CSE 190: Virtual Reality Technologies

LECTURE #20: PANORAMA CAPTURING

Upcoming Deadlines

Sunday, June 6: Project 4 due

June 7+8: Final exam Monday 11:30am – Tuesday 11:30am

App Presentations

M. Emma Morissette

- VRChat

Zheng Zeng

- The Room VR: A Darker Matter

Aneesh Kumar Jalan

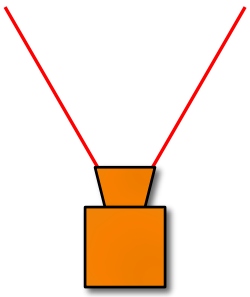
- Creed: Rise to Glory

Panorama Capturing

Panorama v Stereo Movie v Stereo Panorama

Panorama

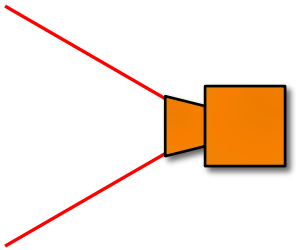
mono & head rotation



Panorama v Stereo Movie v Stereo Panorama

Panorama

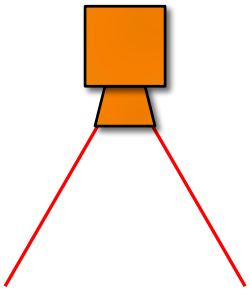
mono & head rotation



Panorama v Stereo Movie v Stereo Panorama

Panorama

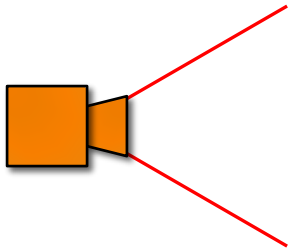
mono & head rotation



Panorama v Stereo Movie v Stereo Panorama

Panorama

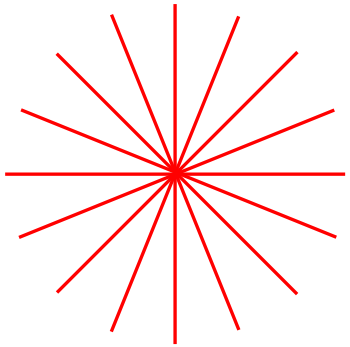
mono & head rotation



Panorama v Stereo Movie v Stereo Panorama

Panorama

mono & head rotation

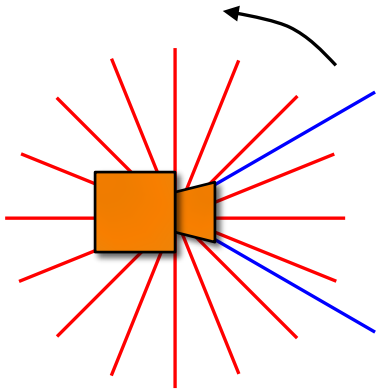


1 center of projection!

Panorama v Stereo Movie v Stereo Panorama

Panorama

mono & head rotation

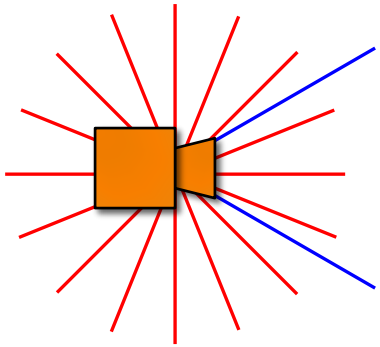


1 center of projection!

Panorama v Stereo Movie v Stereo Panorama

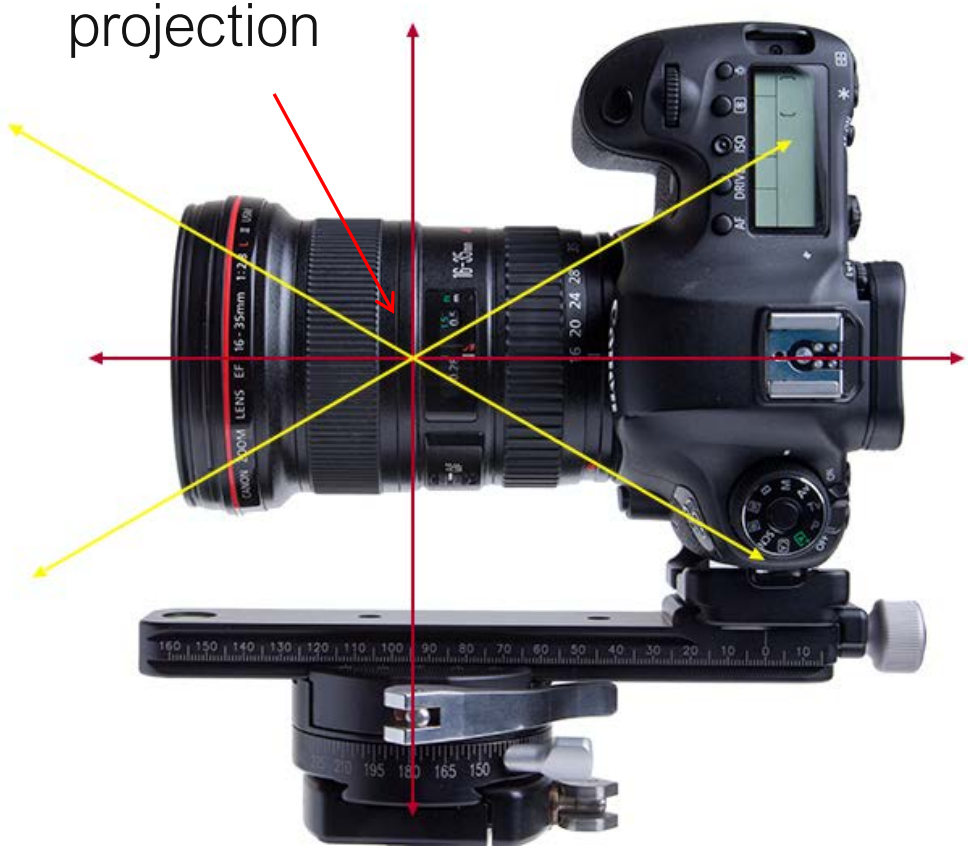
Panorama

mono & head rotation



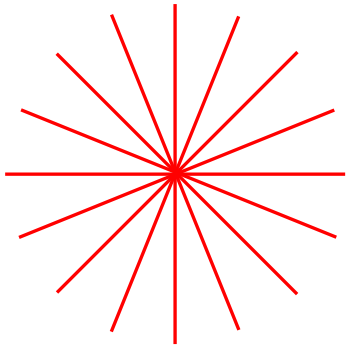
1 center of projection!

center of projection

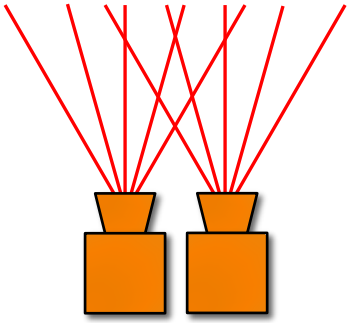


Panorama v Stereo Movie v Stereo Panorama

Panorama	Stereo	Stereo Panorama
mono & head rotation	stereo & no head rotation	stereo & head rotation

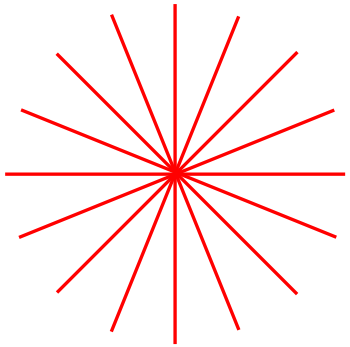


1 center of projection!

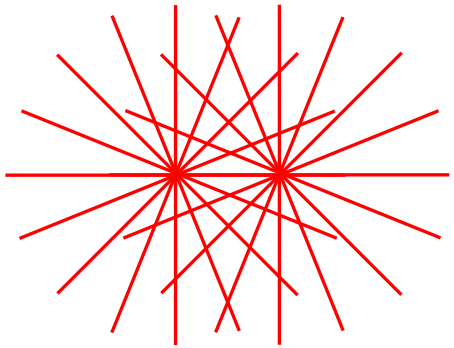


Panorama v Stereo Movie v Stereo Panorama

Panorama	Stereo	Stereo Panorama
mono & head rotation	stereo & no head rotation	stereo & head rotation



1 center of projection!

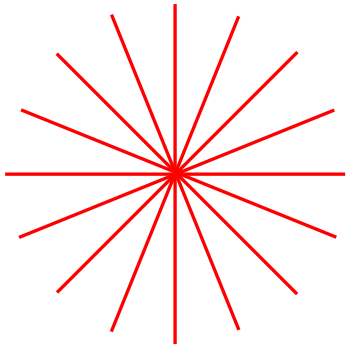


2 centers of projection!

Panorama v Stereo Movie v Stereo Panorama

Panorama

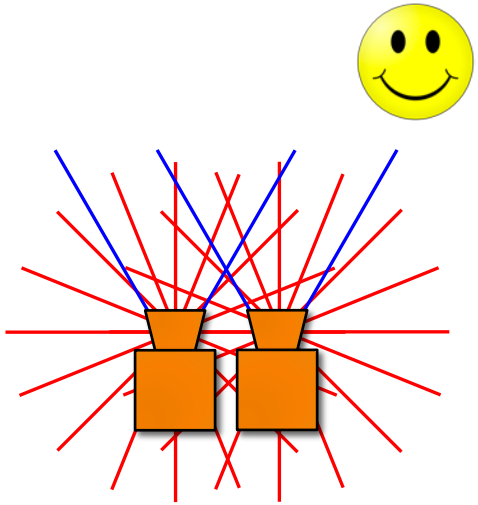
mono & head rotation



1 center of projection!

Stereo

stereo & no head rotation



2 centers of projection!

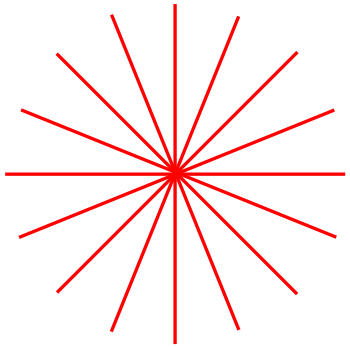
Stereo Panorama

stereo & head rotation

Panorama v Stereo Movie v Stereo Panorama

Panorama

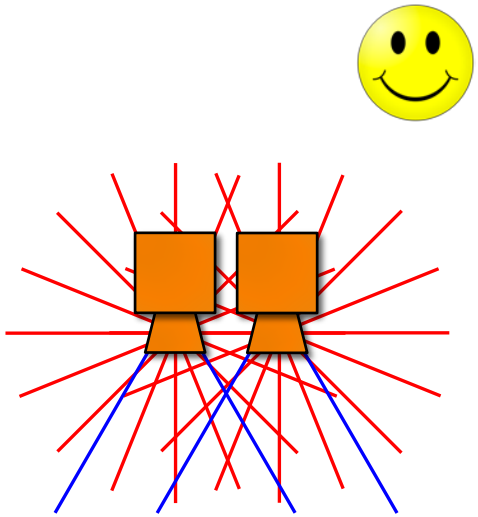
mono & head rotation



1 center of projection!

Stereo

stereo & no head rotation



2 centers of projection!

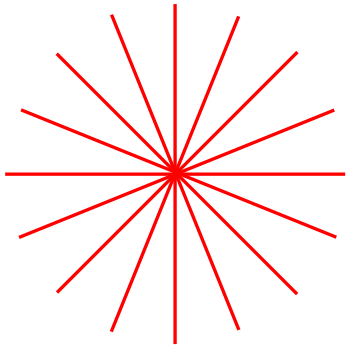
Stereo Panorama

stereo & head rotation

Panorama v Stereo Movie v Stereo Panorama

Panorama

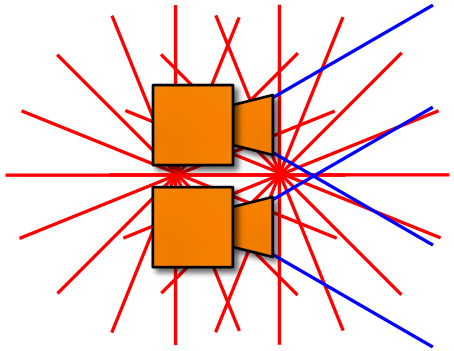
mono & head rotation



1 center of projection!

Stereo

stereo & no head rotation



2 centers of projection!

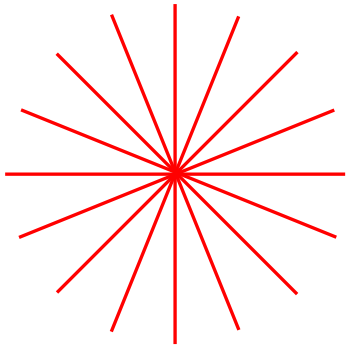
Stereo Panorama

stereo & head rotation

Panorama v Stereo Movie v Stereo Panorama

Panorama

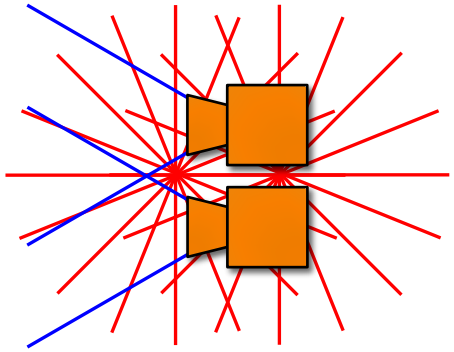
mono & head rotation



1 center of projection!

Stereo

stereo & no head rotation



2 centers of projection!

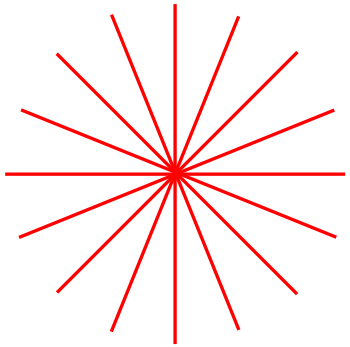
Stereo Panorama

stereo & head rotation

Panorama v Stereo Movie v Stereo Panorama

Panorama

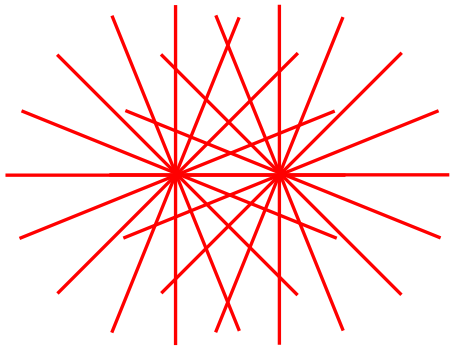
mono & head rotation



1 center of projection!

Stereo

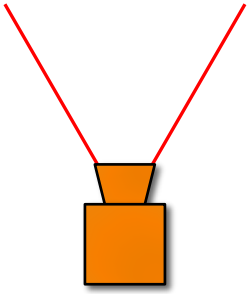
stereo & no head rotation



2 centers of projection!

Stereo Panorama

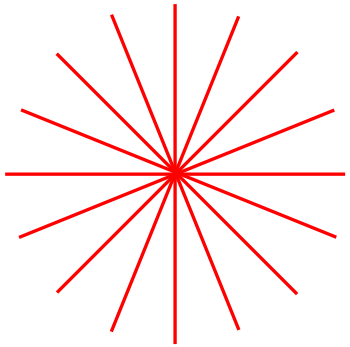
stereo & head rotation



Panorama v Stereo Movie v Stereo Panorama

Panorama

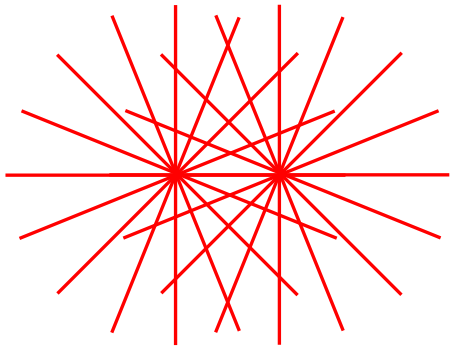
mono & head rotation



1 center of projection!

Stereo

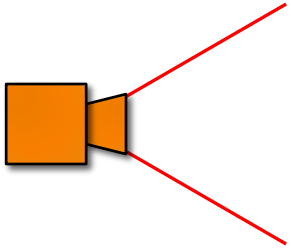
stereo & no head rotation



2 centers of projection!

Stereo Panorama

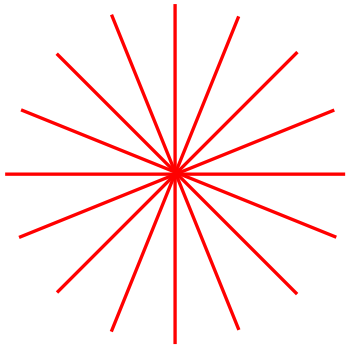
stereo & head rotation



Panorama v Stereo Movie v Stereo Panorama

Panorama

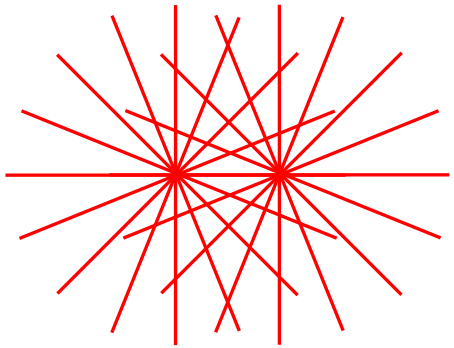
mono & head rotation



1 center of projection!

Stereo

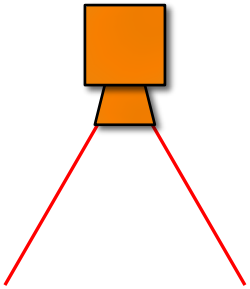
stereo & no head rotation



2 centers of projection!

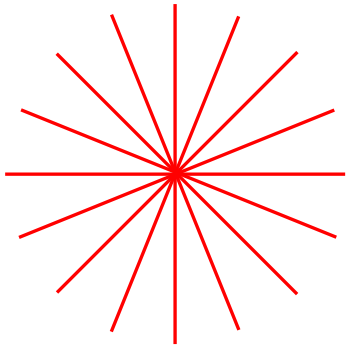
Stereo Panorama

stereo & head rotation

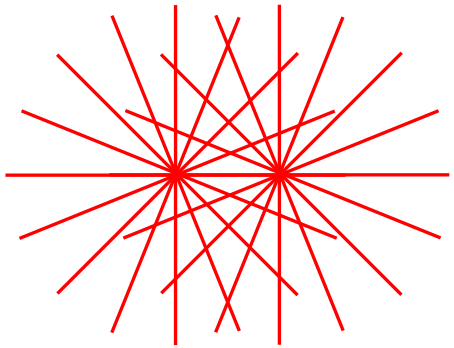


Panorama v Stereo Movie v Stereo Panorama

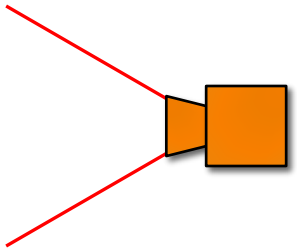
Panorama	Stereo	Stereo Panorama
mono & head rotation	stereo & no head rotation	stereo & head rotation



1 center of projection!



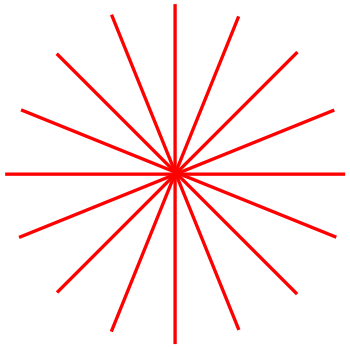
2 centers of projection!



Panorama v Stereo Movie v Stereo Panorama

Panorama

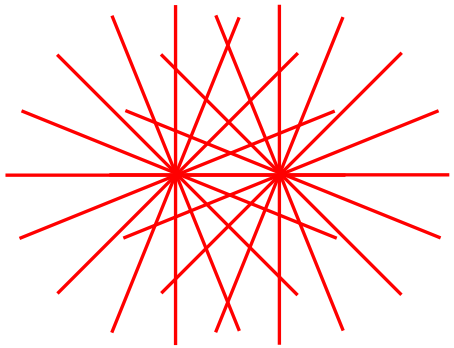
mono & head rotation



1 center of projection!

Stereo

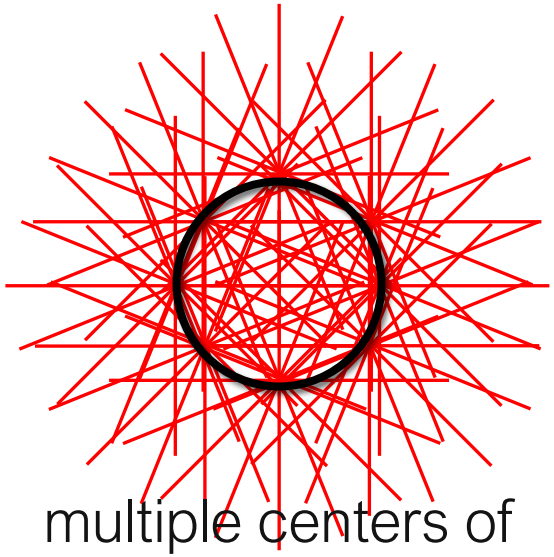
stereo & no head rotation



2 centers of projection!

Stereo Panorama

stereo & head rotation

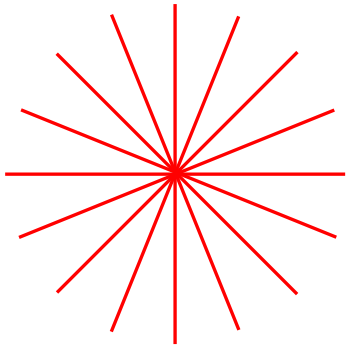


multiple centers of projection

Panorama v Stereo Movie v Stereo Panorama

Panorama

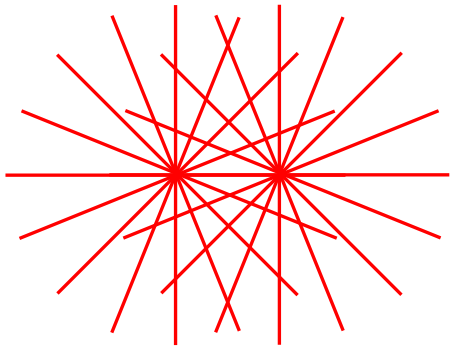
mono & head rotation



1 center of projection!

Stereo

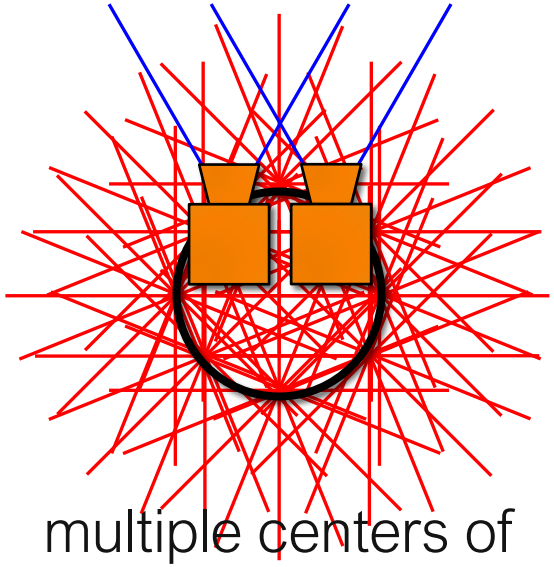
stereo & no head rotation



2 centers of projection!

Stereo Panorama

stereo & head rotation

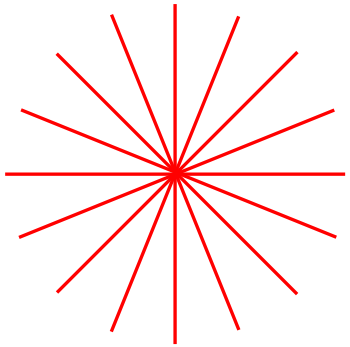


multiple centers of projection

Panorama v Stereo Movie v Stereo Panorama

Panorama

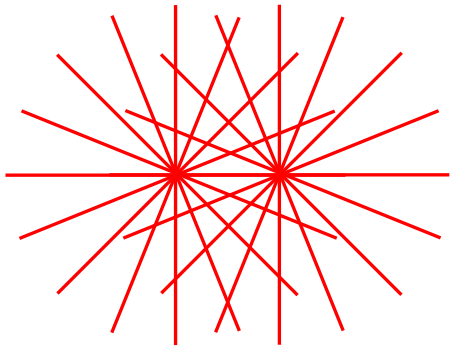
mono & head rotation



1 center of projection!

Stereo

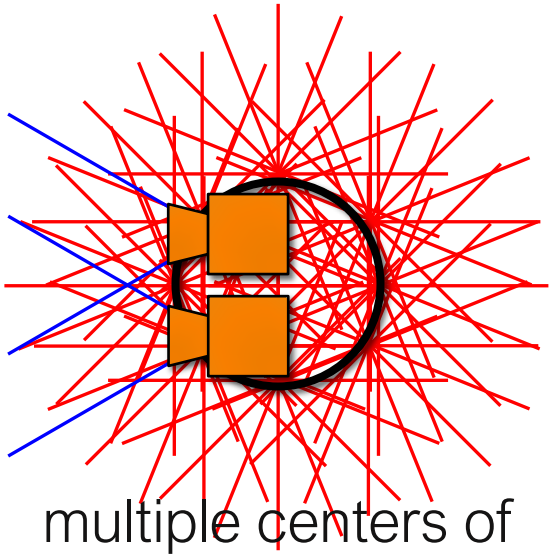
stereo & no head rotation



2 centers of projection!

Stereo Panorama

stereo & head rotation



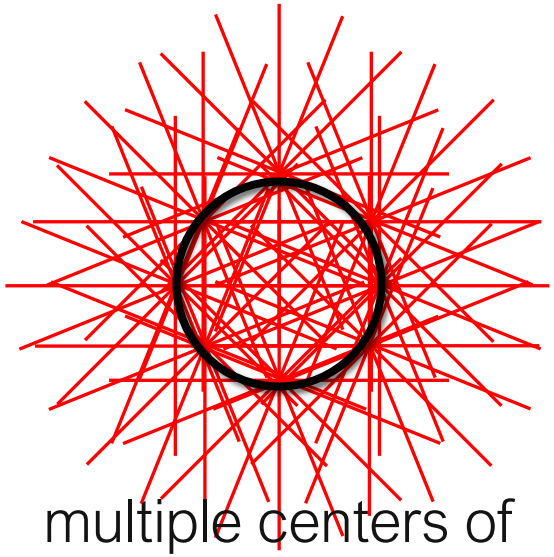
multiple centers of projection

Panorama v Stereo Movie v Stereo Panorama

Light Field!

Stereo Panorama

stereo & head rotation



multiple centers of projection

Panorama v Stereo Movie v Stereo Panorama

Panorama

mono & head rotation

Stereo

stereo & no head rotation

Stereo Panorama

stereo & head rotation

horizontal-only parallax

Stitching

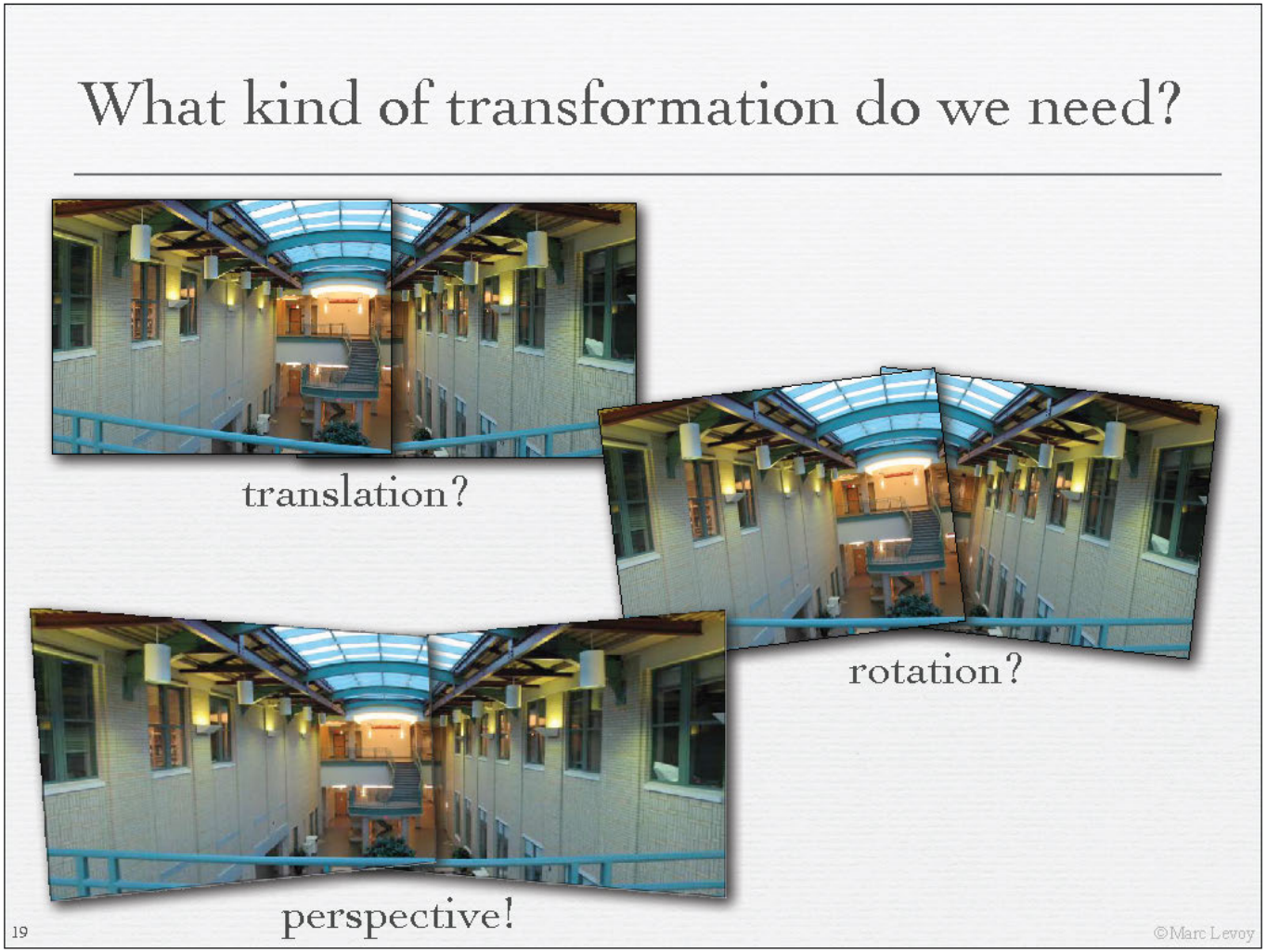
Panoramas

Slides from Marc Levoy's excellent CS 178 course

Stitching images together to make a mosaic

Panoramas

Slides from Marc Levoy's excellent CS 178 course



Panoramas

Slides from Marc Levoy's excellent CS 178 course

Stitching images together to make a mosaic

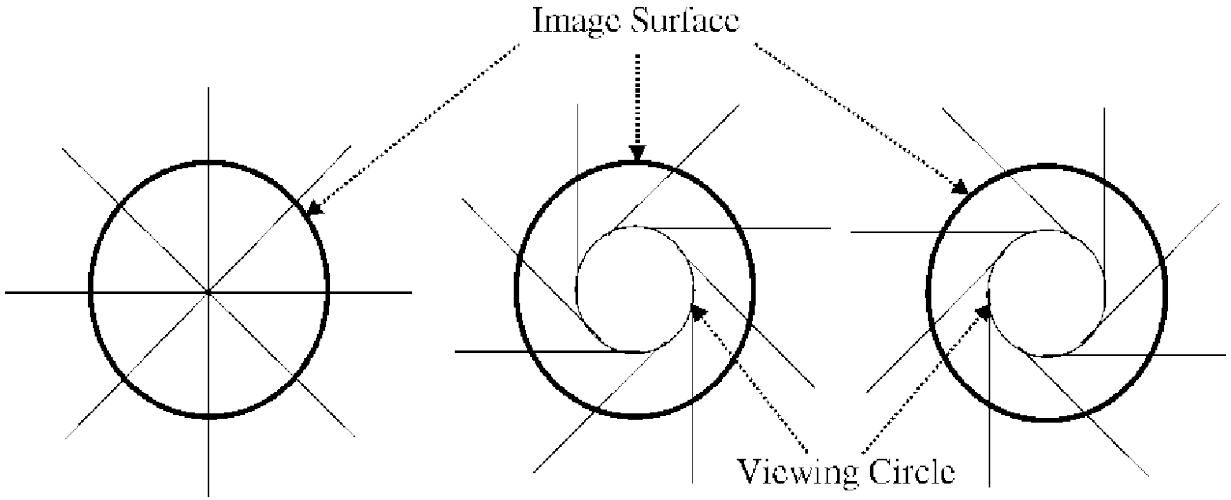
- step 1: find corresponding features in a pair of image
- step 2: compute perspective from 2nd to 1st image
- step 3: warp 2nd image so it overlays 1st image
- step 4: blend images where they overlap one another
- repeat for 3rd image and mosaic of first two, etc.

Omnistereo

Omnistereo

Can we display a 360 degree stereo panorama image in a surround screen virtual environment such as a CAVE so that multiple users can see a correct 3D image in all directions, without head tracking?

Comparison: Mono and Stereo Panoramas



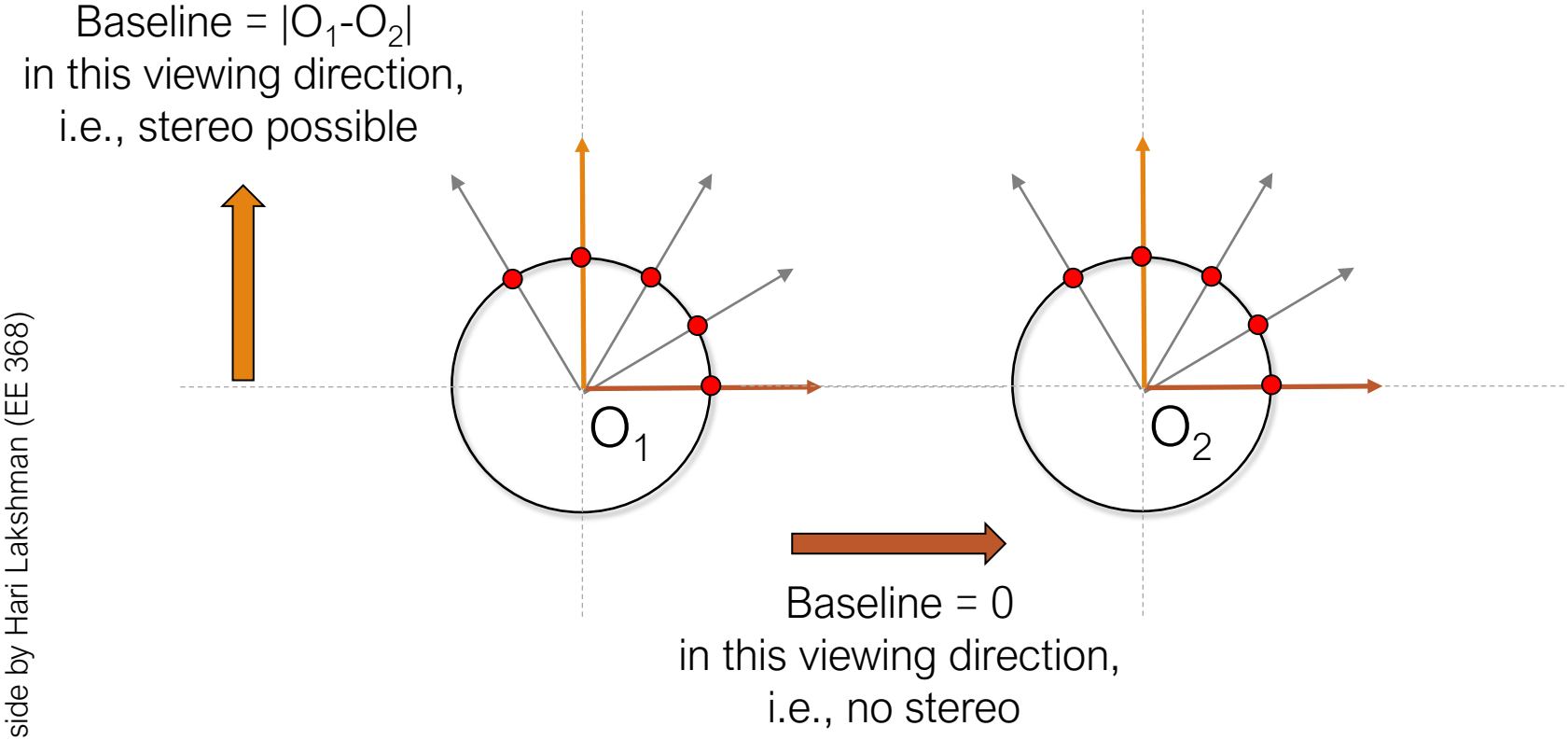
Central,
a.k.a. Mono

Omnistereo,
Multiperspective

Peleg et al. 2001

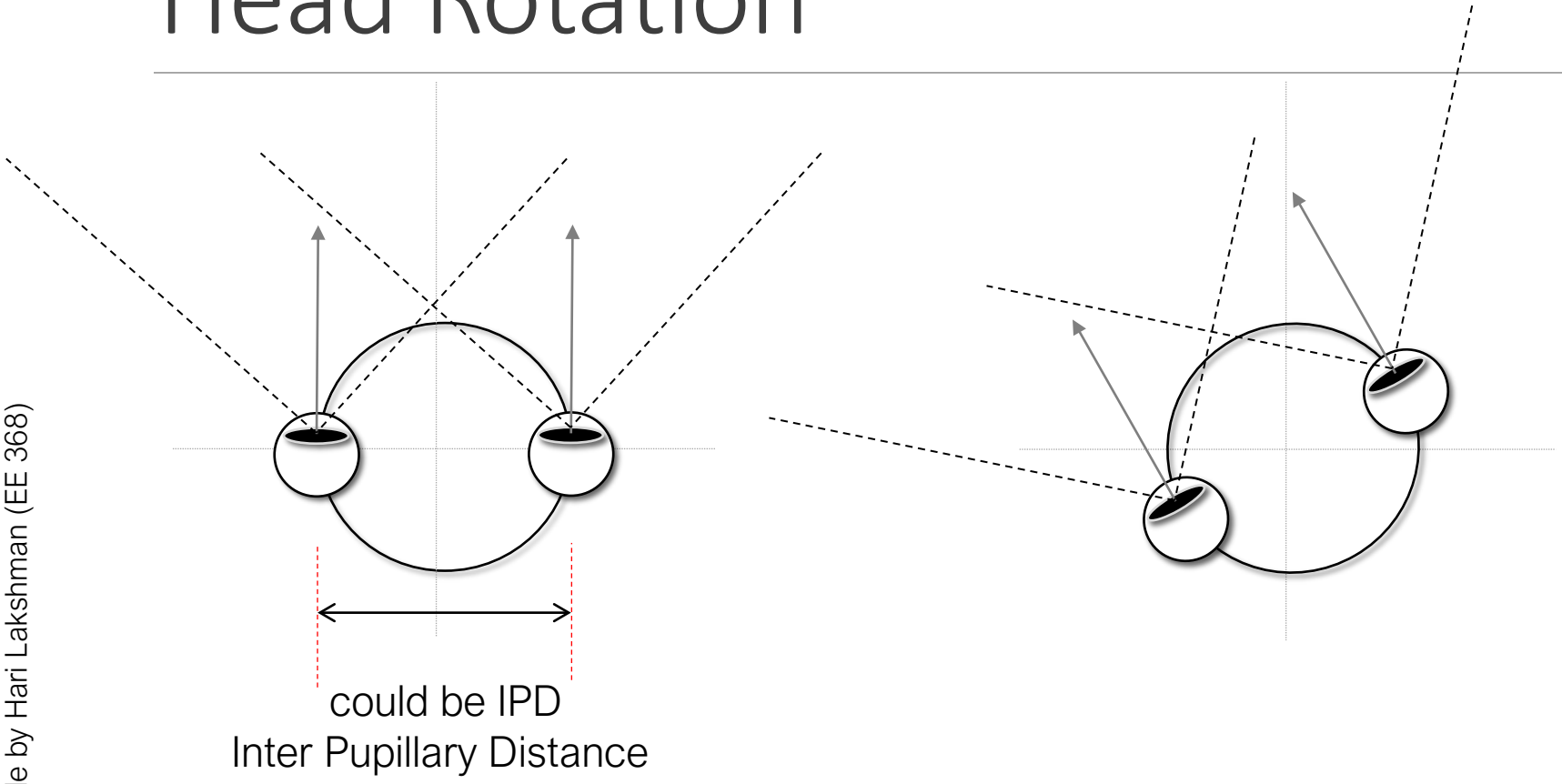
side by Hari Lakshman (EE 368)

A Pair of Mono Panoramas



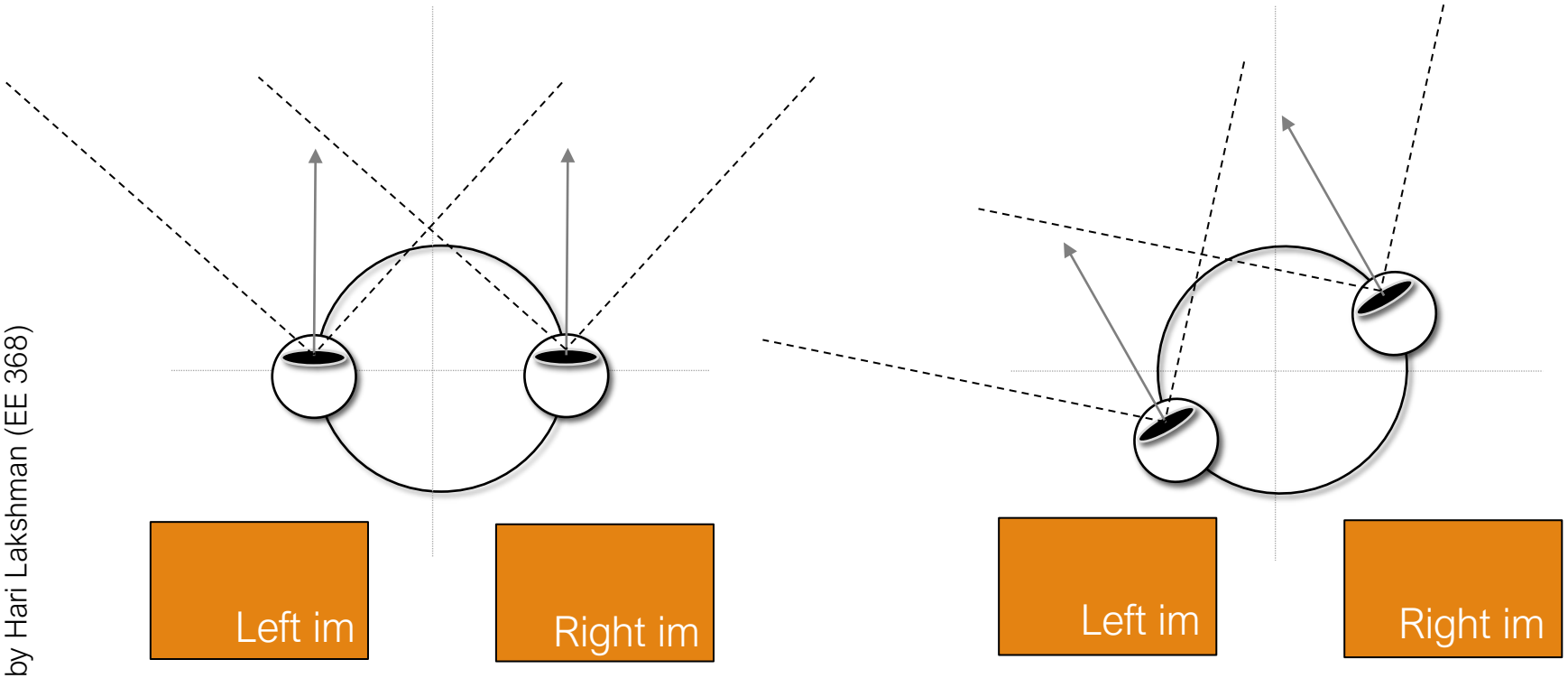
side by Hari Lakshman (EE 368)

Head Rotation



side by Hari Lakshman (EE 368)

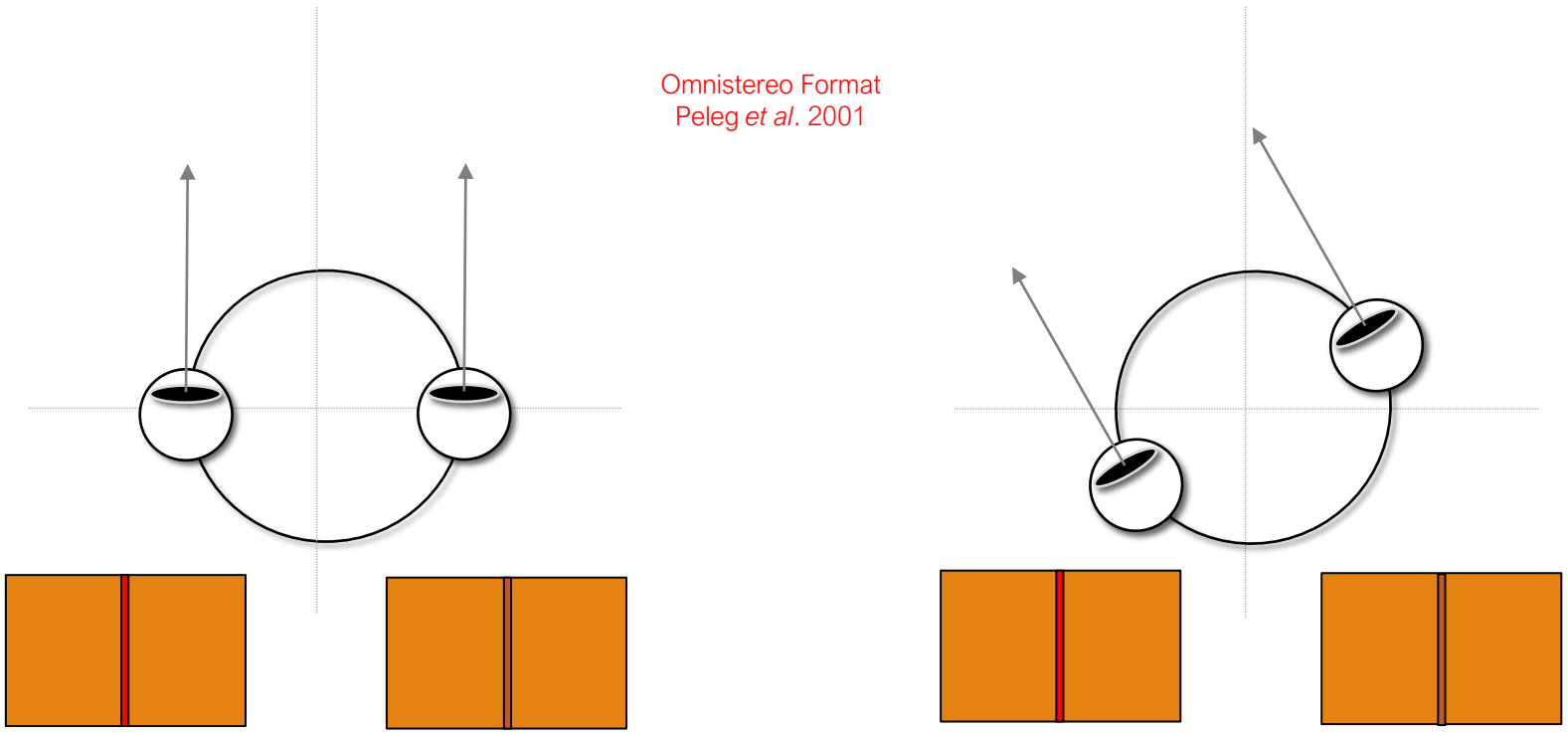
Image Pair for Each Direction



Store image pair for each direction → Problem: Too much data

side by Hari Lakshman (EE 368)

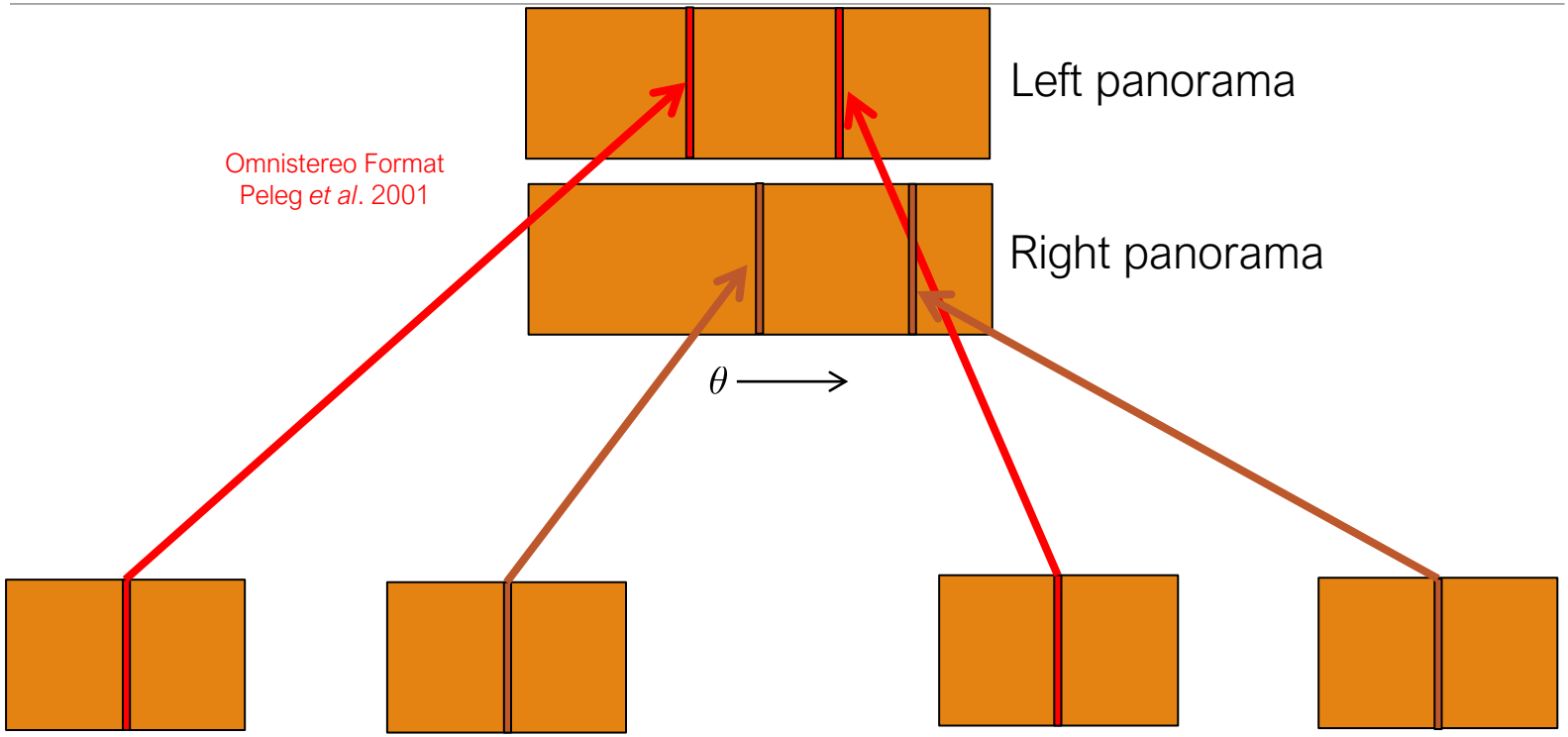
Approximation: Store only Middle Ray



Approximation: store only middle ray for L and R eyes for each direction

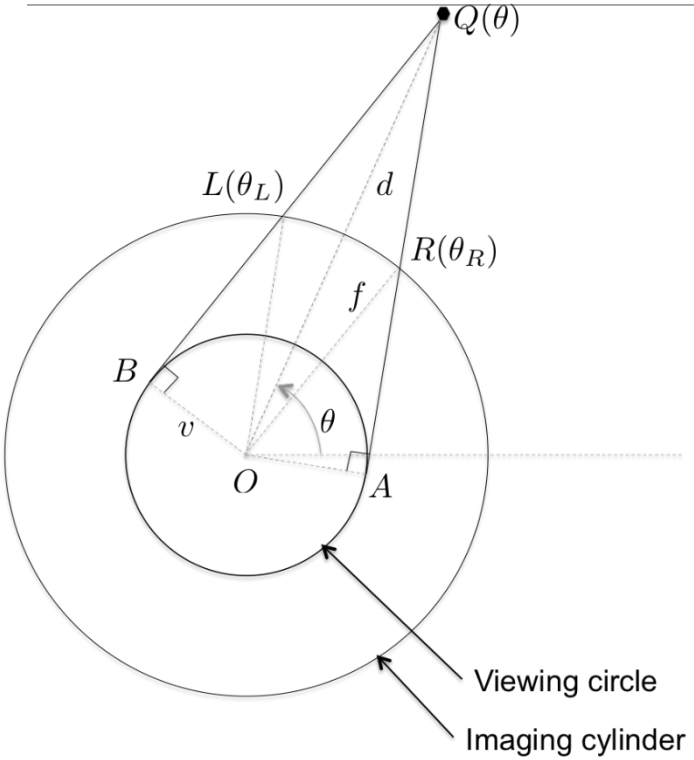
side by Hari Lakshman (EE 368)

Omnistereo Panoramas

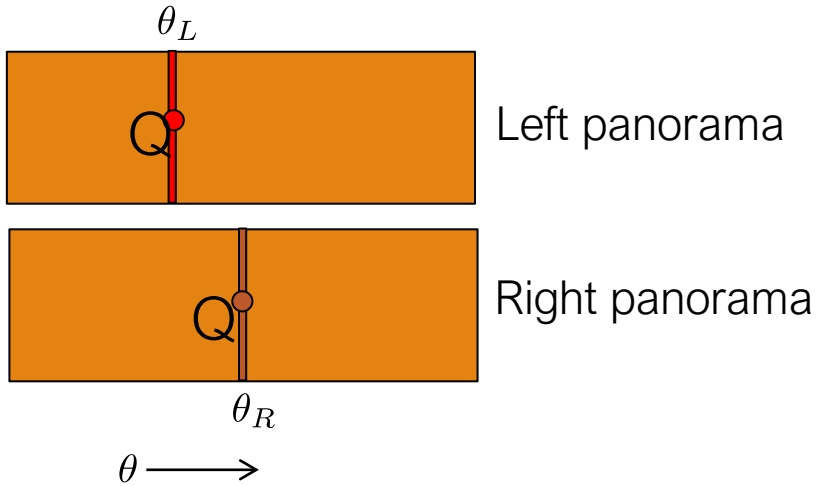


side by Hari Lakshman (EE 368)

Omnistereo: Geometry Details

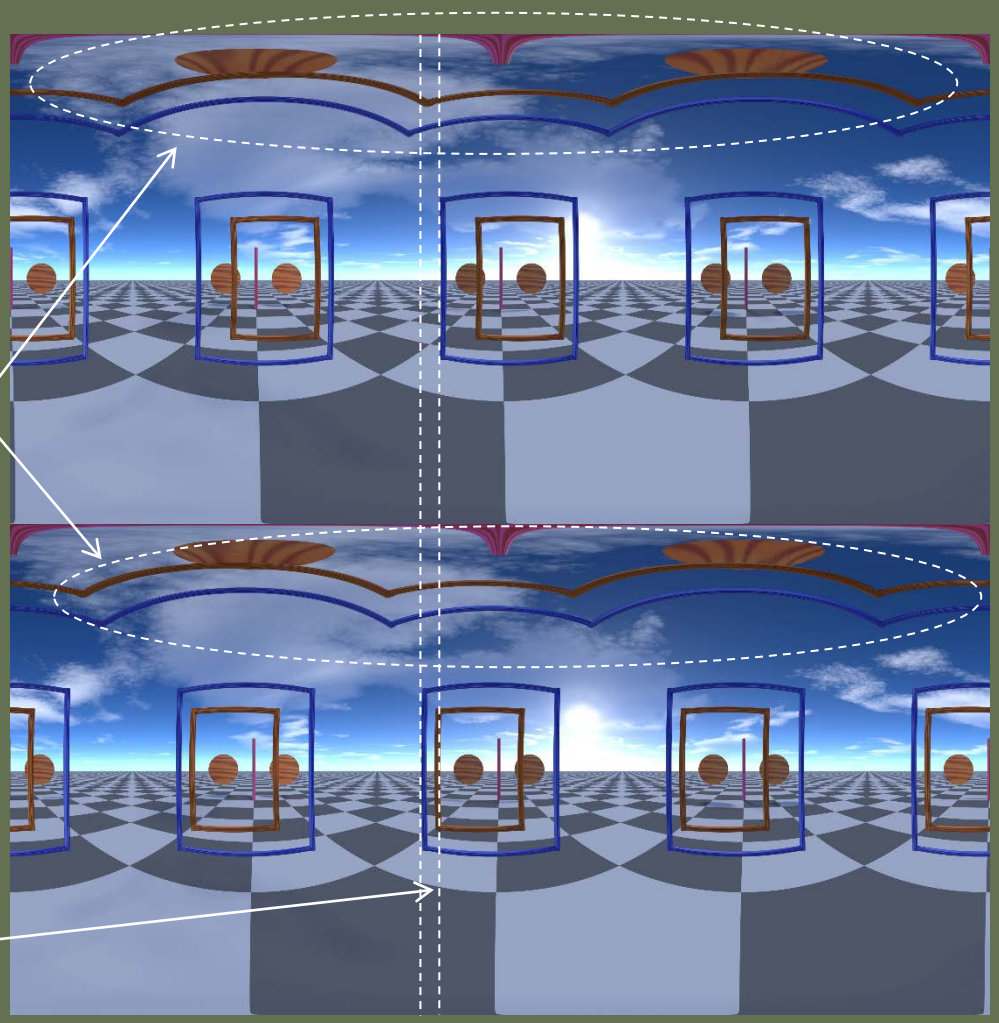


Q: scene point
d: distance to Q from origin
v: viewing circle radius
f: imaging cylinder radius
L, R: coordinates of Q in panoramas



side by Hari Lakshman (EE 368)

Omnistereo example



Left panorama

Sphere-to-plane distortions

Right panorama

Disparity

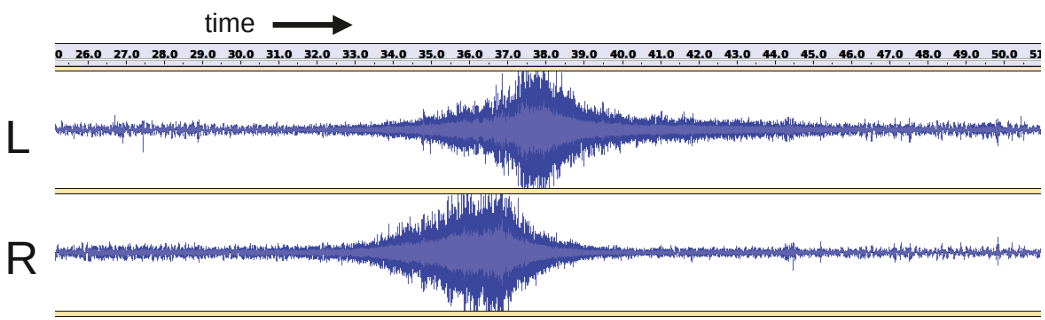
side by Hari Lakshman (EE 368)

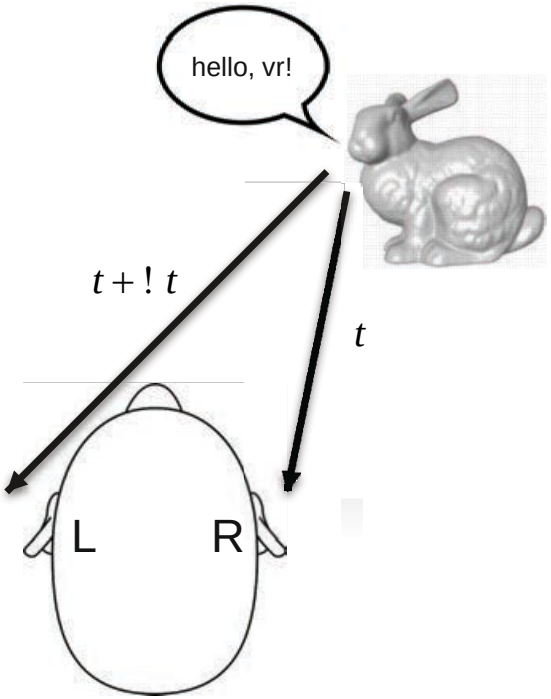
Spatial Audio

Stereophonic Sound

Mainly captures differences between the ears:

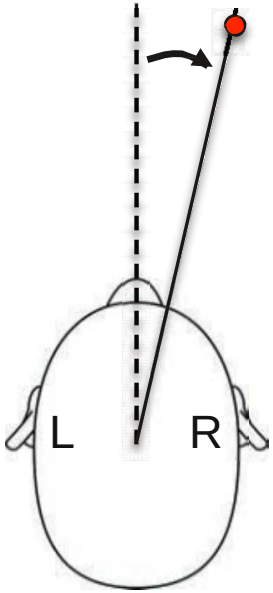
- interaural time difference
- amplitude differences from body shape (nose, head, neck, shoulders, …)





Head-Related Transfer Functions (HRTF)

- Models phase and amplitude differences for all possible sound directions parameterized by azimuth and elevation
- Can be measured with two microphones in ears of mannequin and speakers all around



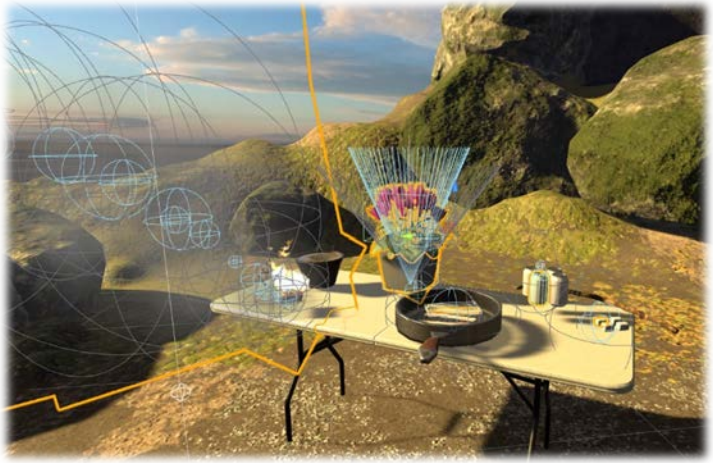
Zhong and Xie, “Head-Related Transfer Functions and Virtual Auditory Display”

Simulation of Smells

Olfactory Displays

Example: OVR Technology ION

- 0.1 millisecond bursts of scent
- Can change between scents in 20 milliseconds
- Attachment for HMDs
- 9 scent actuators with interchangeable cartridges
- Available library of over 250 scents
- Optional custom scent creation



The Future of AR/VR

Vision of the Future of AR

Future Challenges

Reliable and highly accurate co-location of multiple users in physical space

Network infrastructure for massively multi-user AR applications

Internet protocols for applications with geolocated information layers

Photo-realistic AR:

- rendering quality: pixel density, occluding pixels
- field of view
- object anchoring in real-world

Thank you for a great quarter and

Good luck with your final exams!