Perception of Perspective Distortions in Image-Based Rendering

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PALAIS
FLORALIES
15


PALAIS
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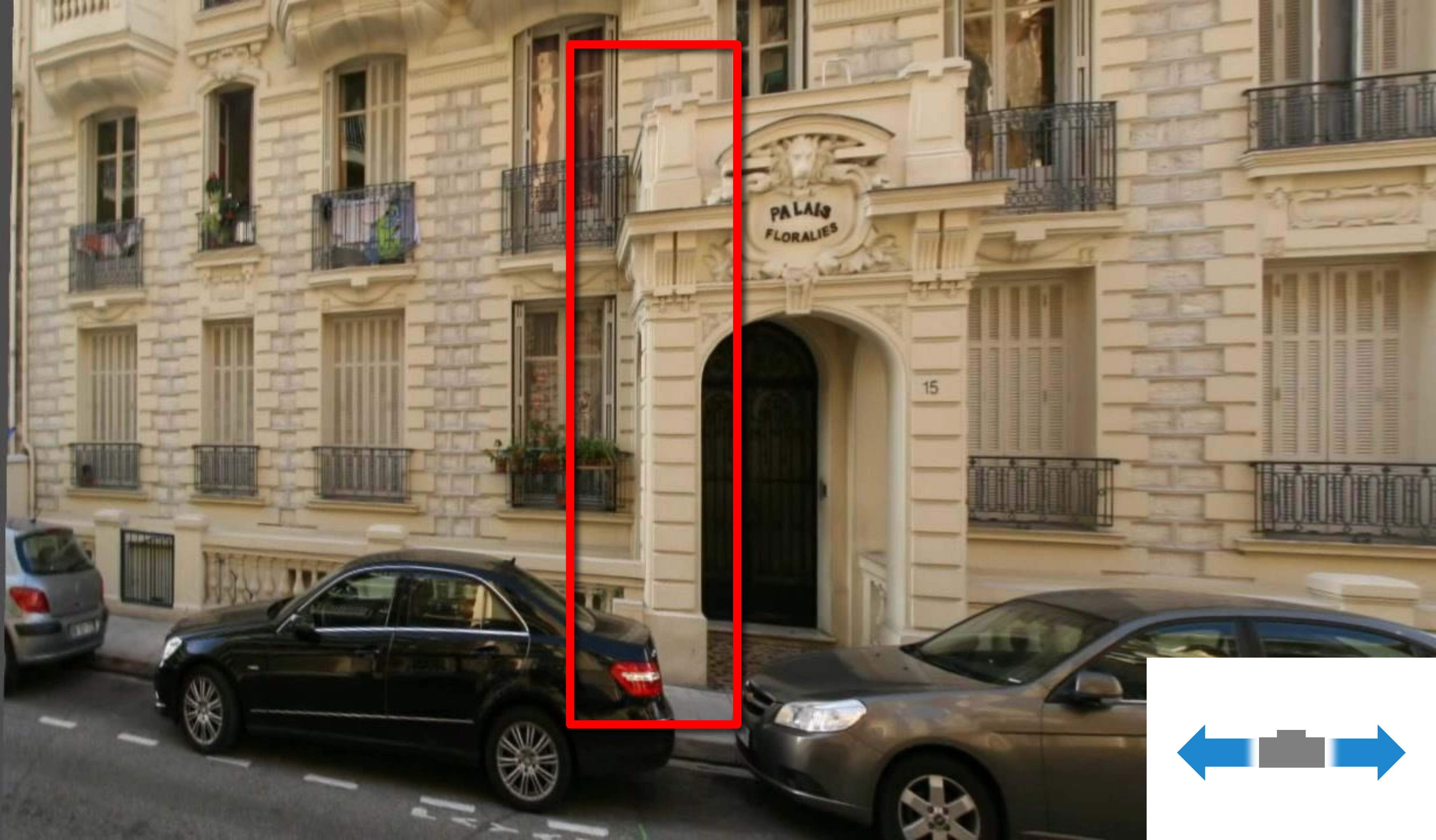
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Goal & Strategy

- Want to study distortions in IBR
  - Identify applicable vision science ideas
  - Extend to street-level IBR context
  - Validate using rigorous experiments
  - Fit predictive models to results
  - Improve IBR applications

Image-based rendering (IBR)

1. Capture a photograph or panorama

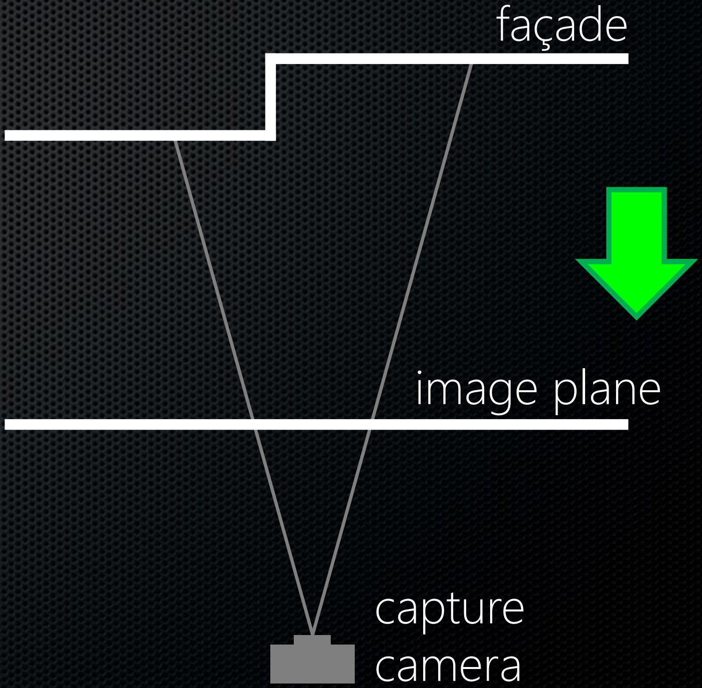


Image-based rendering (IBR)

2. Texture map onto a reconstructed plane

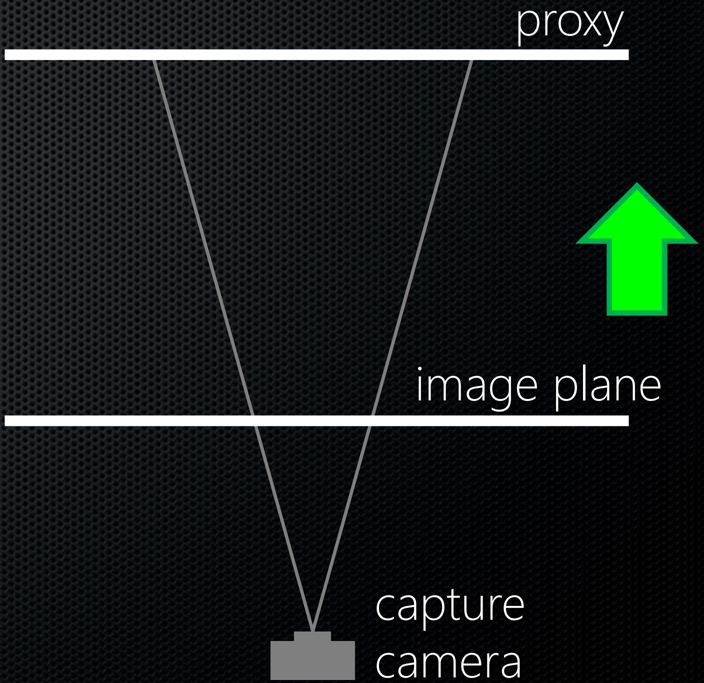
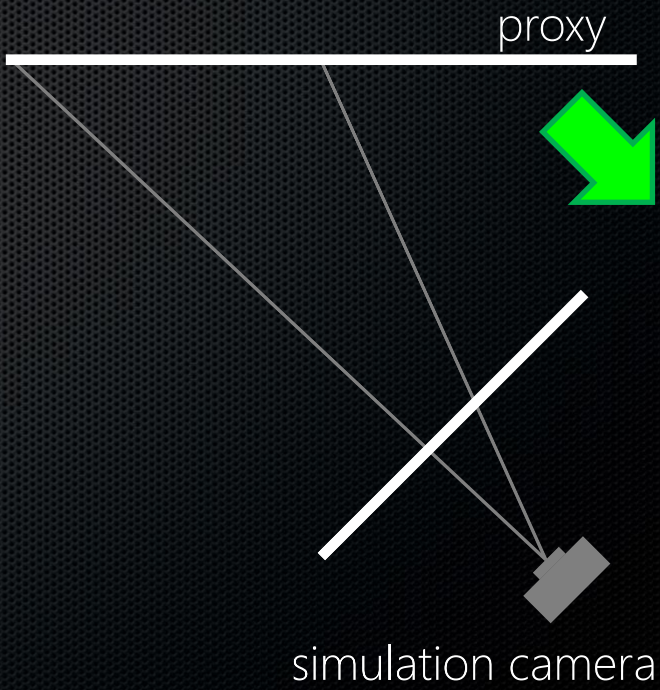


Image-based rendering (IBR)

3. Visualize from any view

➢ Angle distortions



Related work

– Street-level image-based rendering
[e.g., Debevec et al. 1998, Snavely et al. 2006, Kopf et al. 2010]

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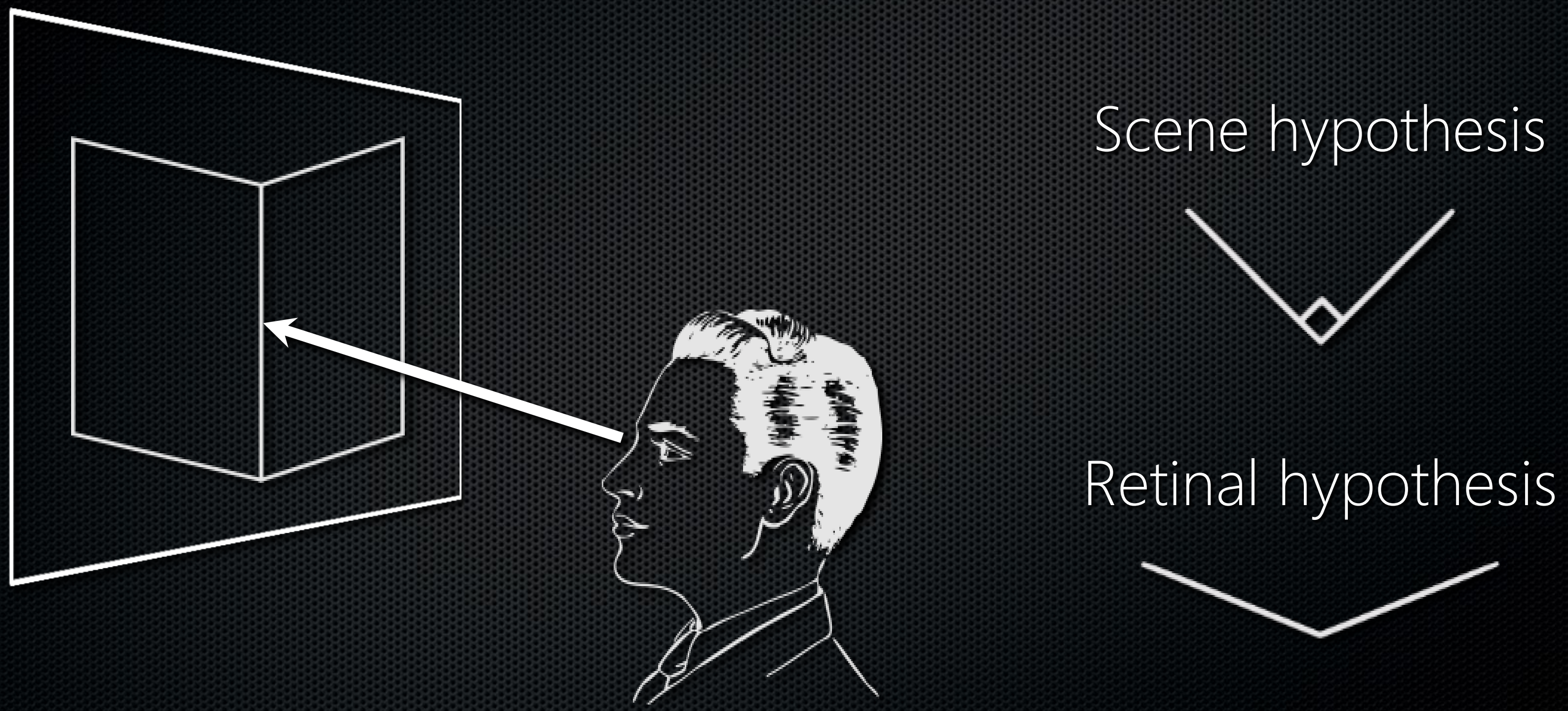
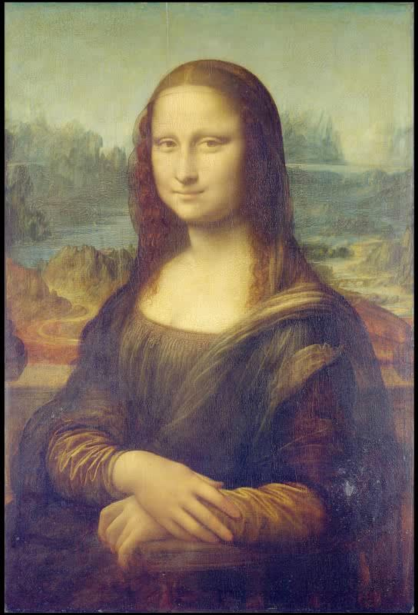
– Perception of artifacts in IBR
[e.g., Morvan & O'Sullivan 2009, Steinicke et al. 2011, Vangorp et al. 2011]

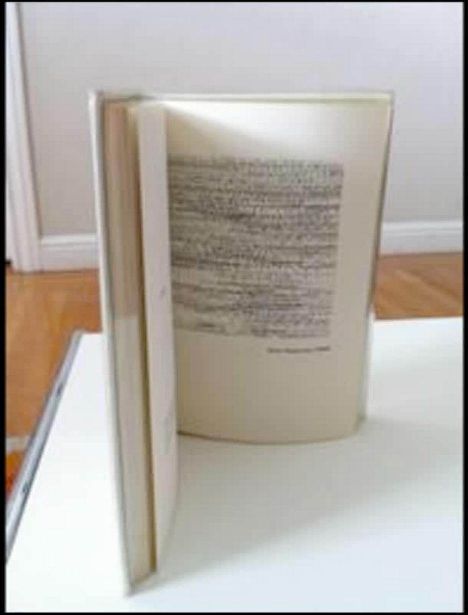
– Vision science on picture perception
[e.g., Perkins 1972, Vishwanath et al. 2005, Yang & Kubovy 1999, Cooper et al. 2012]

Vision science background



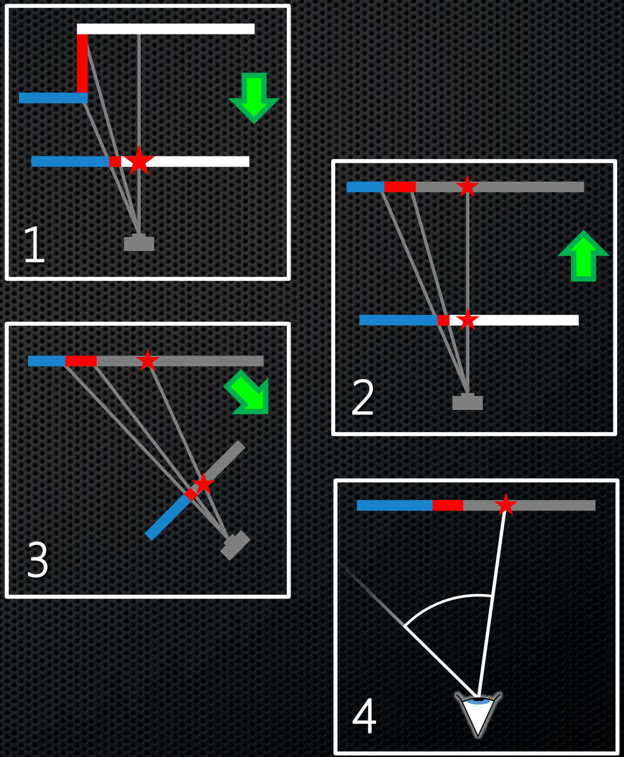
Pointing phenomenon





Extended retinal hypothesis

1. Capture
2. Projection
3. Simulation
4. Display & viewing

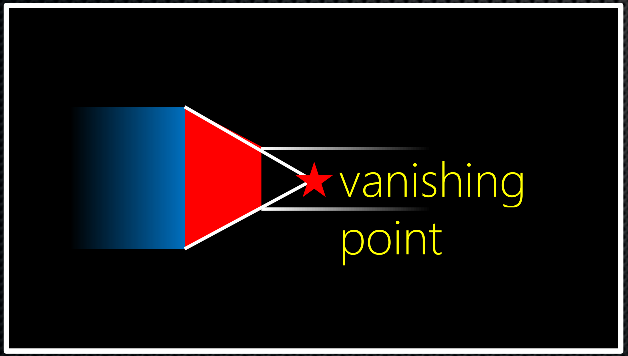


Extended retinal hypothesis

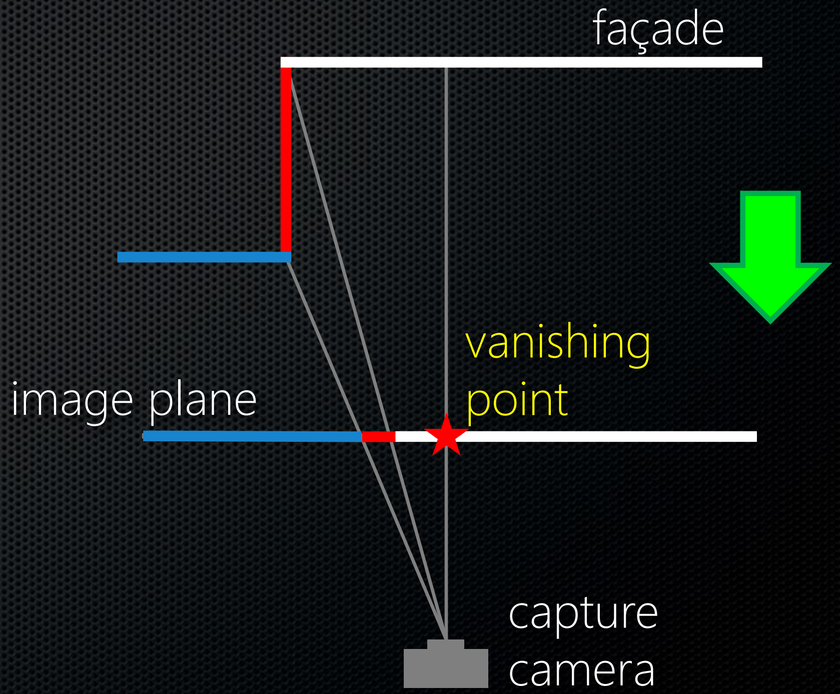
1. Capture
   - Perspective projection

     $$(x', y') = f \cdot (x, y) / z$$

   - Vanishing points: limit at infinity

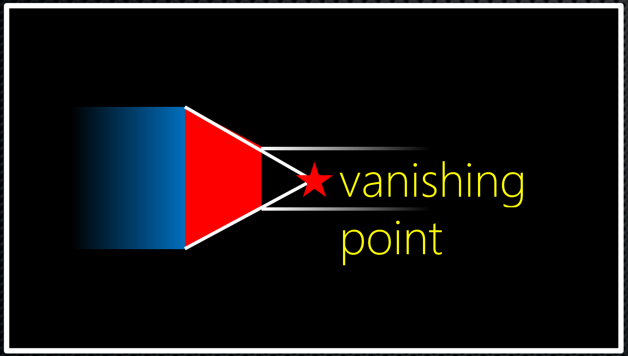


capture camera image

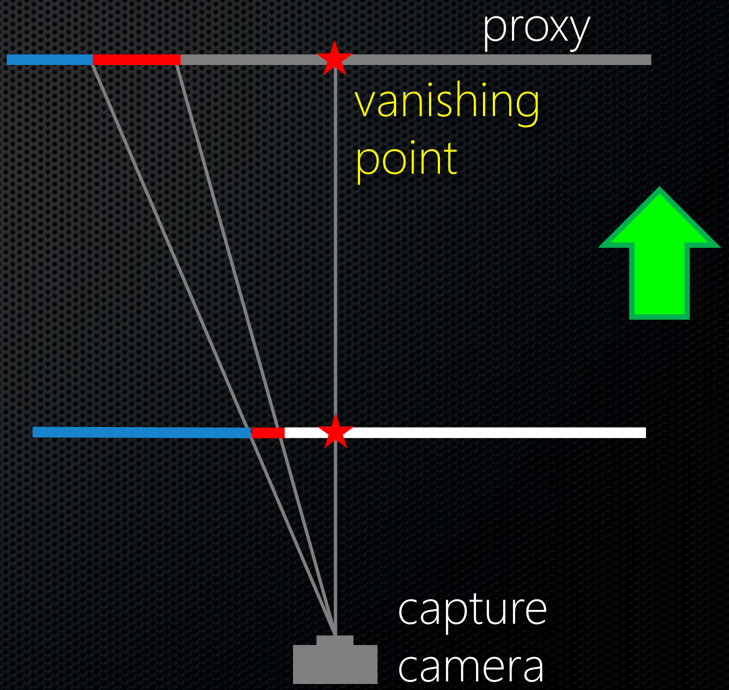


Extended retinal hypothesis

2. Projection
   - Perspective unprojection onto proxy *aka* projective texture mapping
   - Keep track of vanishing points

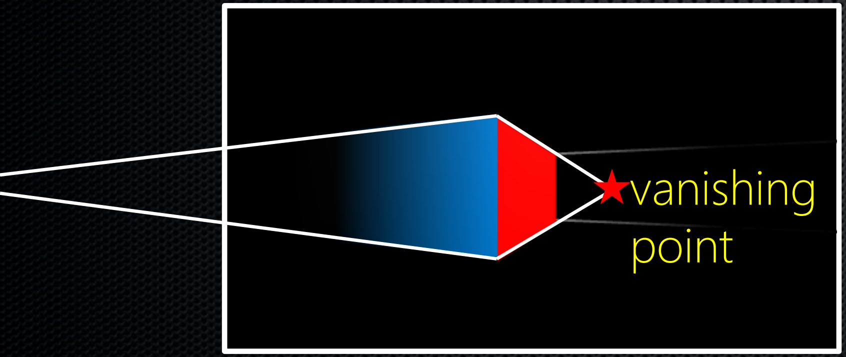


capture camera image

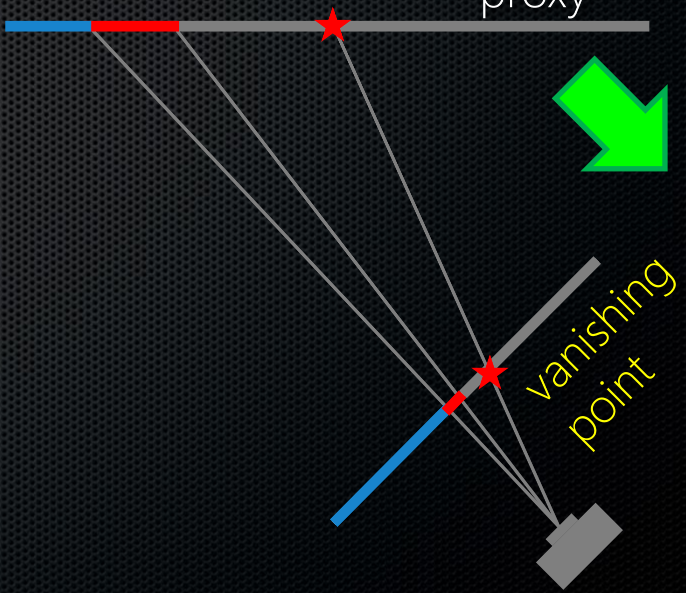


Extended retinal hypothesis

3. Simulation
   - Perspective projection with novel viewpoint
   - Keep track of vanishing points



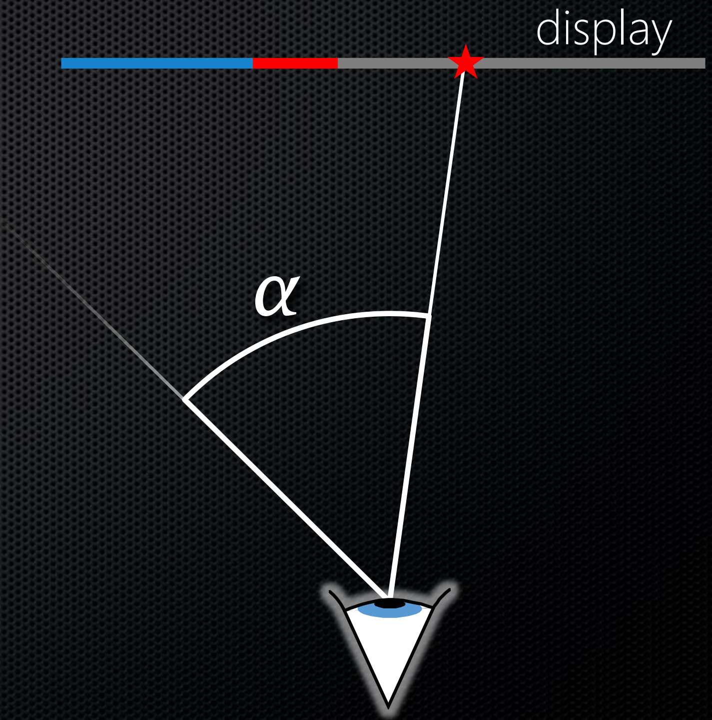
simulation camera image

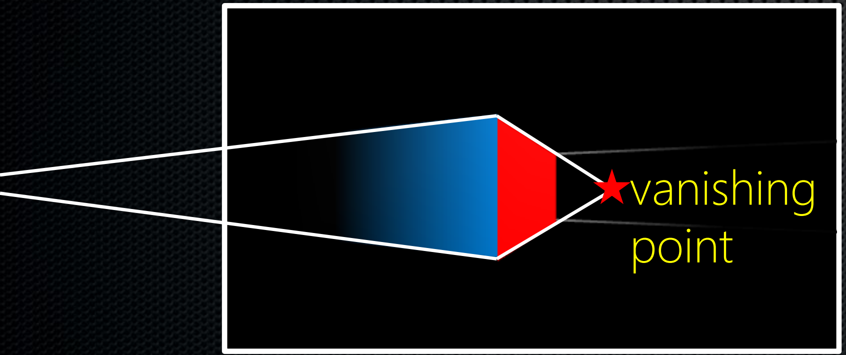


simulation camera

Extended retinal hypothesis

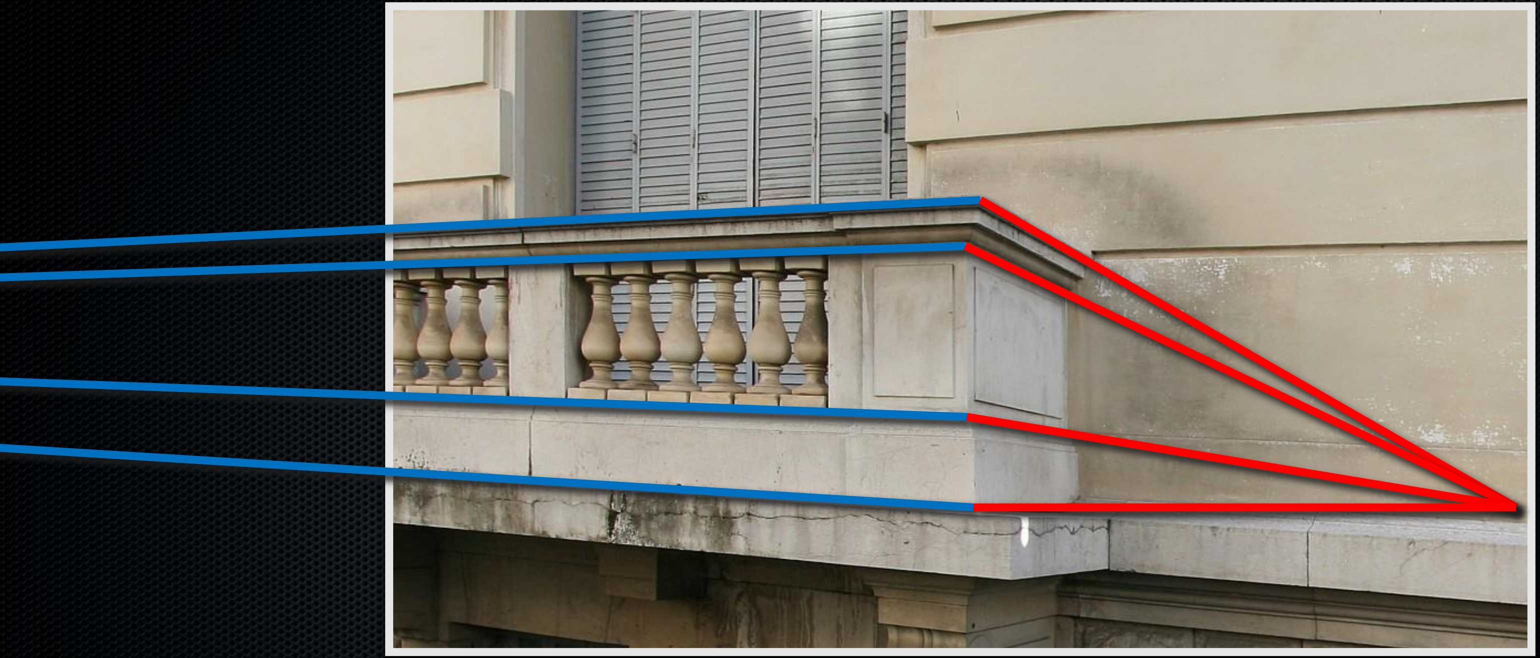
4. Display & Viewing
   – Where are the vanishing points?





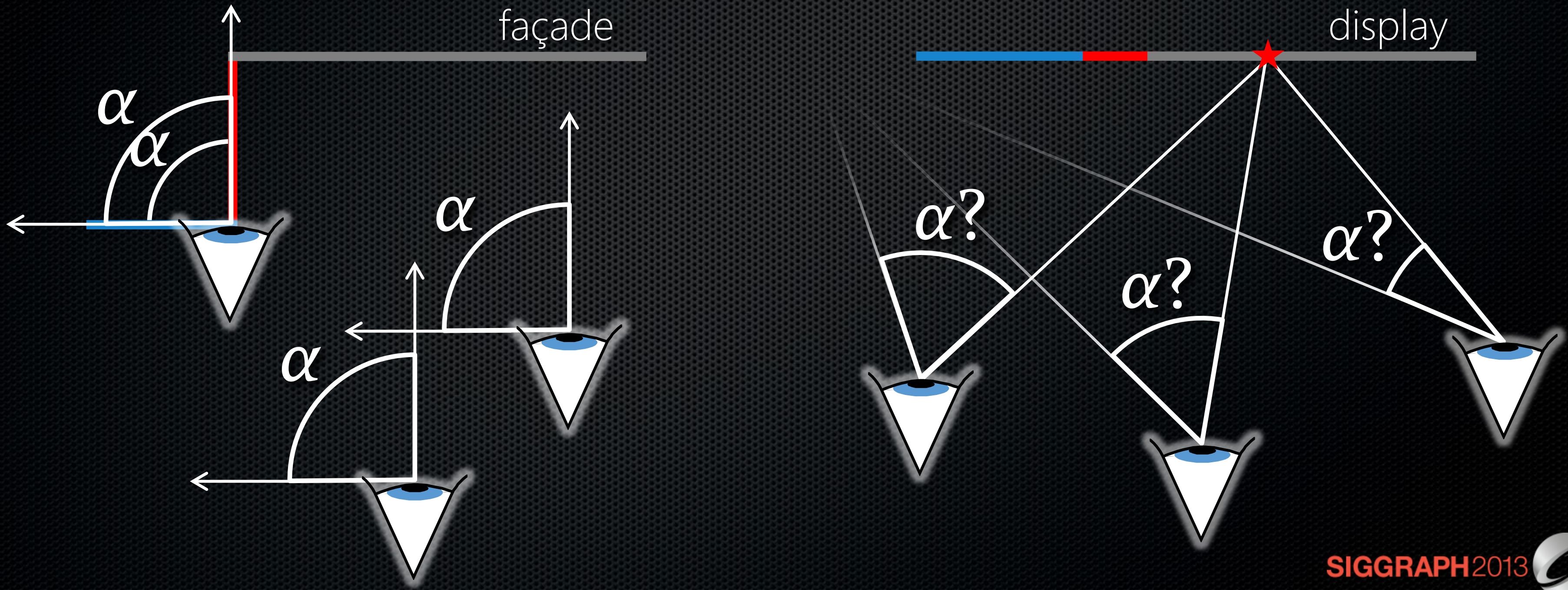
simulation camera image

Extended retinal hypothesis



Angle between vanishing points

– Angle at viewer = angle on façade



Extended retinal hypothesis

$$\alpha_{\text{front}} = \arctan |x_{v,\text{front}}| / z_{v,\text{front}}$$

$$= \begin{cases} 90^\circ & \text{if } \theta_s = 0 \\ \arctan \dfrac{M \cdot f_s}{v \tan |\theta_s|} & \text{otherwise} \end{cases}$$

$$\alpha_{\text{side}} = \arctan |x_{v,\text{side}}| / z_{v,\text{side}}$$

$$= \arctan \left(\frac{M \cdot f_s}{v} \cdot \left| \frac{\tan \theta_e \cdot \cos \theta_s}{\tan \theta_e \cdot \sin \theta_s + 1} \right| \right)$$

$$\alpha_{\text{total}} = \alpha_{\text{front}} + \alpha_{\text{side}}$$

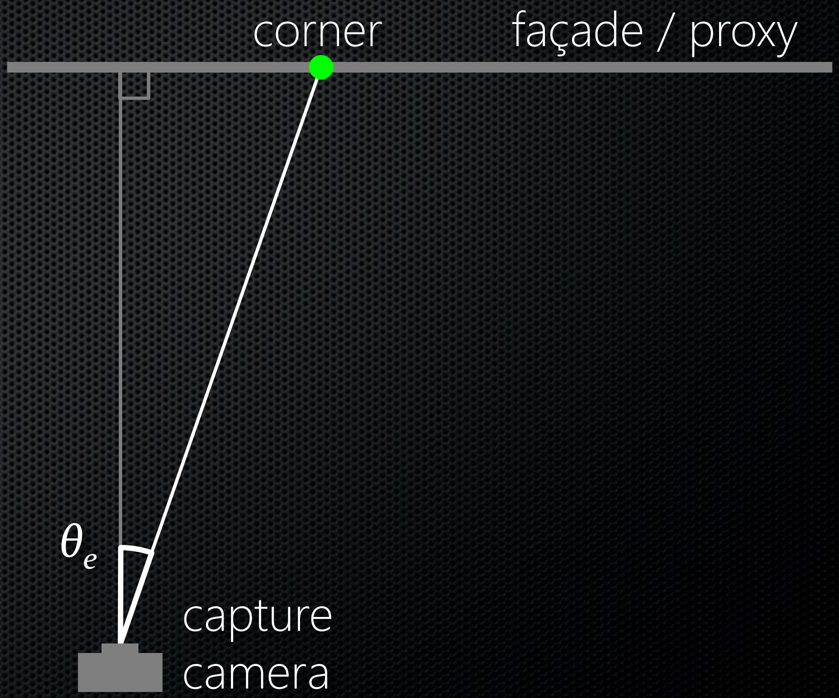
Parameters

– Eccentricity angle θ_e

–30° –20° –10° 0° 10° 20° 30°

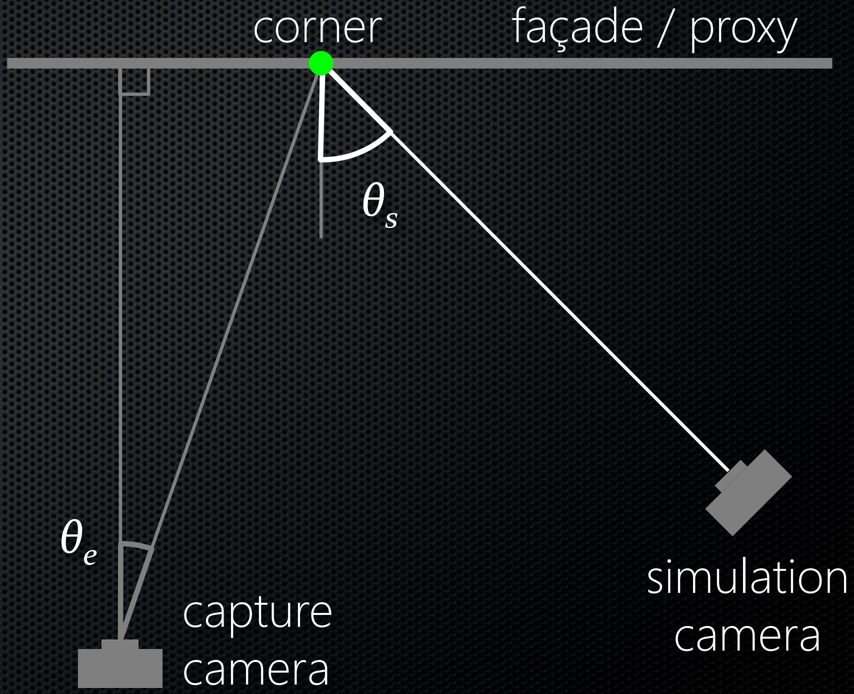
Parameters

– Eccentricity angle θ_e



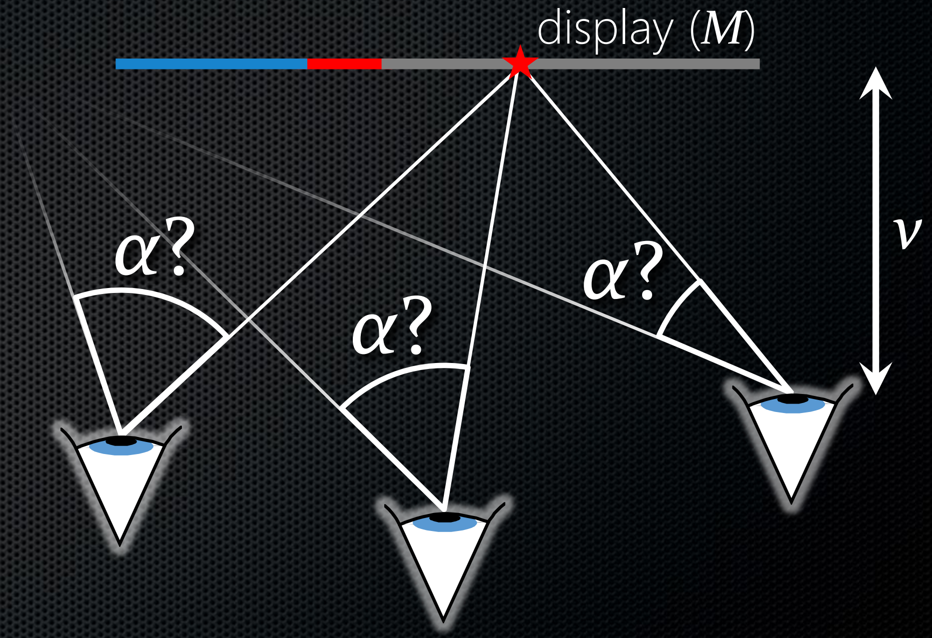
Parameters

– Eccentricity angle θ_e
– Simulation angle θ_s



Parameters

- Eccentricity angle θ_e
- Simulation angle θ_s
- Display size M
- Viewing distance v



Experiments

Stimuli & Conditions

– 3 synthetic façade designs with 3 depth variations:

– 4 eccentricity angles: –32°, –7.1°, 7.1°, 32°
– 5 simulation angles: –30°, –15°, 0°, 15°, 30°
– 4 display sizes: smartphone (3.5″), tablet (9.7″), PC (24″), TV (55″)

Experiments

- 2 experiments: angle matching + angle rating
- 180 stimulus images, each repeated twice
  - for each experiment and on each display
  - additional repetitions for consistency check
- 6 paid participants, ~7 hours each
- Over 9000 trials per experiment

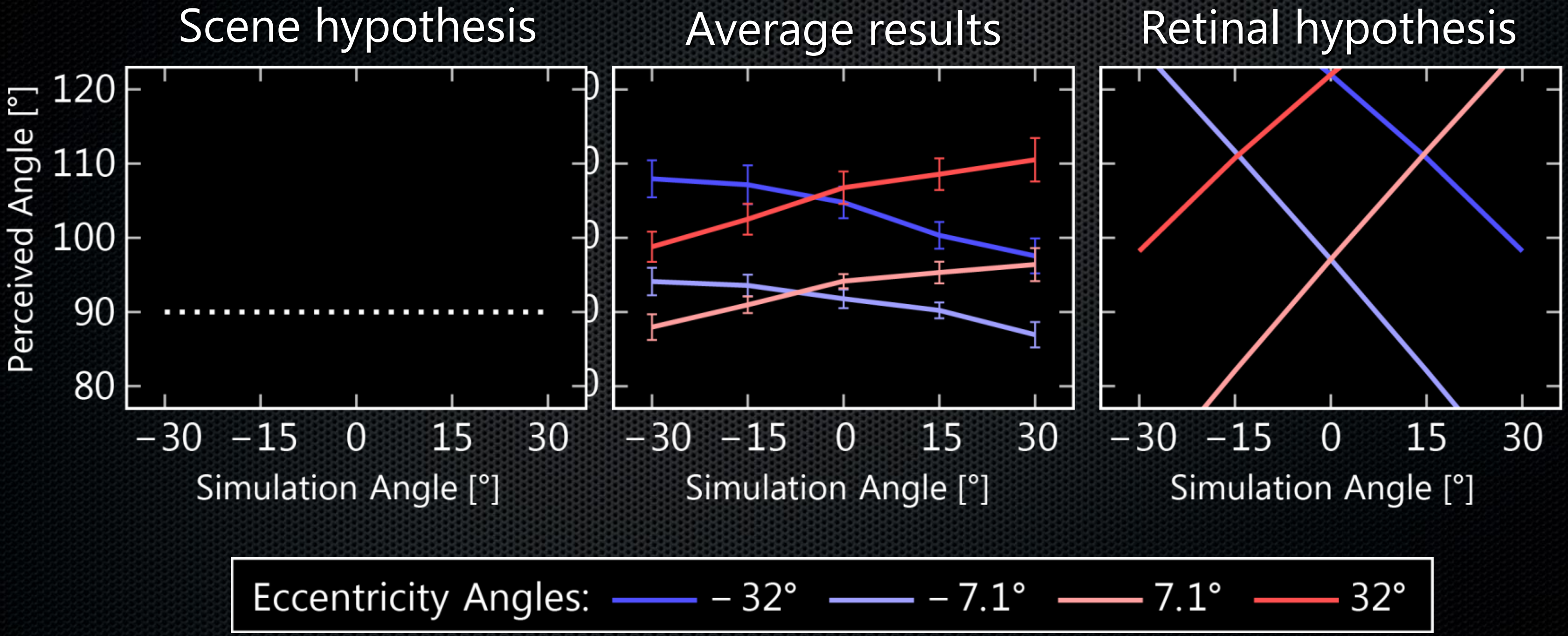
Experiment 1:
Angle Matching

Look at the convex corner at the center of the image. Set the hinge device to the angle you perceive (and not what you think it should be). Press ENTER when the hinge device is set ...

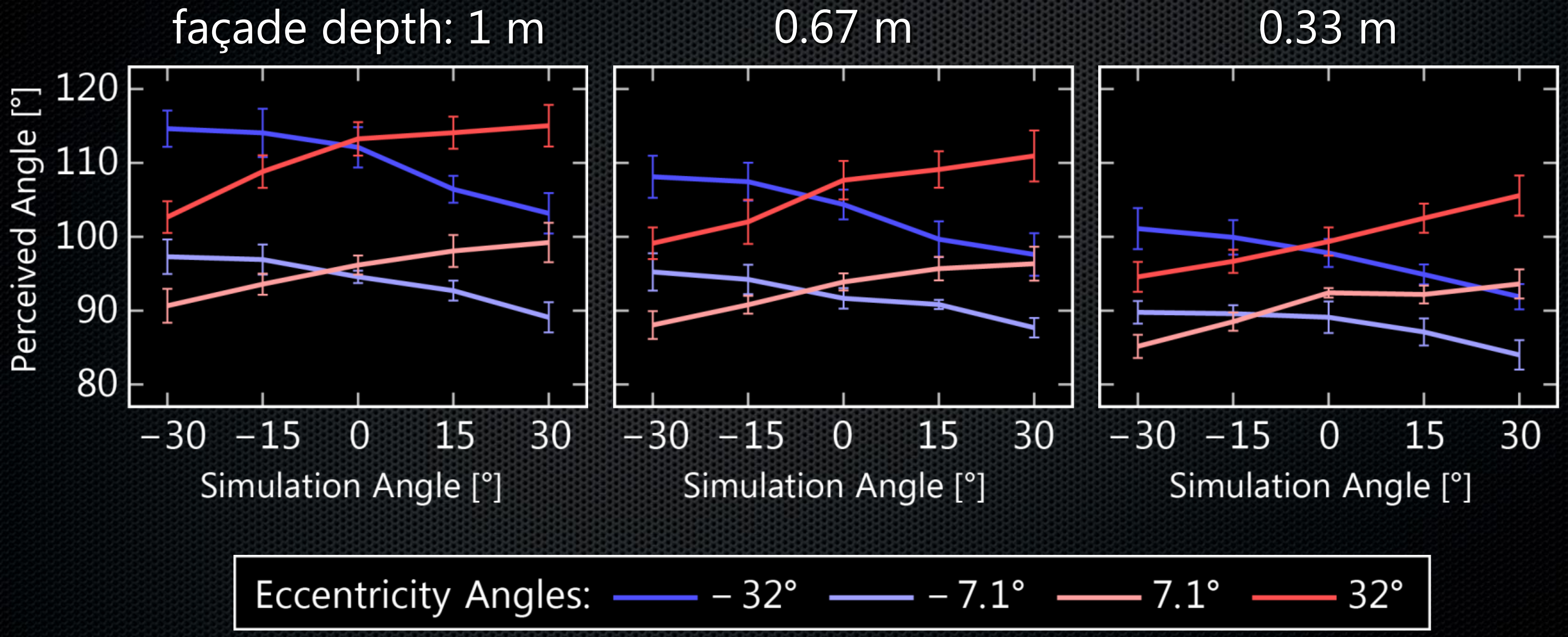
Trial 1/128


Look at the convex corner at the center of the image. Set the hinge device to the angle you perceive (and not what you think it should be). Press ENTER when the hinge device is set ...

Angle-matching results



Angle-matching results



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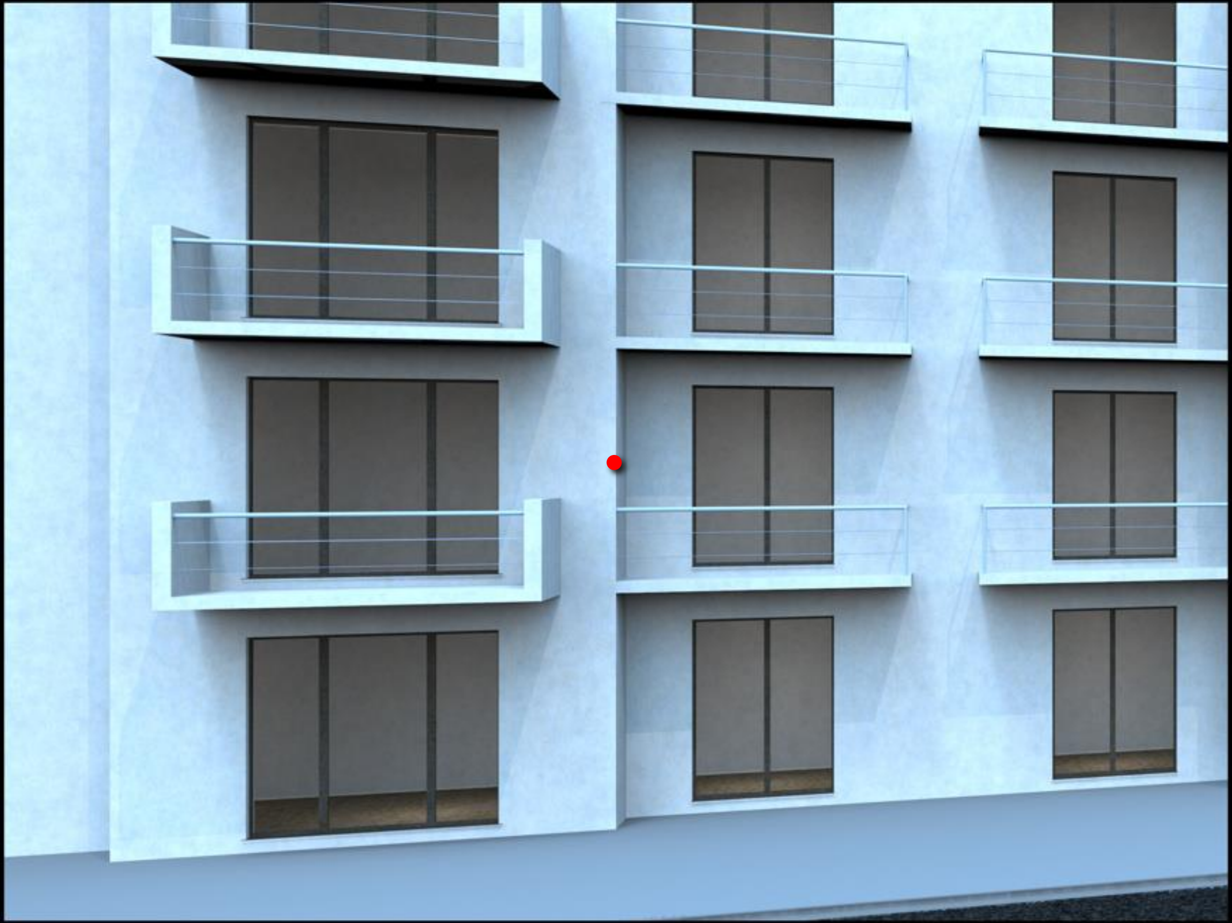
Experiment 2:
Angle Rating

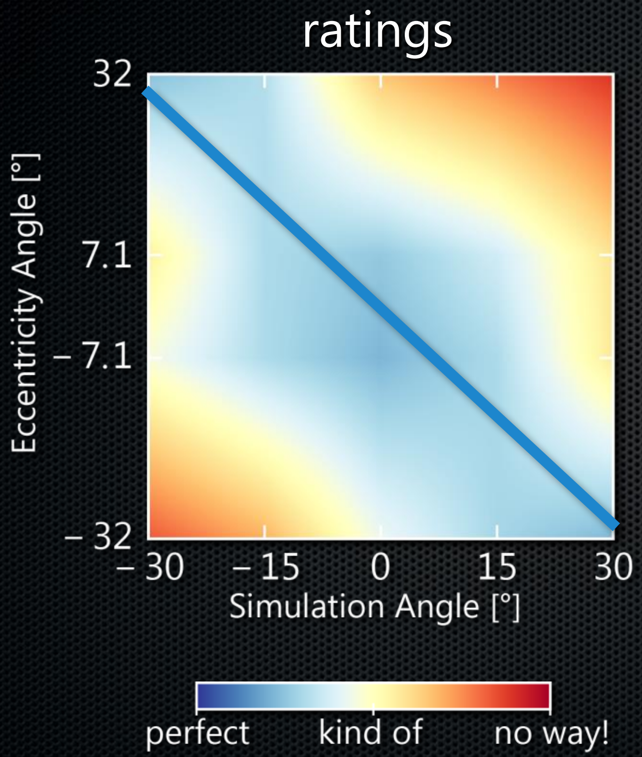
Look at the convex corner at the center of the image. How close does it look to a right angle?

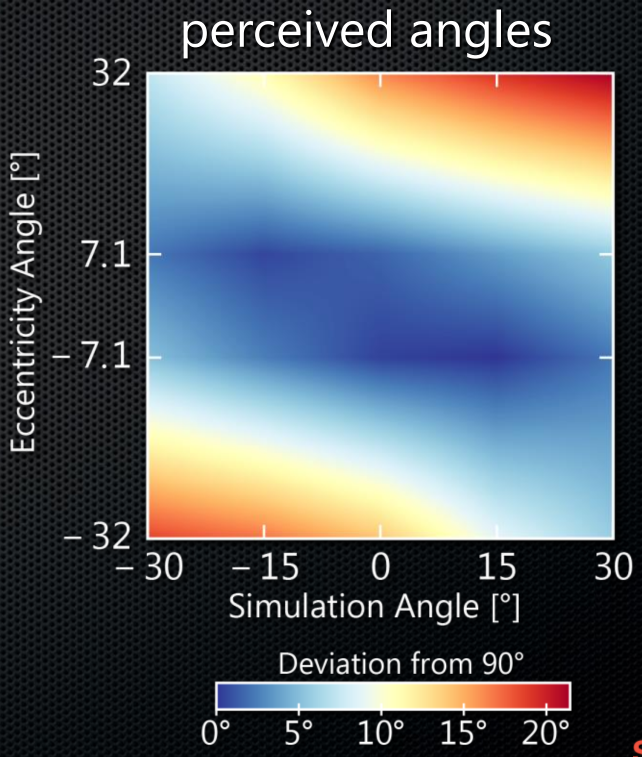
1 = perfect | 2 = close enough | 3 = kind of | 4 = not really | 5 = no way!



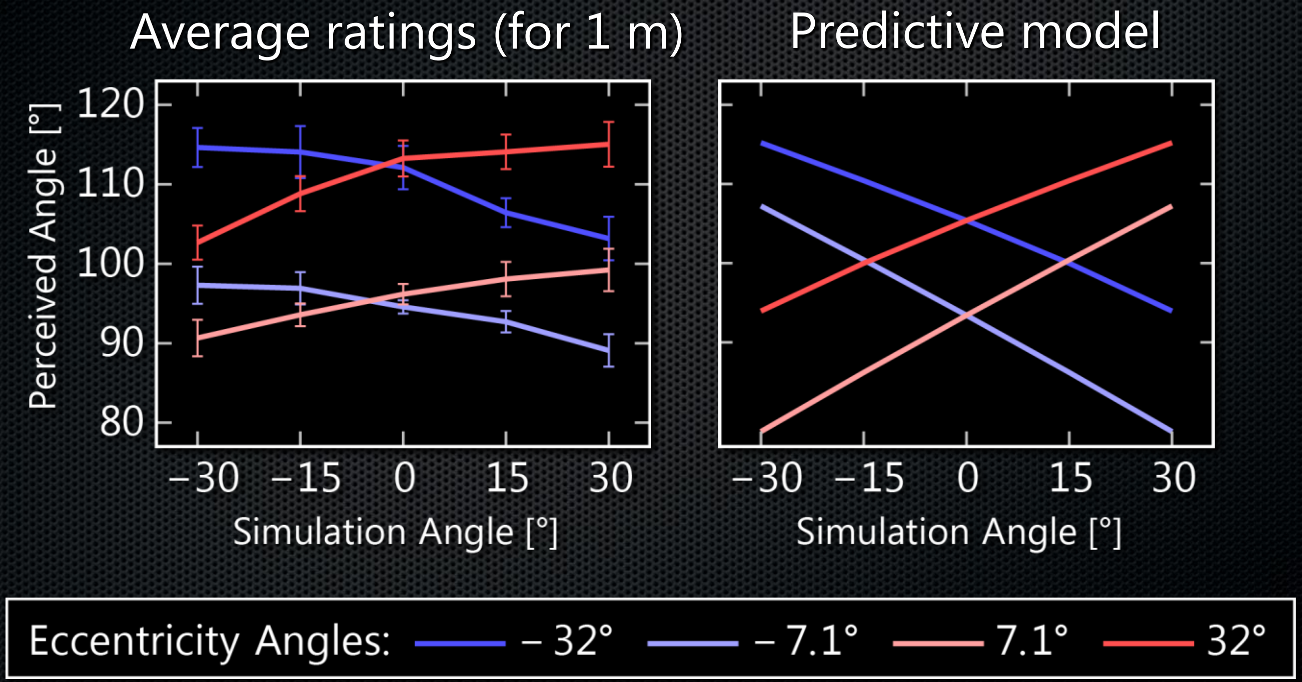
Press ENTER to confirm ...
Trial 69/128

Ratings vs. perceived angles

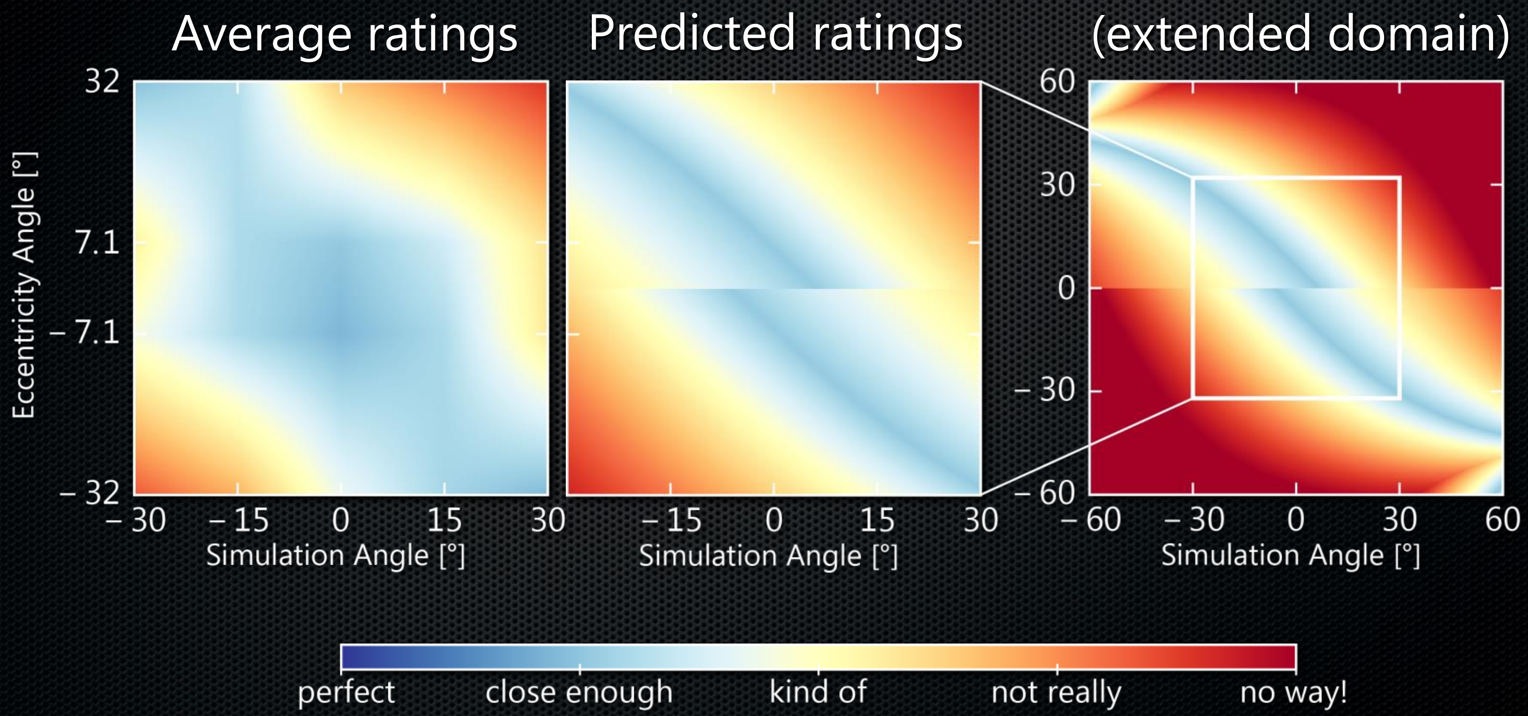




Fit predictive model



Distortion guideline



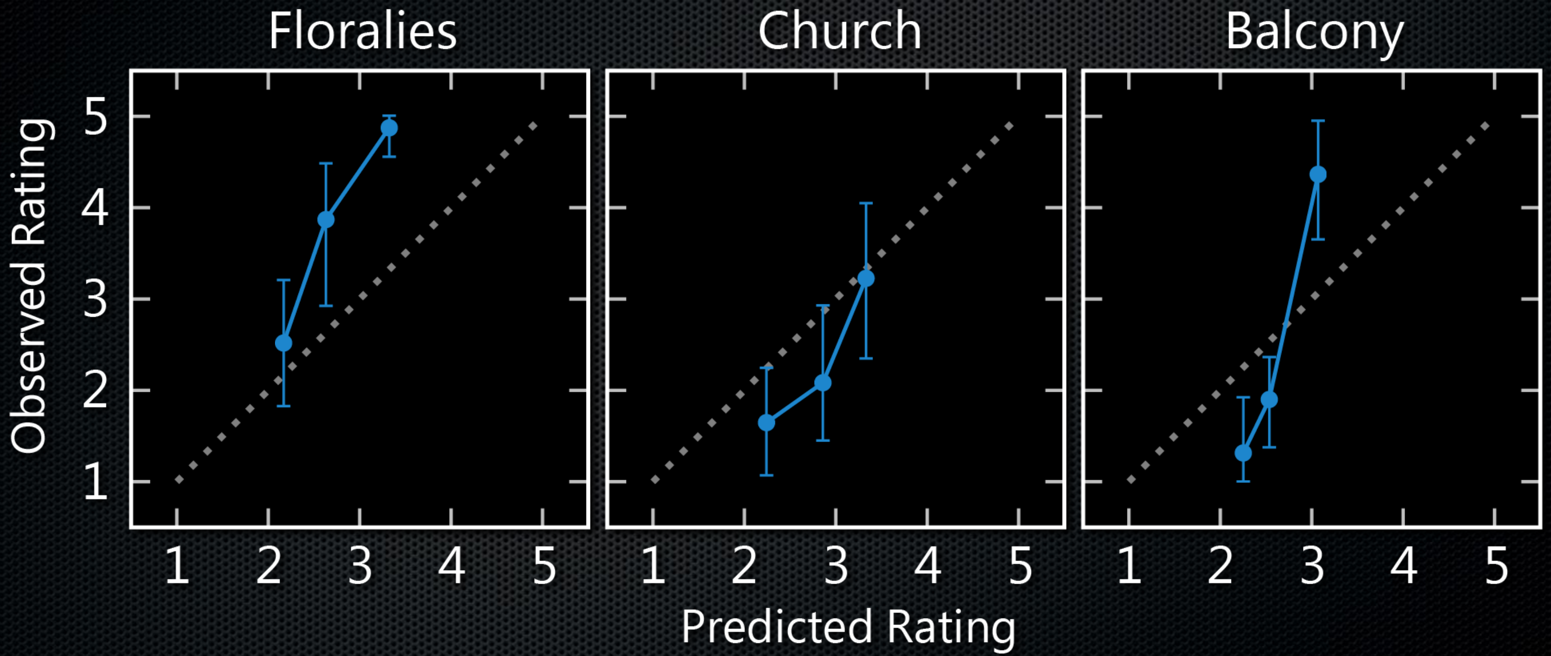
Validation experiment

good path

medium path

bad path

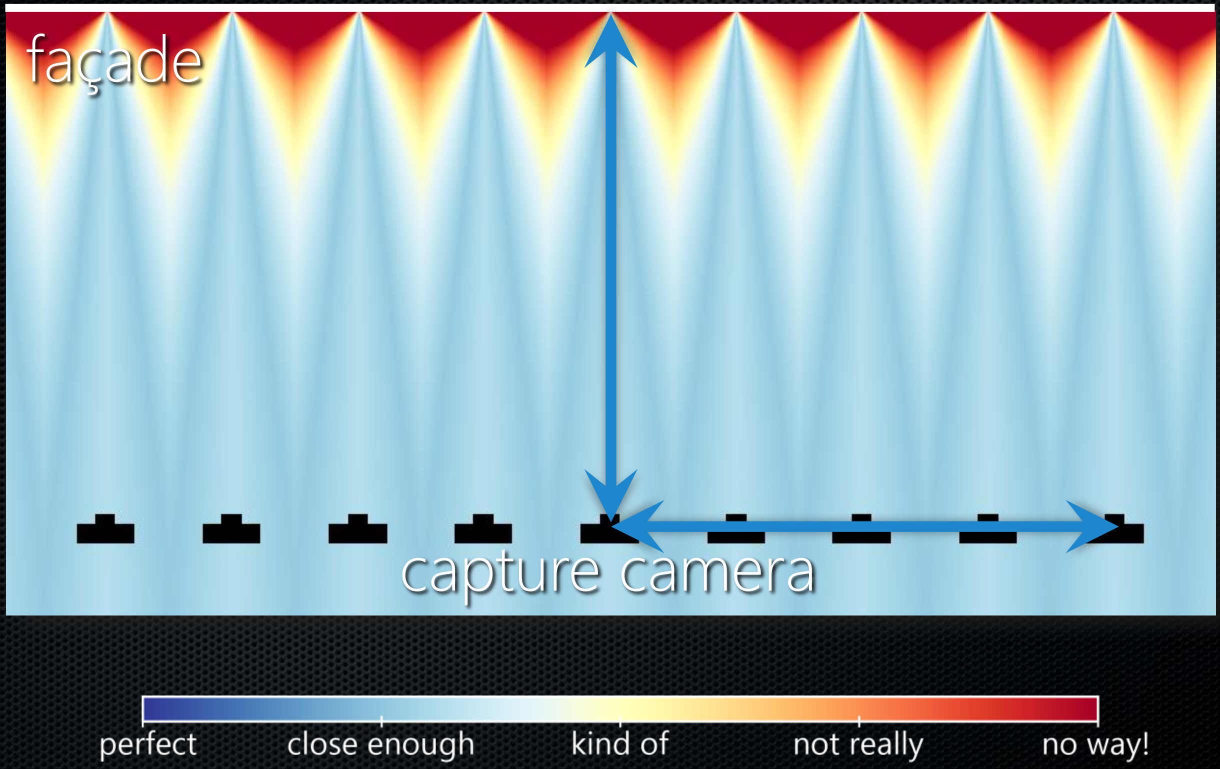
Validation experiment



Applications

1. Guideline for capture density
2. Interactive navigation of street-level IBR
3. Visualization of IBR path designs

Capture guidelines




Viewer
Interactive navigation
Façade
Capture
Camera
(hidden)
Simulation
Camera
Novel Viewpoint

2×

Visualization of IBR paths

2×

Summary

– Extension of vision science research to IBR
– Study of distortions in rigorous experiments
– Predictive model of perspective distortions
– Three applications: capture guideline, interactive navigation & path visualization

Future work

– Stereoscopic viewing
– Angles other than right angles
– More complex proxy geometry
– Moving the simulation camera over time
– Study of transition artifacts

Thanks. Questions?

Funding: INRIA CRISP associate team, EU project VERVE, Adobe & Autodesk
(verveconsortium.eu)

Extra slides

Pointing phenomenon

- Retinal hypothesis
- Finger/gaze straight out
- VPs at fingertip/eyes
- Perceived direction straight at you