UNIVERSITI TEKNOLOGI PETRONAS
ESTCON
WORLD ENGINEERING, SCIENCE & TECHNOLOGY CONGRESS
International Conference on Future Trends in Smart Communities
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ICFTSC 2022
Theme: Human Centric Technologies

General framework of geometric simplification for mitigating cybersickness

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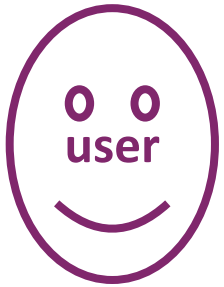
01/12/2022

Arts et Métiers Sciences et Technologies
lispen
Université de Strasbourg
ICUBE

Context

- **Virtual reality (VR)**

Real world



Perception

Intervention

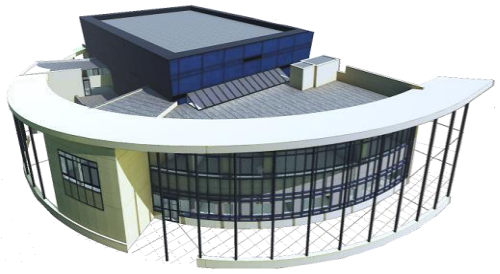
VR interfaces

output: *screen, haptic, …*

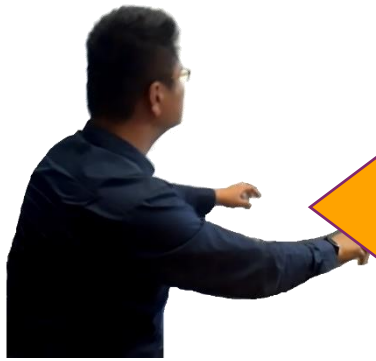
input: *joystick, motion capture, …*

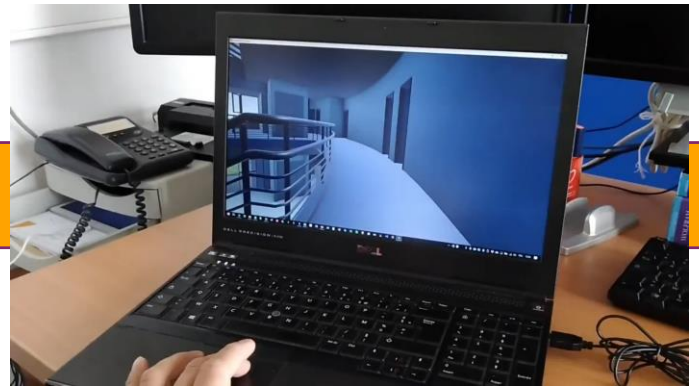
computation

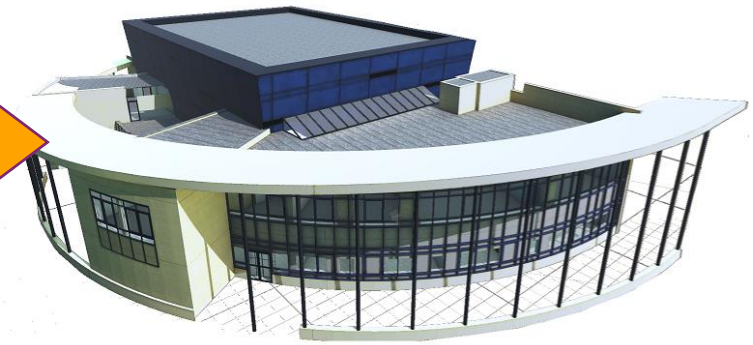
Virtual world



Example of interaction :







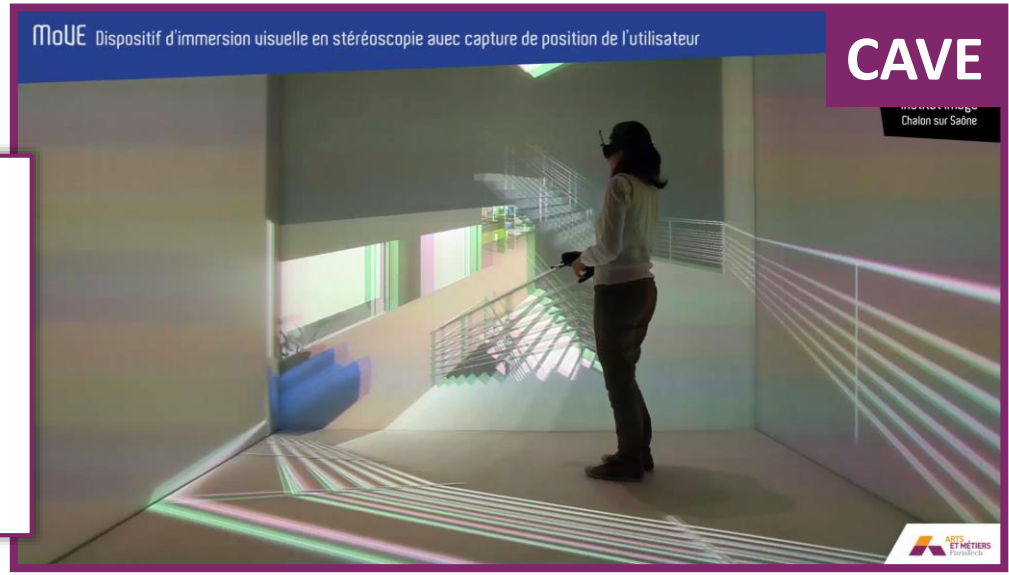
Context

From simple visualization to immersion in VR

- Reduced scale
- Monoscopy
- Small FOV display

- 1:1 scale
- Stereoscopy
- Adapted POV
- Large FOV display

CAVE



HMD

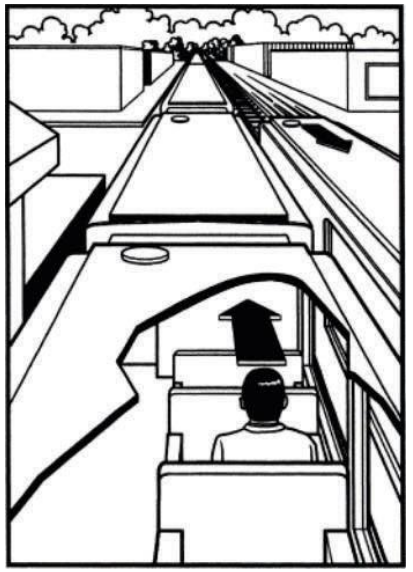
- Cut off from the real world

POV: Point Of View
FOV: Field Of View
CAVE: Cave automatic virtual environment
HMD: Head-Mounted Display

Scientific issue

Immersive visualization => visually induced self-motion

≈



Physically statistic: Using VR input device to move in virtual environment

Sensory **conflict** and cybersickness

self-motion ≠ self-motion

Perception

Perception

Eyes

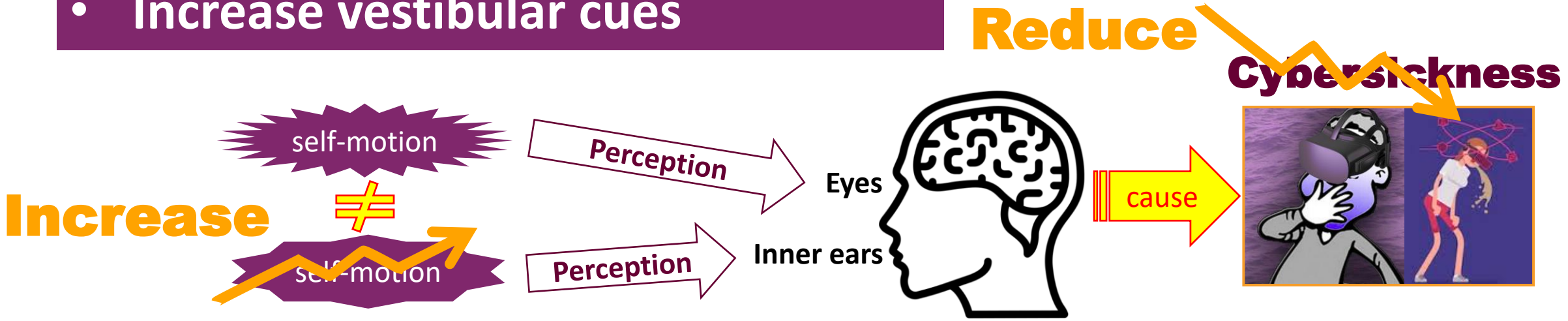
Inner ears

cause

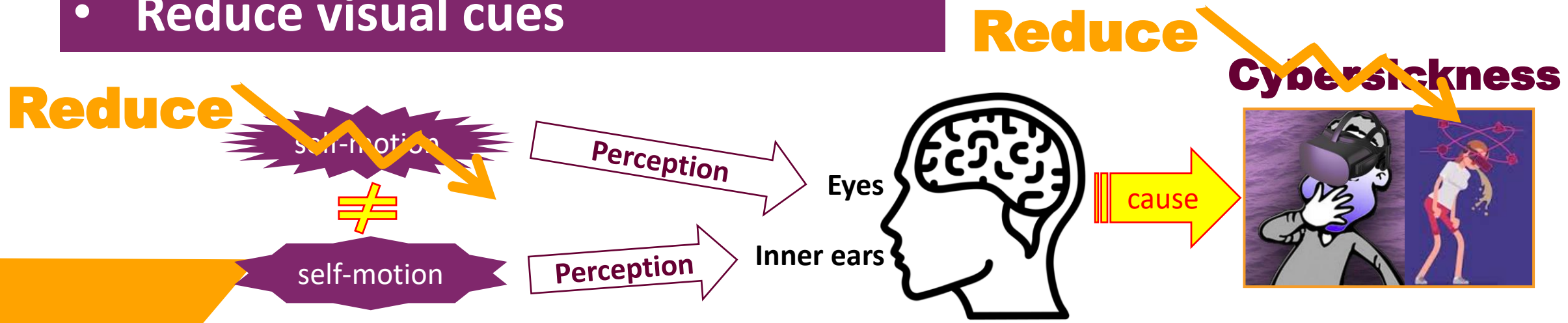
Cybersickness

Reduce cybersickness

- Increase vestibular cues



- Reduce visual cues



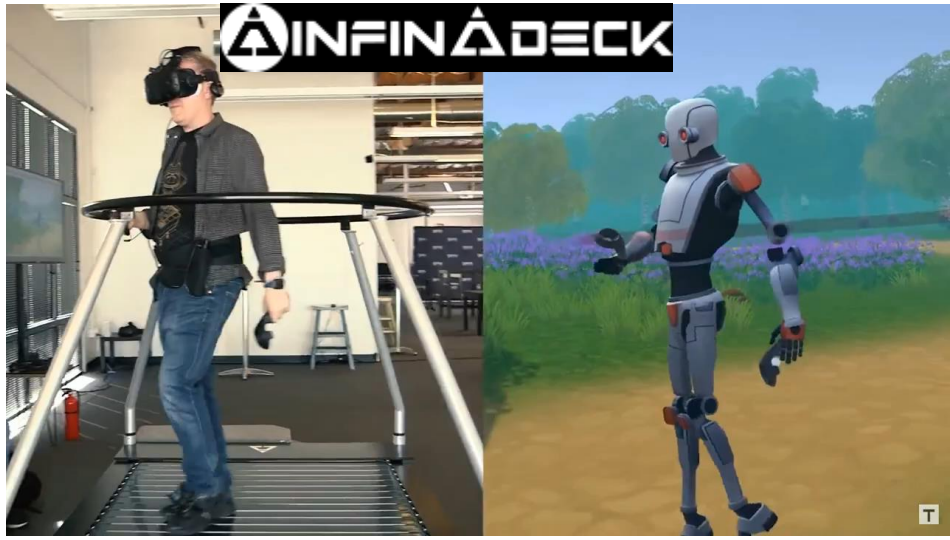
State of the art

Increase self-motion cues for inner ears

- Locomotion simulator [3]
  - Virtusphere [1]
  - Omni-Directional Treadmill [2]
  - Others

Limits

- Realism
- Equilibrium
- Volume, Cost
- etc.



[1] M. Eliana et al (2008) Virtusphere: Walking in a Human Size VR “Hamster Ball
[2] Souman et al. (2011) CyberWalk: Enabling unconstrained omnidirectional walking
[3] I. Bishop, and M. R. Abid (2018) Survey of Locomotion Systems in Virtual Reality

State of the art

Increase self-motion cues for inner ears

- Locomotion simulator
- Physiological stimulation
  - Galvanic vestibular stimulation [1, 2]
  - Proprioceptive vibration [3, 4]

Limits

- Efficiency,
- Intrusiveness,
- setup for personal use,
- etc.

[1] Maeda et al (2005) Shaking the world: Galvanic vestibular stimulation
[2] C. Groth et al (2022) Omnidirectional Galvanic Vestibular Stimulation in Virtual Reality
[3] Plouzeau et al (2015) Effect of proprioceptive vibrations on simulator sickness during navigation task in virtual environment
[4] Peng et al (2020) WalkingVibe: Reducing Virtual Reality Sickness and Improving Realism while Walking in VR using Unobtrusive Head-mounted Vibrotactile Feedback

State of the art

Increase self-motion cues for inner ears

Reduce self-motion cues for eyes

- Virtual navigation restriction
  - Locomotion acceleration / speed control [1, 3]
  - Teleportation [◊]
  - Head motion: rotation lock [2]

Limits

- Difficult to ensure the **navigation quality**

[1] Argelaguet (2014) Adaptive navigation for virtual environments
[2] Kemeny et al (2017) New VR Navigation Techniques to Reduce Cybersickness
[3] Plouzeau et al. (2018) Using cybersickness indicators to adapt navigation in virtual reality

State of the art

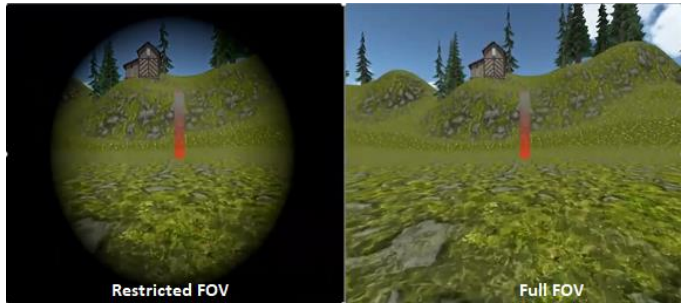
Increase self-motion cues for inner ears

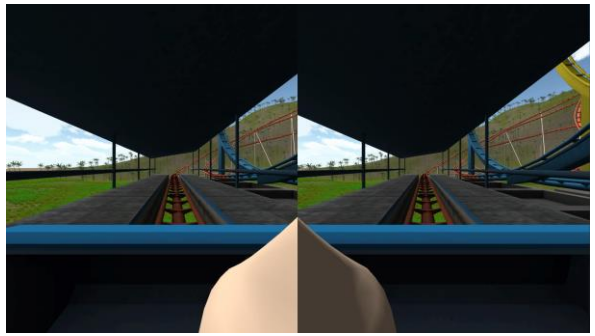
Reduce self-motion cues for eyes

- Virtual locomotion restriction
- Visual rendering adaptation
  - Rendered images blurring [1]
  - Field of view (FOV) restriction [2, 3]
- Intruder in the visualization
  - Adding virtual nose [4]

Limits

- Difficult to ensure the **immersion degree**





[1] Budhiraja et al (2017) Rotation Blurring: Use of Artificial Blurring to Reduce Cybersickness in Virtual Reality
[2] Rogers et al (2017) Peripheral Visual Cues Contribute to the Perception of Object Movement During Self-Movement
[3] Al Zayer et al (2019) The Effect of Field-of-View Restriction on Sex Bias in VR Sickness and Spatial Navigation Performance
[4] Whittinghill et al (2015) Nasum virtualis: A simple technique for reducing simulator sickness

Our approach

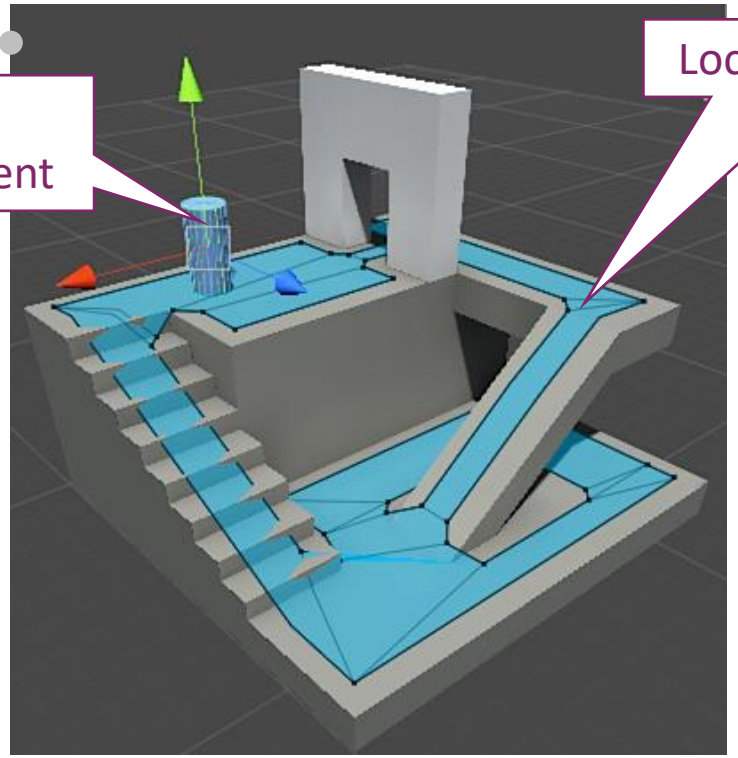
Reduce self-motion cues for eyes by geometric simplification of the virtual scene

Offline

- Locomotion zone definition
- Navigation simulation and optic flow analysis
- Optic flow based scene segmentation
- High optic flow geometric simplification

Runtime

- Original and simplified scenes mixing ratio computation
- Mixed scenes (original and simplified) rendering



Courtesy Unity3D documentation
"Creating a NavMesh Agent"

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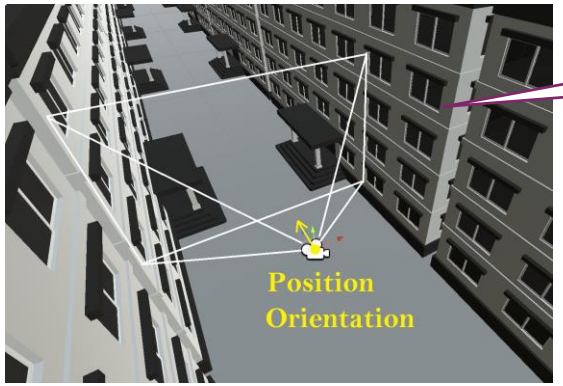
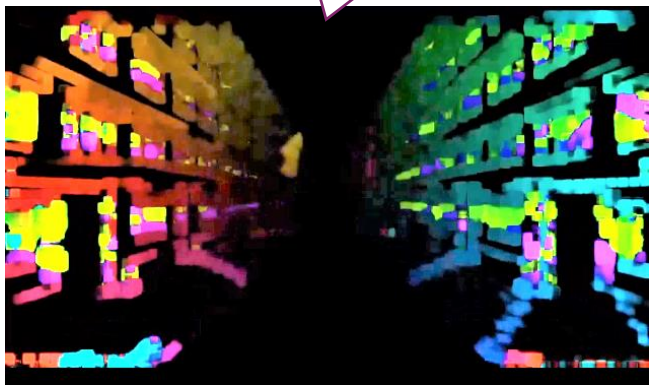


Agent is moving in the virtual scene

Image seen by agent

Optic flow [1] analyzed on the image



[1] Ji et al (2004) Integrating a computational model of optical flow into the cybersickness dose value prediction model

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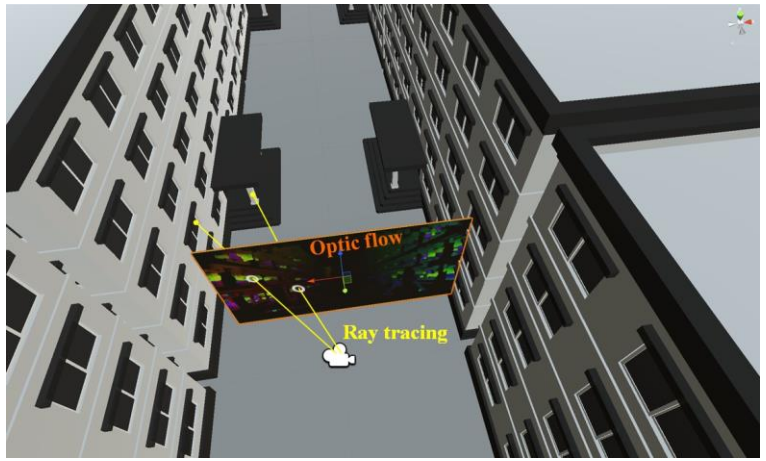
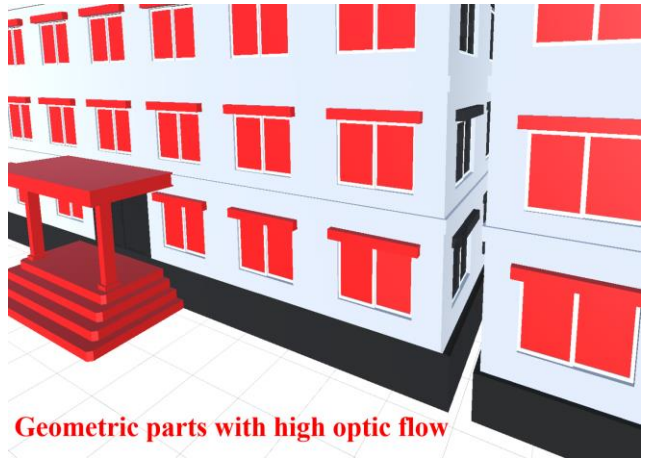
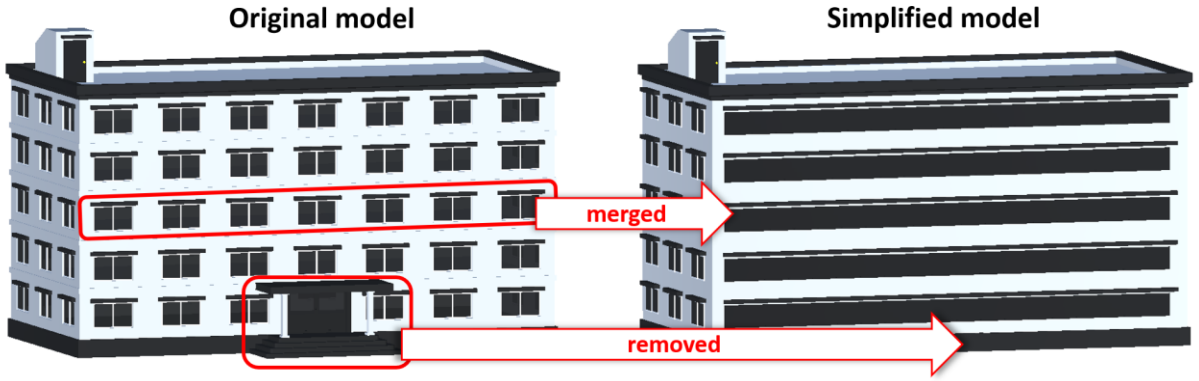
Projection of optic flow onto the virtual scene for segmentation





Scene geometry optimization (Optic flow vs Realism)



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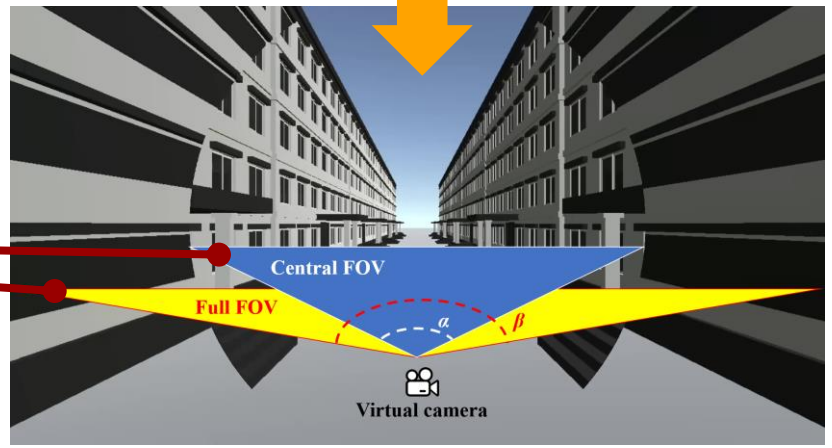
Circular mask

Overlap the mask on the simplified scene

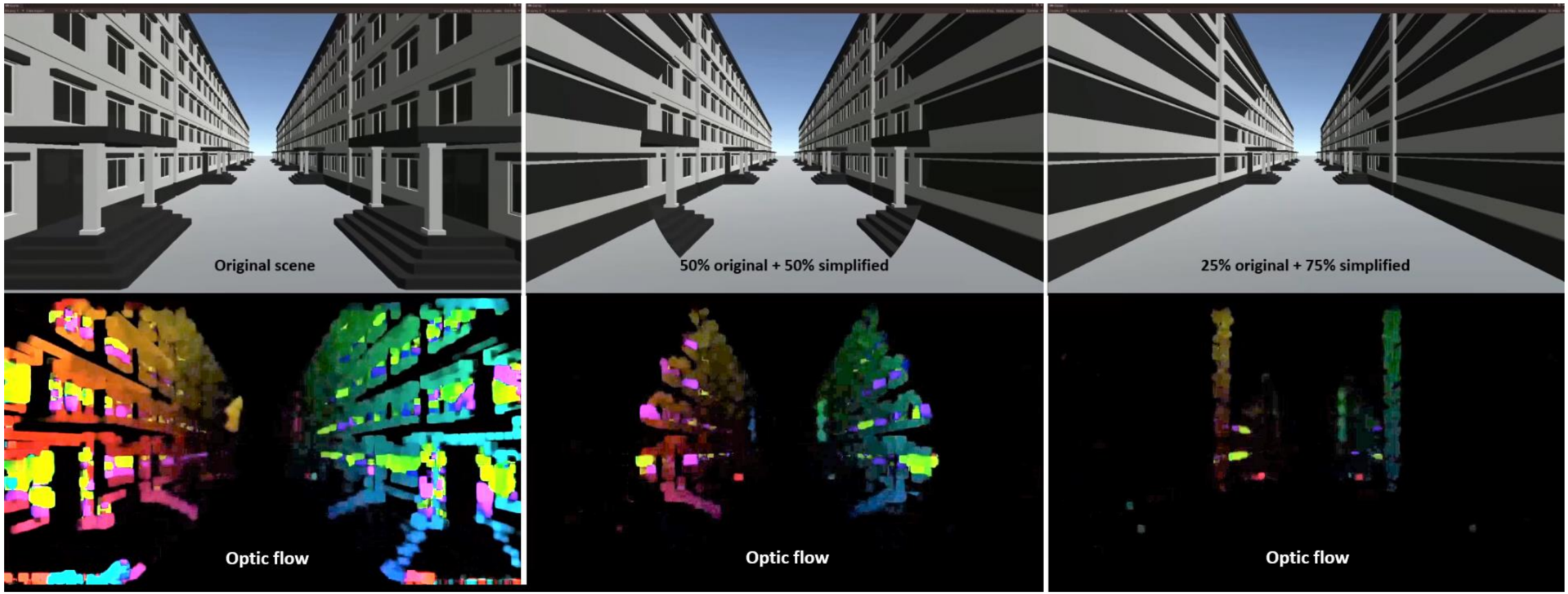
$$\frac{\text{Central FOV}}{\text{Full FOV}}$$

according to the navigation



Results

Optic flow [1] analyzed is reduced in the peripheral FOV thanks to geometric simplification



[1] Ji et al (2004) Integrating a computational model of optical flow into the cybersickness dose value prediction model

Conclusion & perspectives

General framework of geometric simplification

- Simplification of high optic flow parts seen in the peripheral FOV
- Preservation of scene seen in the central FOV
- Adaptation of ratio $\frac{\text{peripheral FOV}}{\text{full FOV}}$ according to navigation parameters

Future works

- Automation of scene segmentation and simplification
- Game design and experimentation with participants
  - User tasks design and performance evaluation
  - Sickness evaluation using subjective questionnaires and bio-feedback
- Design of other geometric processing methods

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Thanks

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Questions ?

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