

INTRODUCTION TO 360° VIDEO

Oliver Wang
Adobe Research

OUTLINE

What is 360
video?

OUTLINE

What is 360
video?

How do we
represent it?



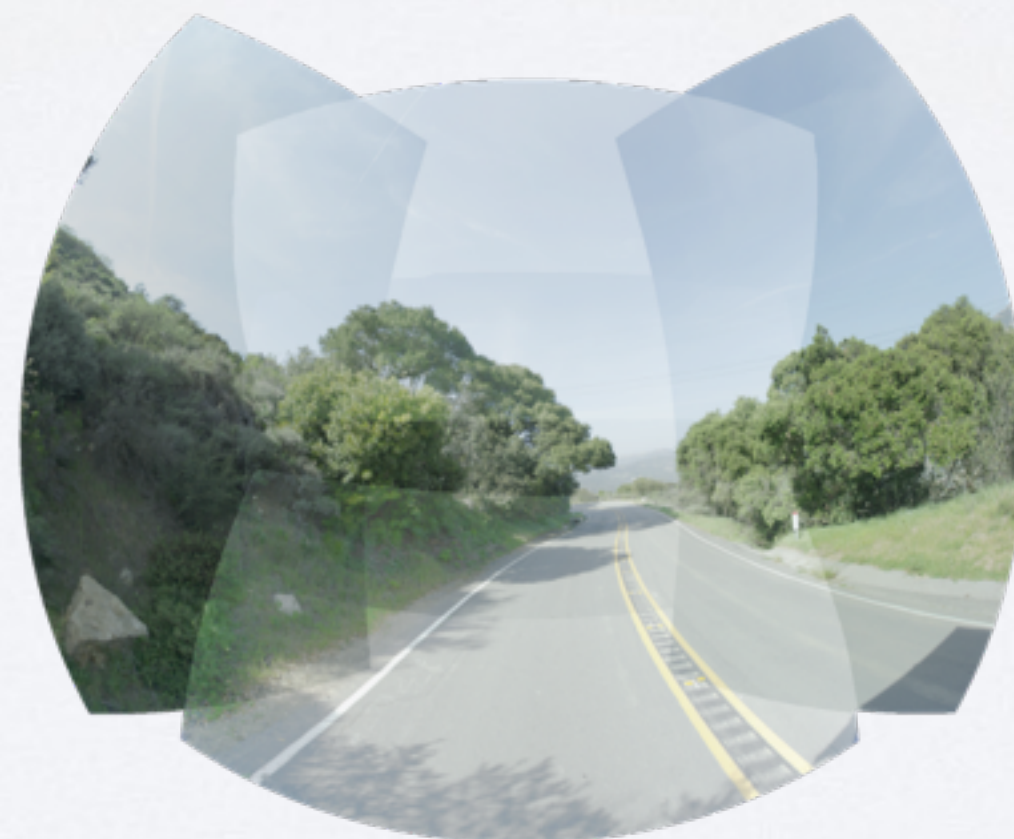
Formats

OUTLINE

What is 360
video?

How do we
represent it?

How do we
create it?



Stitching

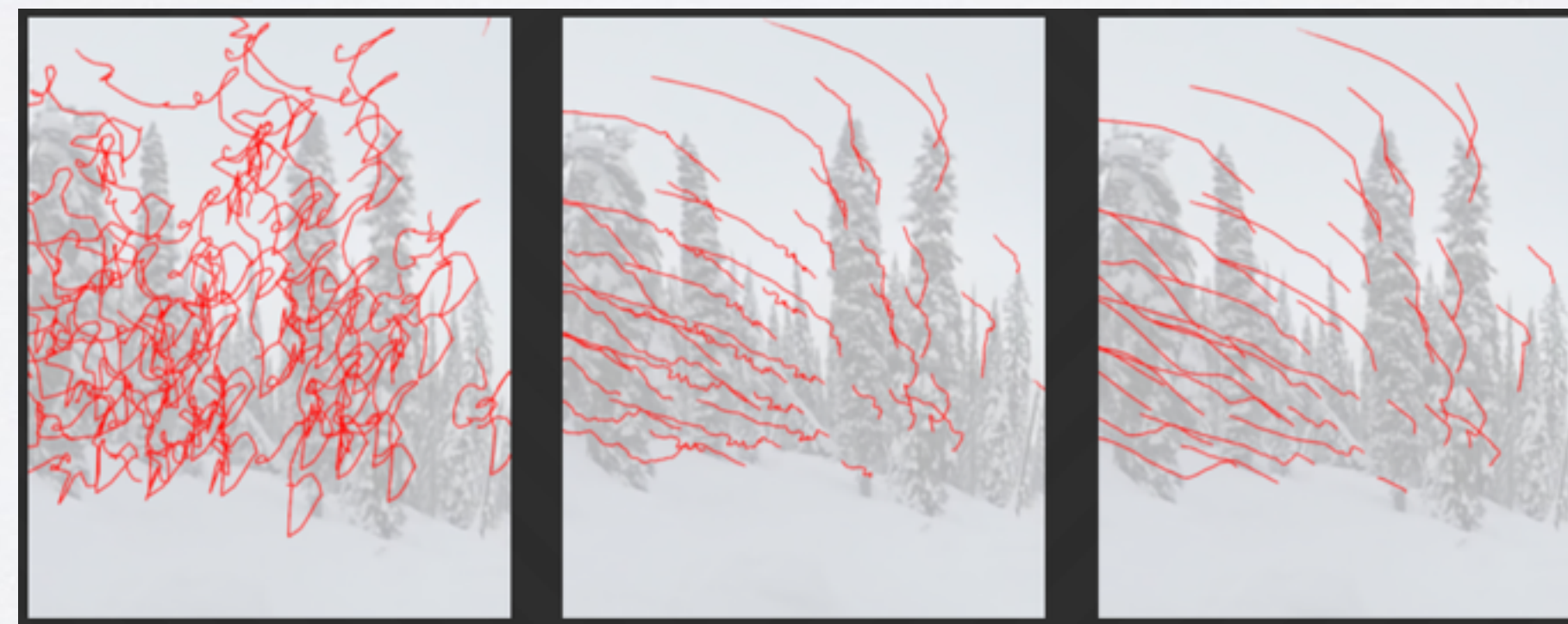
OUTLINE

What is 360
video?

How do we
represent it?

How do we
create it?

What can we
do with it?



Stabilization

OUTLINE

What is 360
video?

How do we
represent it?

How do we
create it?

What can we
do with it?

What can't
we do with
it?



Future Areas

OUTLINE

What is 360
video?

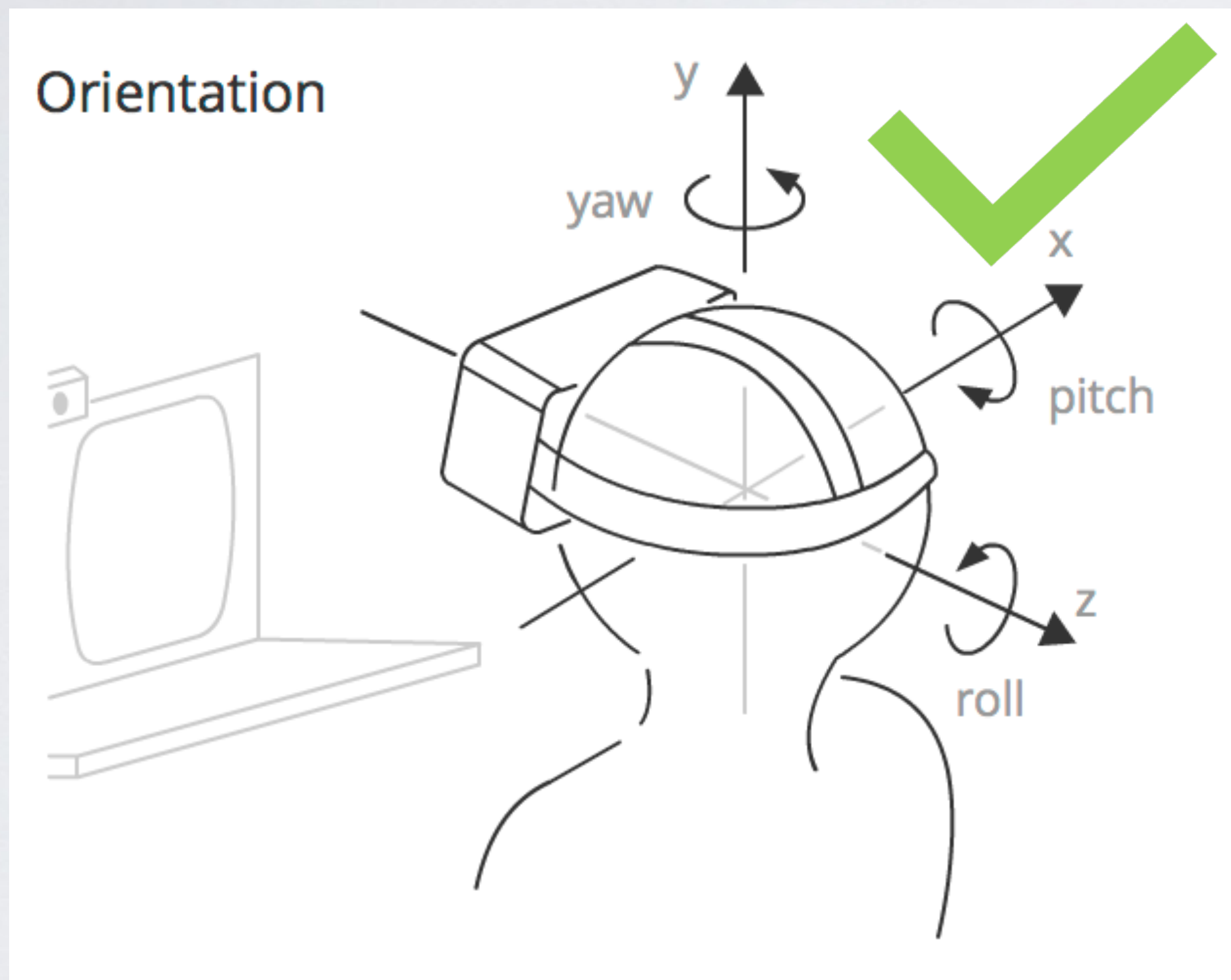
How do we
represent it?

How do we
create it?

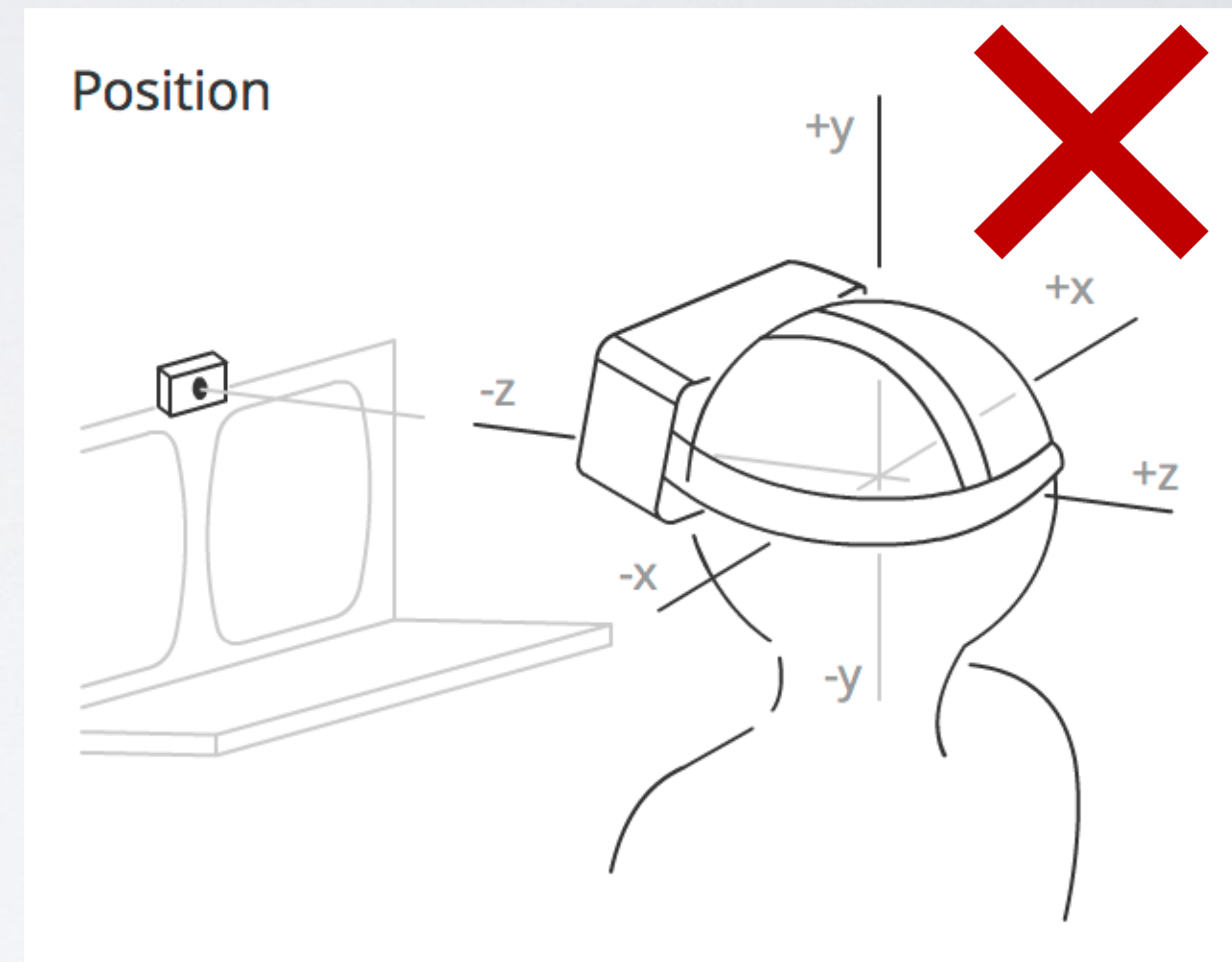
What can we
do with it?

What can't
we do with
it?

360° VIDEO VS “FULL” VR VIDEO

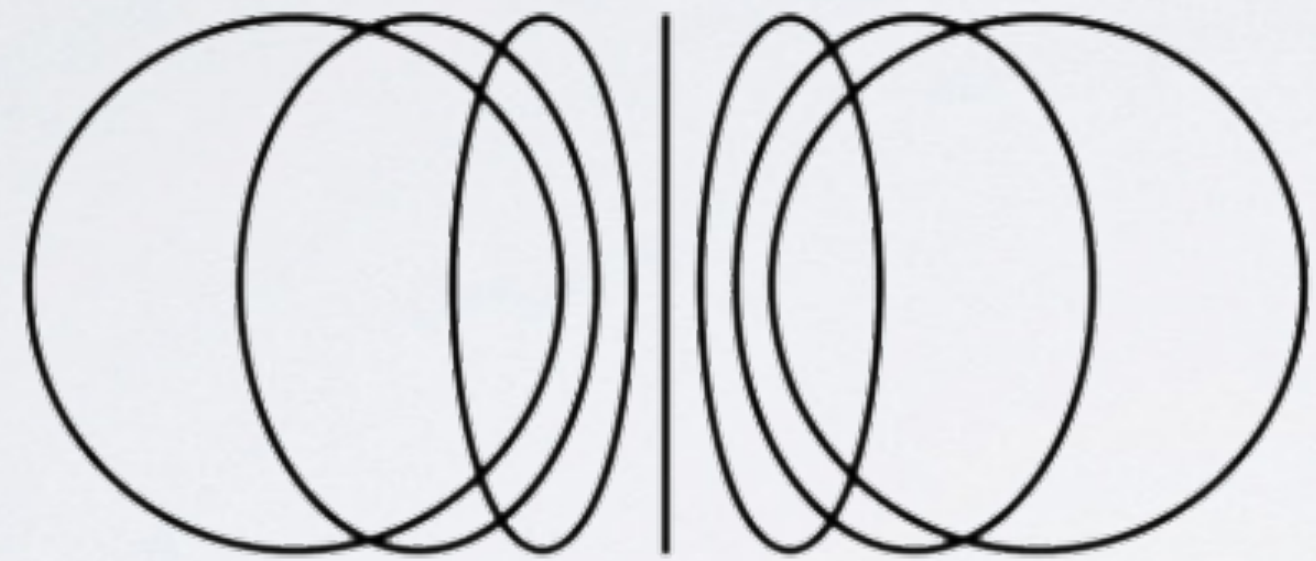


3DoF



6DoF

ONE OF THE MOST POPULAR FORMS OF VR



facebook 360



360° VIDEO VS "FULL"

Capture



VS



Display



OUTLINE

What is 360
video?

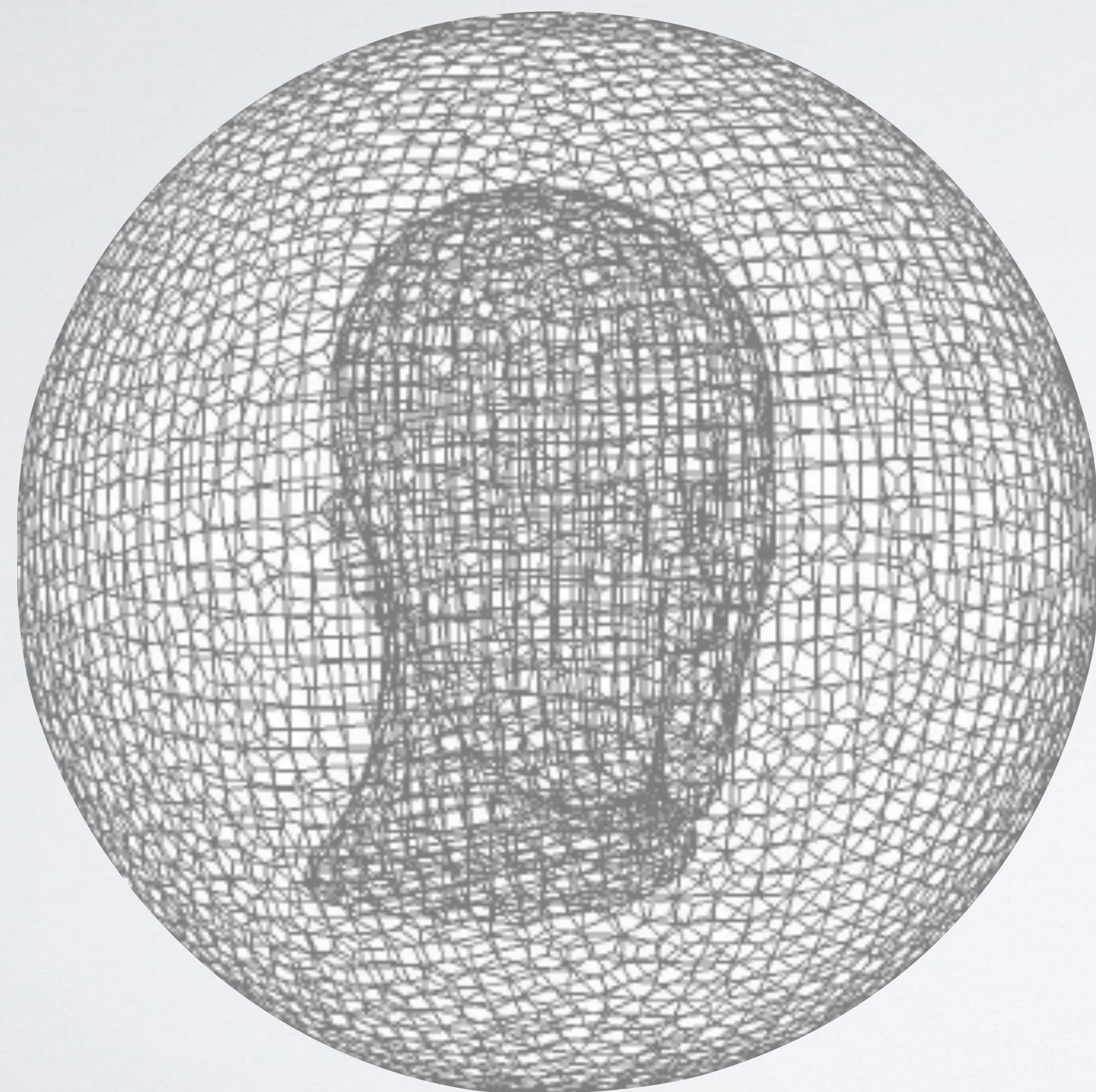
How do we
represent it?

How do we
create it?

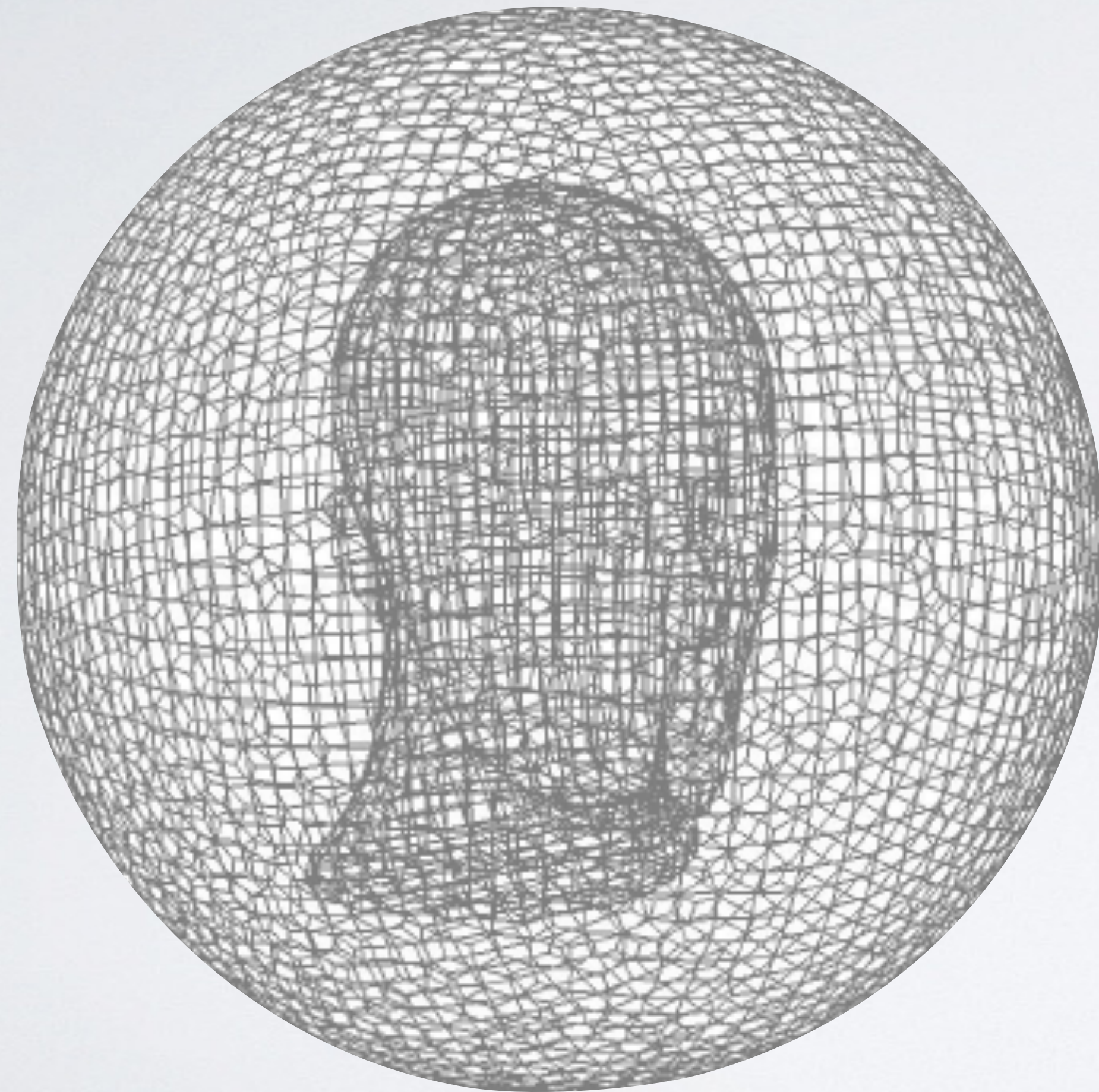
What can we
do with it?

What can't
we do with
it?

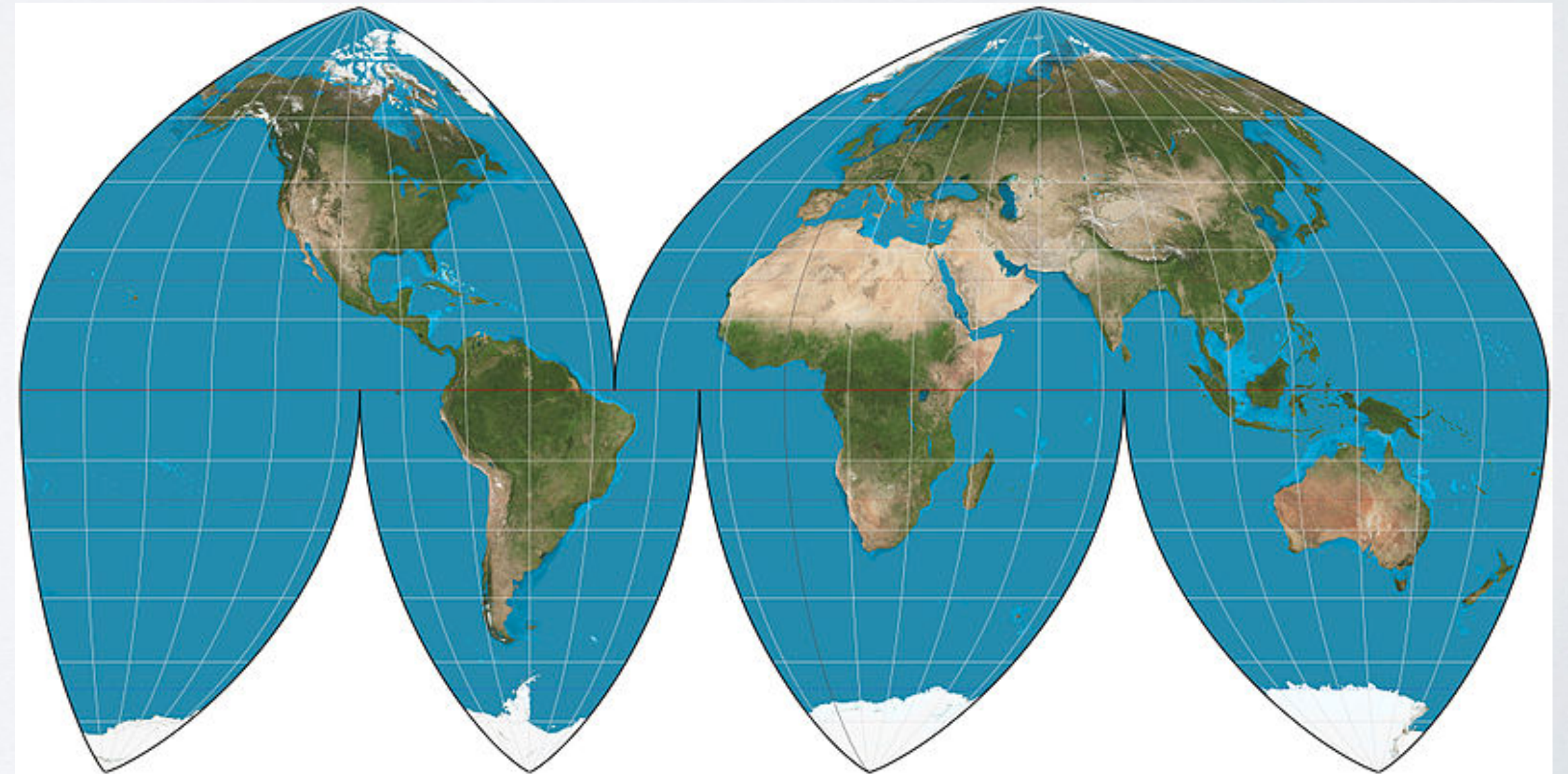
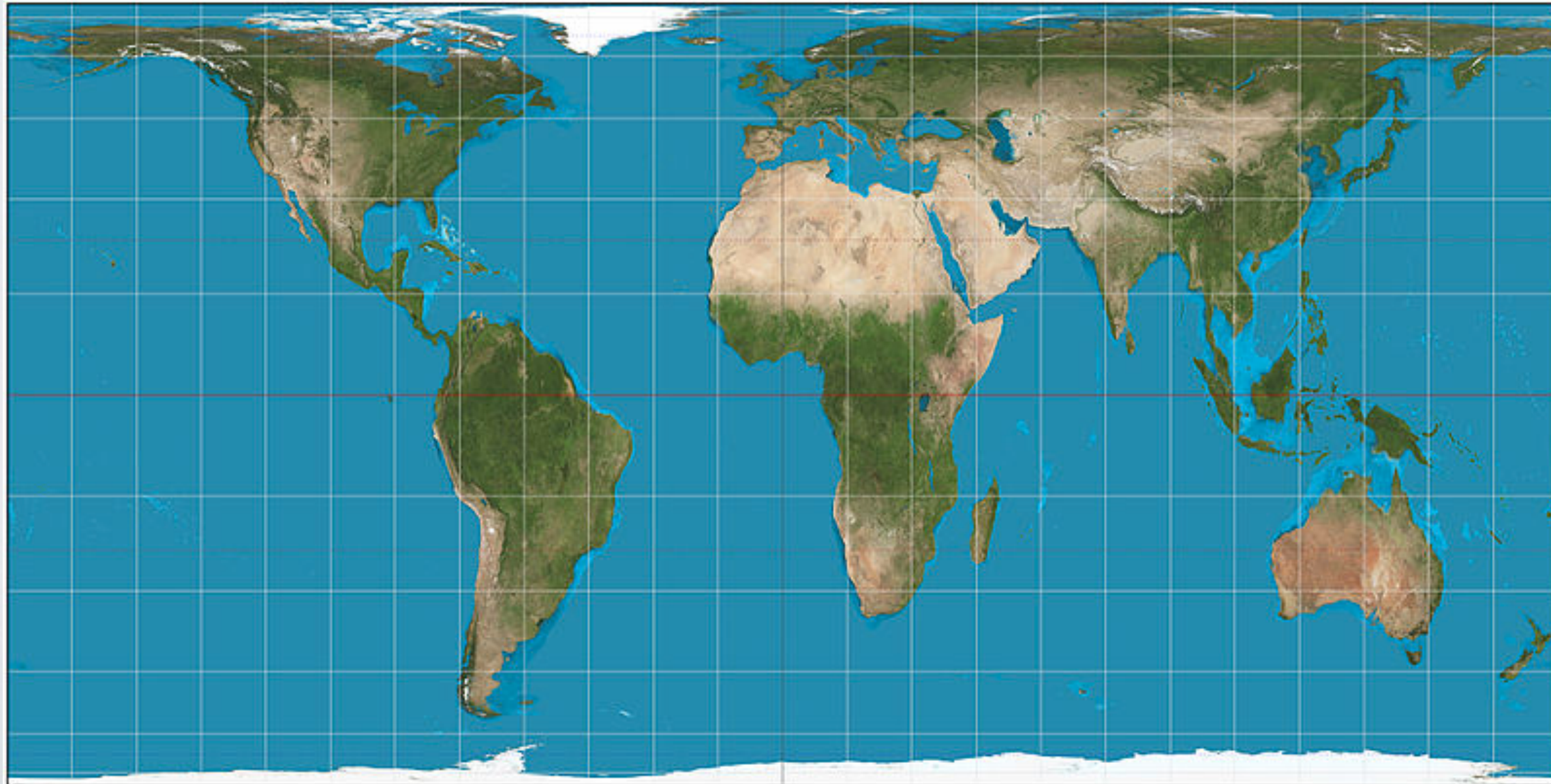
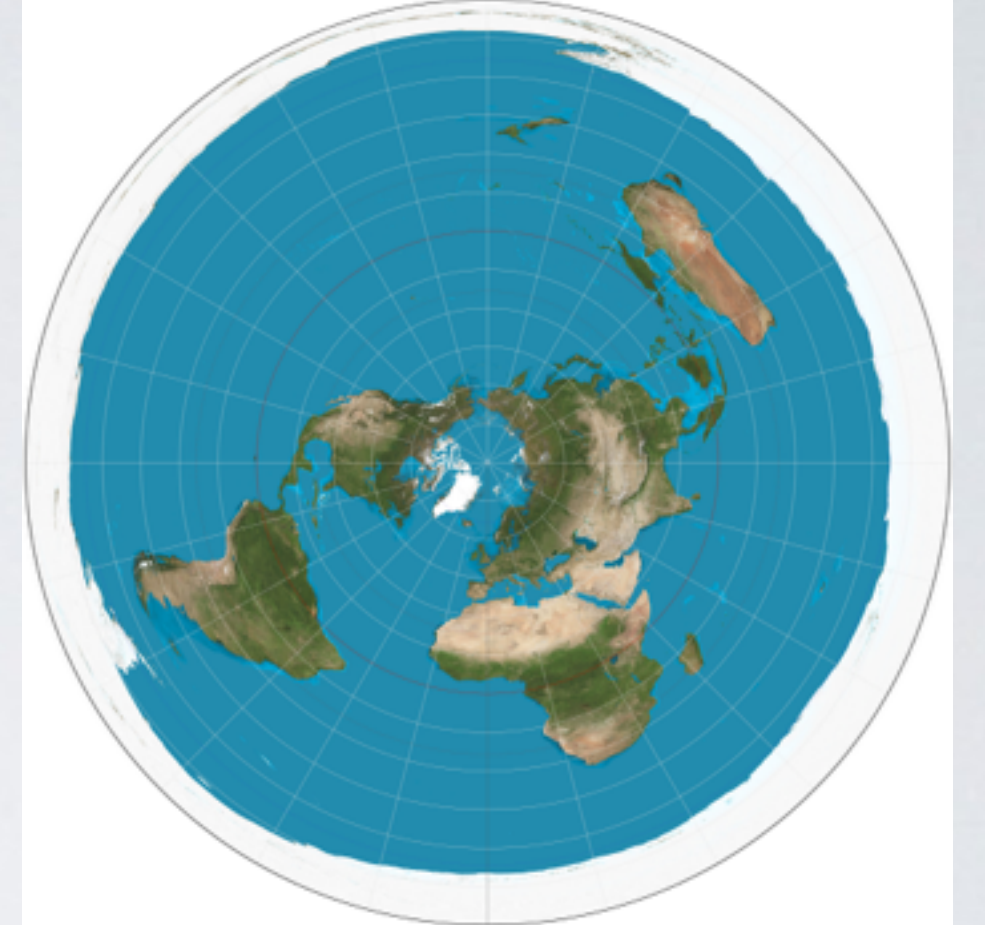
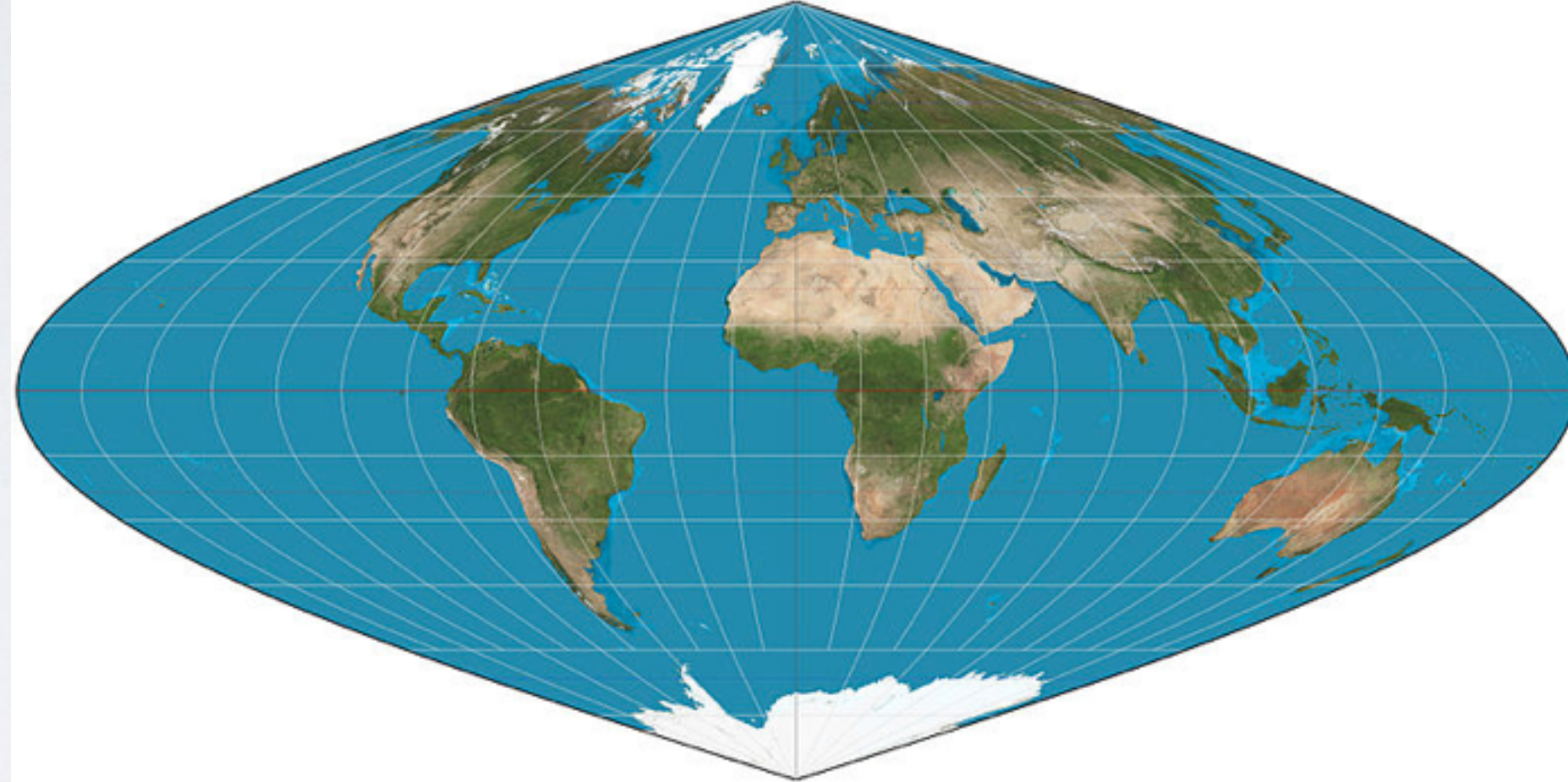
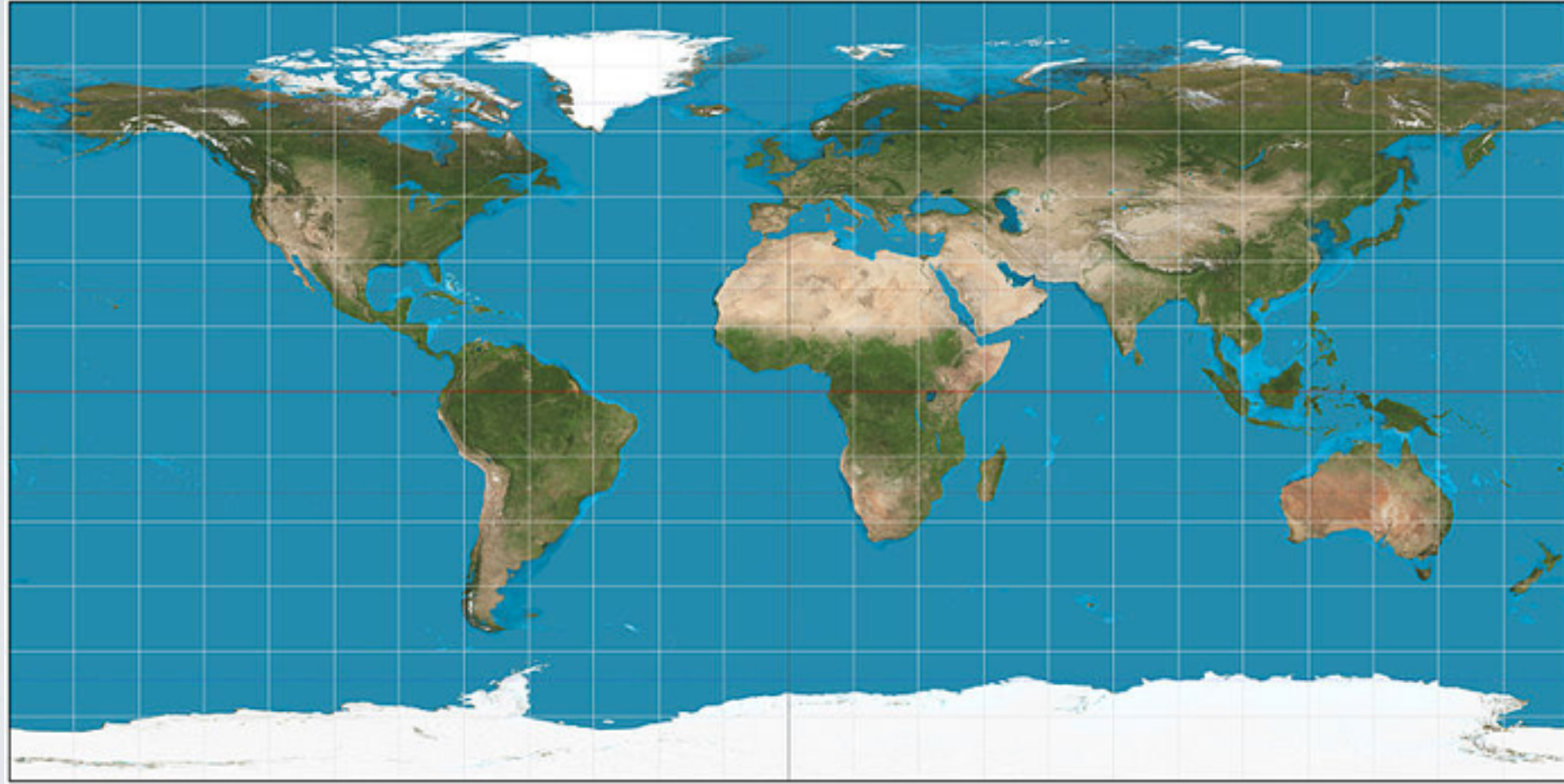
360° VIDEO FORMATS



360° VIDEO FORMATS



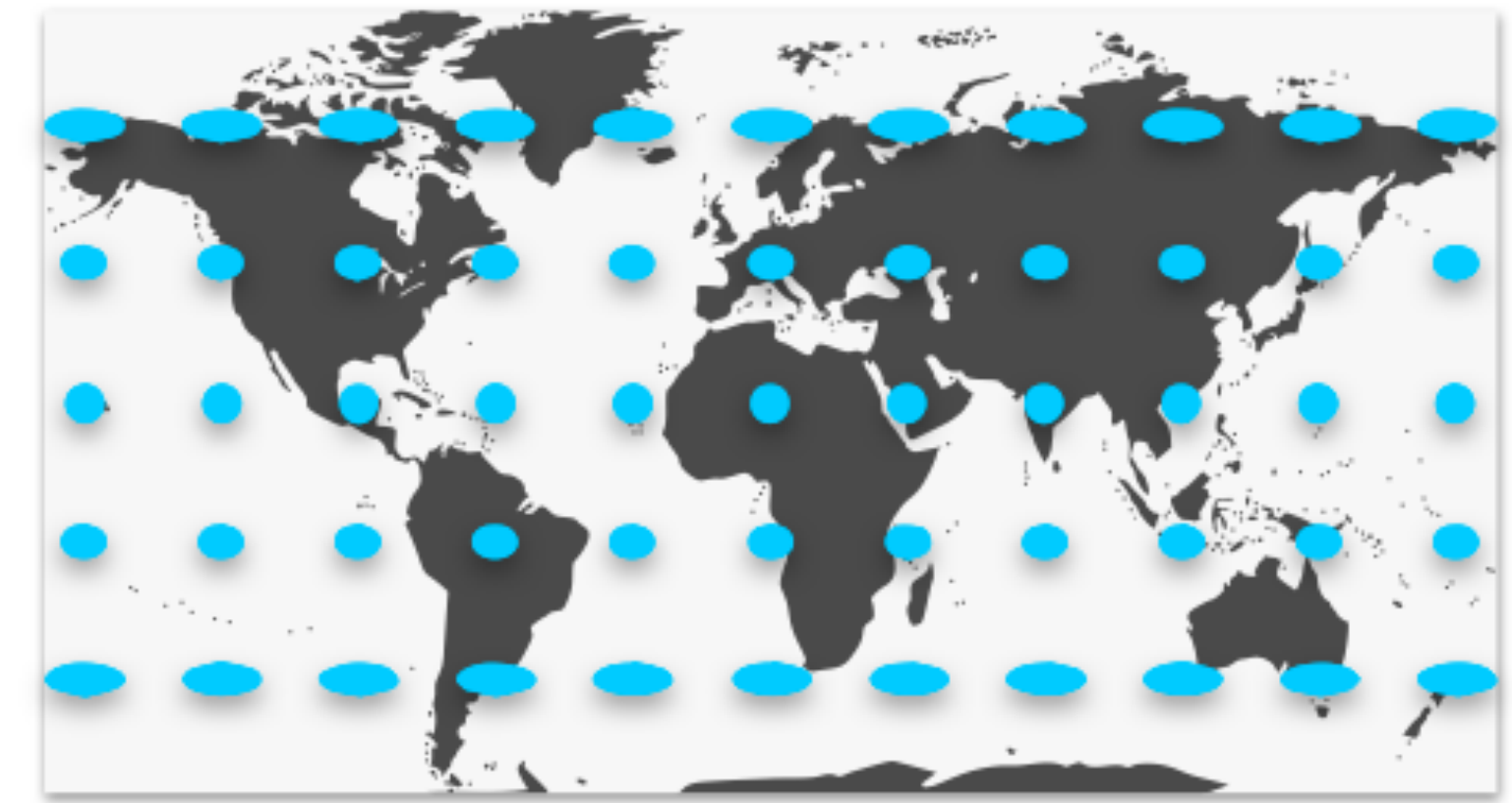
360° VIDEO FORMATS



EQUIRECTANGULAR



EQUIRECTANGULAR



<https://blog.google/products/google-vr/bringing-pixels-front-and-center-vr-video/>

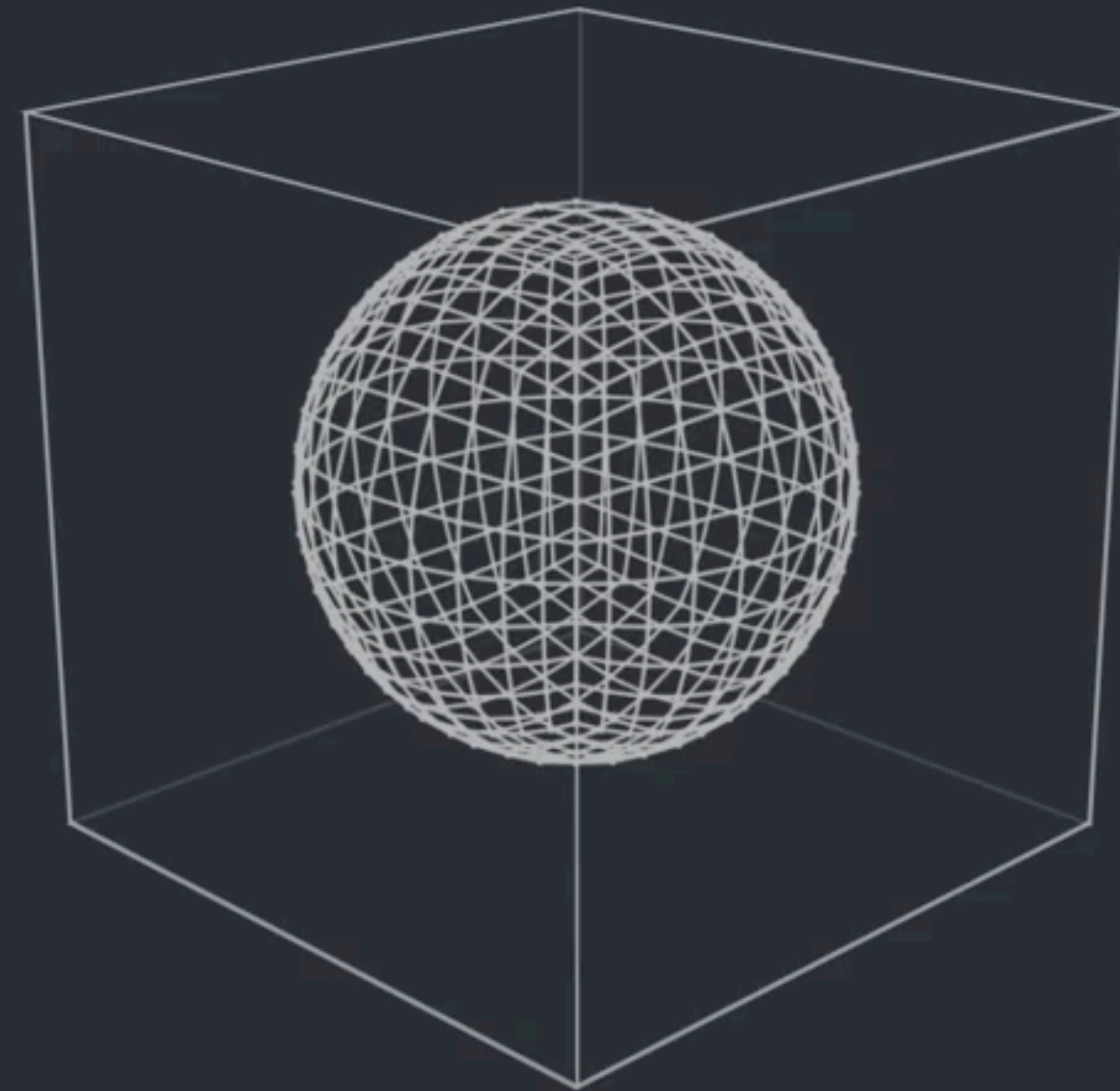
- **Positive**

- Visually interpretable
- Easy to process

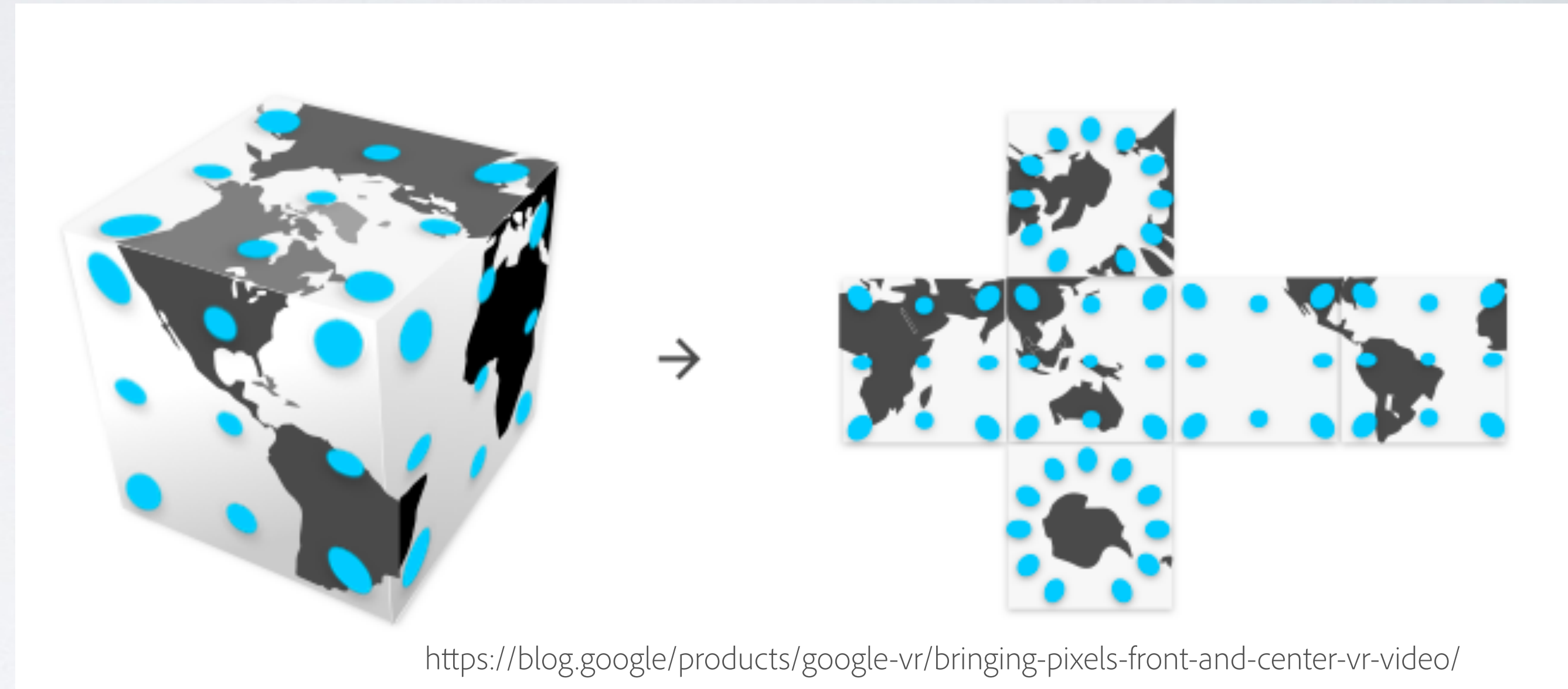
- **Negative**

- Distortion on poles
- Low pixel density on horizon

CUBEMAPS



CUBEMAPS



- Graphics pipeline friendly
- Low distortion (25% storage reduction)
- Hard to interpret/process

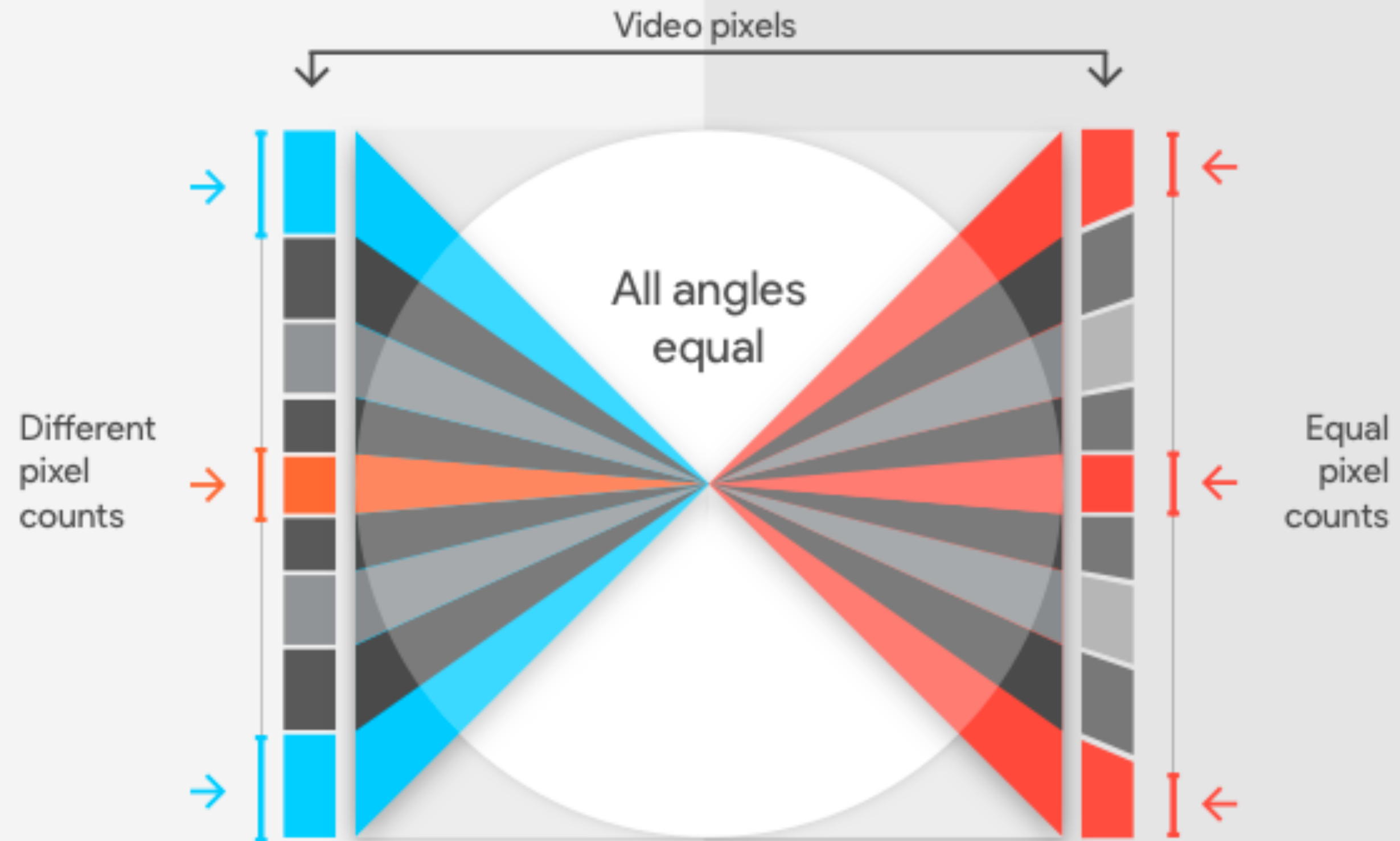
EQUIANGULAR CUBEMAPS



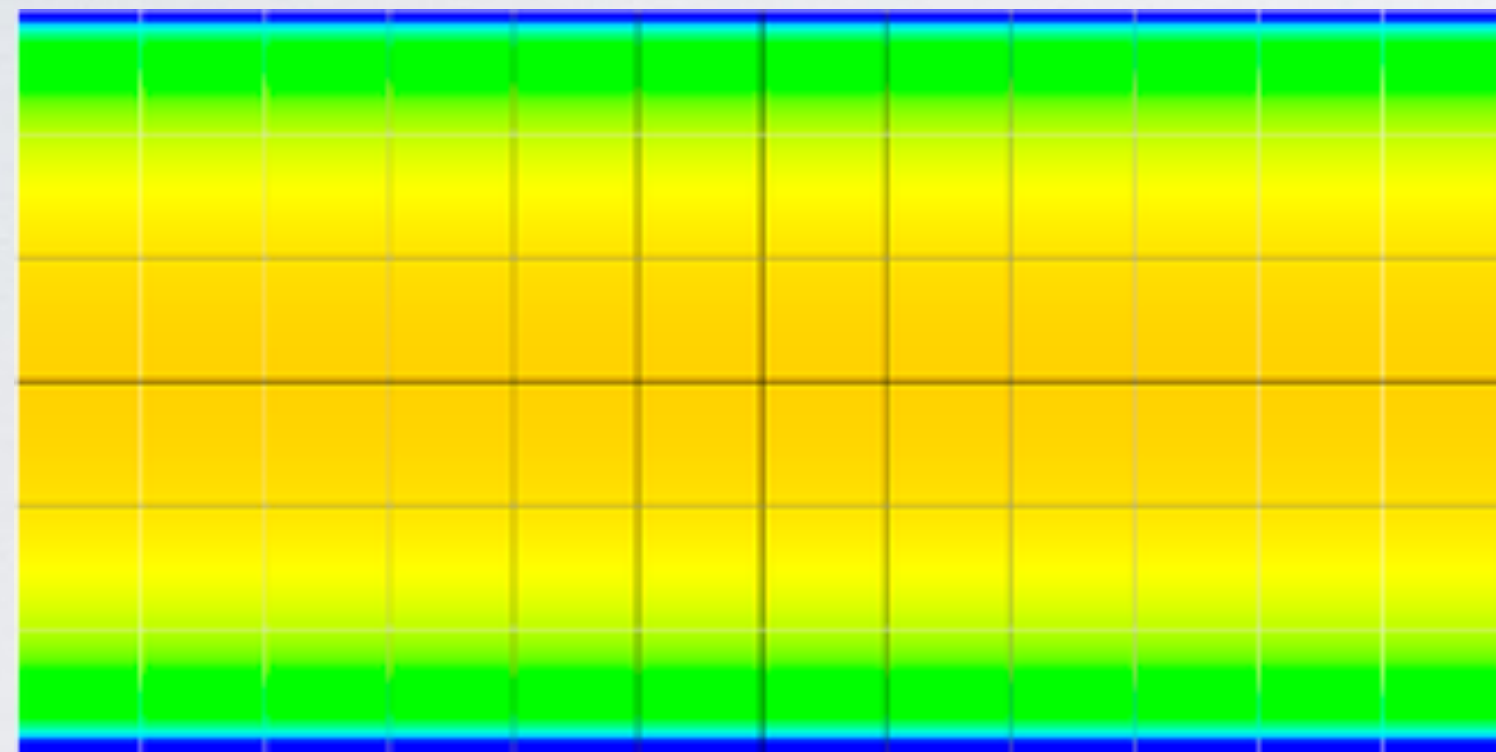
YouTube 360

Standard
Cubemap

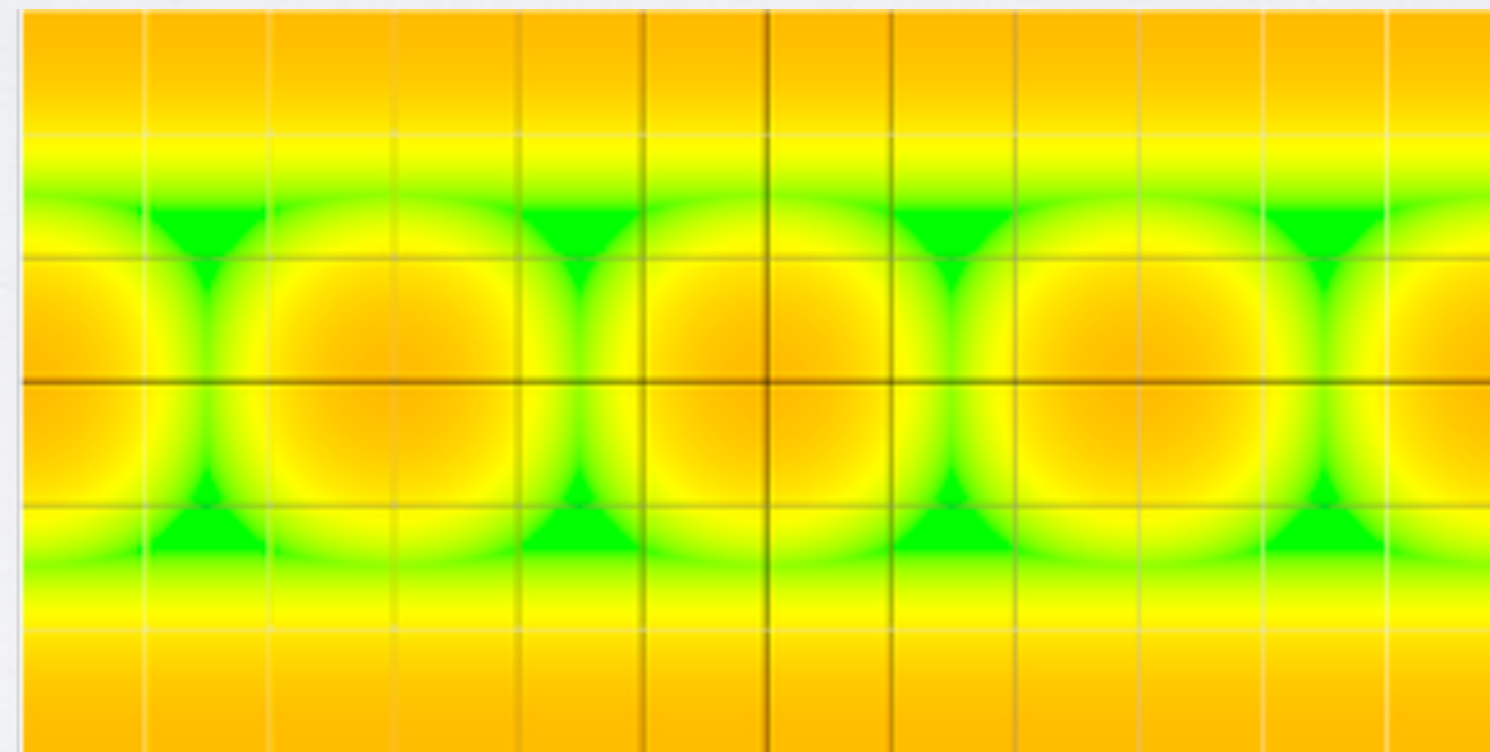
Equi-Angular
Cubemap



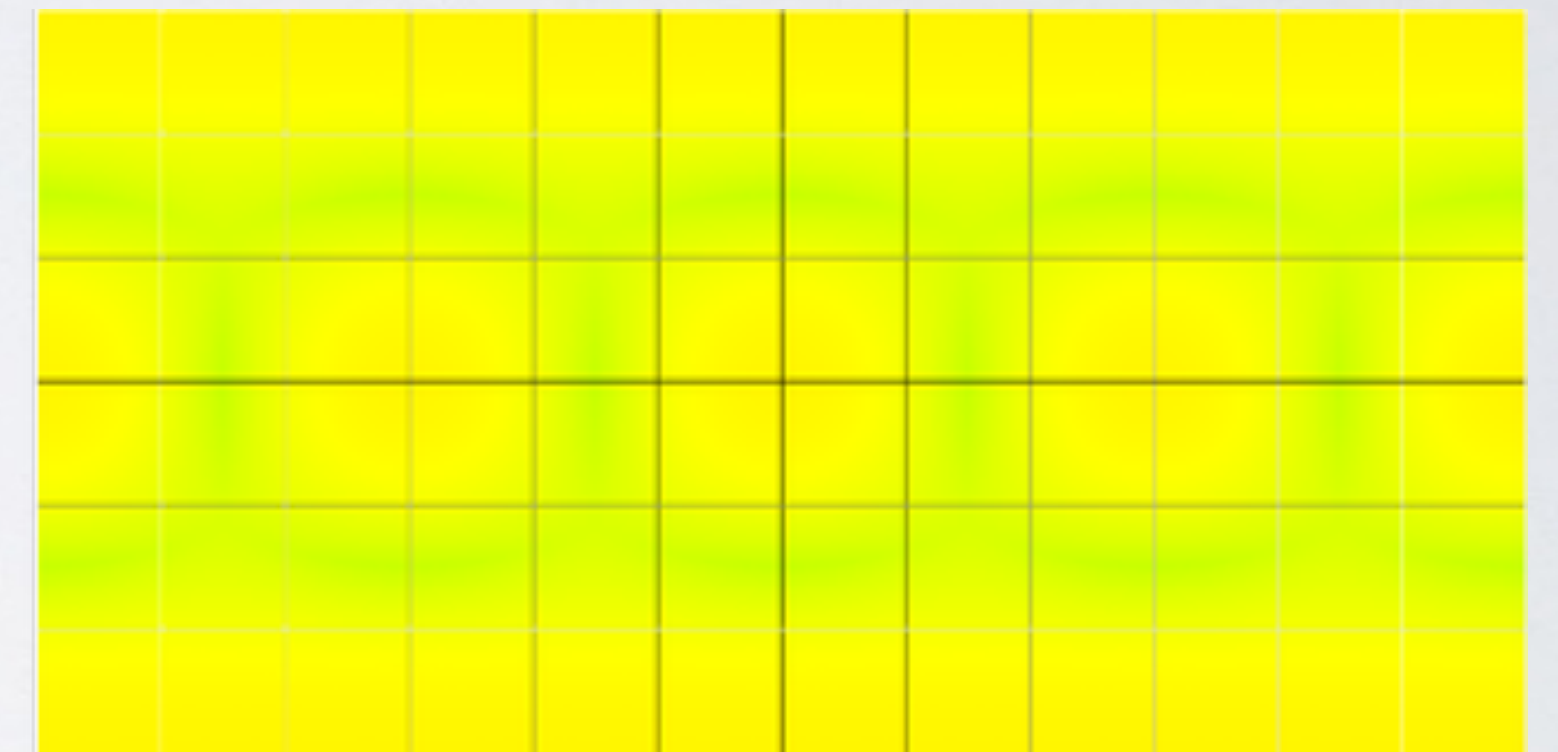
EQUIANGULAR CUBEMAPS



Equirectangular Projection



Cubemap

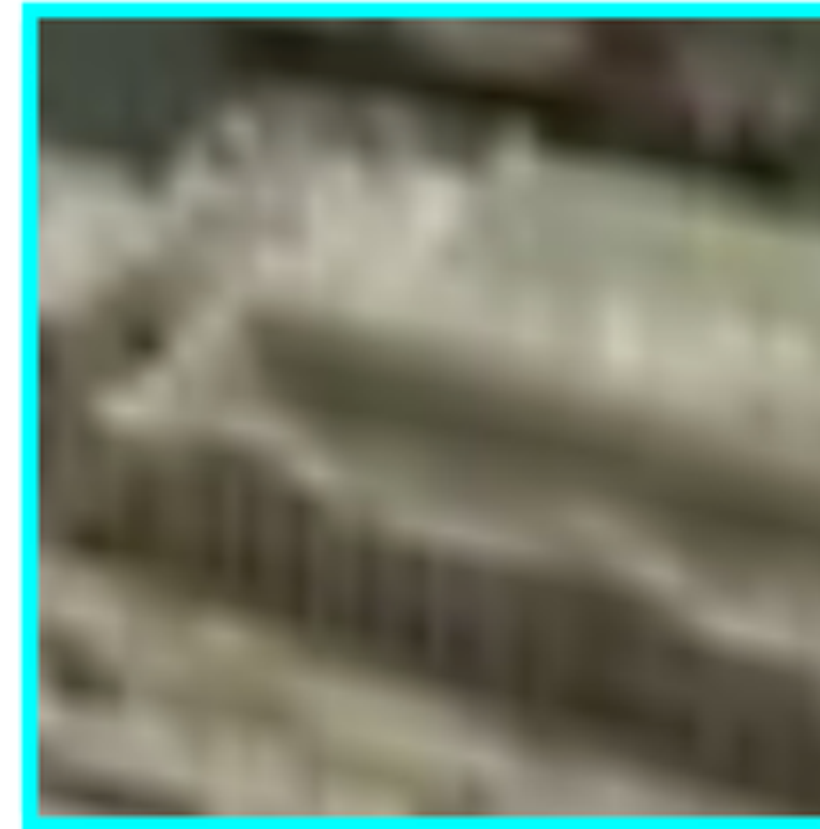


Equiangular Cubemap

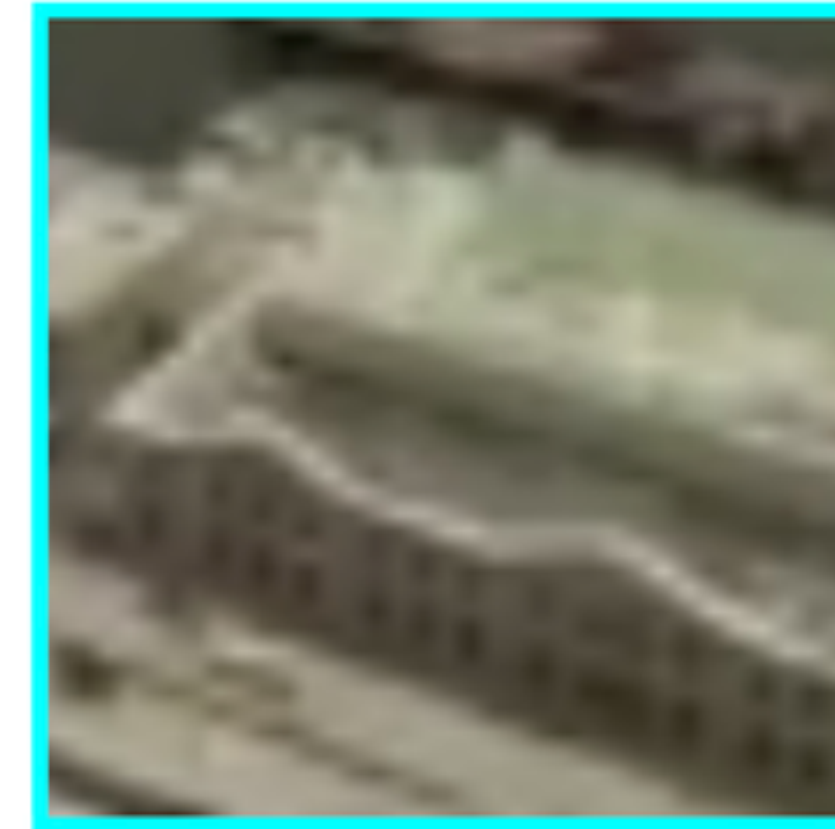
EQUI**ANG**ULAR CUBEMAPS



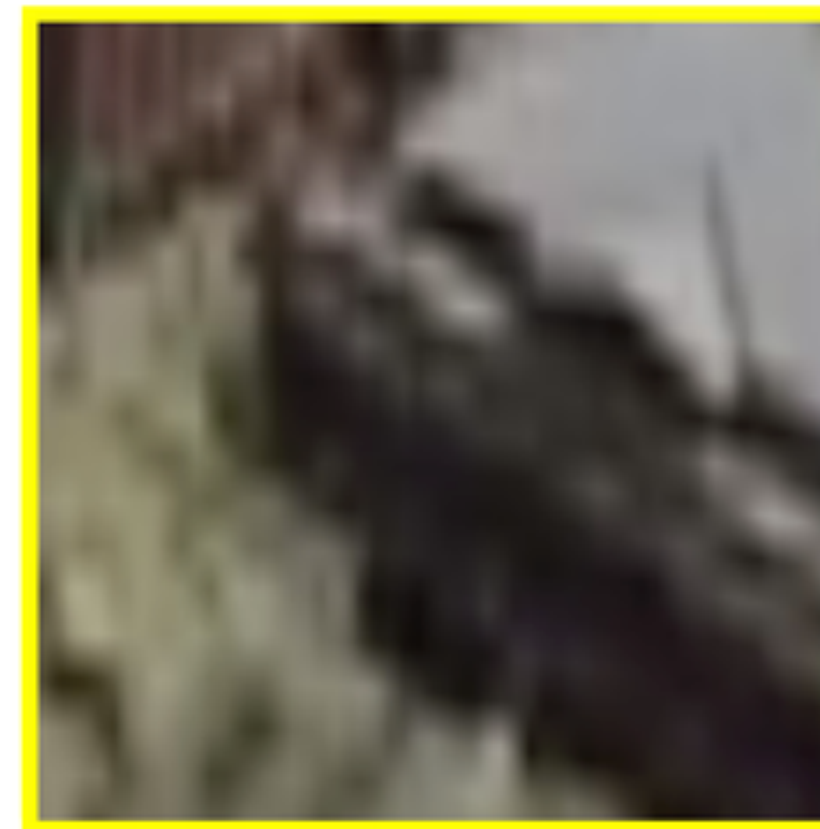
Video frame as viewed in VR headset



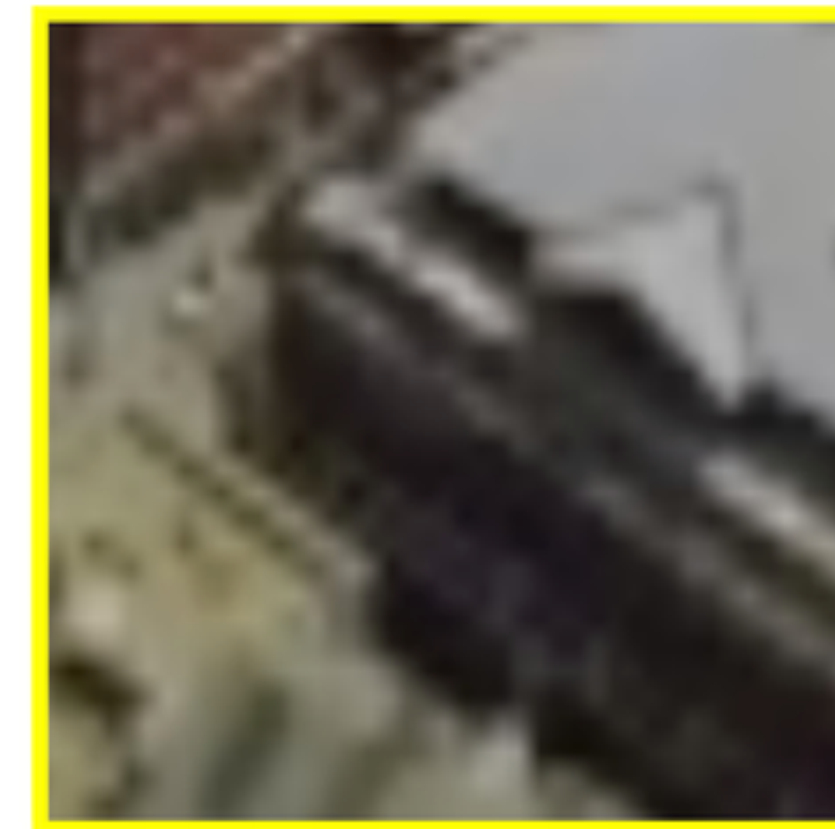
Equirectangular



EAC

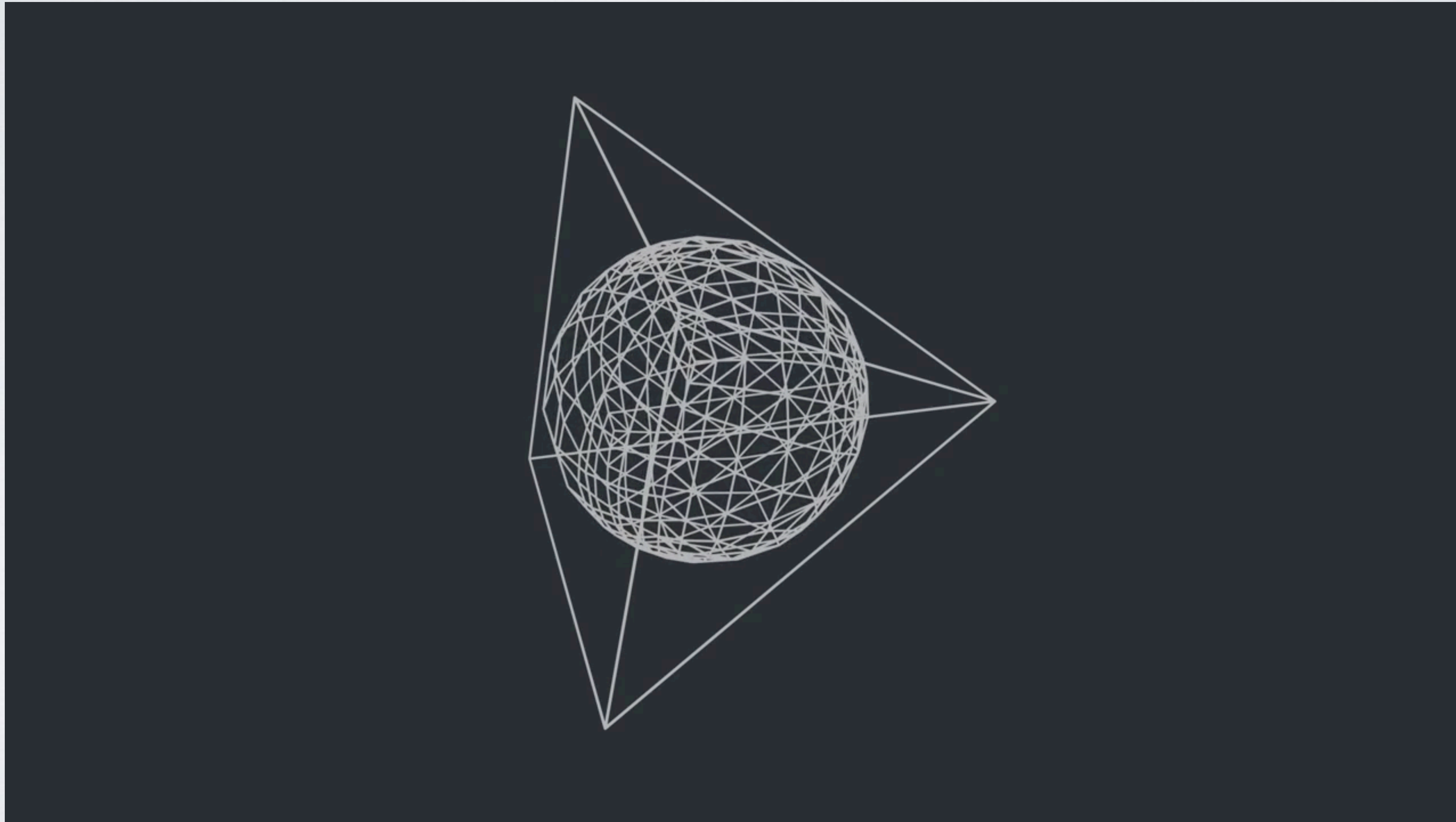


Equirectangular



EAC

PYRAMIDS



PYRAMIDS



360° VIDEO CONTENT CREATION

What is 360 video?

How do we represent it?

How do we create it?

What can we do with it?

What can't we do with it?

MULTI-LENS CAMERAS

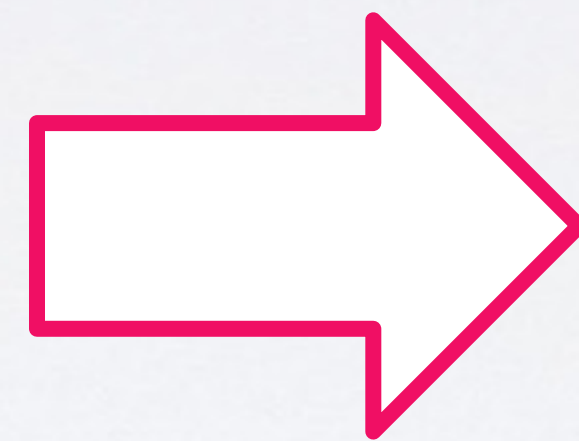
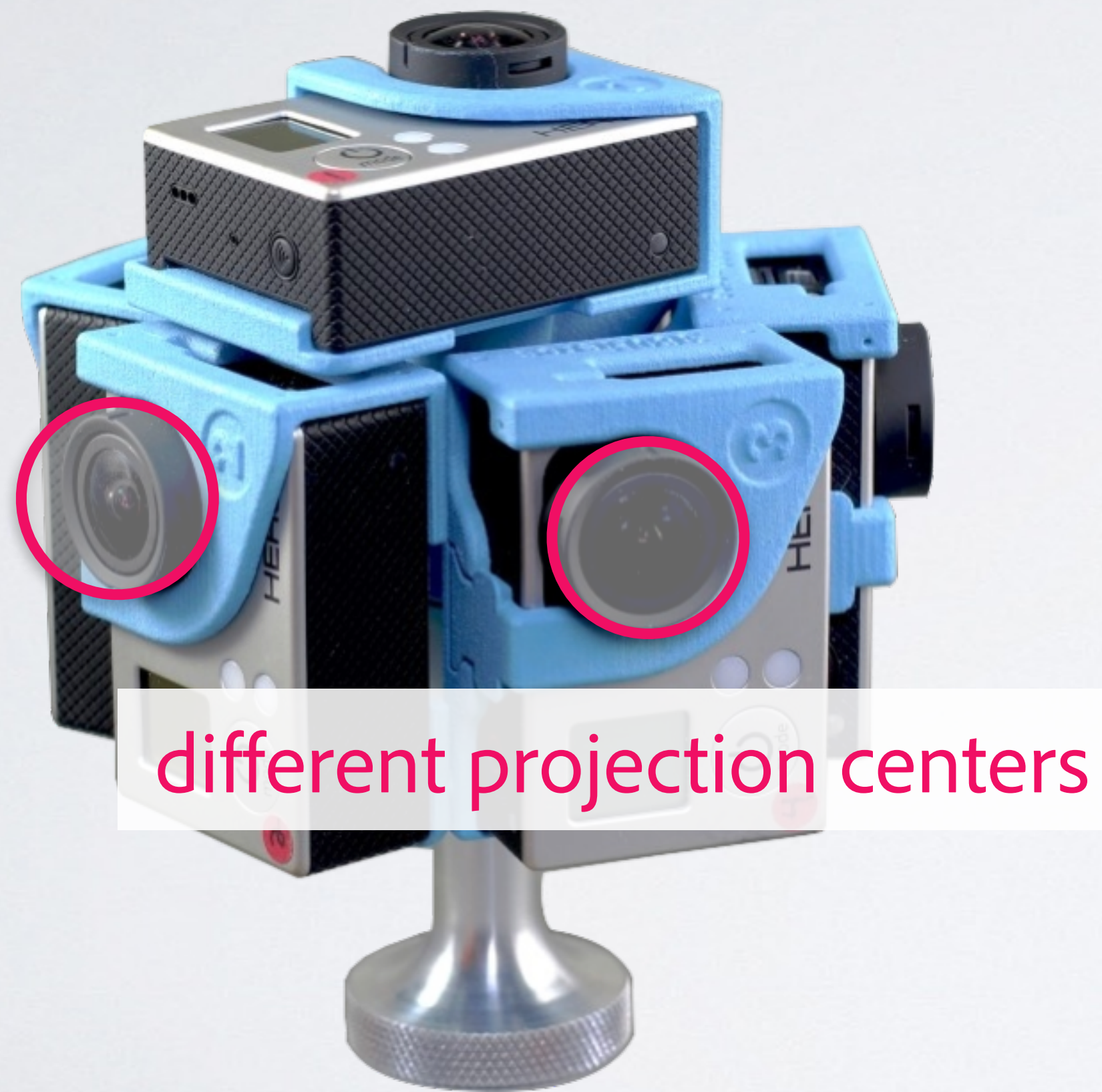


STITCHING

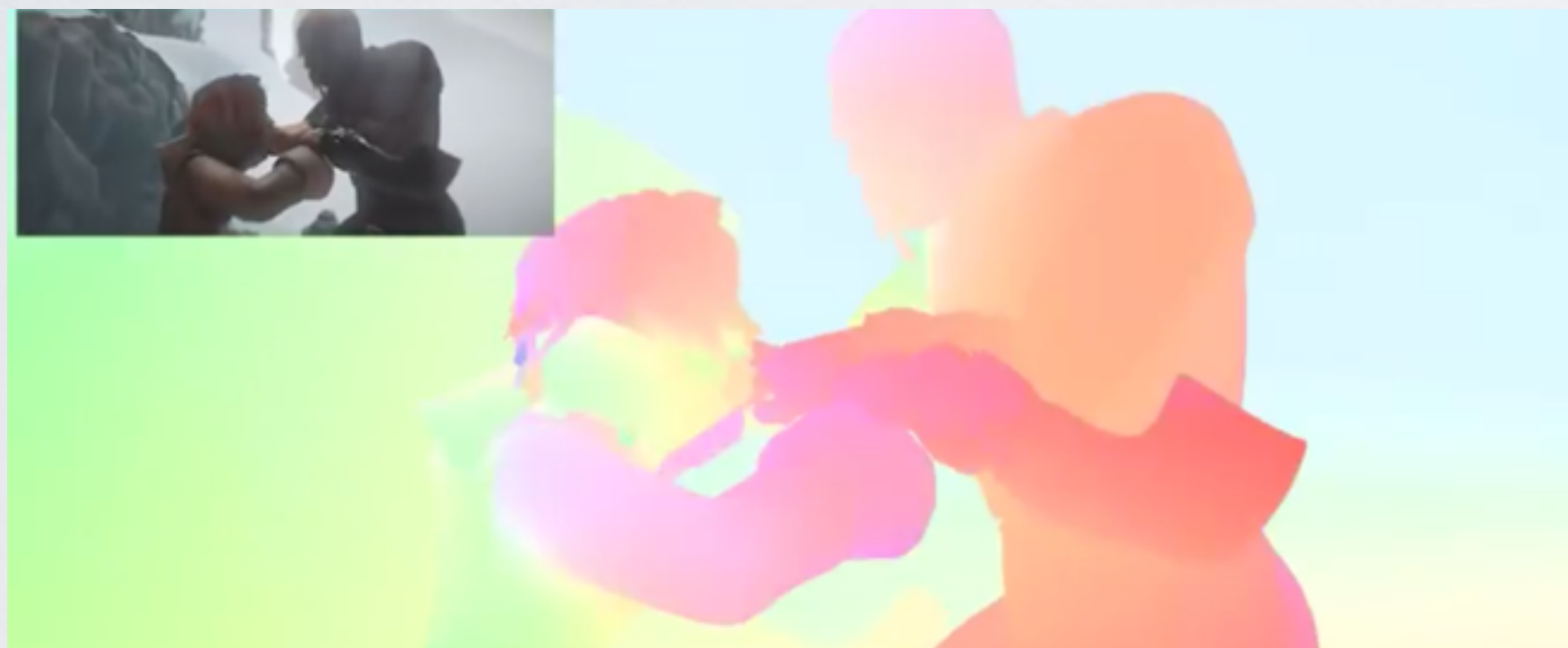


Image Alignment and Stitching [Szeliski, Richard 2005]

PARALLAX ARTIFACTS

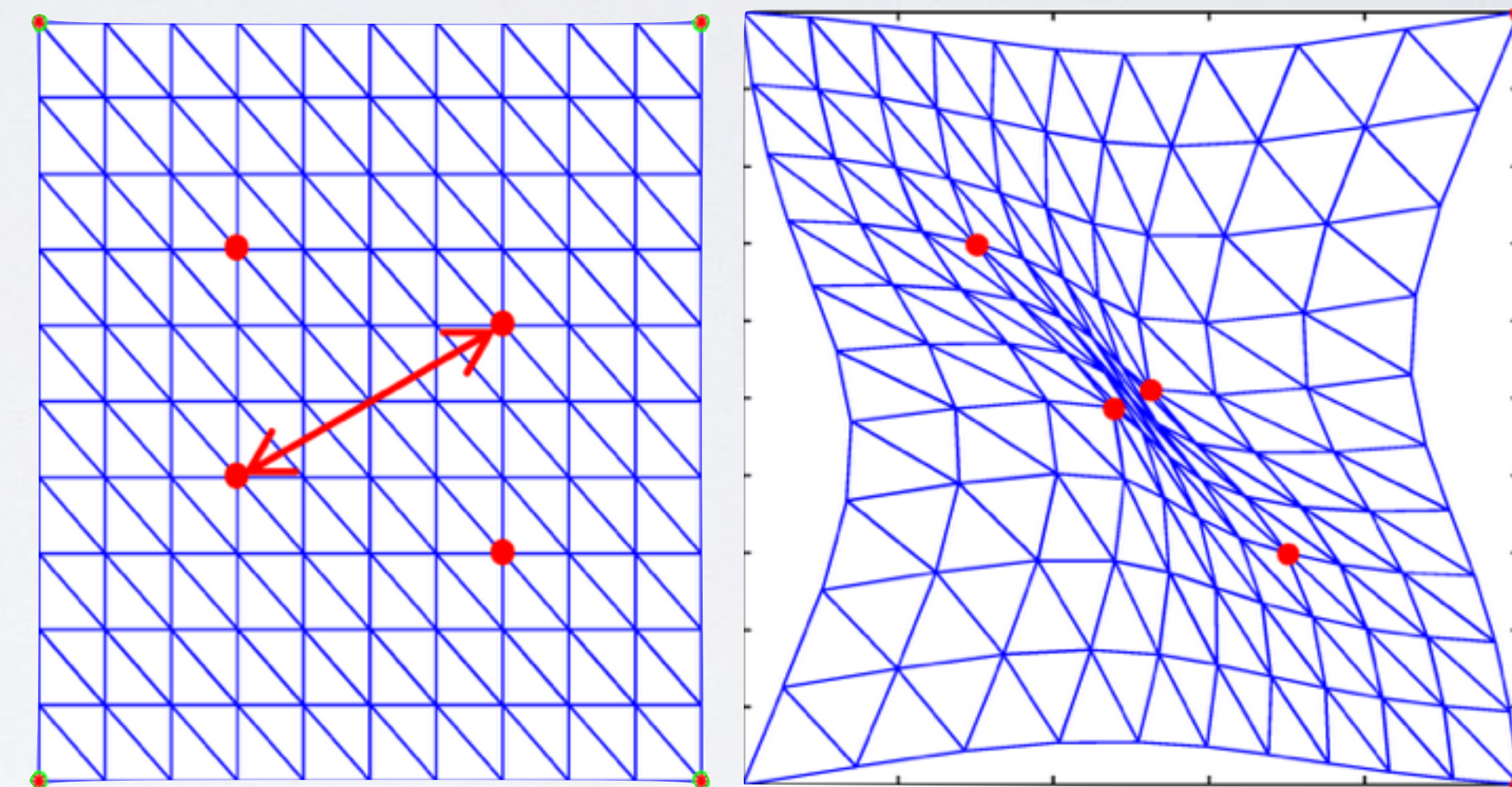


PARALLAX COMPENSATION



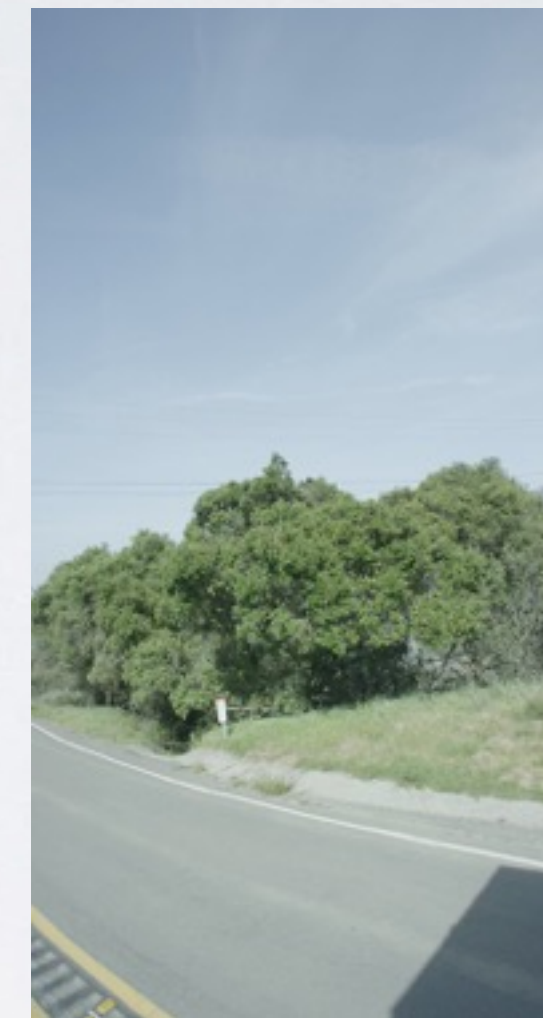
<http://sintel.is.tue.mpg.de/>

Optical Flow



Mesh Warping

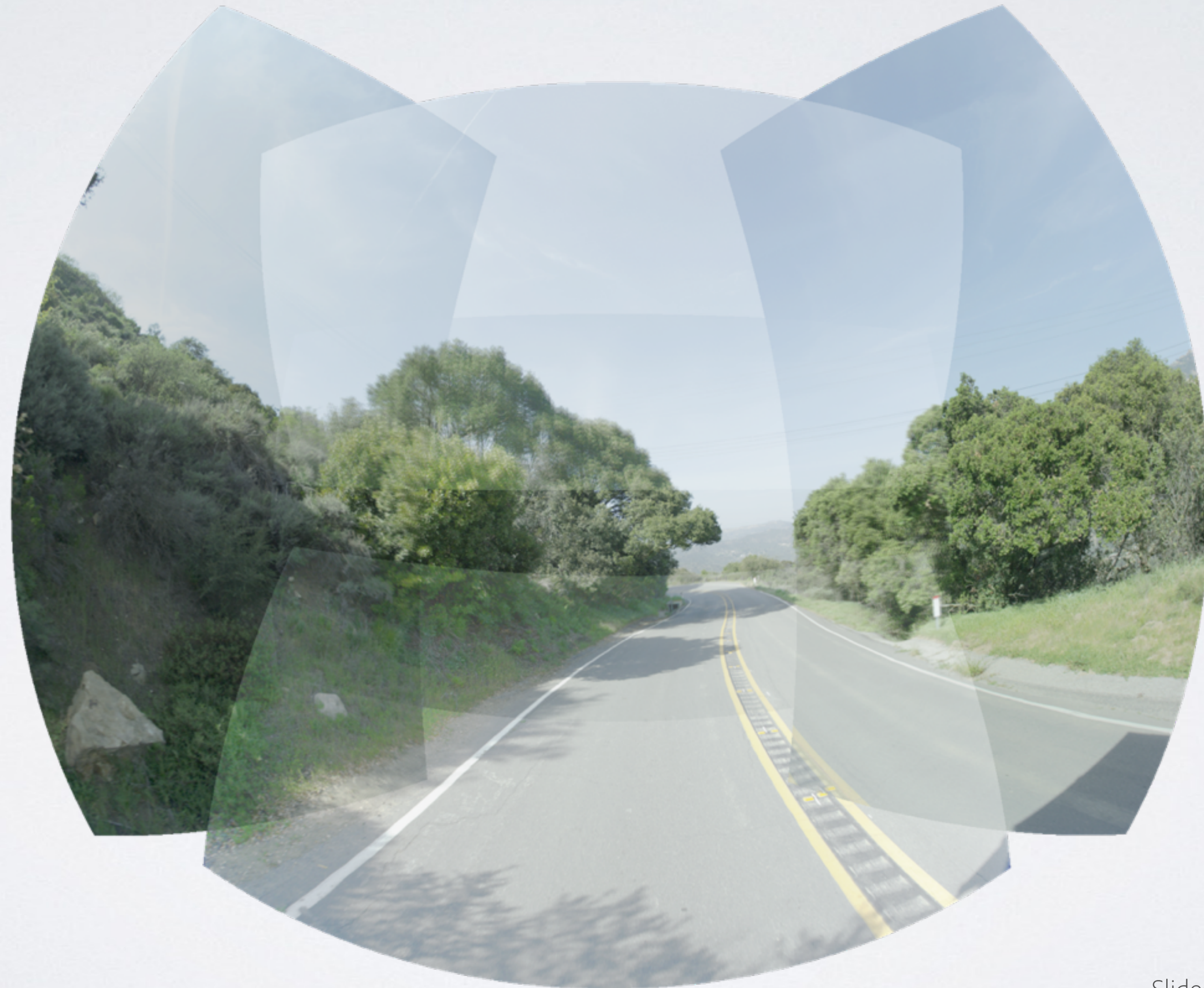
HIGH-LEVEL PIPELINE - INPUT



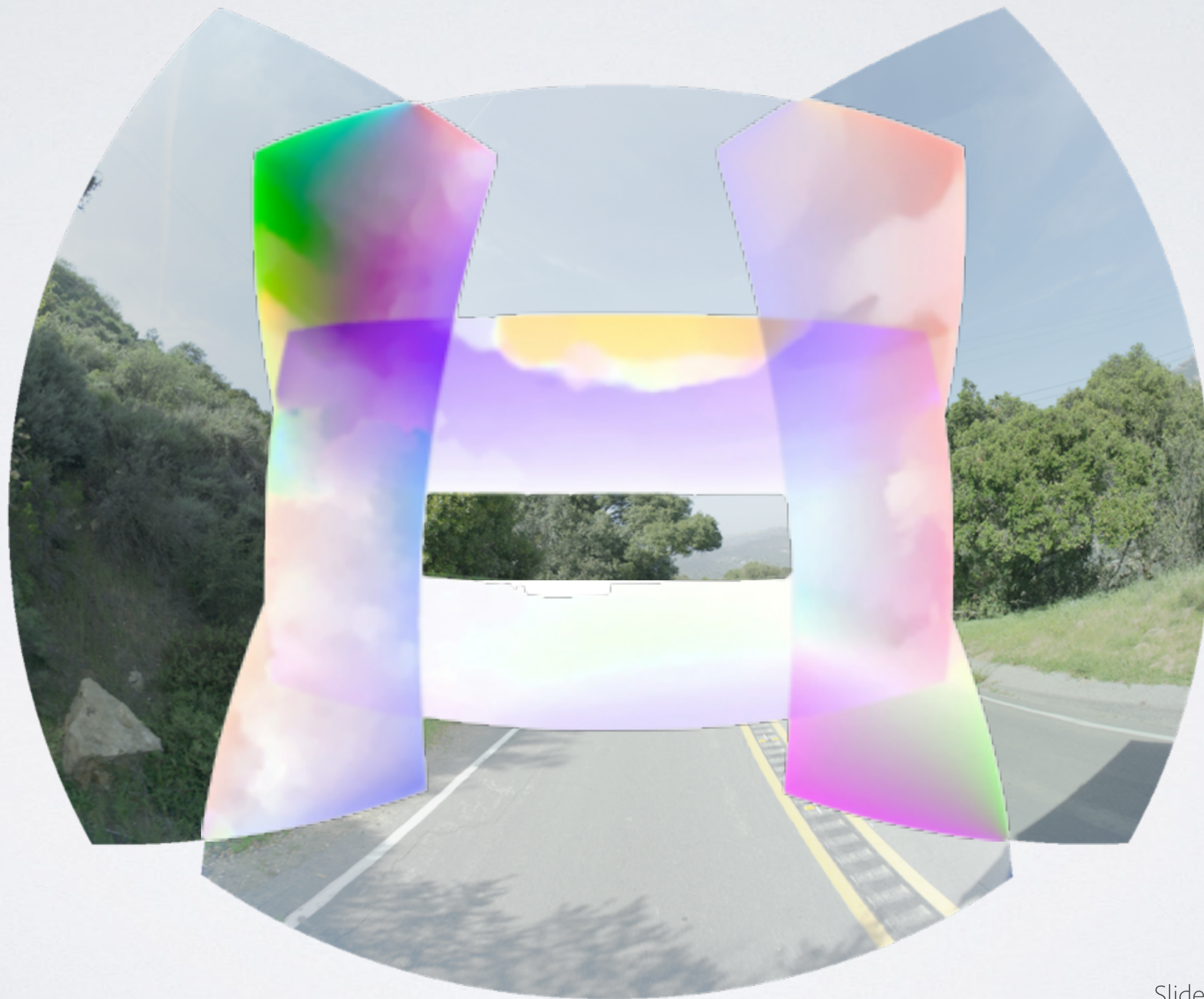
Panoramic Video from Unstructured Camera Arrays

[Perazzi et al. Eurographics 2015]

REFERENCE PROJECTION



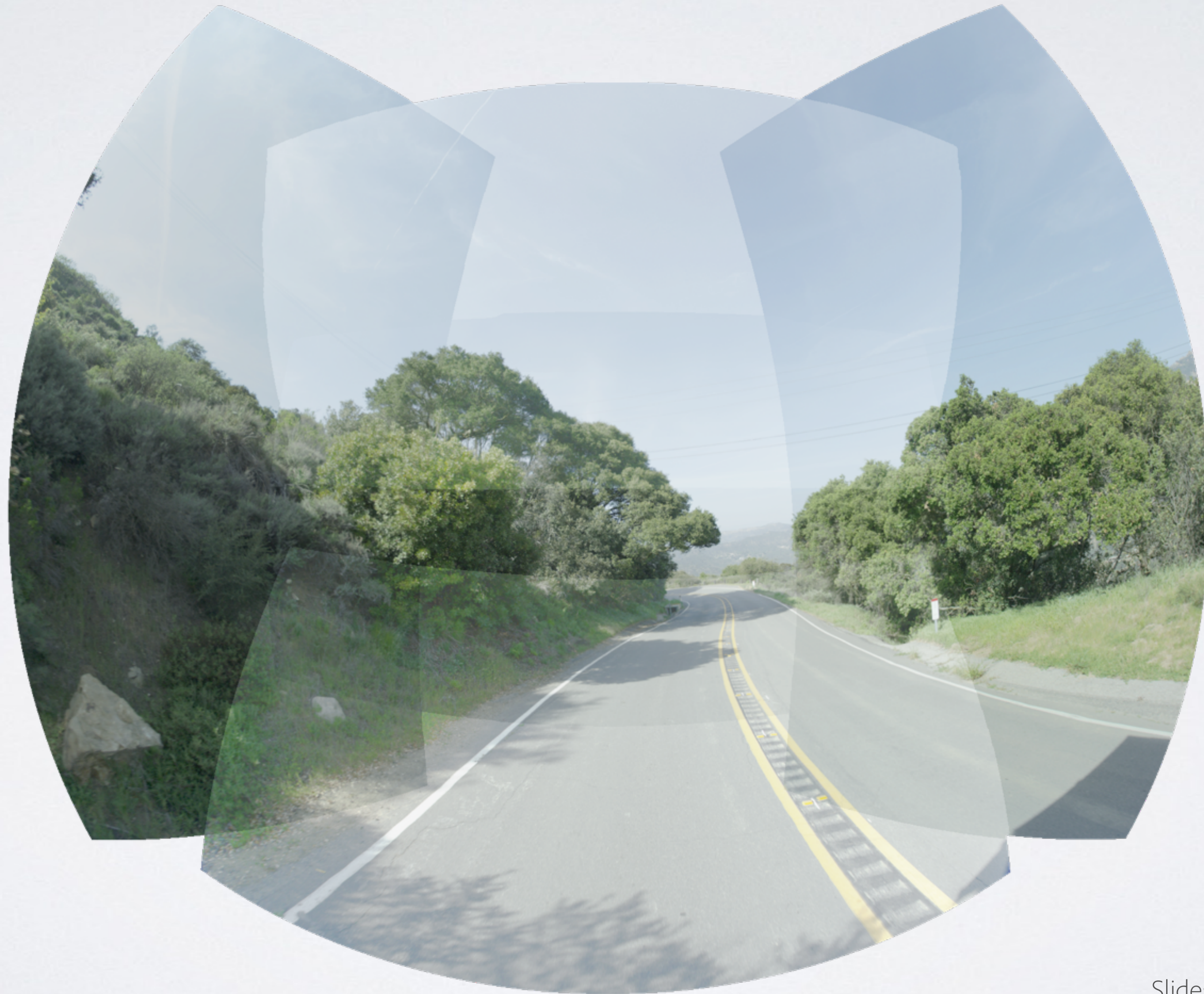
PARALLAX COMPENSATION



PARALLAX COMPENSATION



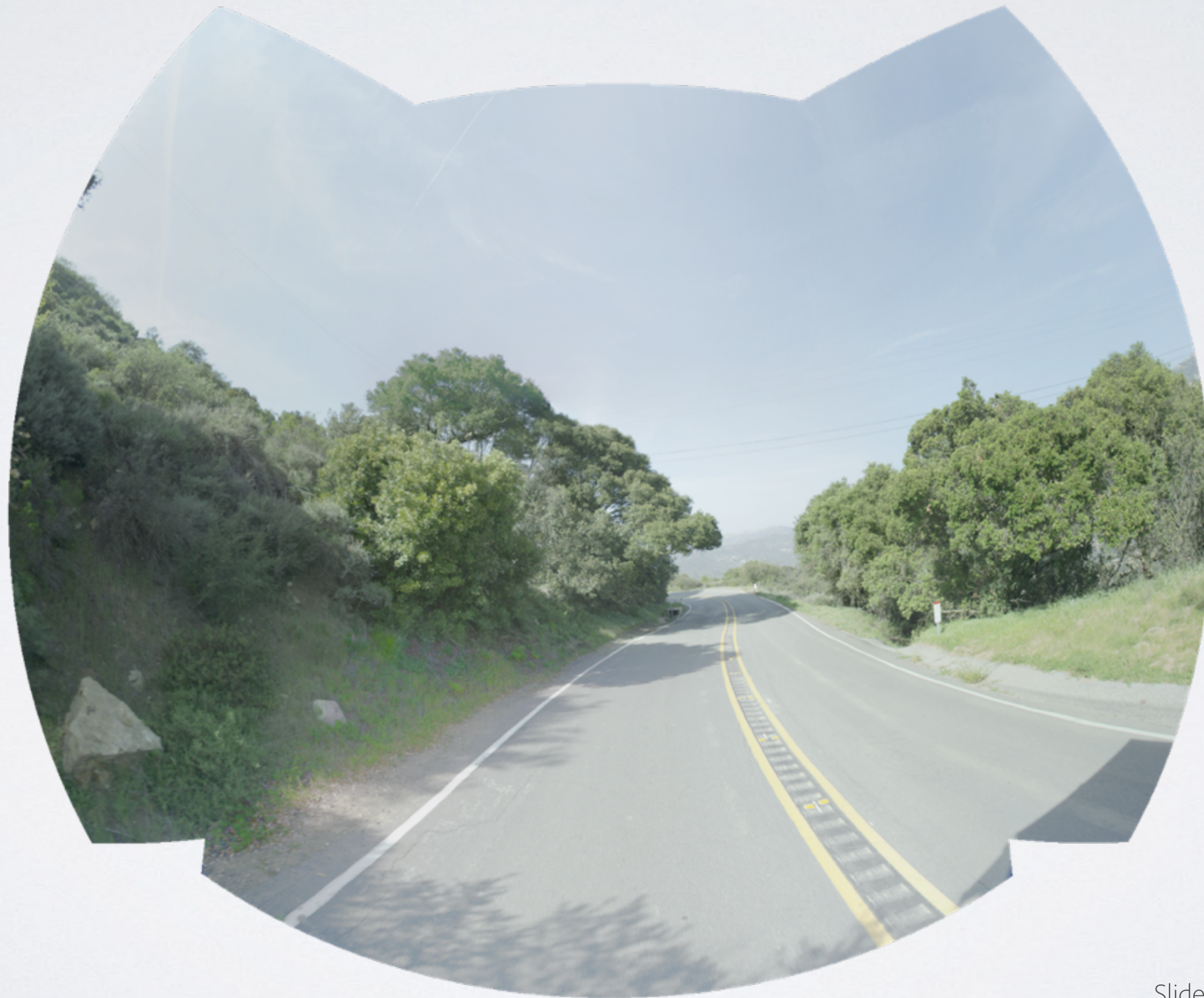
BLENDING



BLENDING



A Multiresolution Spline
With Application to
Image Mosaics [Burt and
Adelson 1983]





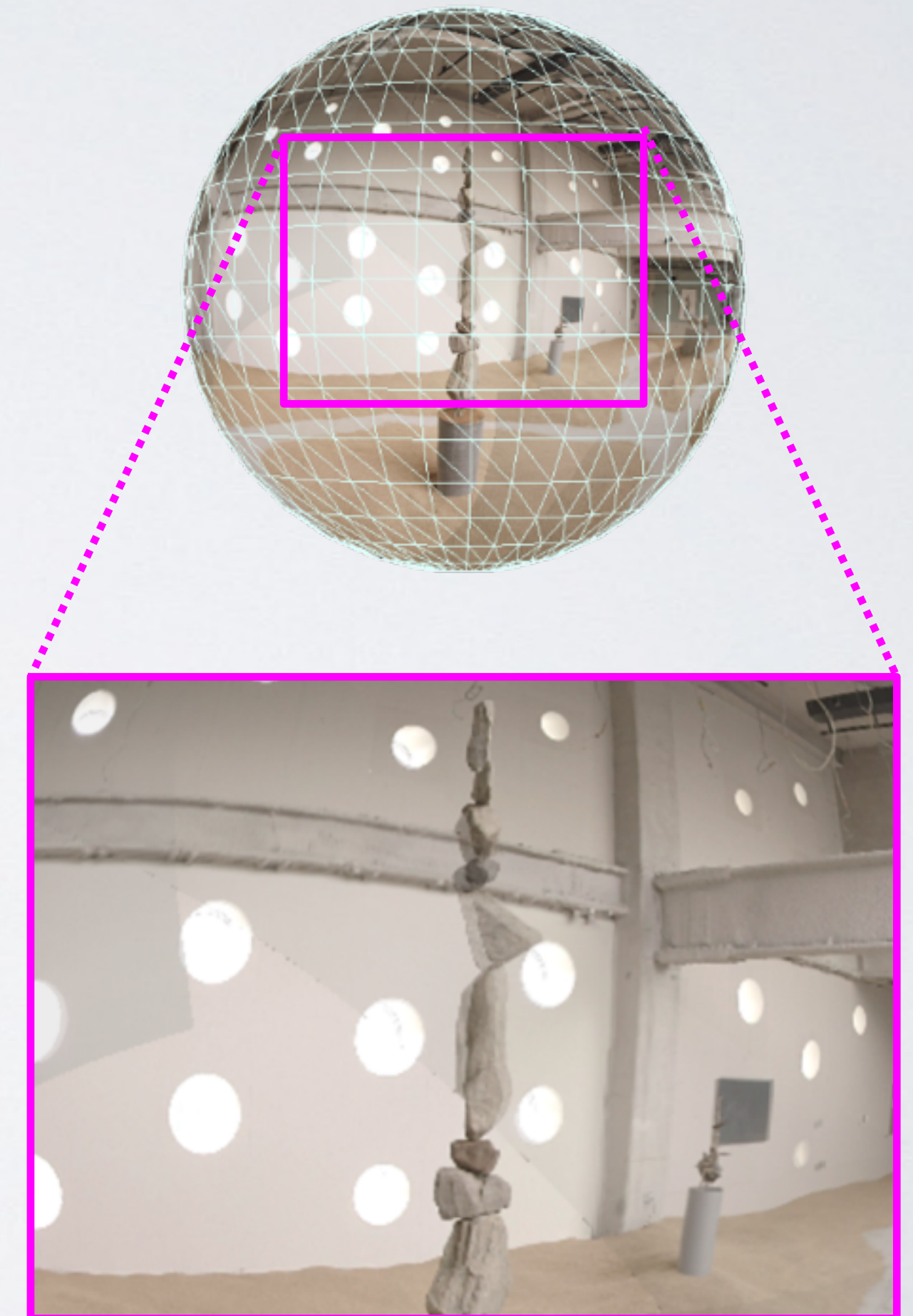
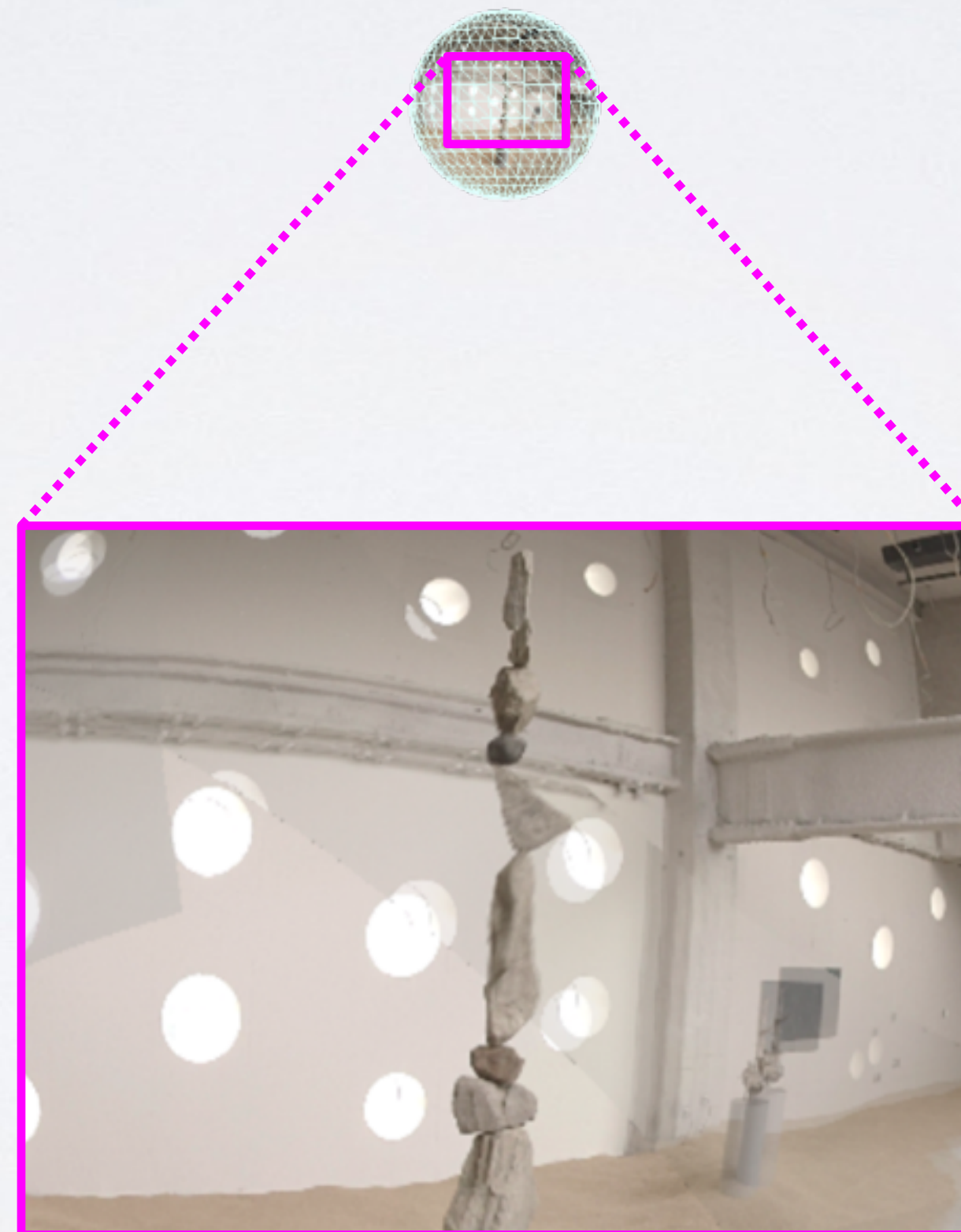
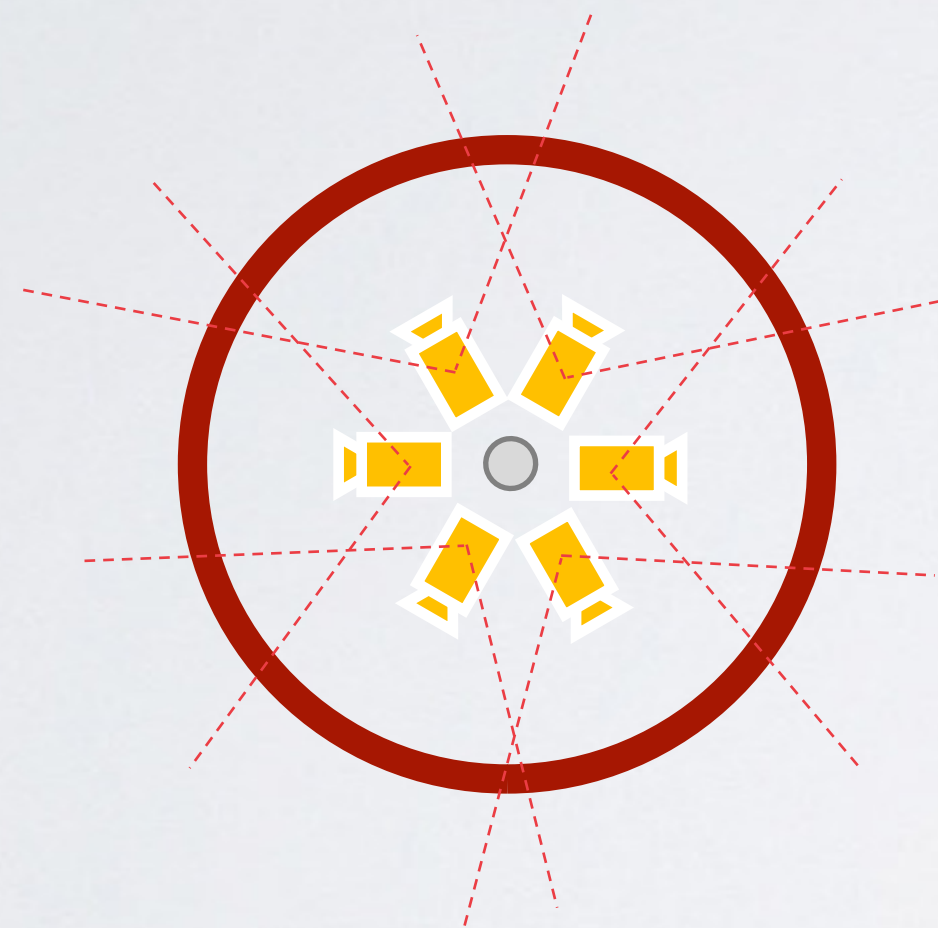


360 Degree Panorama

ANOTHER WAY TO THINK ABOUT IT

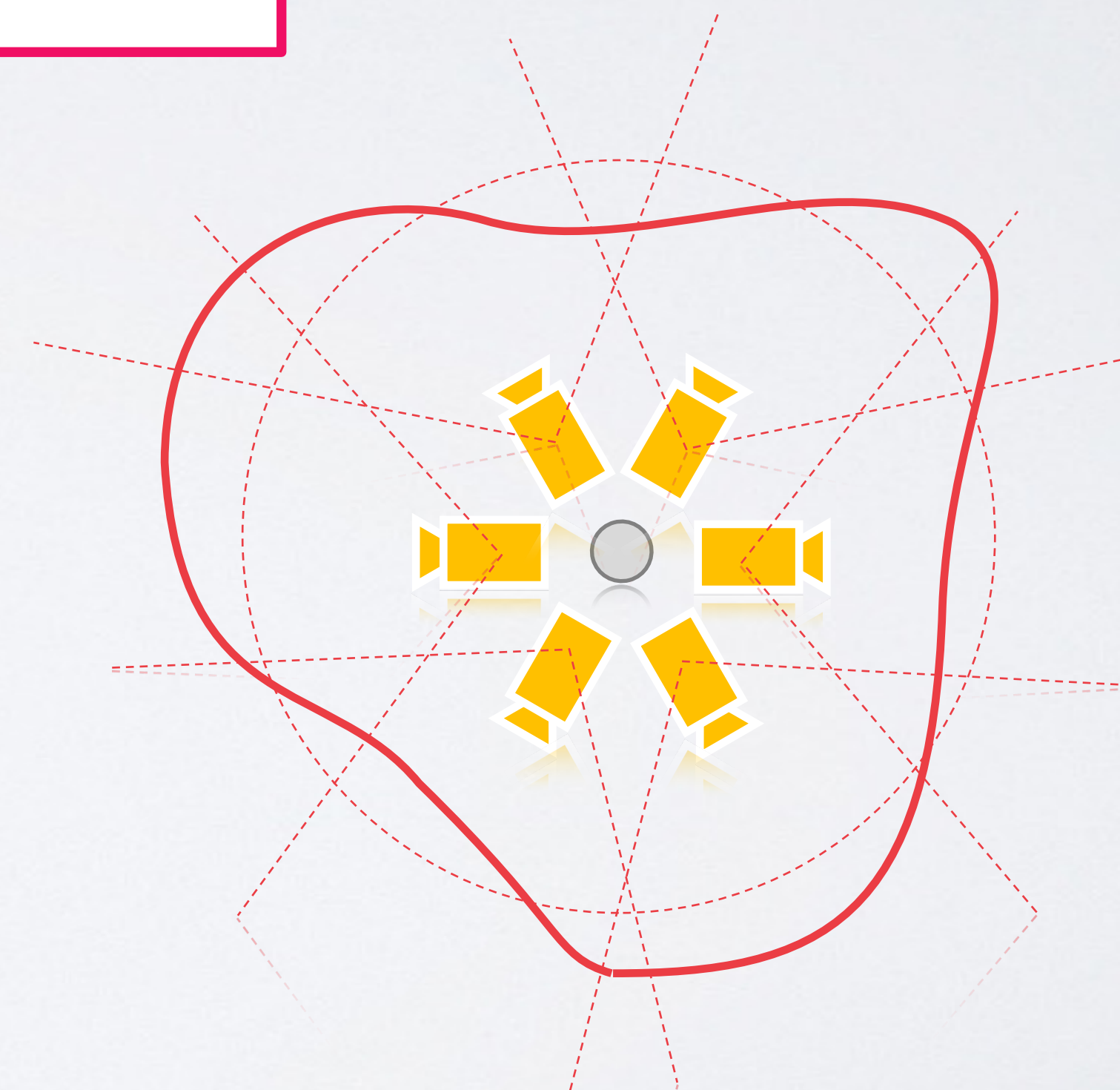
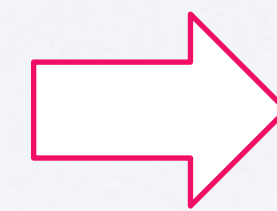
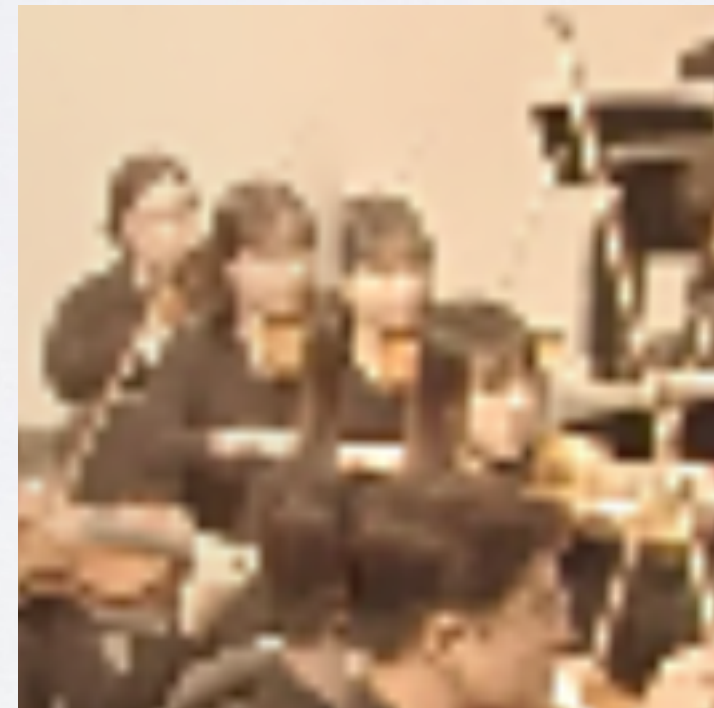
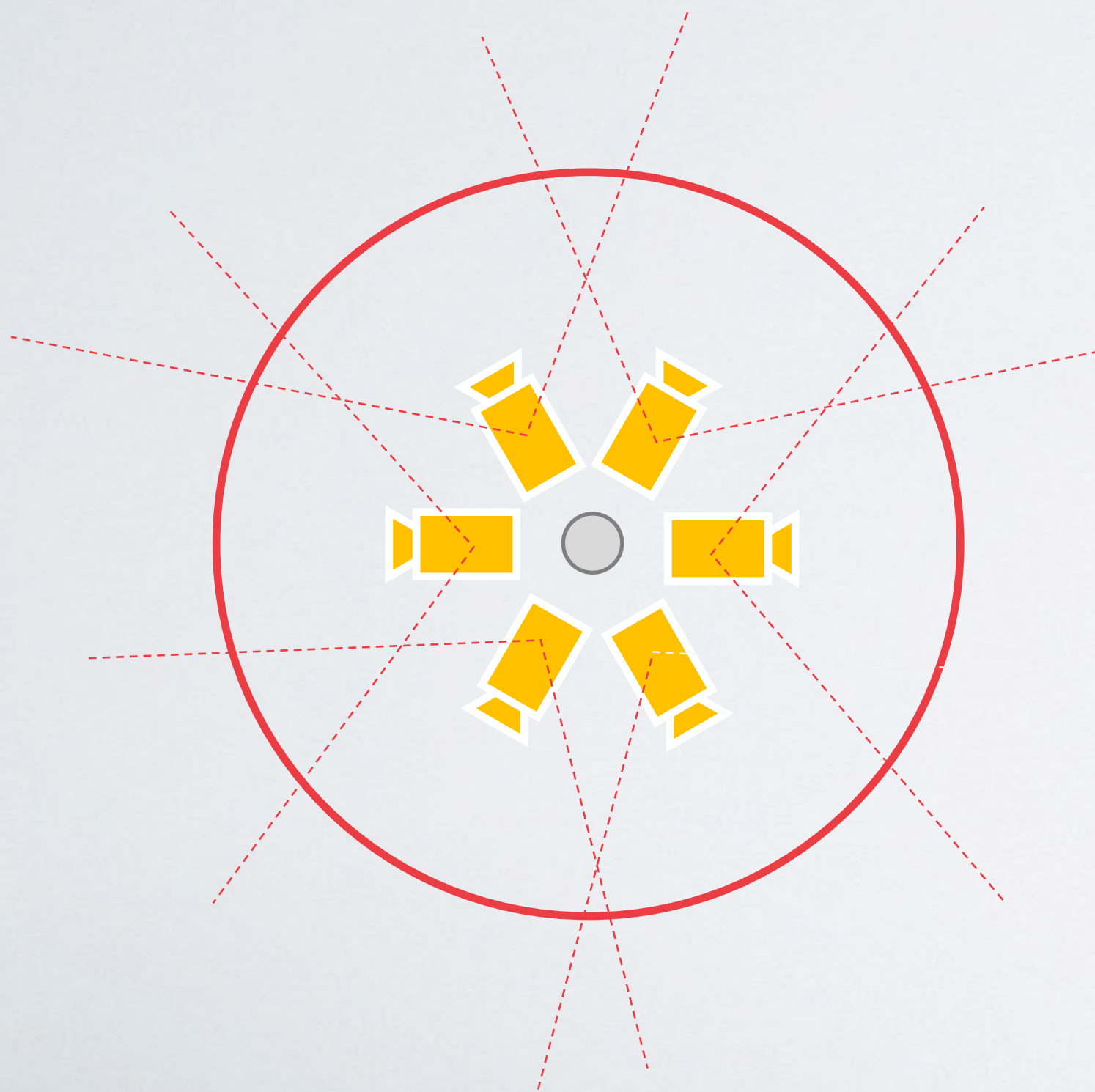
Rich360: Optimized Spherical Representation from Structured Panoramic Camera Arrays

[Lee et al. SIGGRAPH 2016]

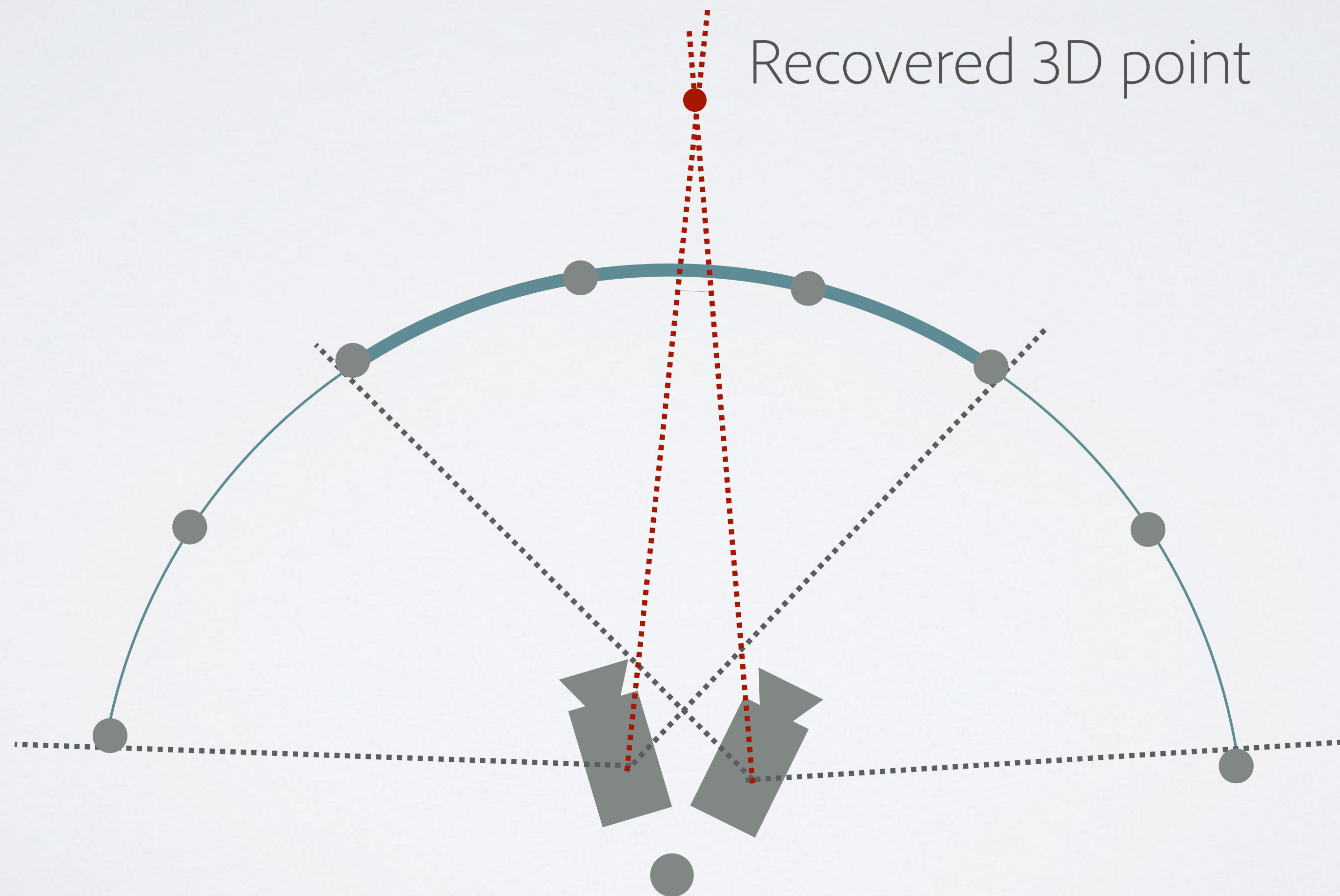


MESH DEFORMATION

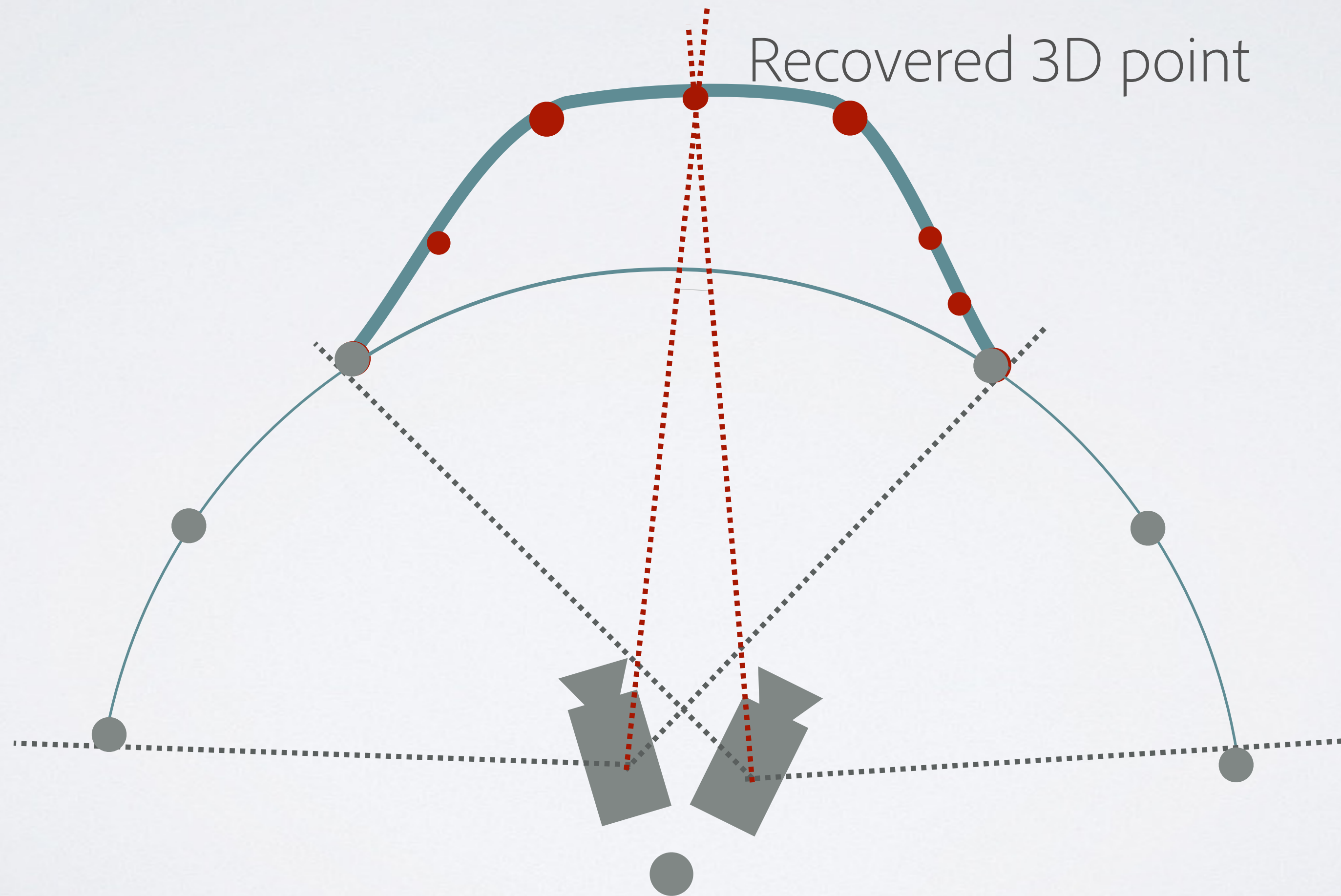
Deformation of
the projection sphere



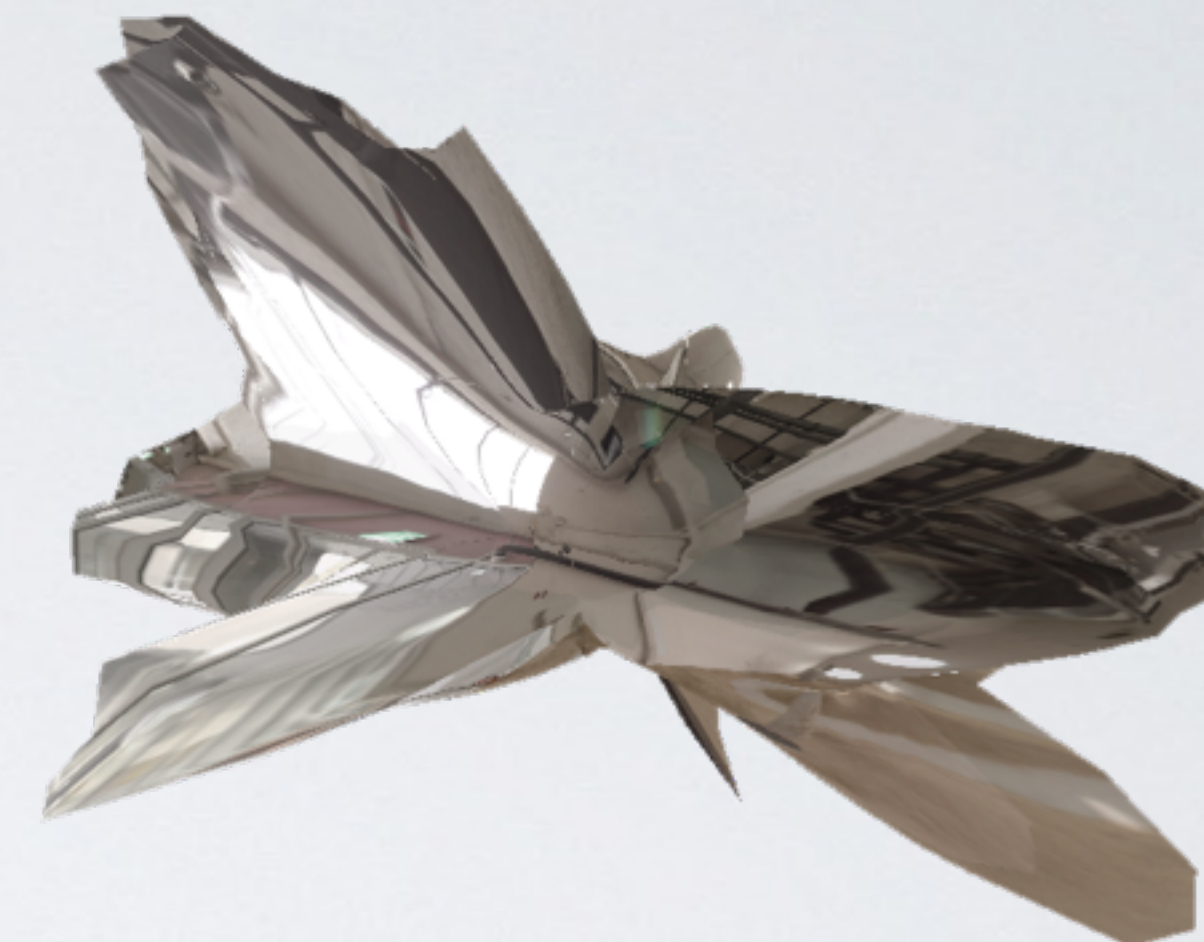
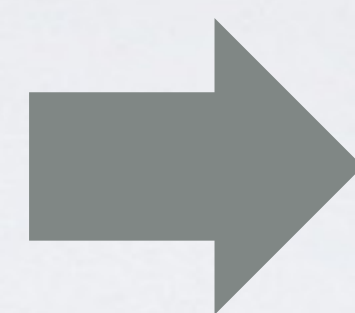
DEFORMABLE SPHERICAL PROJECTION SURFACE



DEFORMABLE SPHERICAL PROJECTION SURFACE



DEFORMABLE SPHERICAL PROJECTION SURFACE

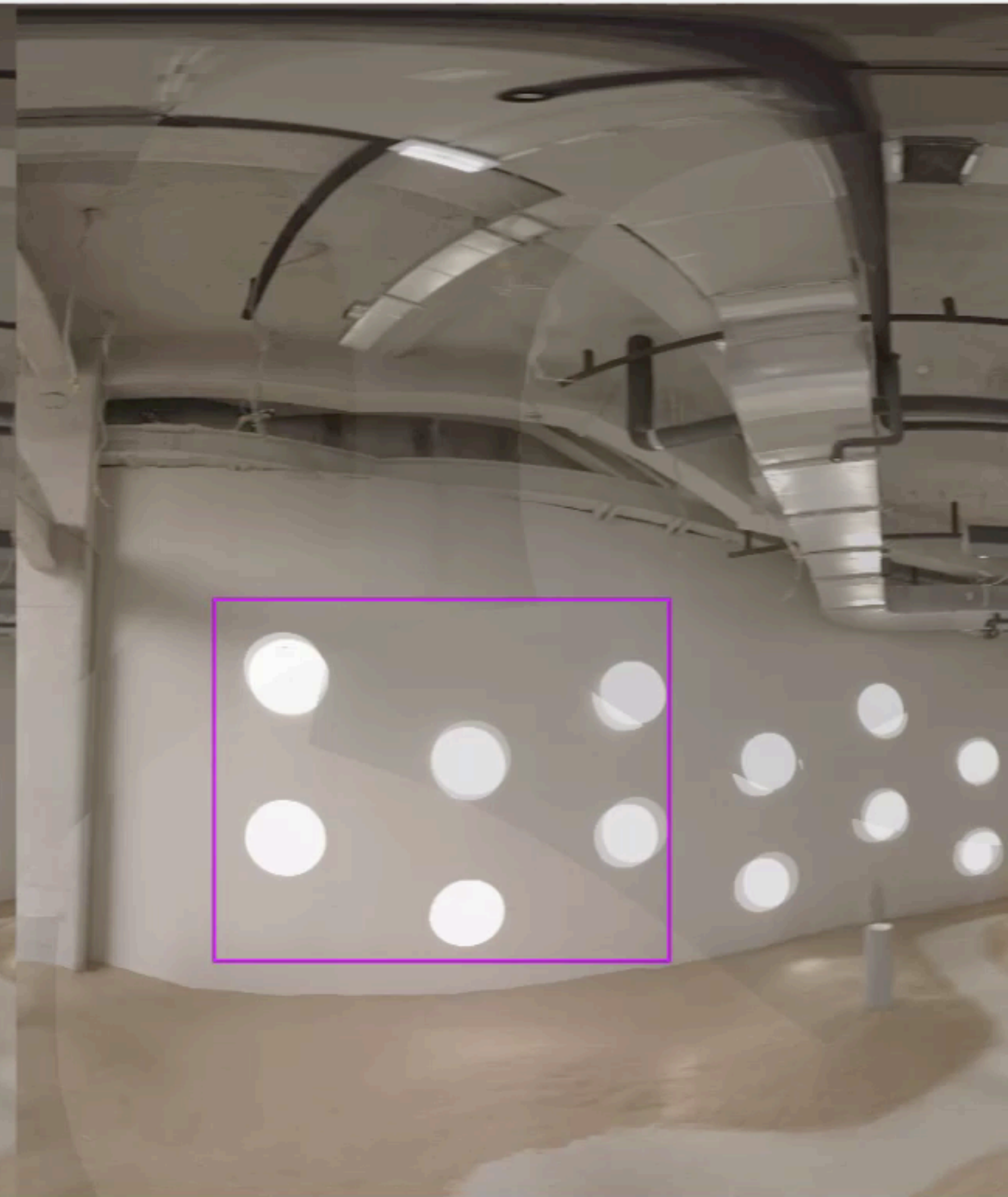




Rich360

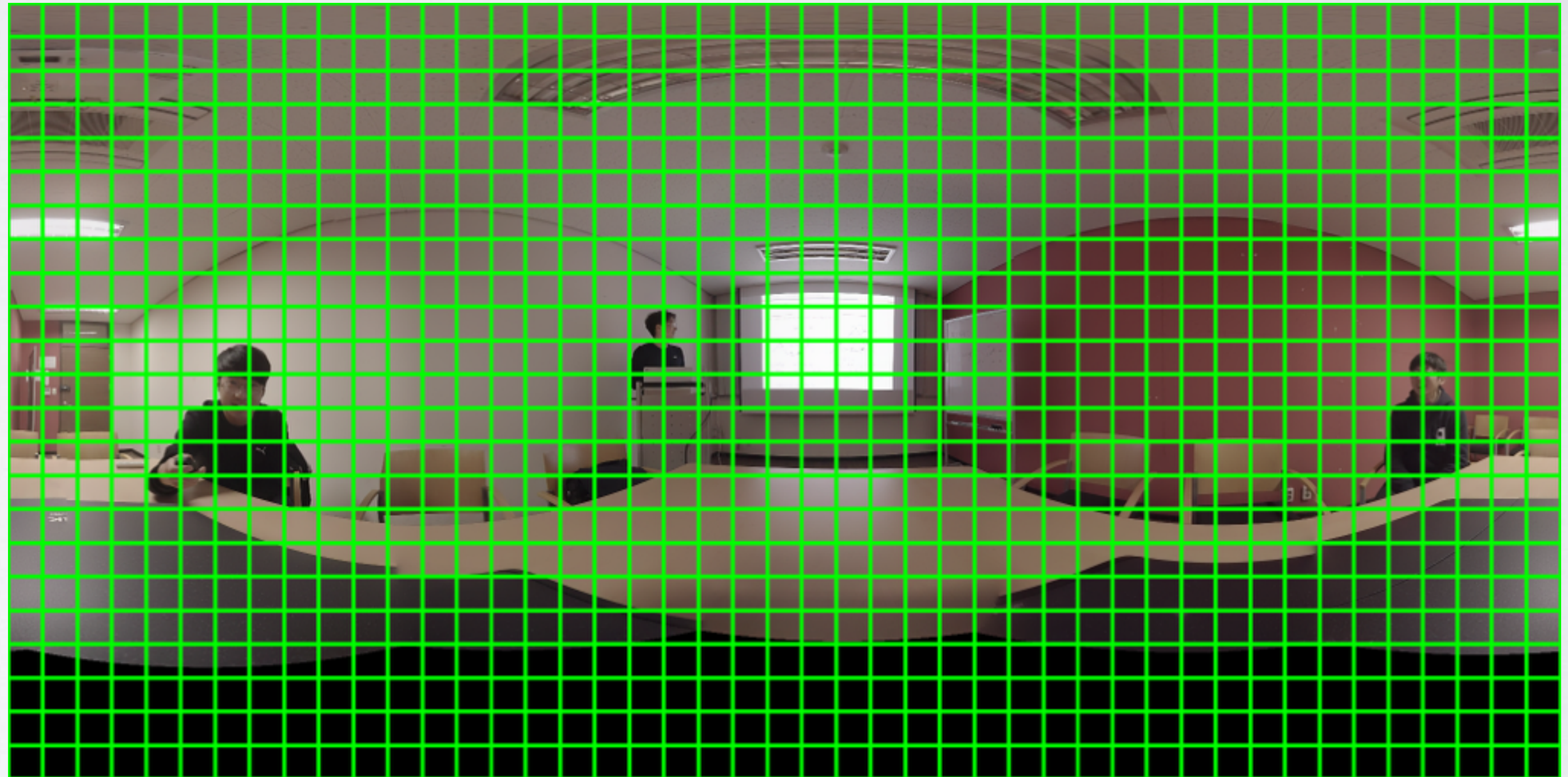
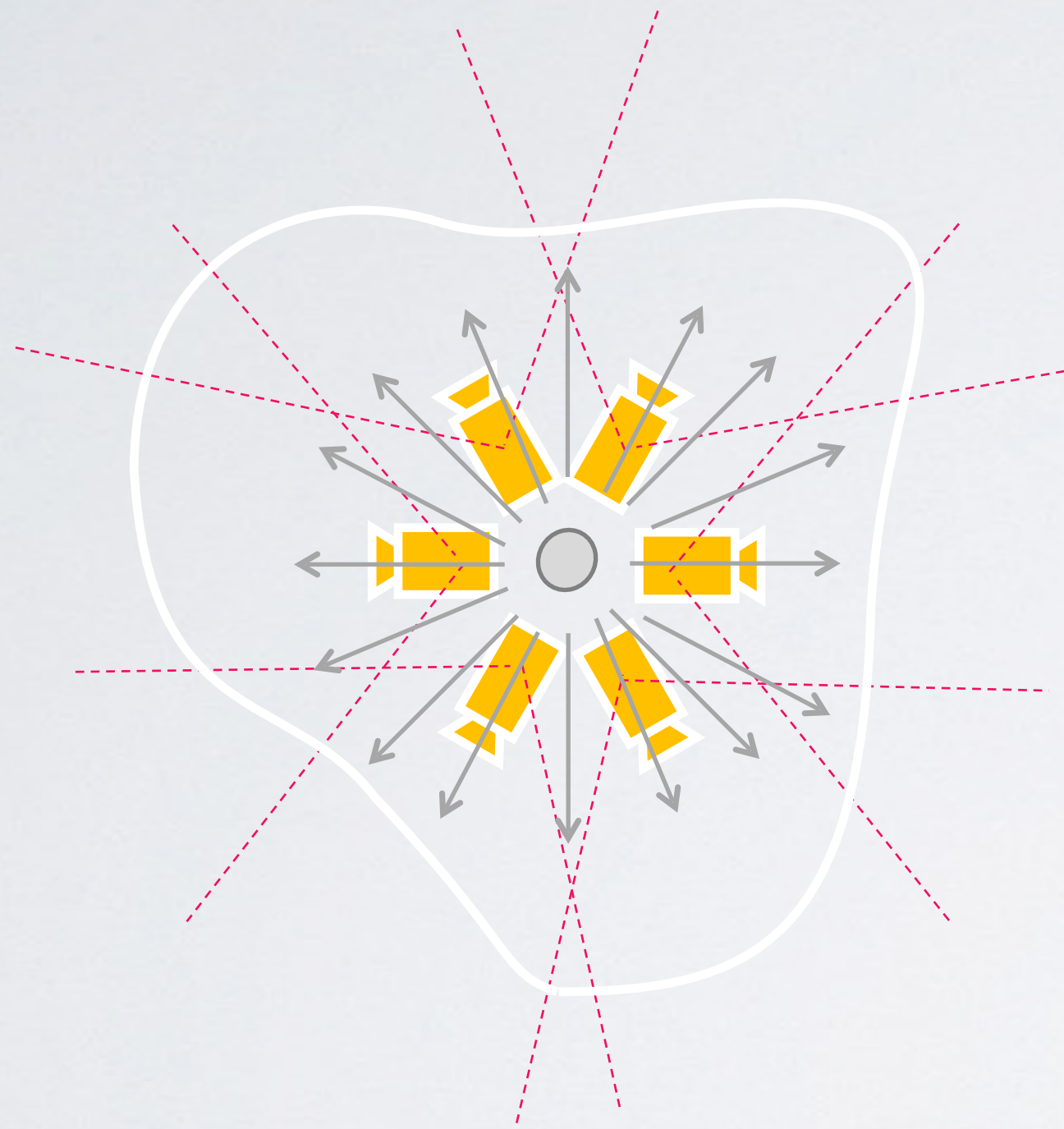


GCW

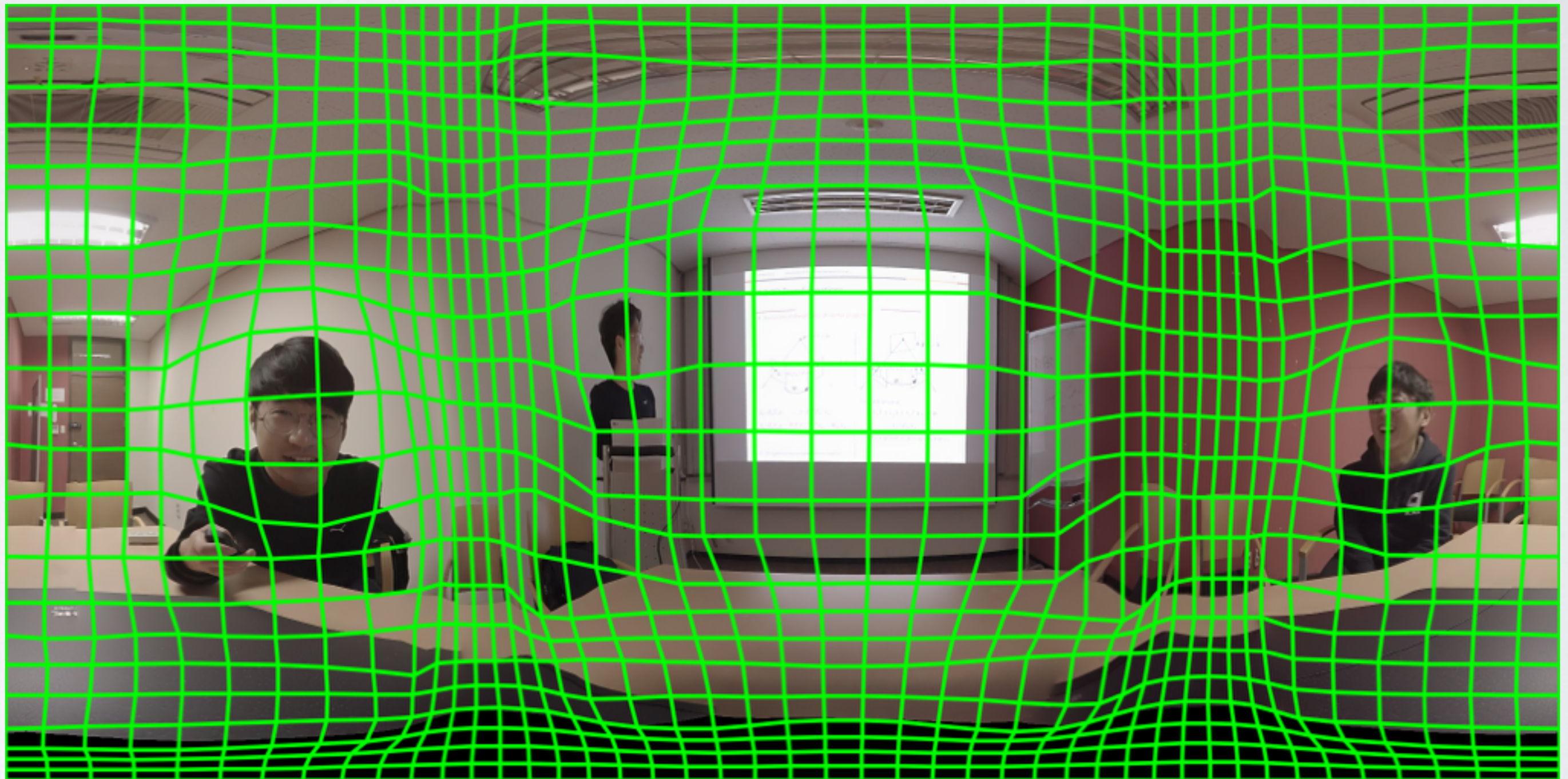
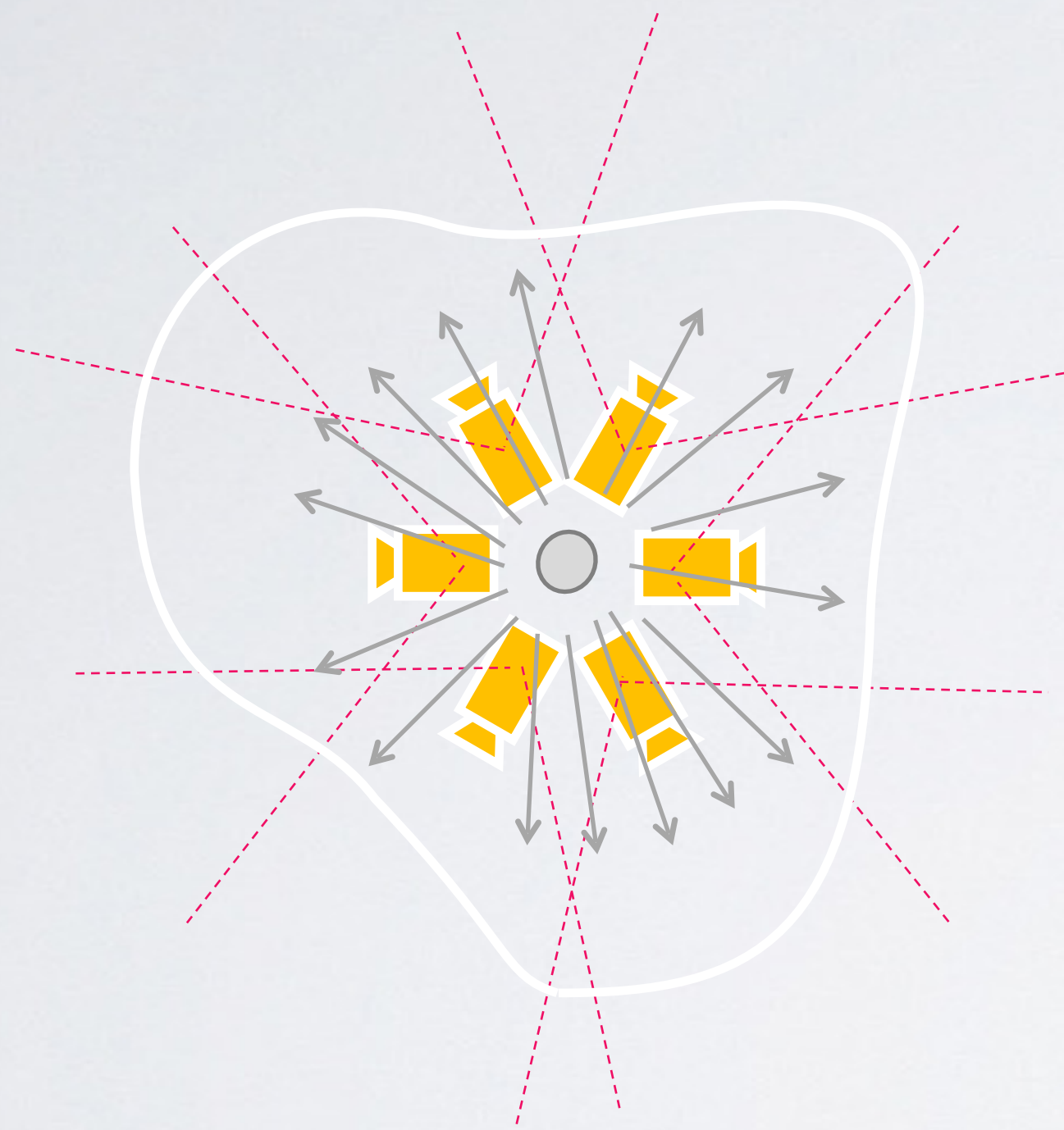


STCPW

NON-UNIFORM RAY SAMPLING



NON-UNIFORM RAY SAMPLING







Rich360: Non-uniform Ray Sampling

The Equirectangular Projection

360° Video Processing

What is 360 video?

How do we represent it?

How do we create it?

What can we do with it?

What can't we do with it?

360° VIDEO STABILIZATION

[Johannes Kopf, SIGGRAPH Asia 2016]



Slides courtesy of Johannes Kopf, Facebook



Slides courtesy of Johannes Kopf, Facebook

TRACK



Narrow FOV

FIT MOTION MODEL
+ SMOOTHING



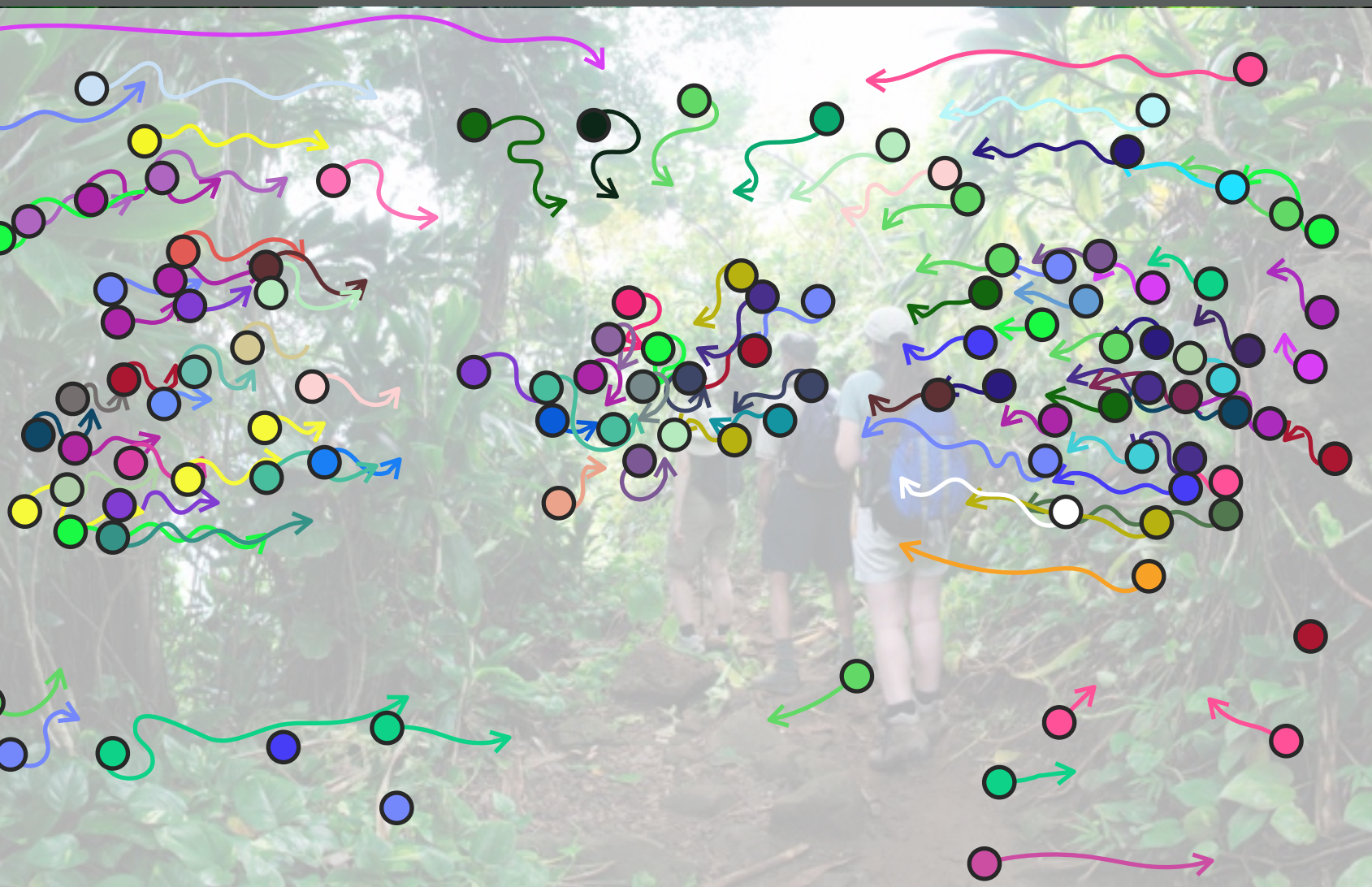
2D or 3D

WARP



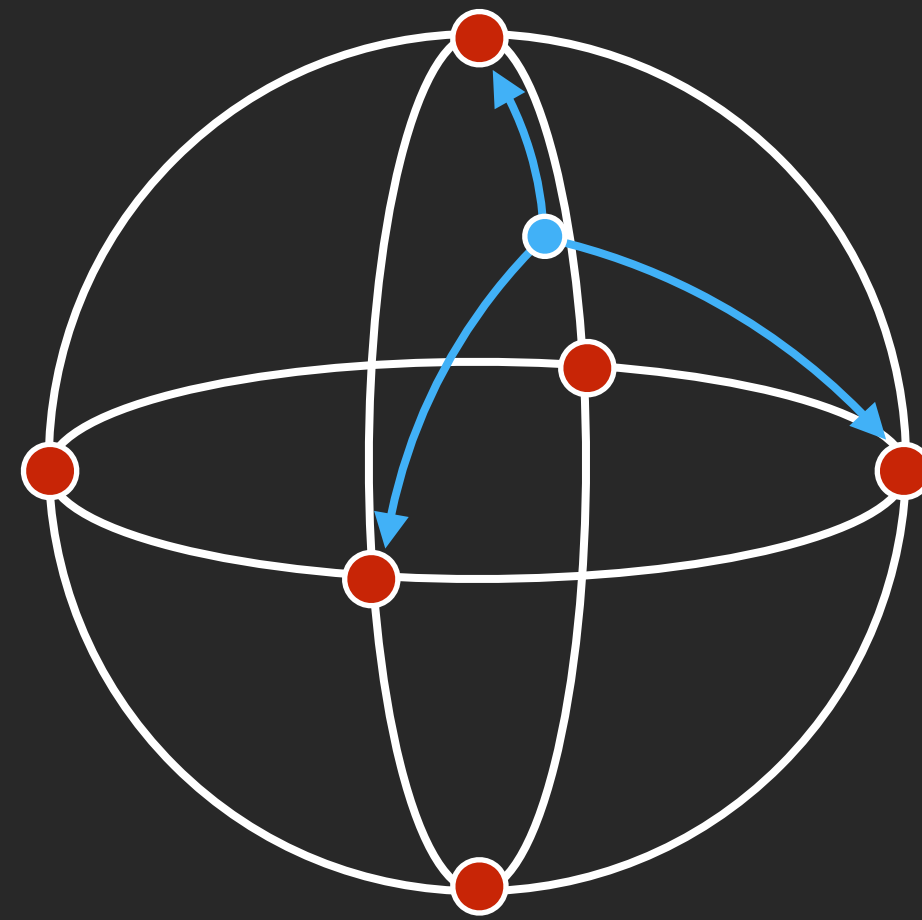
Cropped

TRACK



Full 360

FIT MOTION MODEL
+ SMOOTHING



Hybrid 3D-2D

WARP



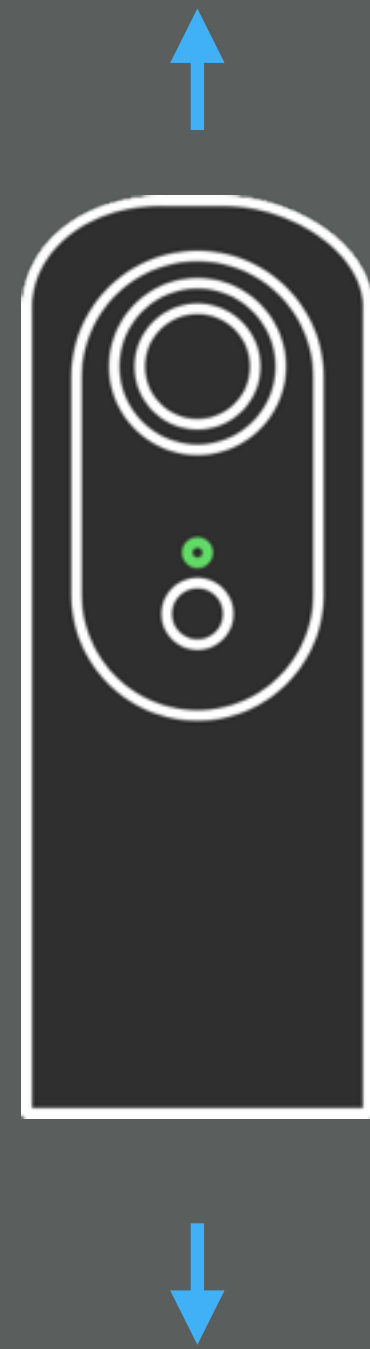
Not Cropped



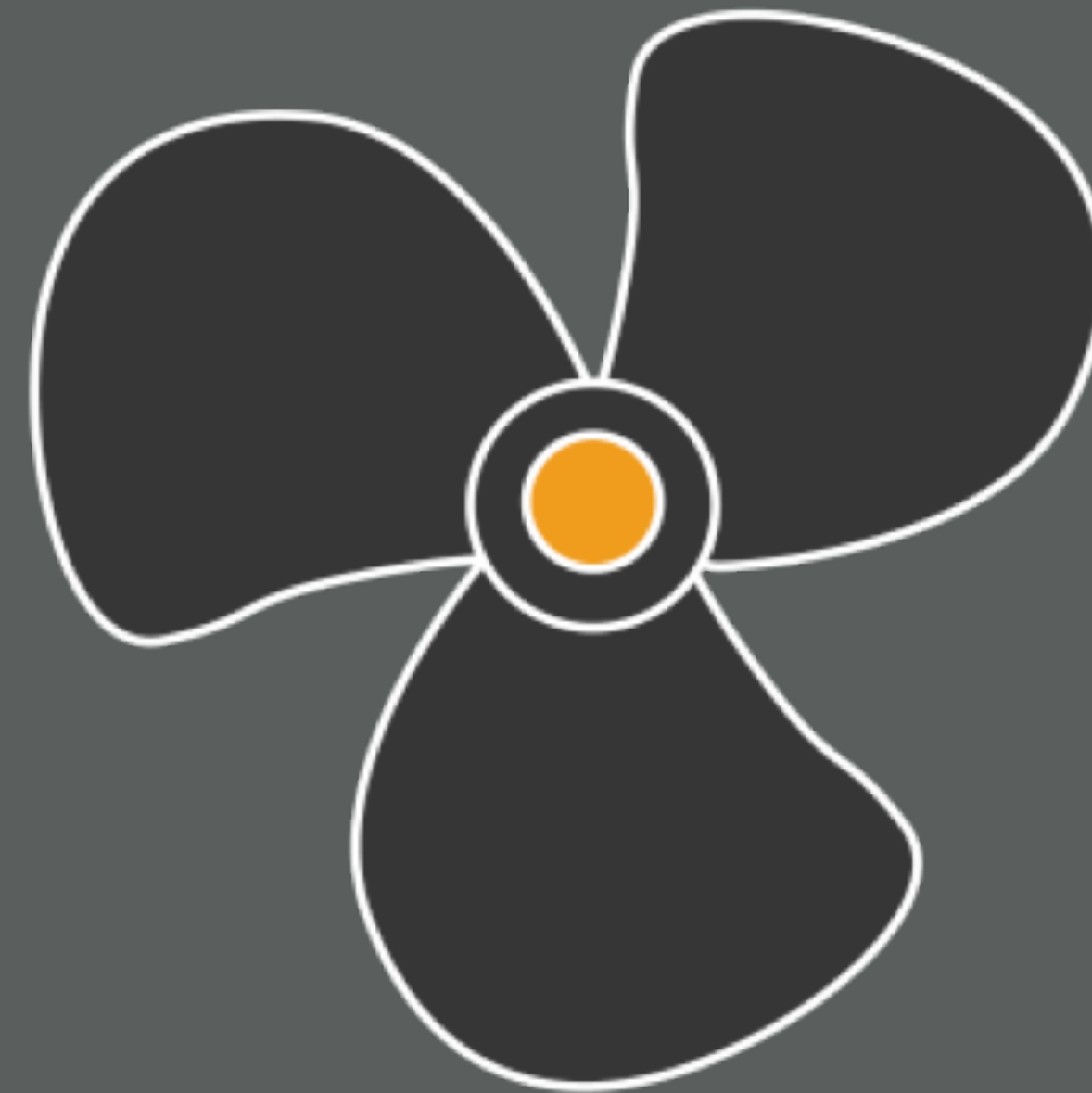
Input video



Pure-rotation stabilization



Translation effects



Rolling shutter/lens deformation



Pure-rotation



Deformed-rotation

CREATING NARROW FOV VIDEOS FROM 360 VIDEO

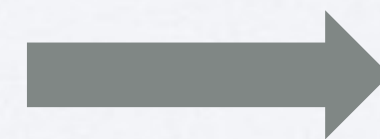
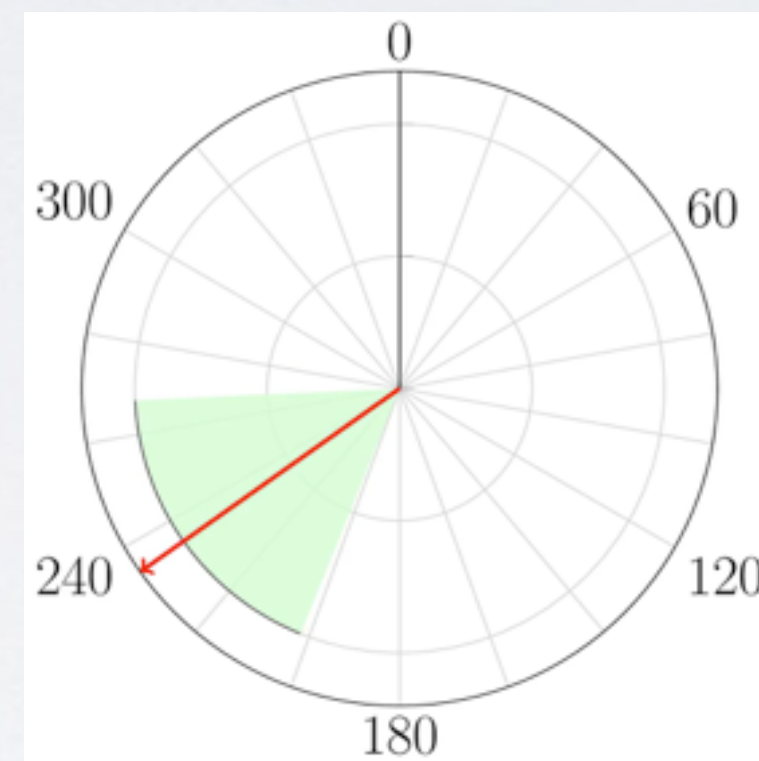
Pano2Vid: Automatic Cinematography for Watching 360° Video

[Su et al. ACCV 2016]

PANO2VID

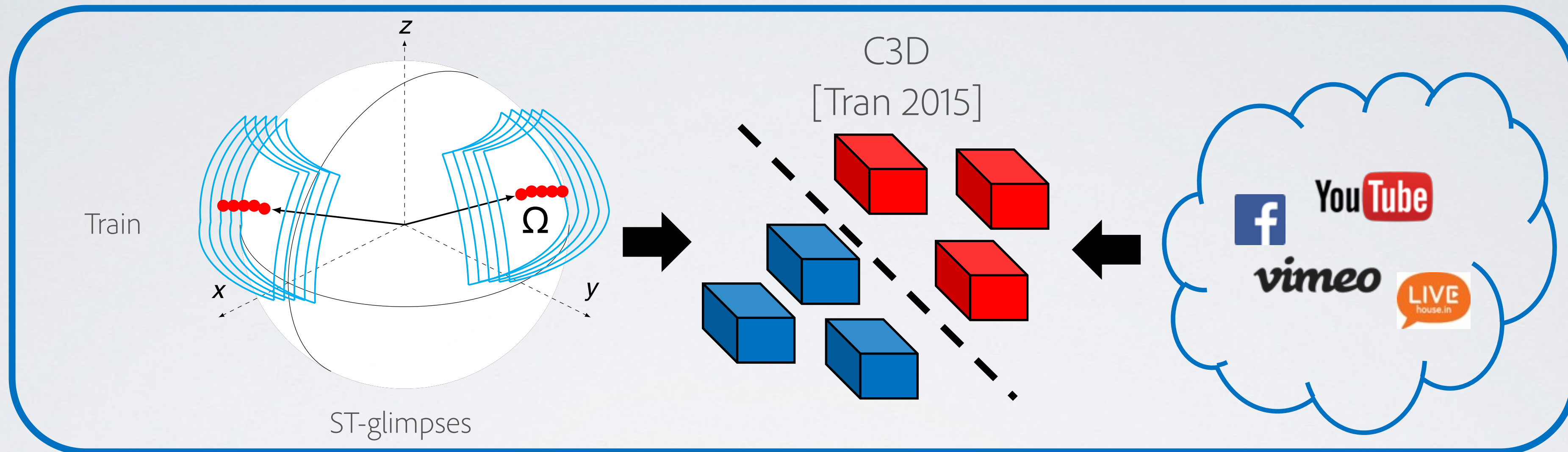


Input: 360° Video

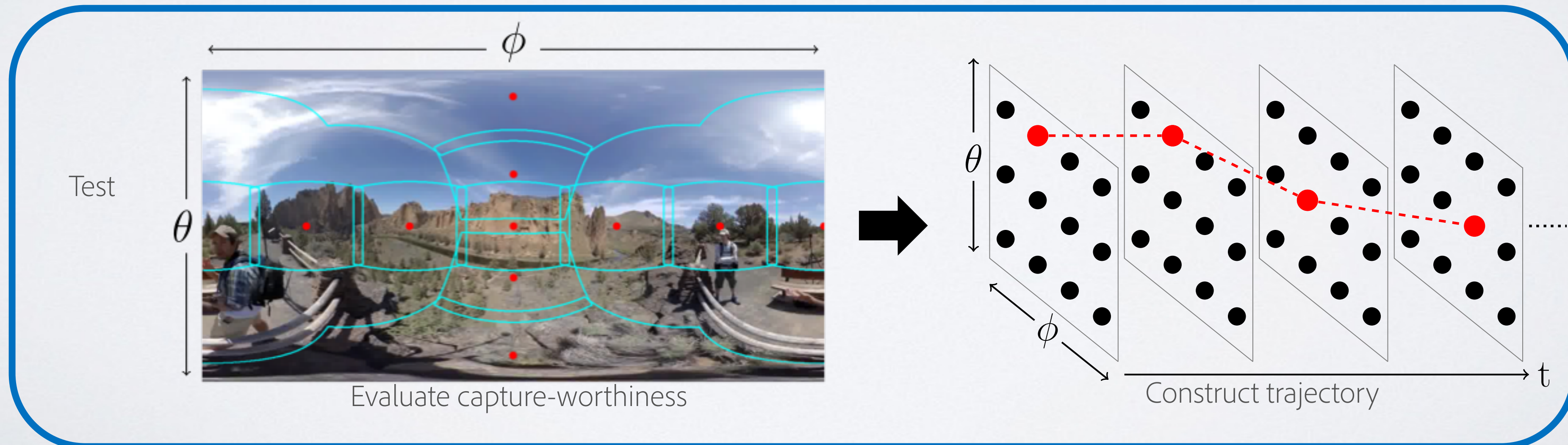
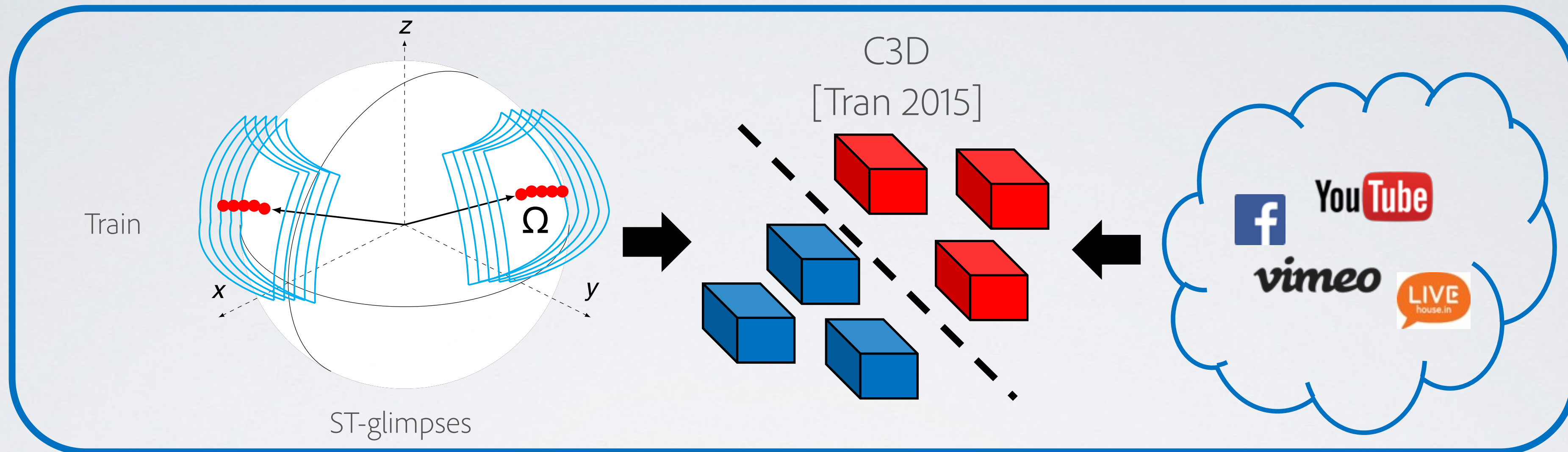


Output: normal-field-of-view
(NFOV) Video

PANO2VID



PANO2VID

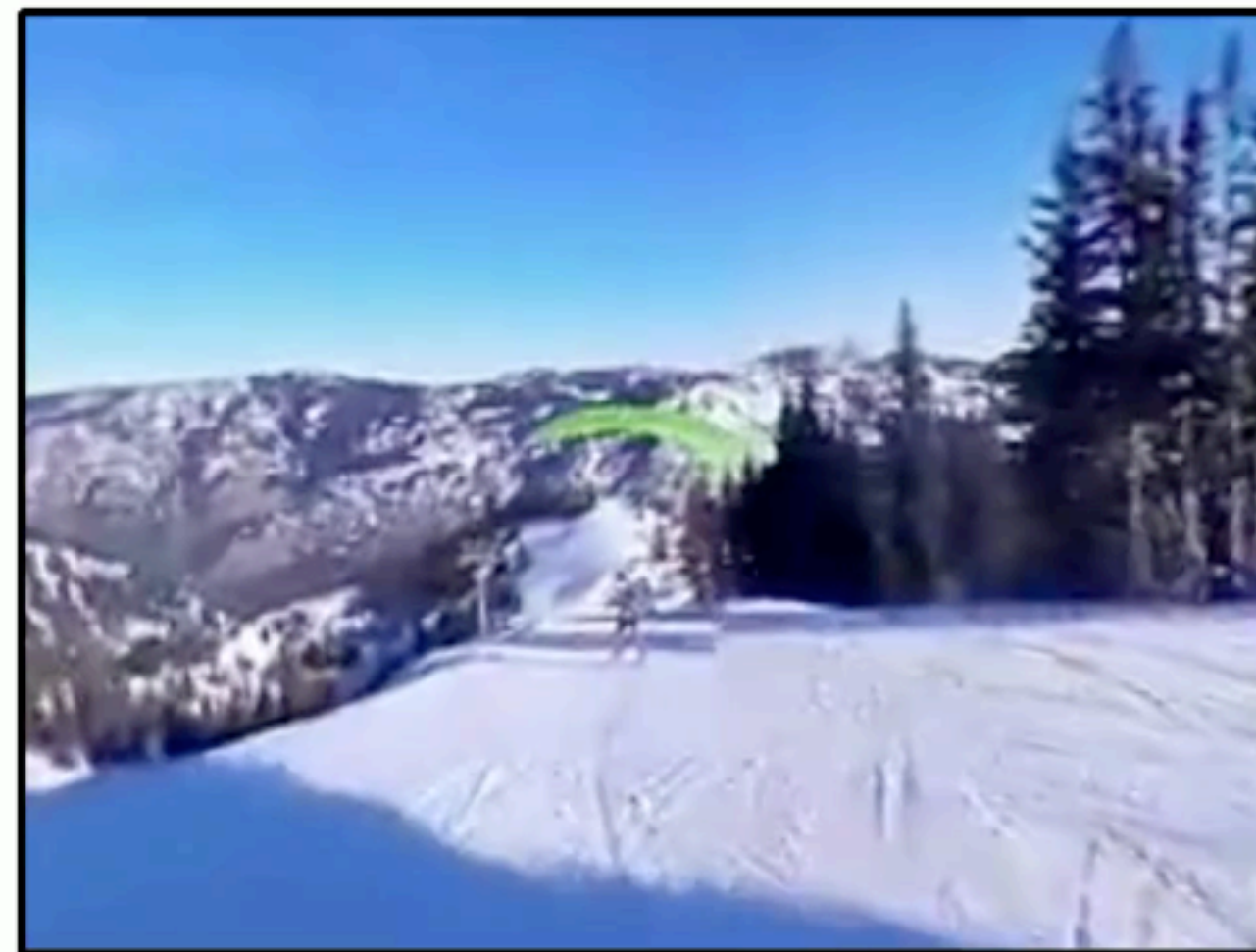


HUMAN VALIDATION

HumanEdit
Screenshot

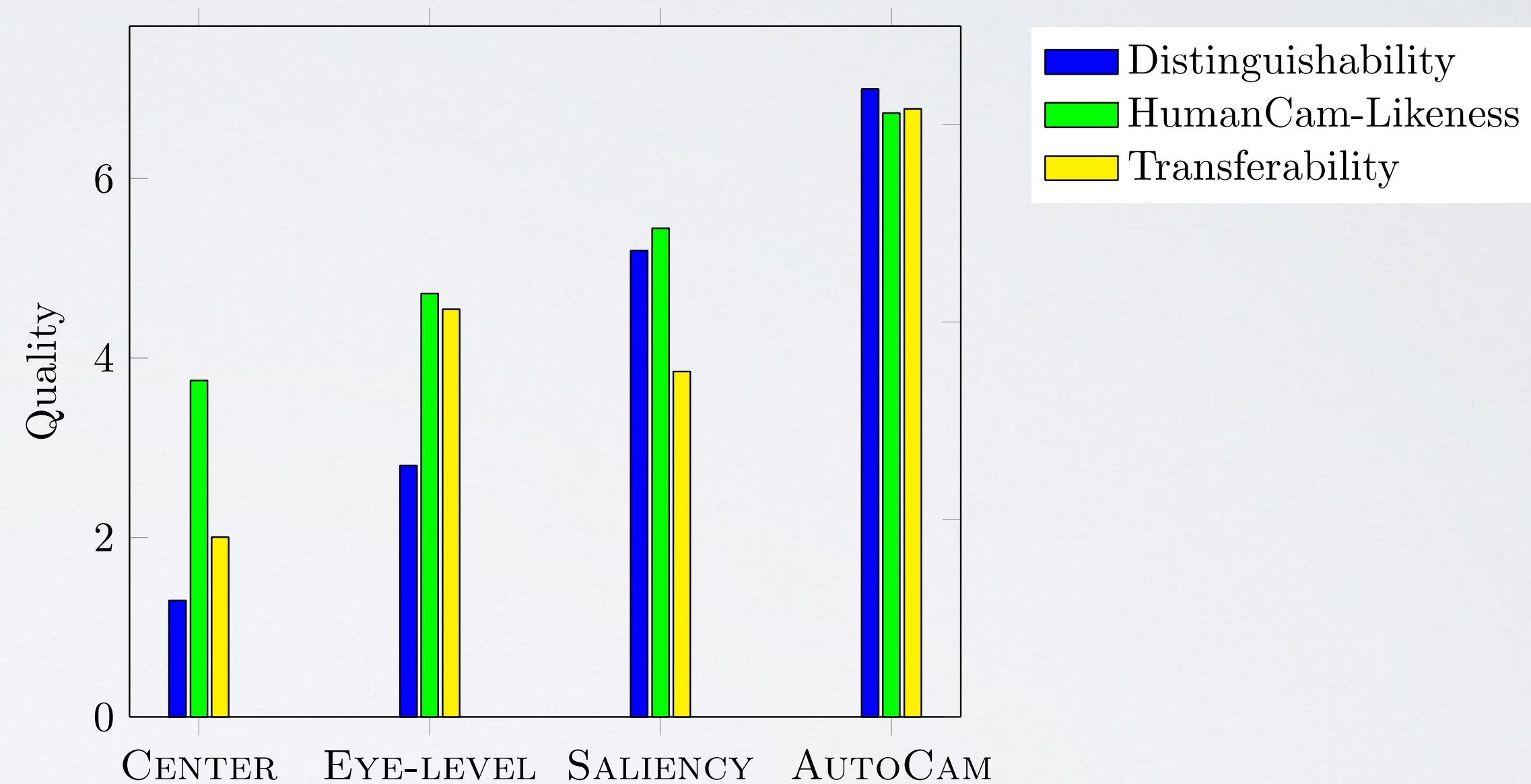


HumanEdit
NFOV Video



HUMAN VALIDATION

	# videos	Total length
360° videos	86	7.3 hours
HumanCam	9,171	343 hours

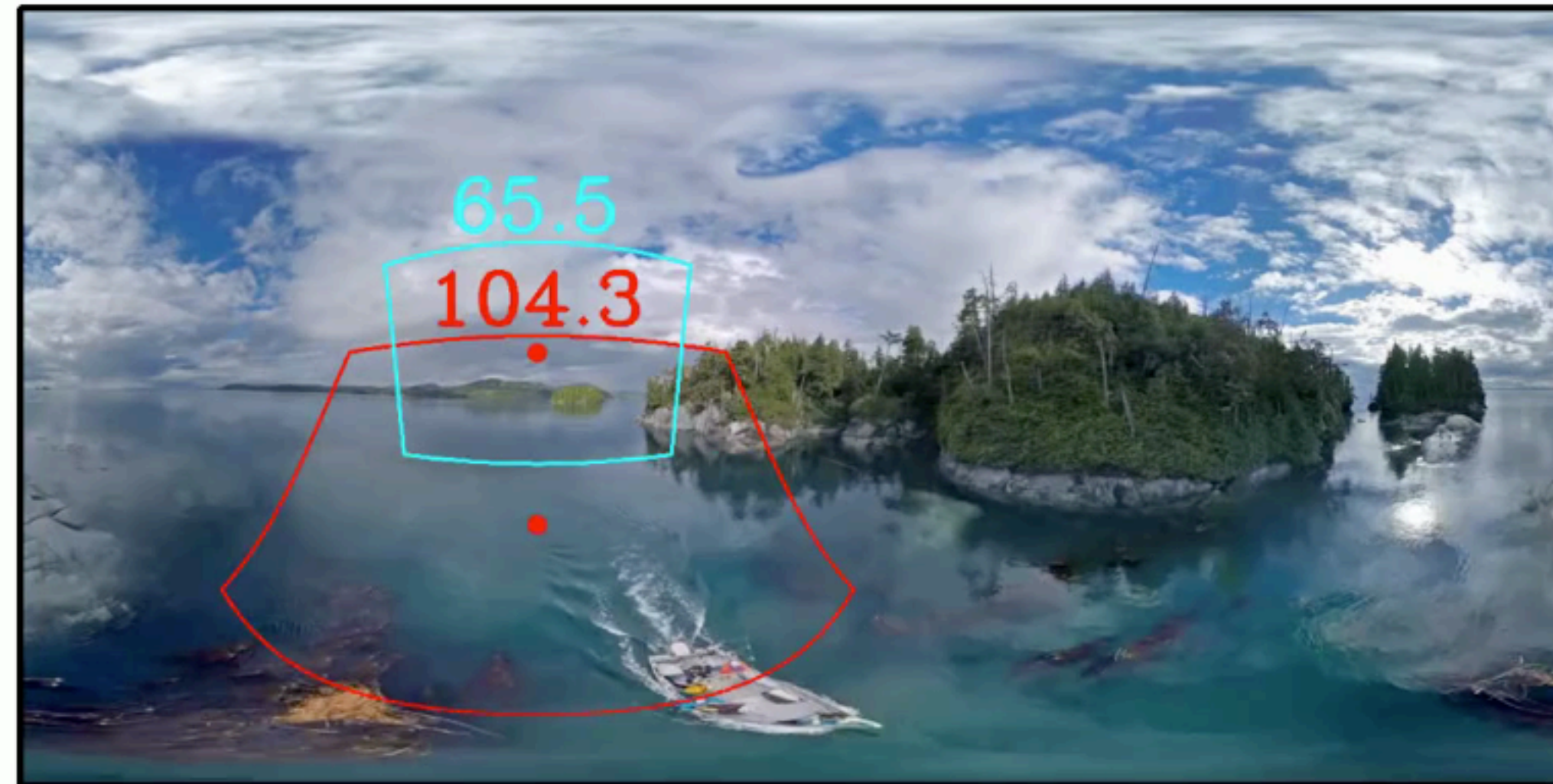


AutoCam performs the best
Justified by multiple metrics

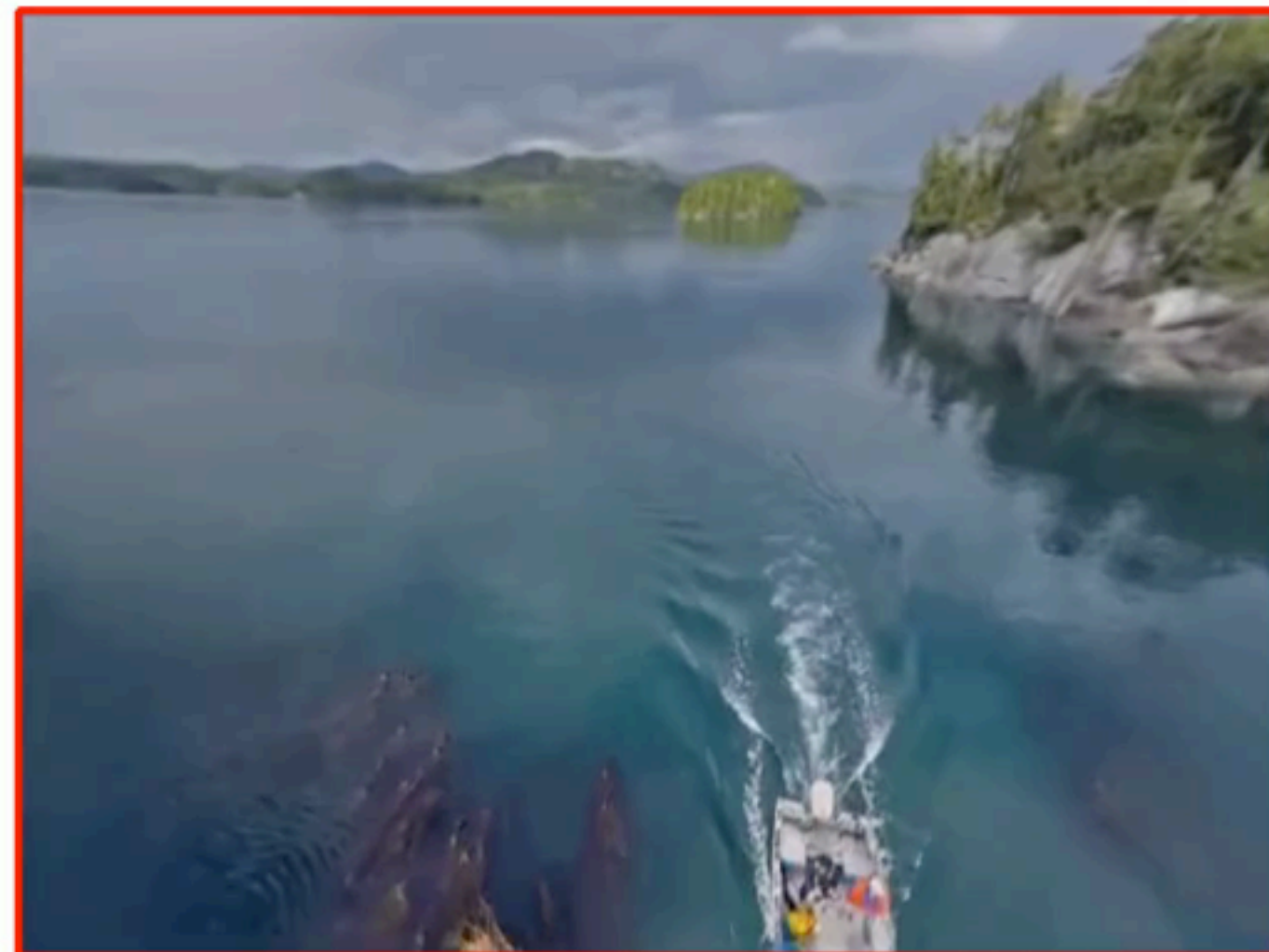
Making 360° Video Watchable in 2D: Learning Videography for Click Free Viewing

[Su and Grauman CVPR 2017]

360 Video
(Equirectangular)
+
Camera Trajectories



Ours
NFOV Video



AutoCam
(Su et al. 2016)



FUTURE PROBLEMS

What is 360
video?

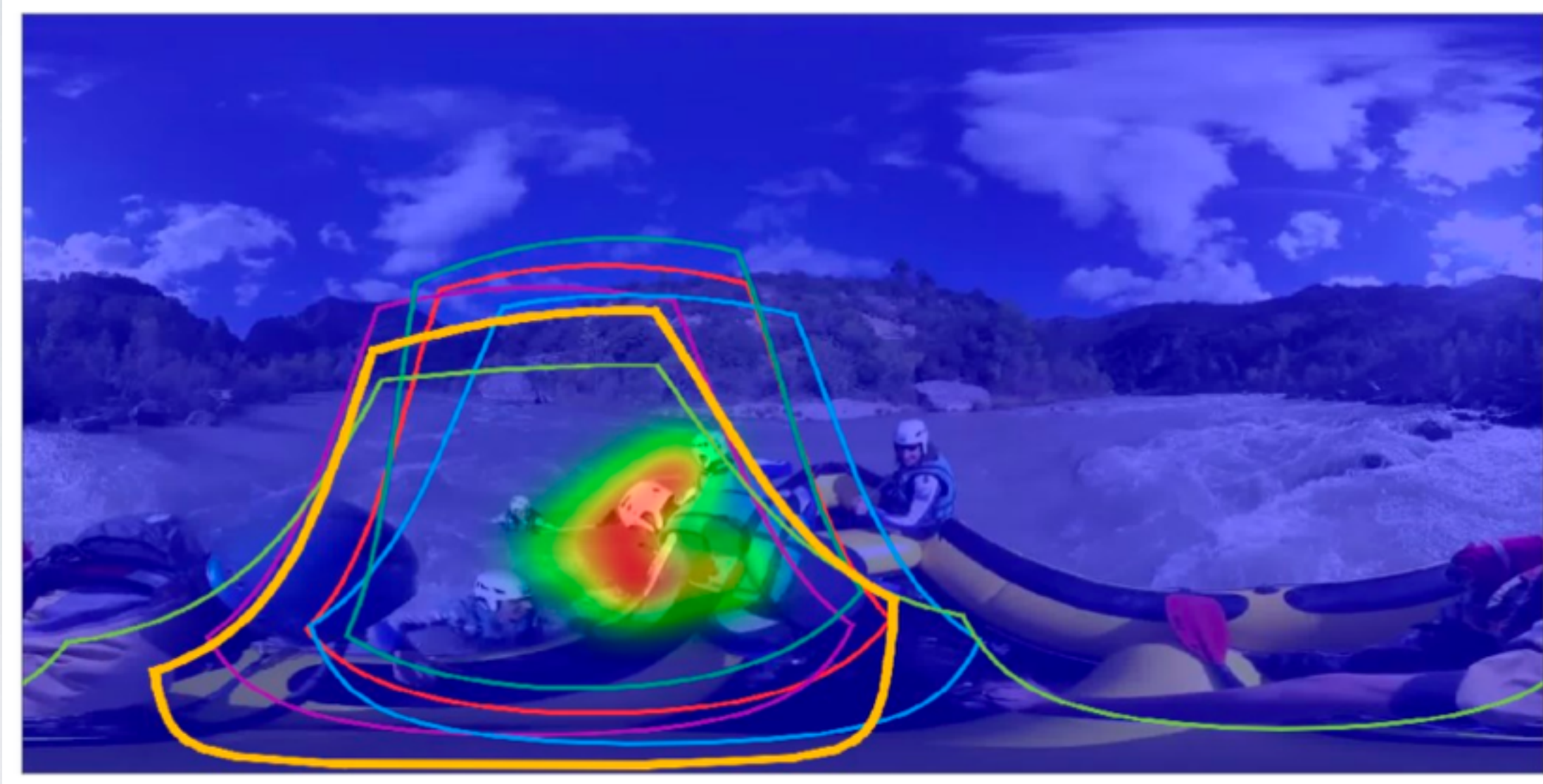
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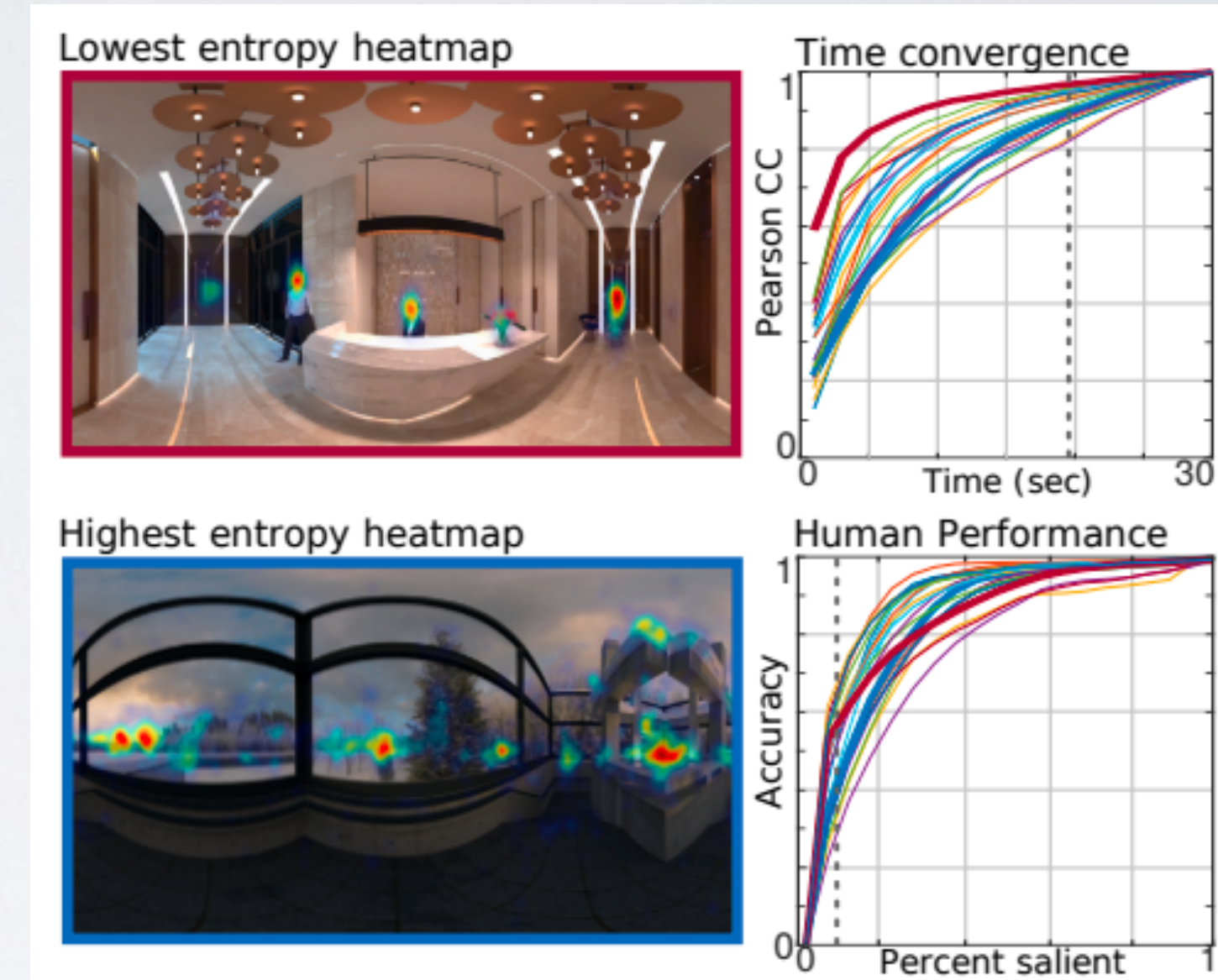
What can we
do with it?

What can't
we do with
it?

PERCEPTION



Gaze Visualization for Immersive Video
Thomas Löwe, Michael Stengel, Emmy-Charlotte Förster,
Steve Grogorick, Marcus Magnor
Eye Tracking and Visualization (Springer), 2017



Saliency in VR: How do people explore virtual environments?
Vincent Sitzmann, Ana Serrano, Amy Pavel, Maneesh Agrawala,
Diego Gutierrez, Gordon Wetzstein.
Arxiv 2016

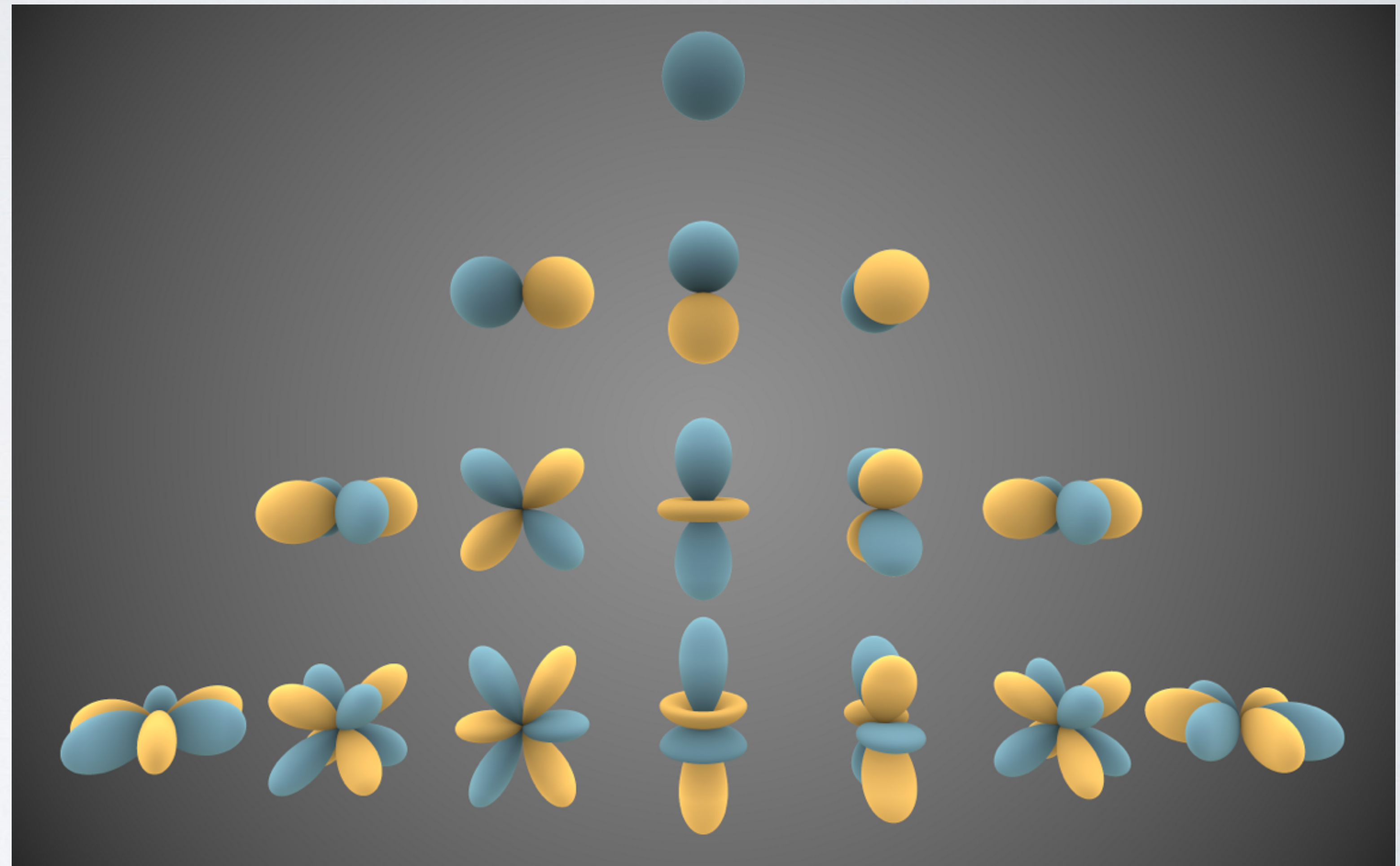
CINEMATOGRAPHY RULES

- Constraint on camera motion
- Zooms
- Cuts (coming up)
- Lighting

SPATIAL AUDIO



Core Sound TetraMic



360° VIDEO

Oliver Wang
Adobe Research