hallway
Avatar Start Position
360° Camera
Transition Point
BEYOND - Letters to collect


Large room
BEYOND
BEYOND

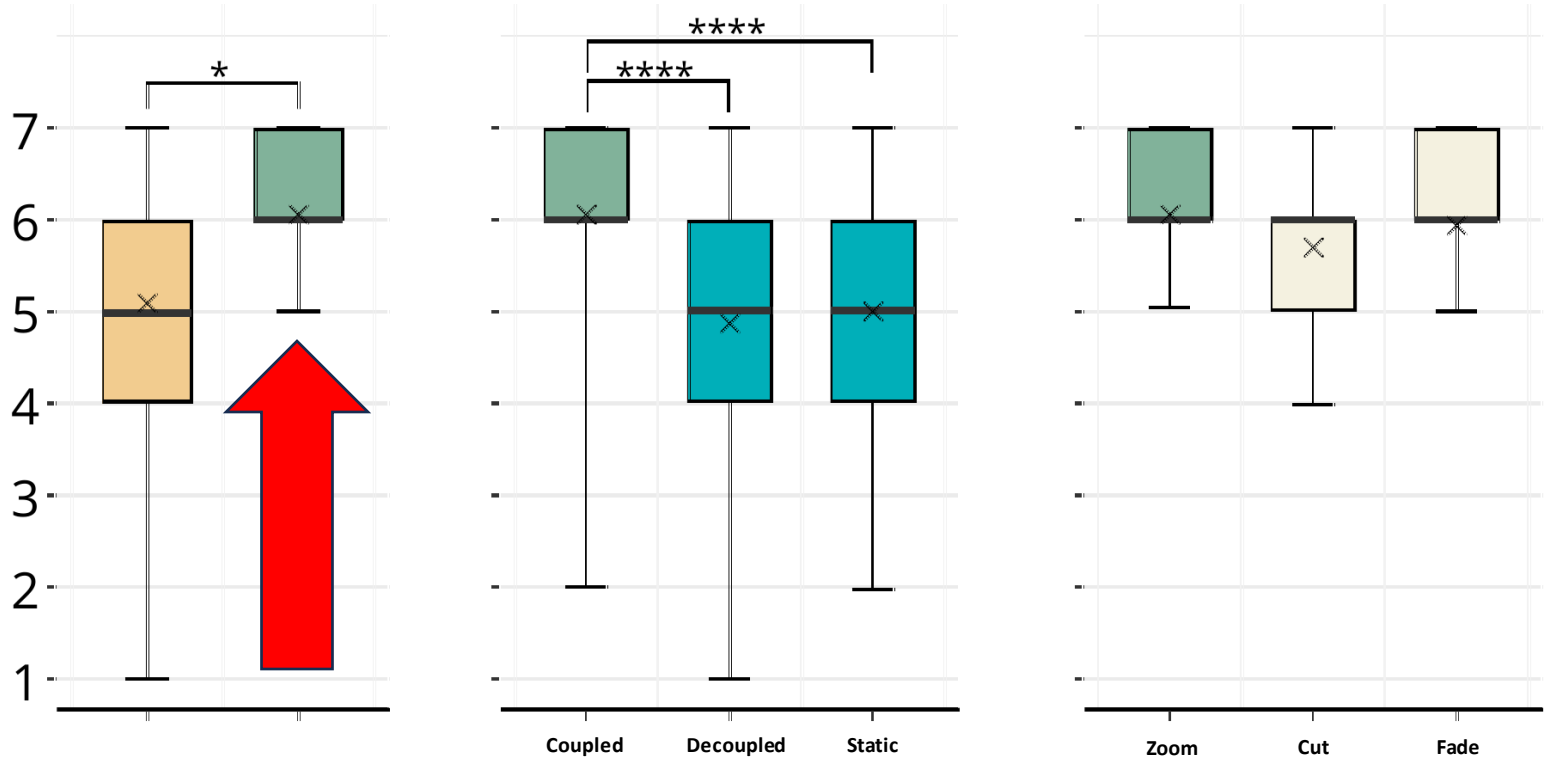

Small hallway
BEYOND
BEYOND


Large hallway
BEYOND
BEYOND


Small room
BEYOND
BEYOND

Results

Sense of Movement

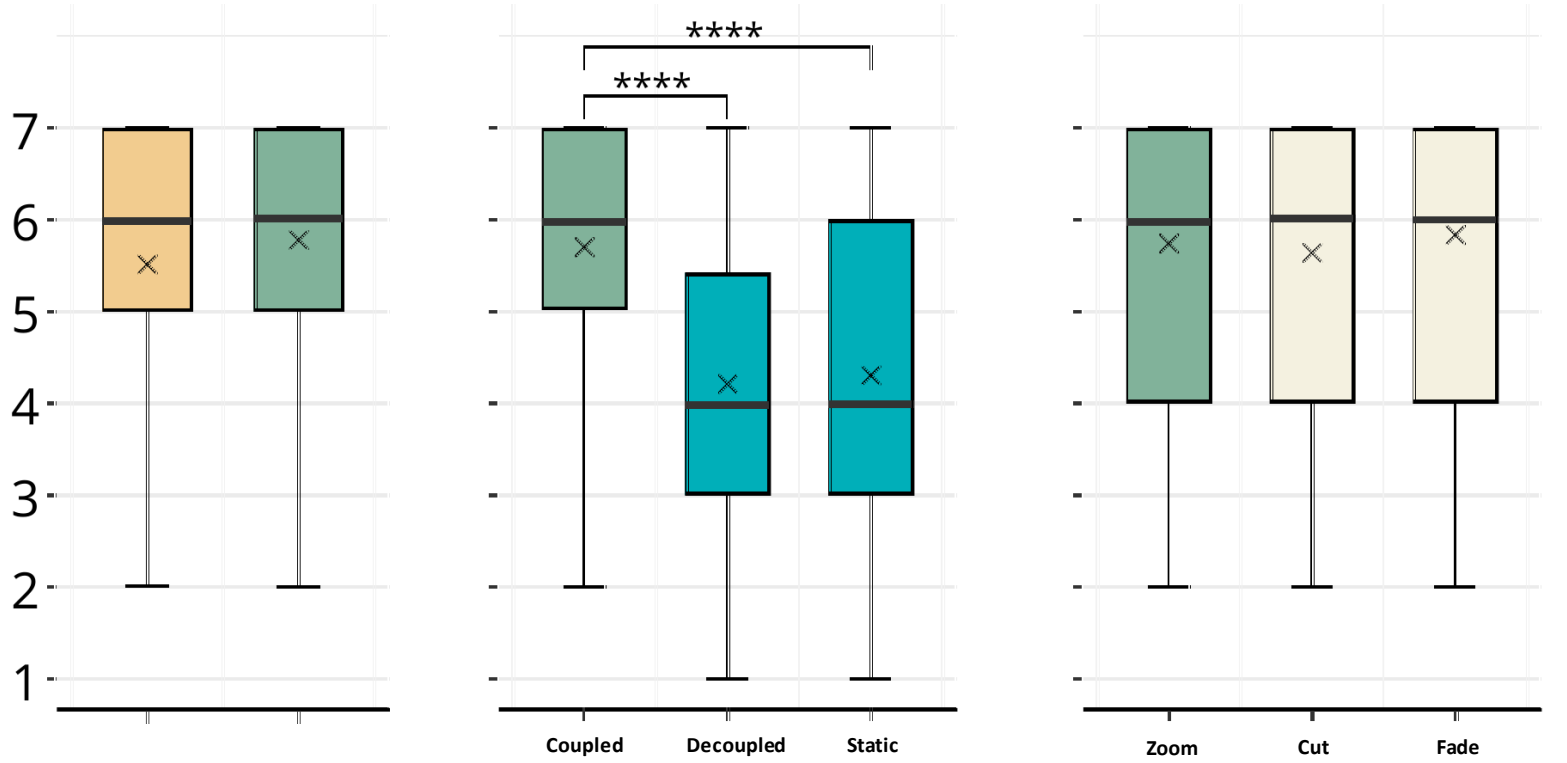


No Avatar Vs. Avatar (a)

View Control Compairson (b)

View Transition Comparison (c)

Disorientation



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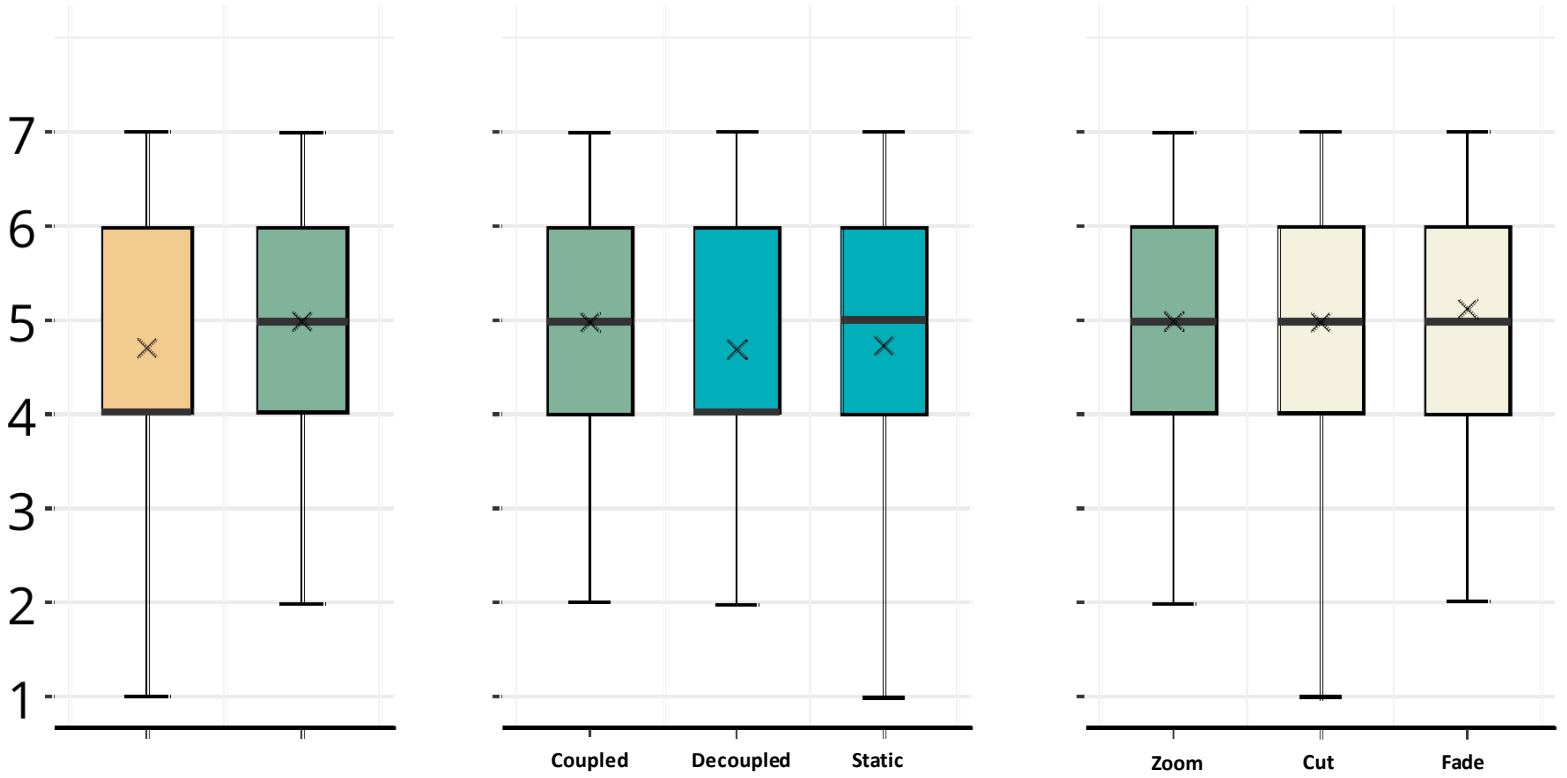
IPQ



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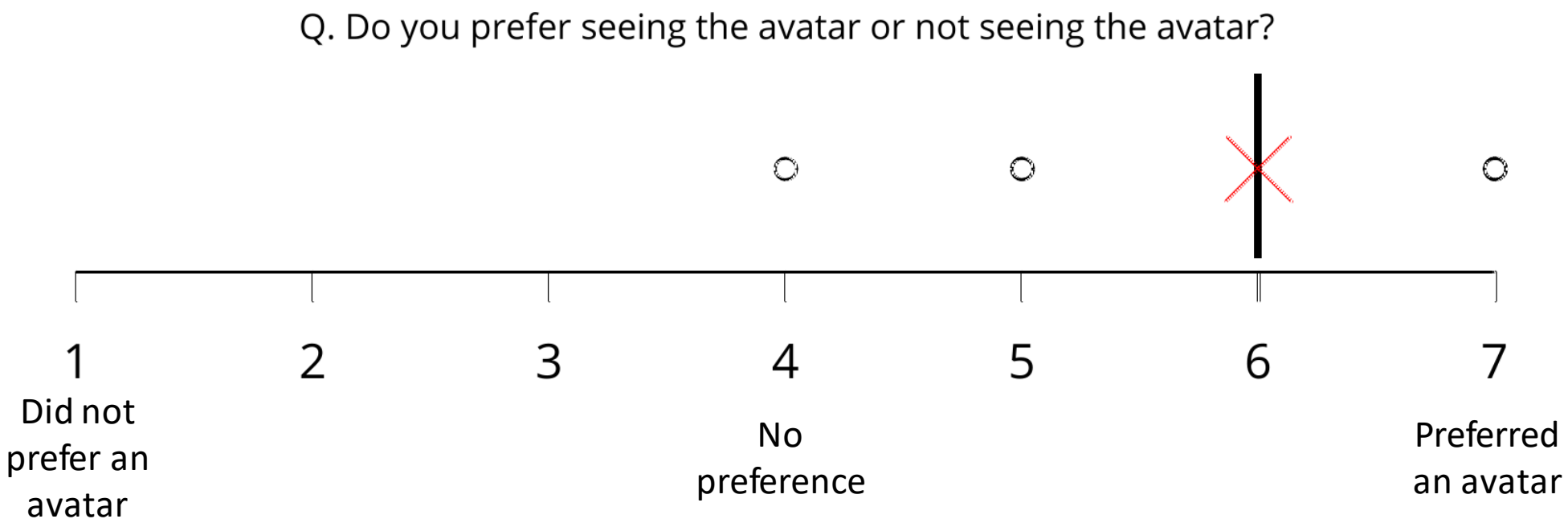
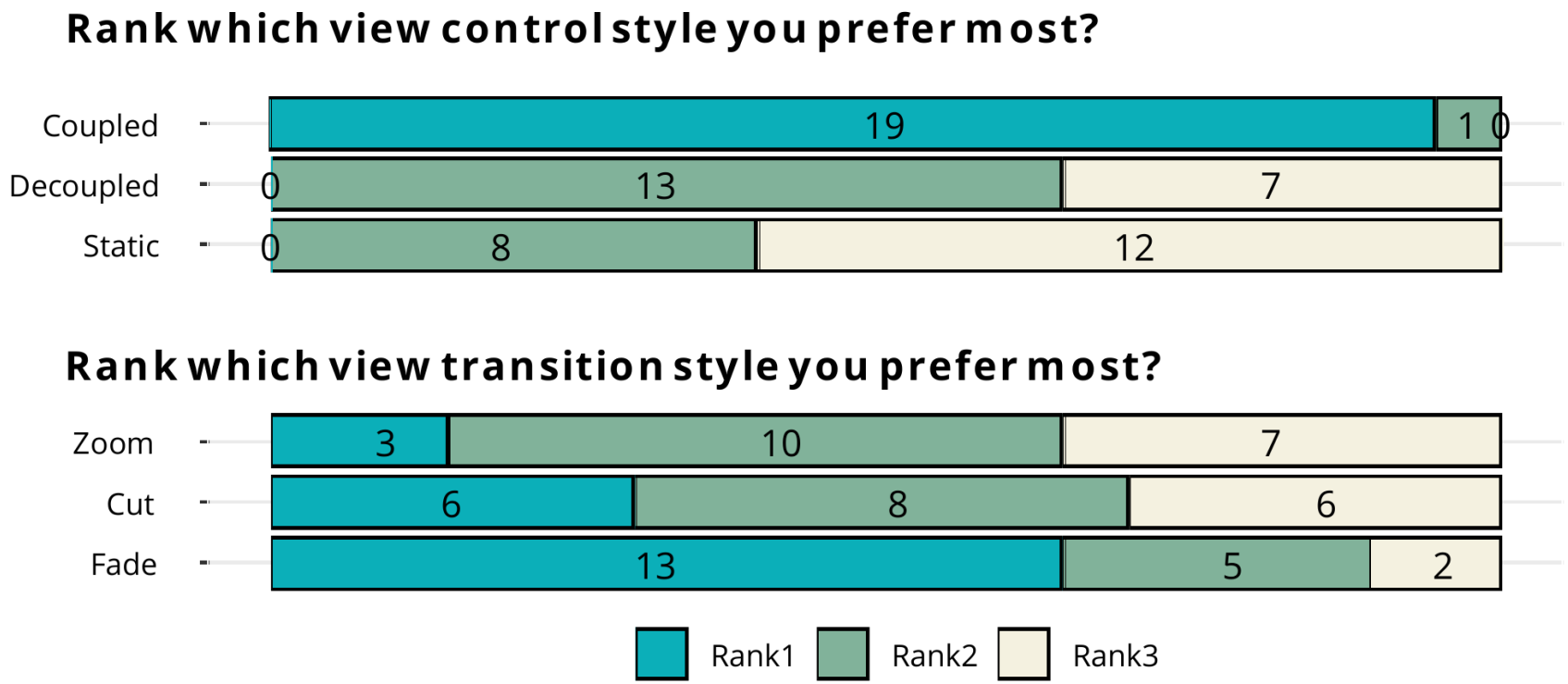
Avatar Preference



View/Transition Preference



Conclusion

- Avatar360 provides an exocentric 6-DoF navigational experience within 360° panoramas
- We defined the Avatar360 system
  - Capturing, modeling, blending, navigation
- User study takeaways
  - Avatar assisted navigation elicits the sensation of movement in 360 panoramas
  - Camera view synchronized with avatar performed better than decoupled/static
  - Camera transitions (zoom, cut, fade) showed no difference

Limitations and Future Work

- Test more environments (stairs, outdoor spaces, different terrain, etc.)
- Test more view and transition control techniques
- Multiple avatars
- Explore alternate hardware modalities (e.g., HMD)
- Panoramic video/live streaming
- Spatially disconnected panoramas

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