

Live ODS Video

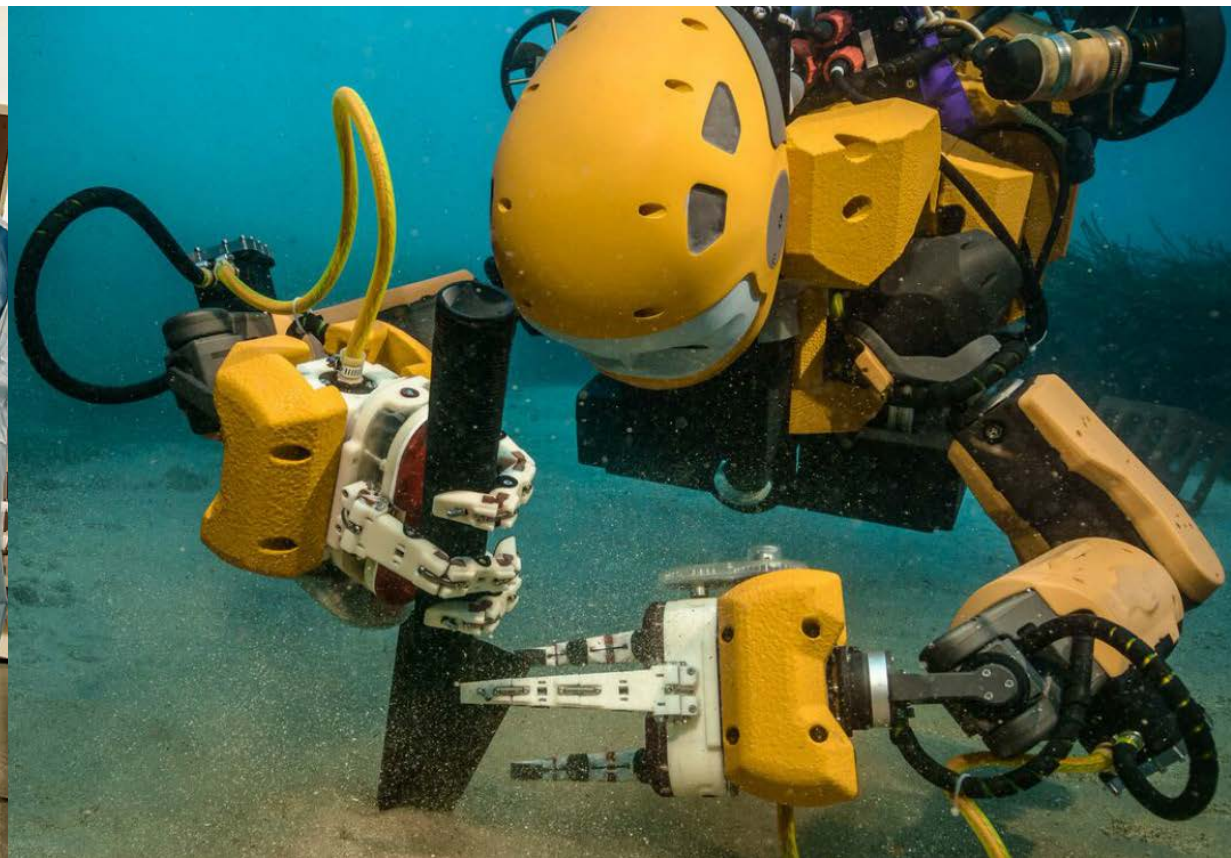
Robert Konrad



SCI | STANFORD
COMPUTATIONAL
IMAGING LAB



Live ODS Video



(Some) Stereo VR Cameras

Z-Cam V1 Pro



Kandao Obsidian R



Insta360 Titan



Facebook Surround 360



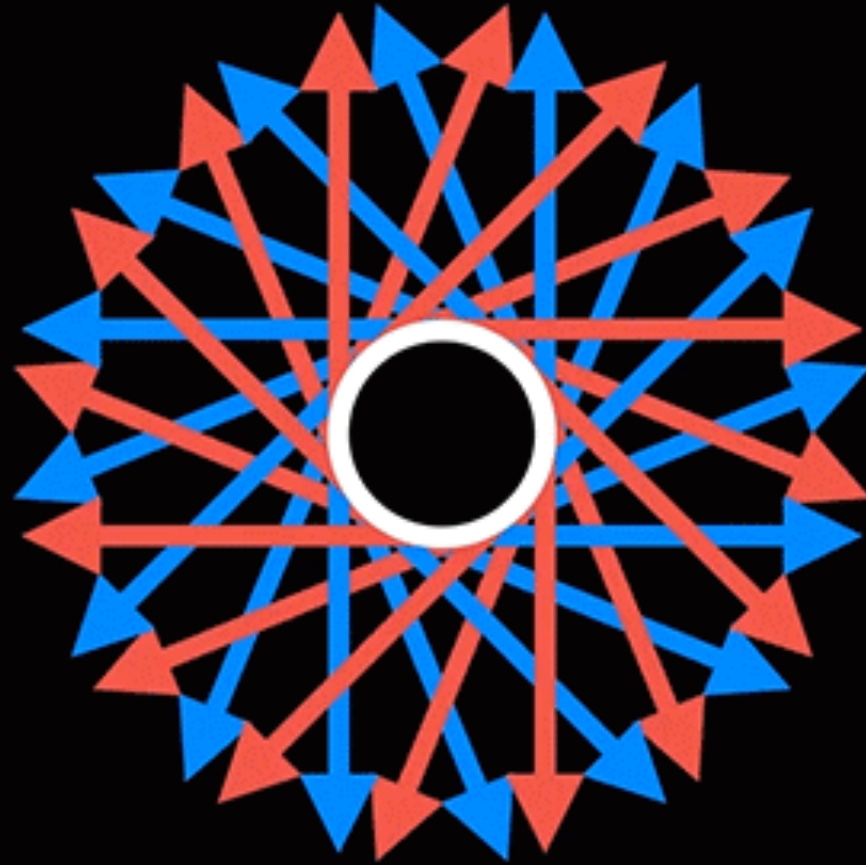
Facebook Manifold



Yi Halo



Omnidirectional Stereo (ODS)



Ishiguro et al. 1990

Peleg et al. 2001

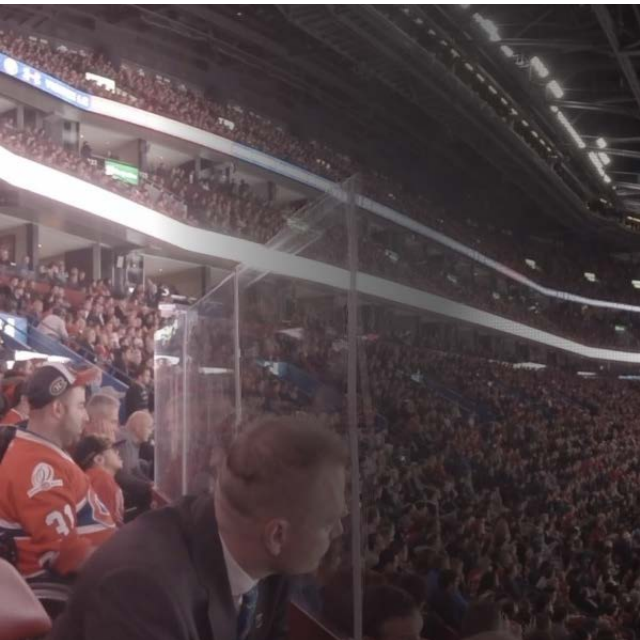
Getting these tangential rays is non-trivial from camera arrays!

[Anderson et. al, SIGGRAPH Asia 2016]

CAMERA 1



Challenges for optical flow



Transparency, reflections



Flow mismatches

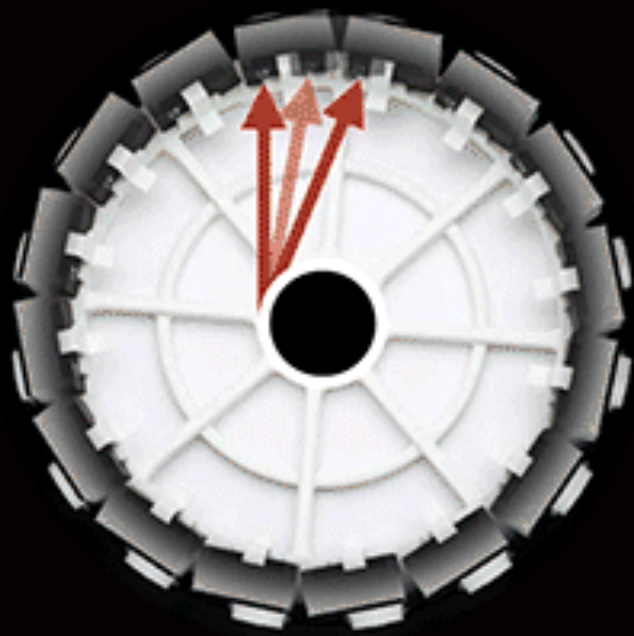


Fine Structures



Too Close

INTERPOLATION




Per-Frame Flow



Temporally Consistent Flow


Google Jump – Computation Time Breakdown

60 sec / frame

(single machine)

Google Jump – Computation Time Breakdown

Video Length

1 hour

60 sec / frame

(single machine)

Total time to process

75 days

Google Jump – Computation Time Breakdown

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1 hour

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Total time to process

75 days

1 hour

321 sec / frame
→
(parallelized on
1000 cores)

10 hours

Google Jump – Computation Time Breakdown

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Total time to process

1 hour

60 sec / frame
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(single machine)

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321 sec / frame
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(parallelized on
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10 hours

Operation	Time (sec.)
Flow computation	183
Compositing	54
Frame IO and rectification	40
Flow compression/decompression	38
Post processing/one off setup	6
Total	321

Google Jump – Computation Time Breakdown

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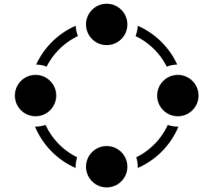
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What is real time?

processing time \leq capture rate

capture rate \neq display rate

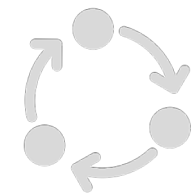
Live Streaming Camera Arrays



Single Shot ODS capture



Rotating ODS capture



Live Streaming Camera Arrays



Kandao Obsidian R



Samsung Round



Z-Cam V1 Pro



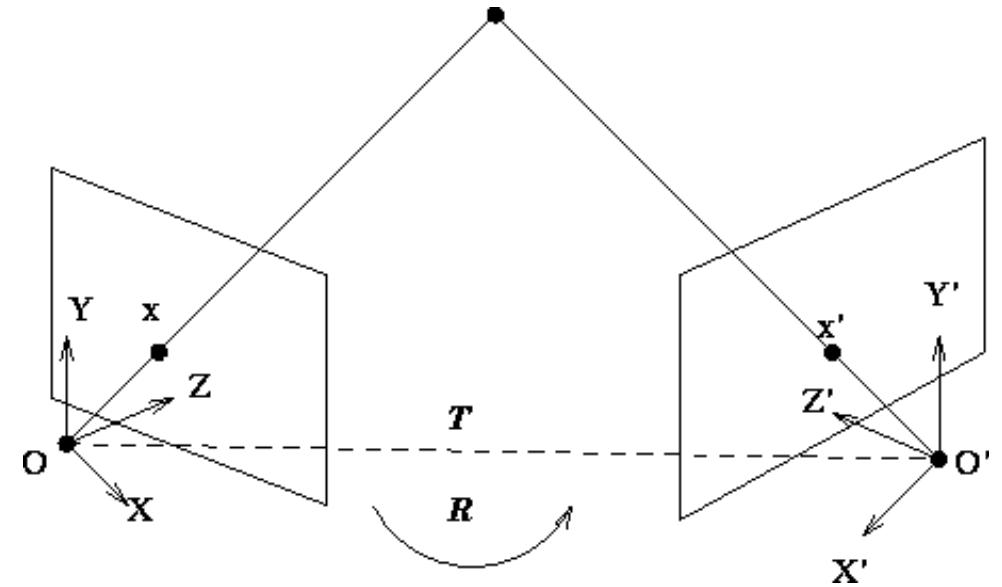
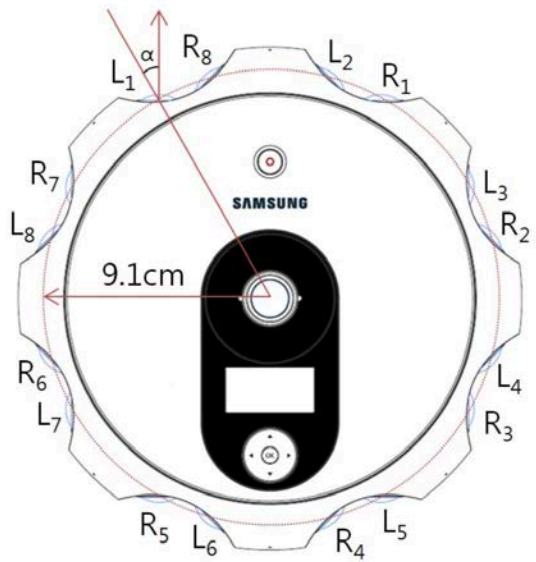
LivePlanet



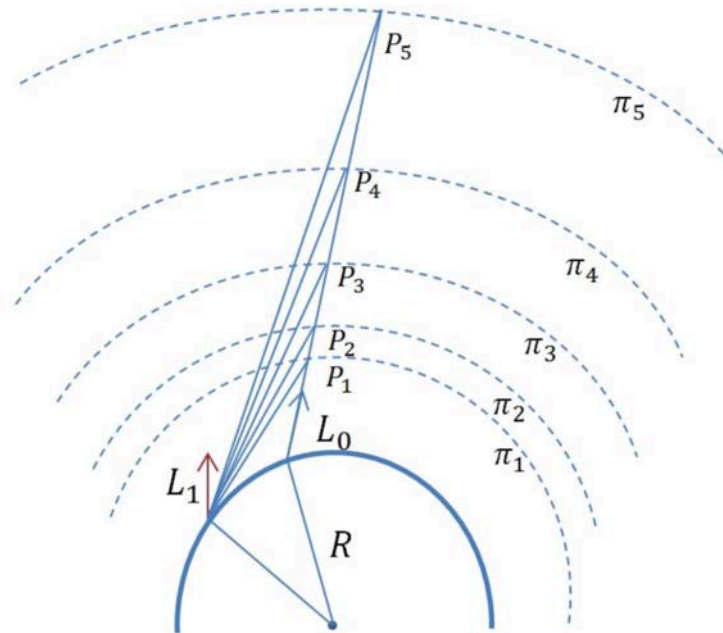
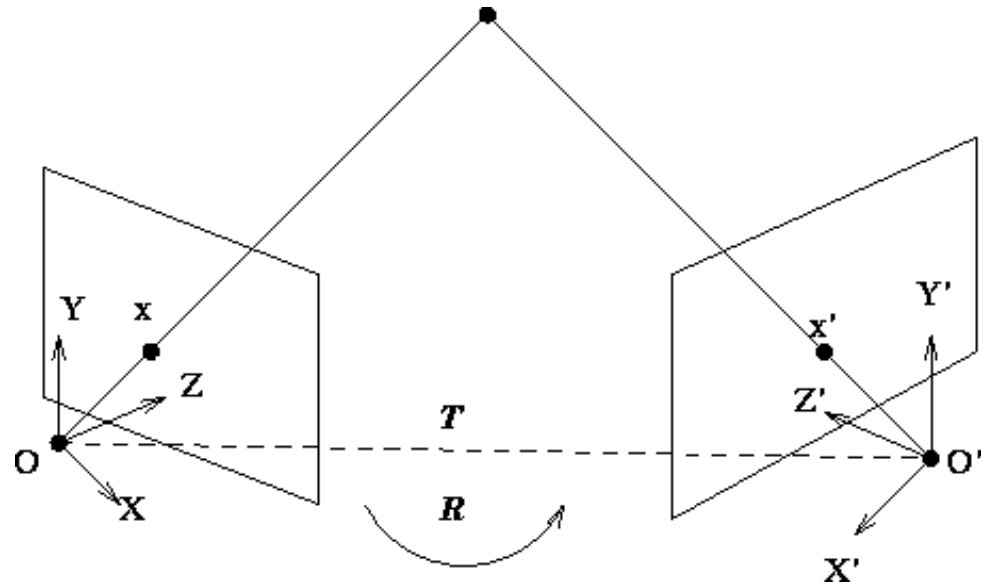
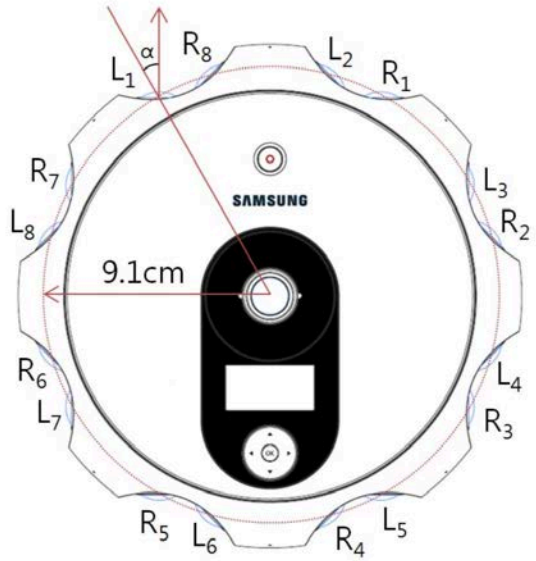
Insta360 Titan



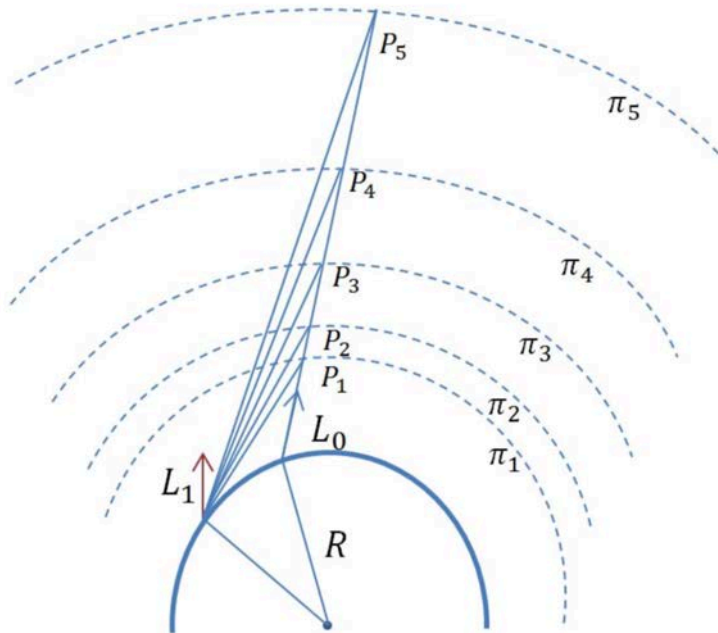
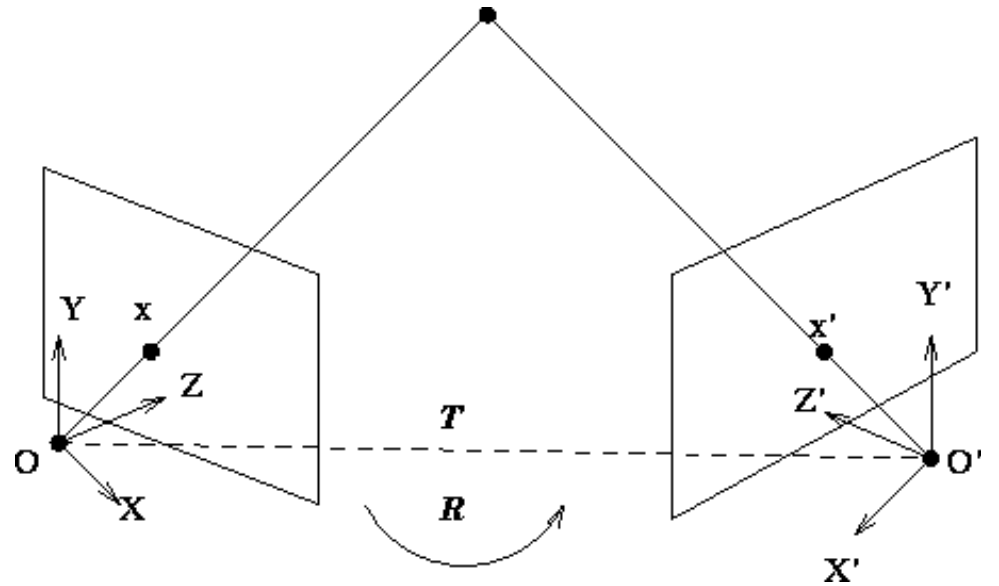
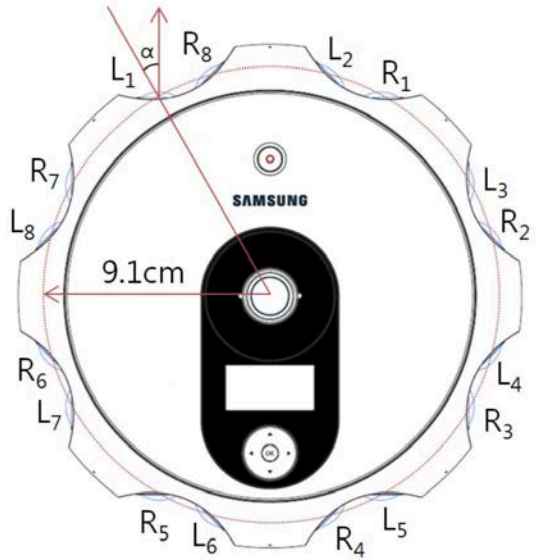
Rely on calibration



Rely on calibration

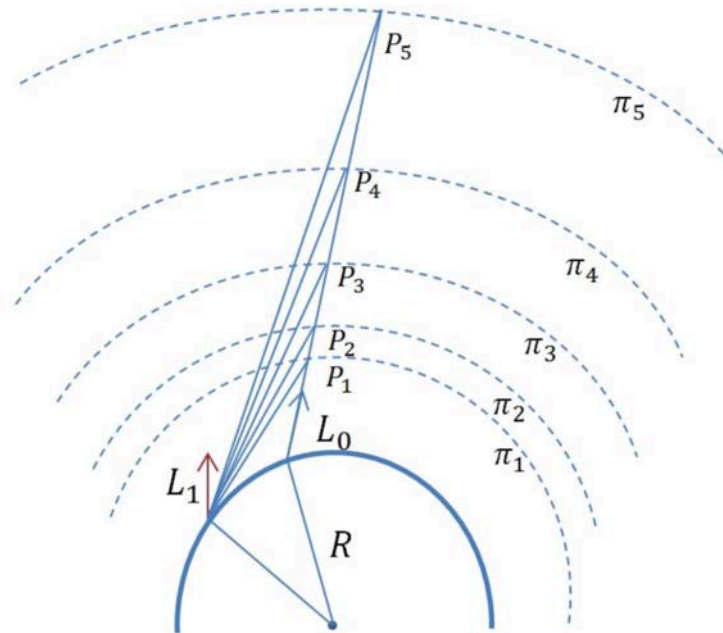
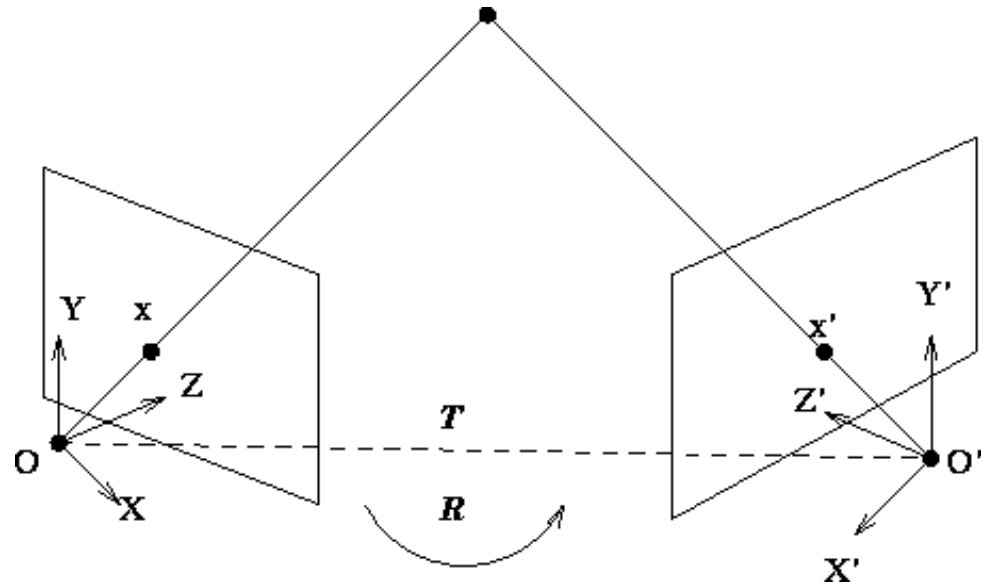
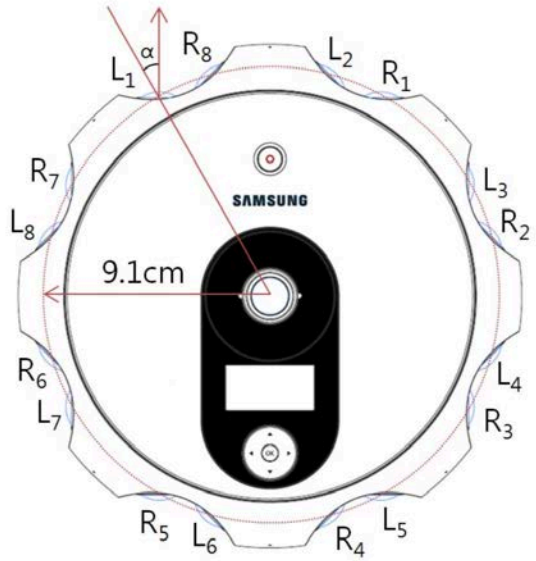


Rely on calibration



Don't compute 2D optical flow

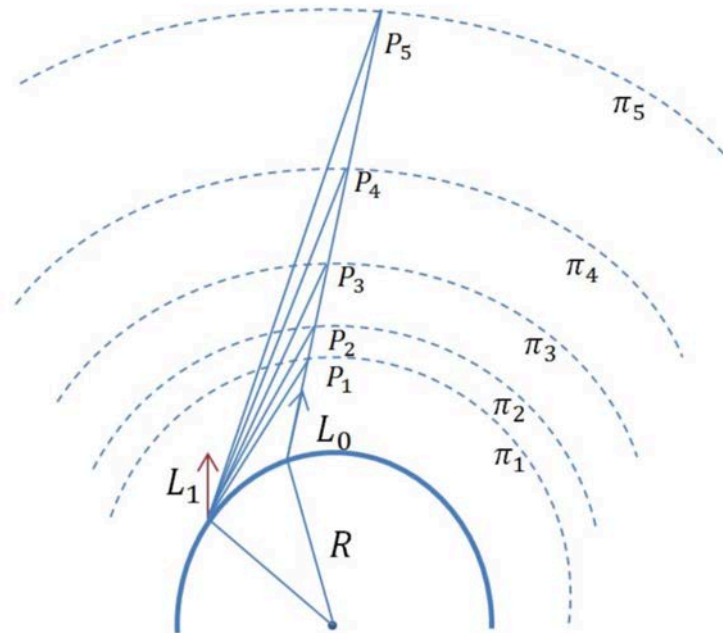
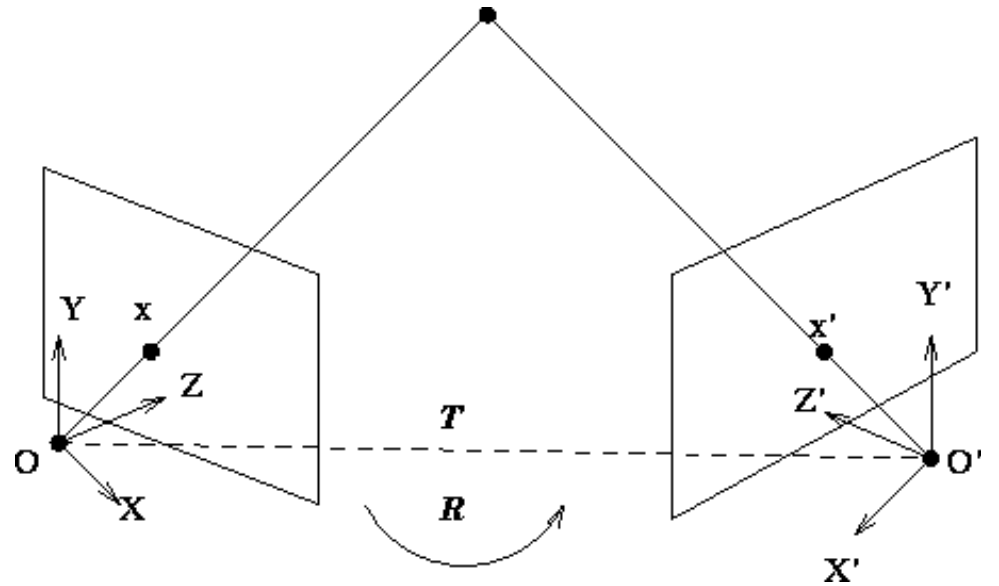
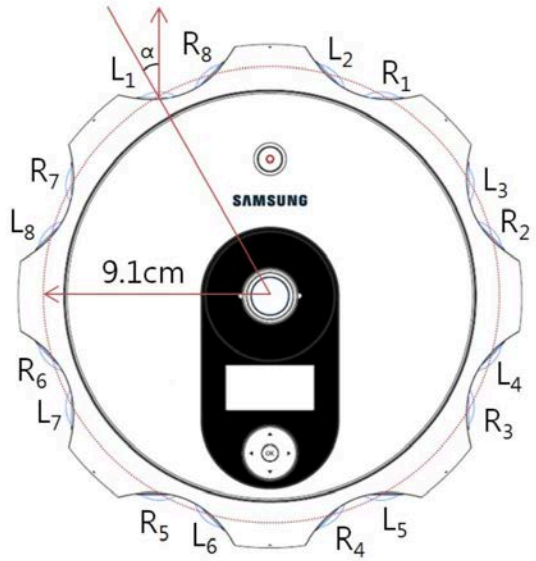
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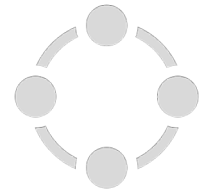
No guarantee on temporal consistency

Artifacts



(video courtesy of CreatorUp Youtube Channel)

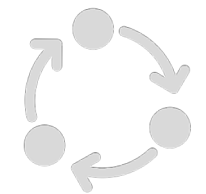
Live Streaming Camera Arrays



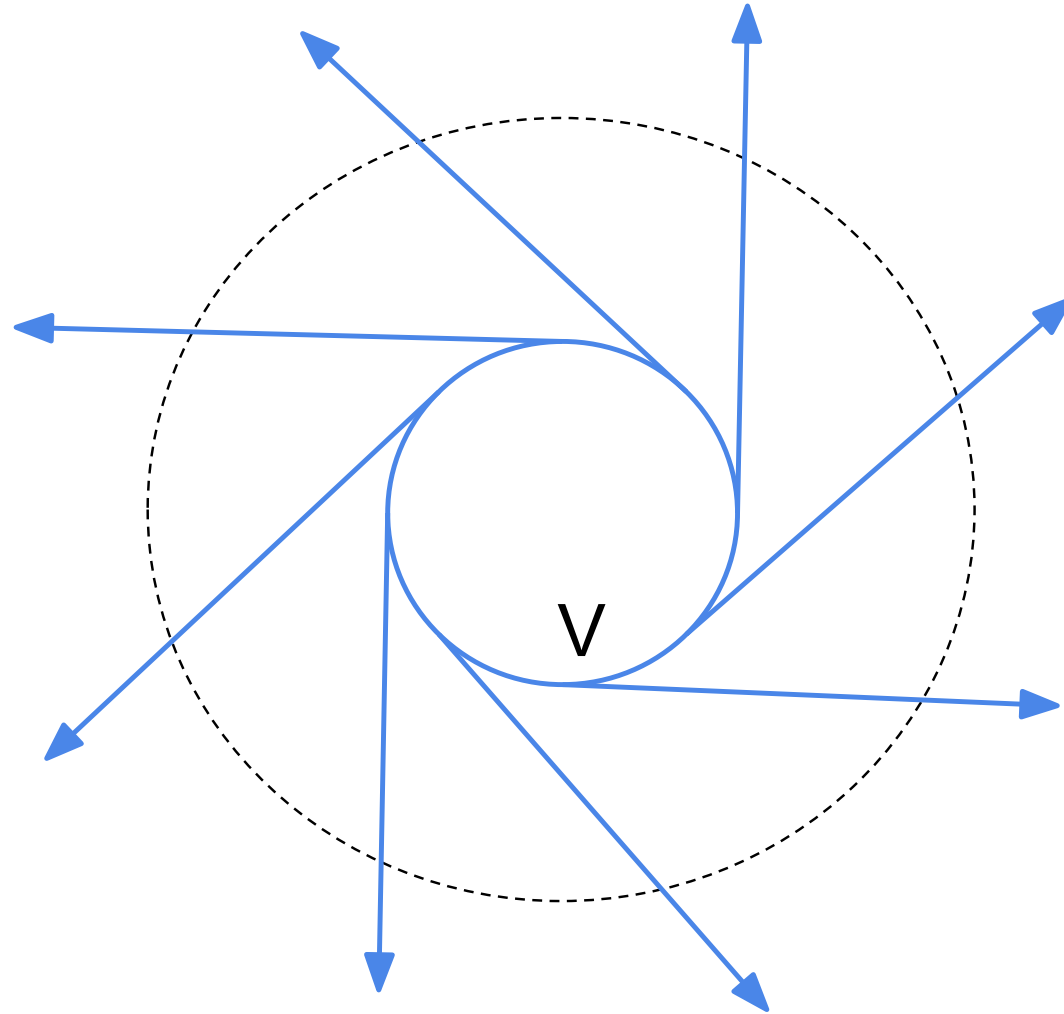
Single Shot ODS capture



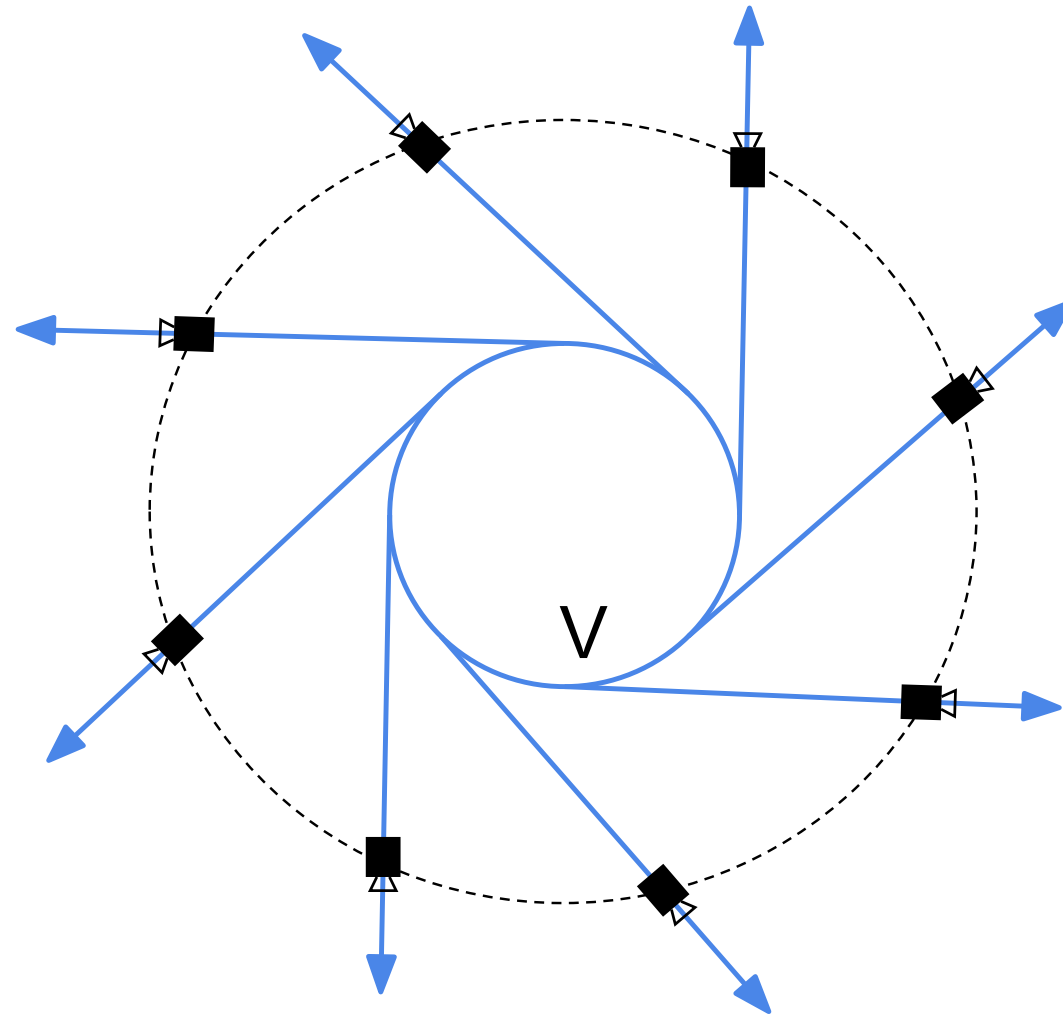
Rotating ODS capture



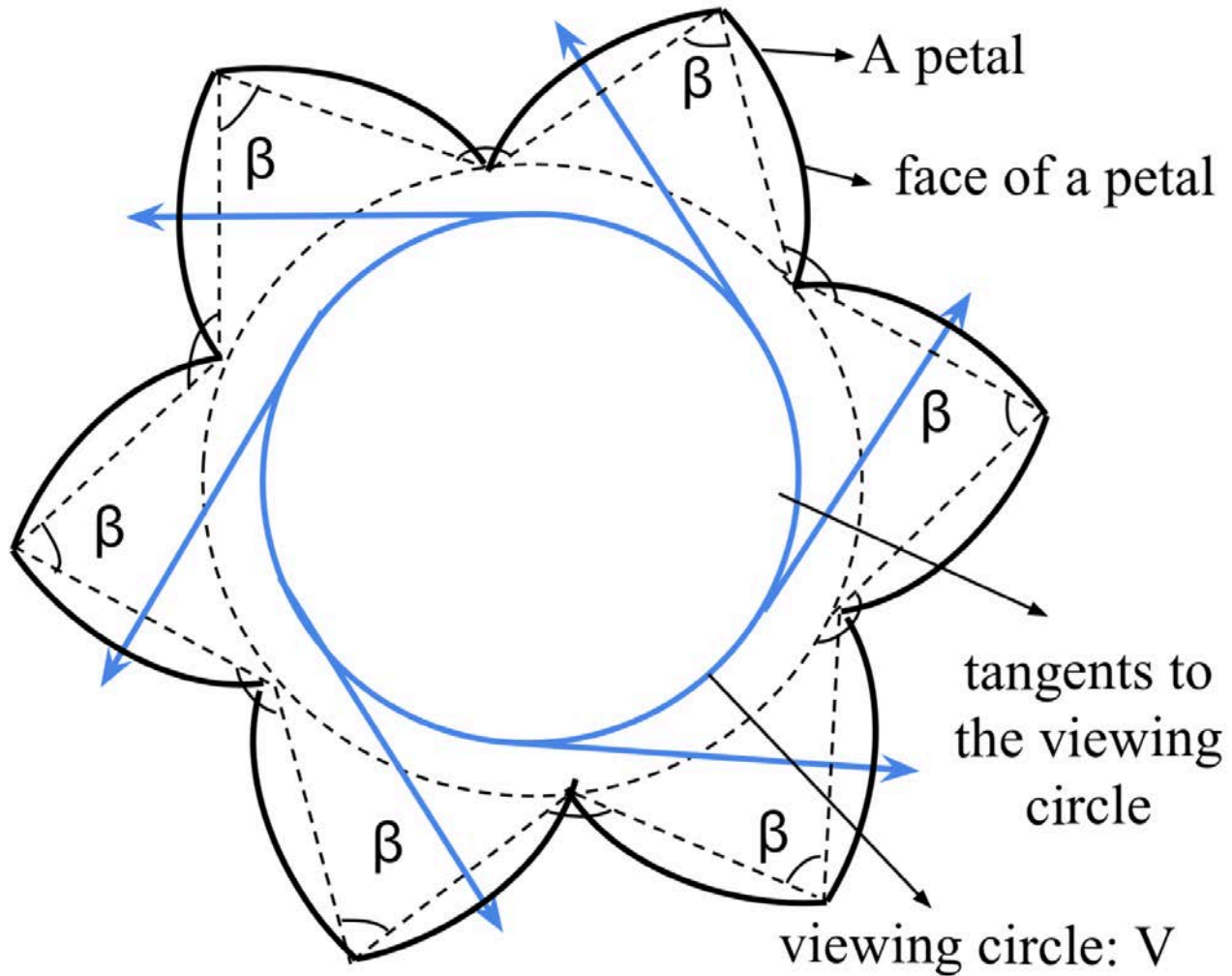
Single Shot Stereo ODS



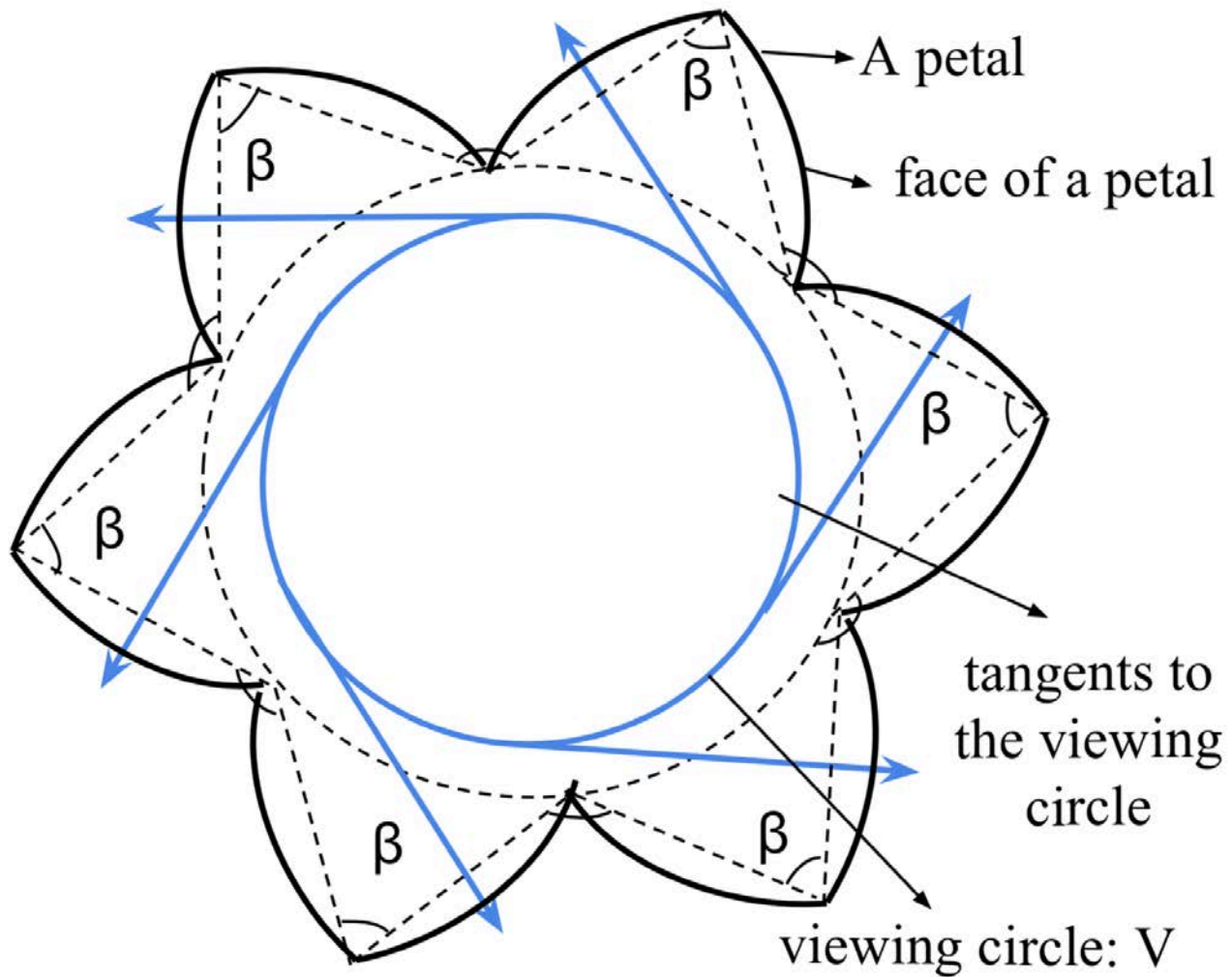
Single Shot Stereo ODS



Single Shot Stereo ODS



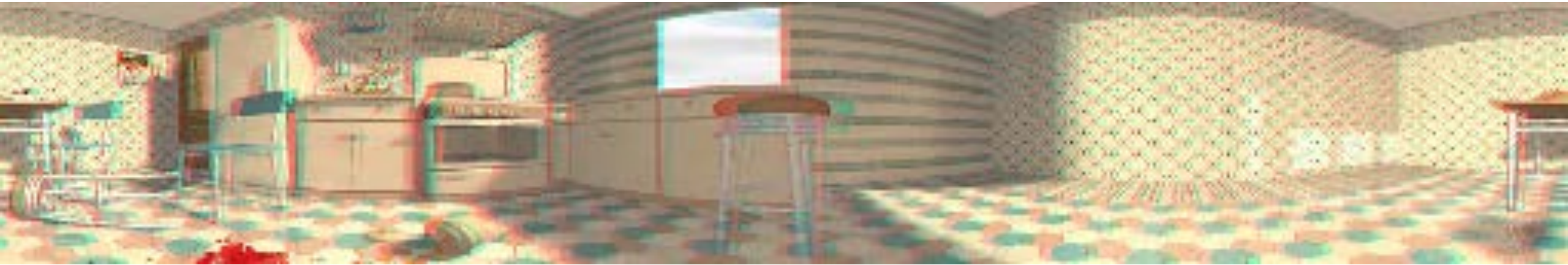
Single Shot Stereo ODS



Simulated Capture



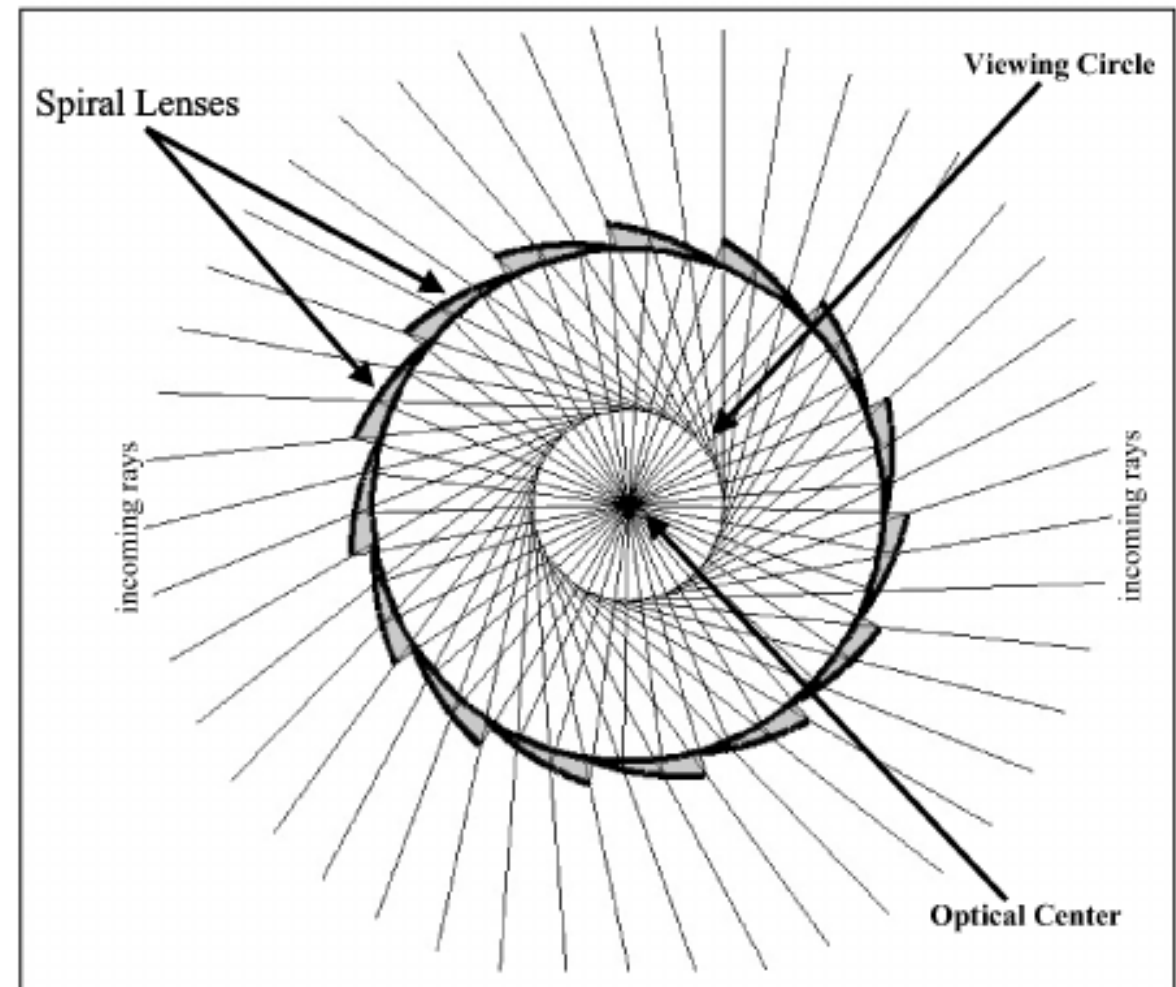
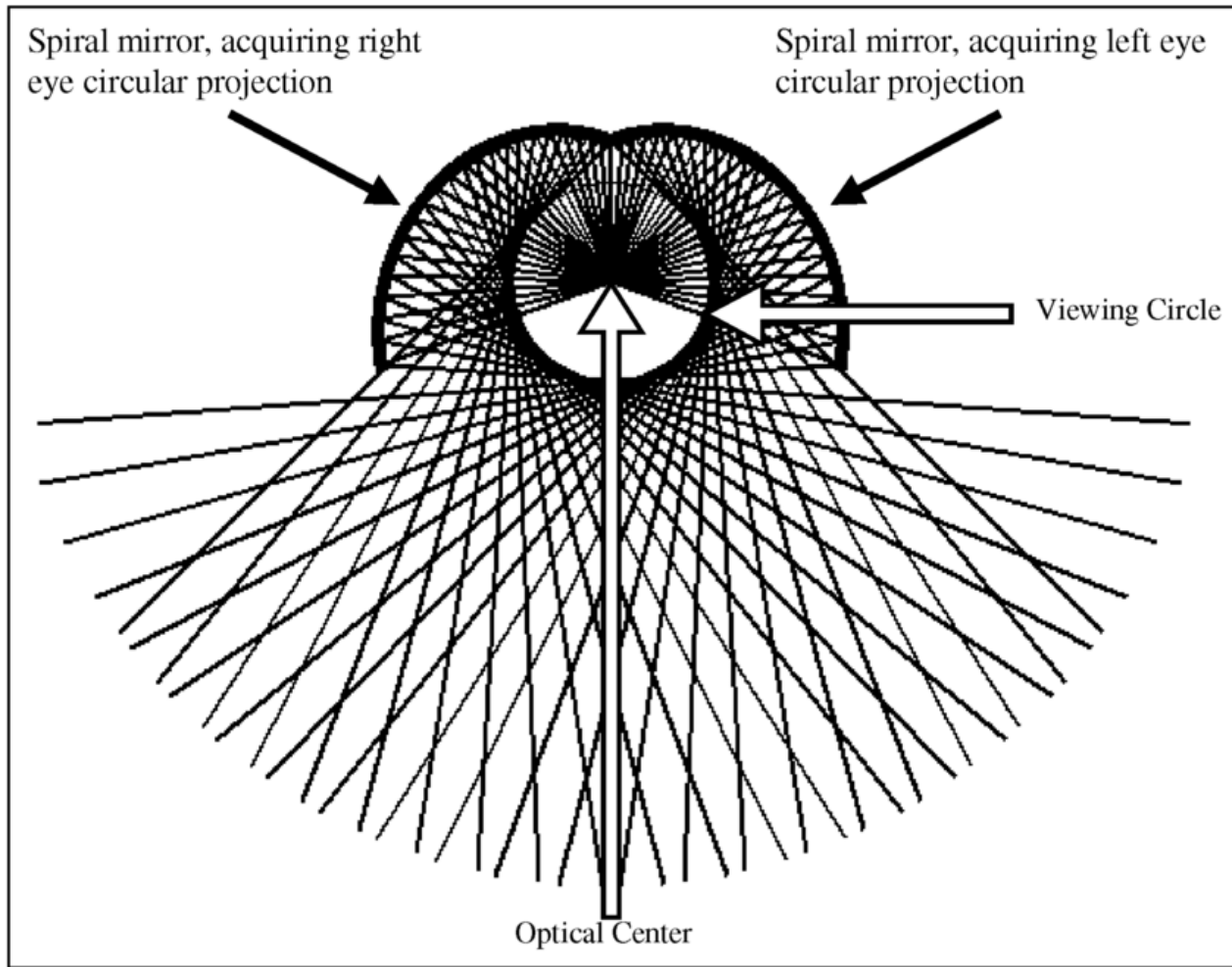
Simulated Capture



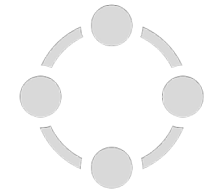
Real Capture



Other Optical Designs



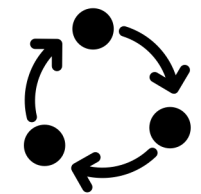
Live Streaming Camera Arrays



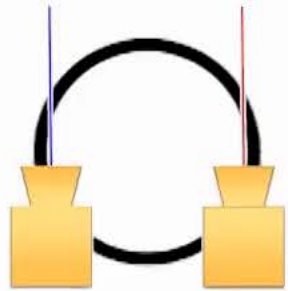
Single Shot ODS capture



Rotating ODS capture



Omnidirectional Stereo (ODS)



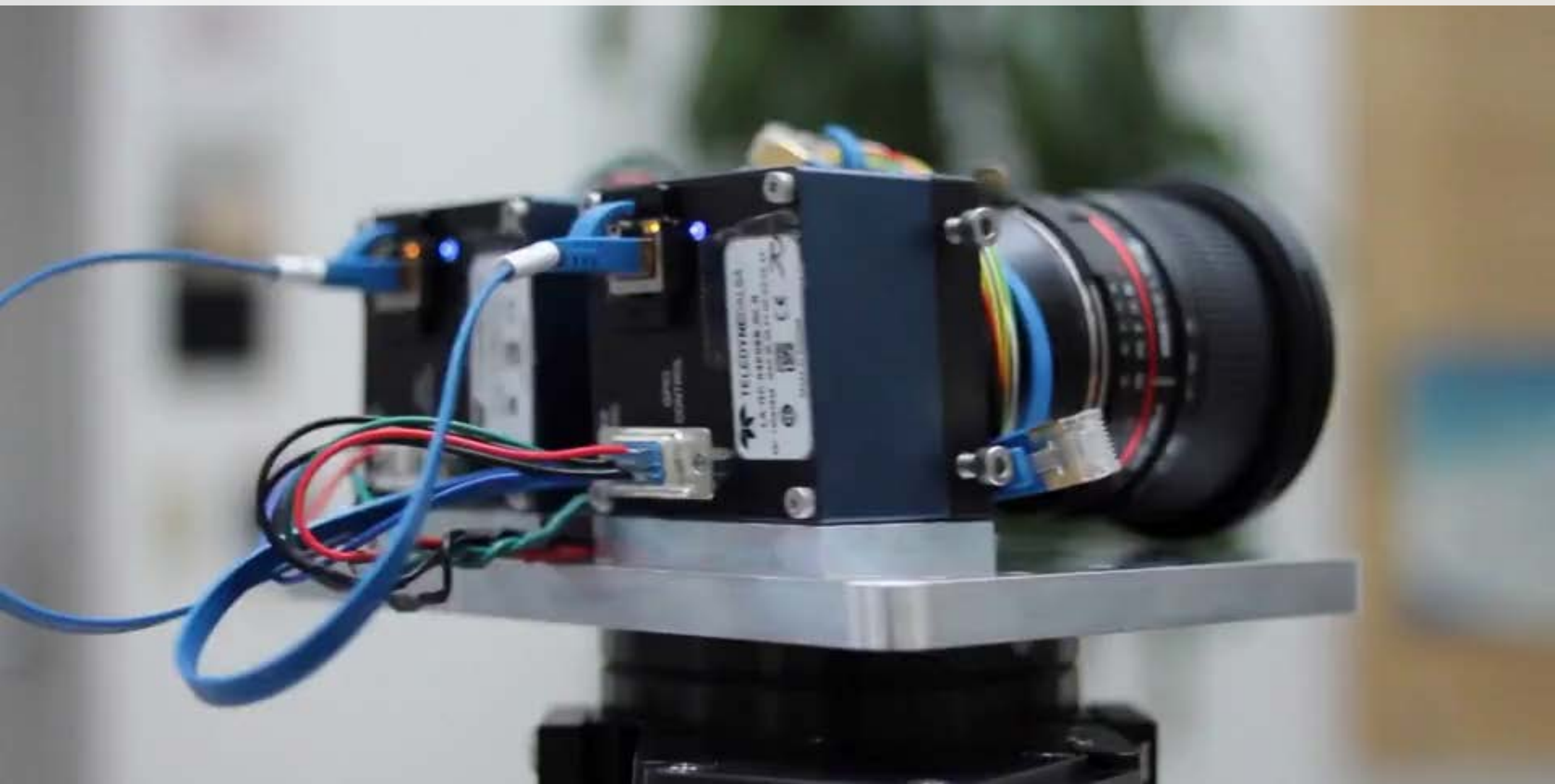
Left Eye



Right Eye



SpinVR



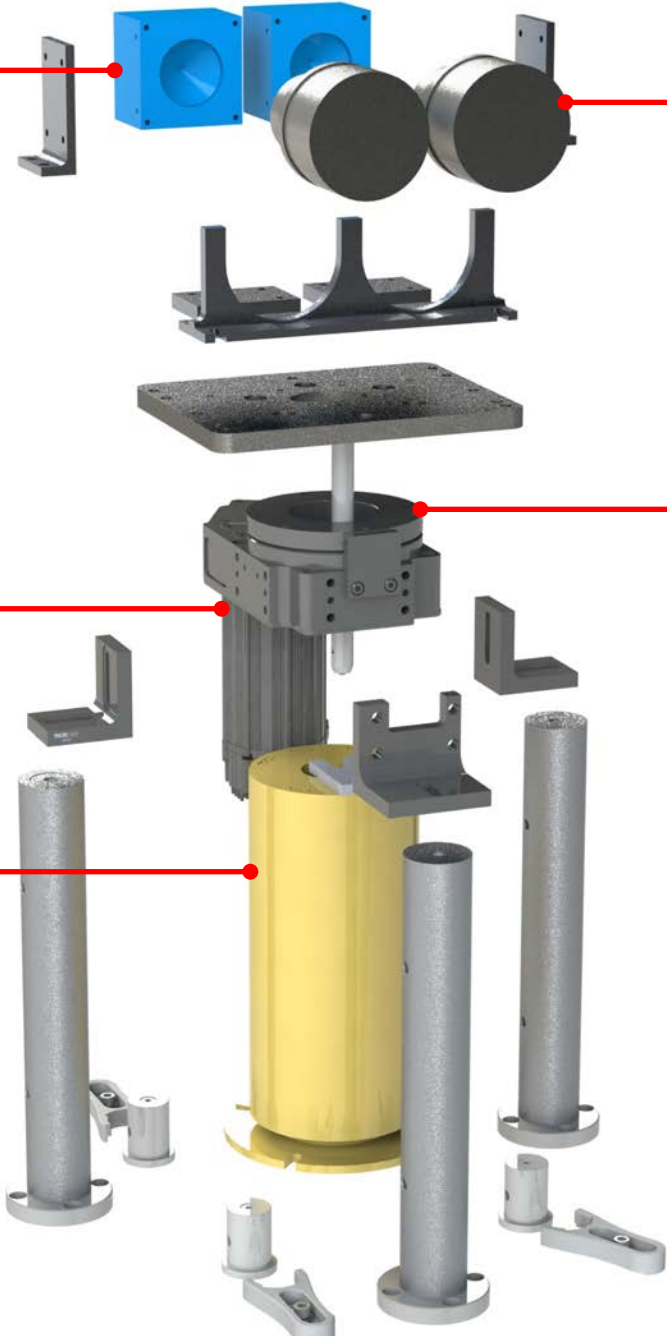
Line scan cameras

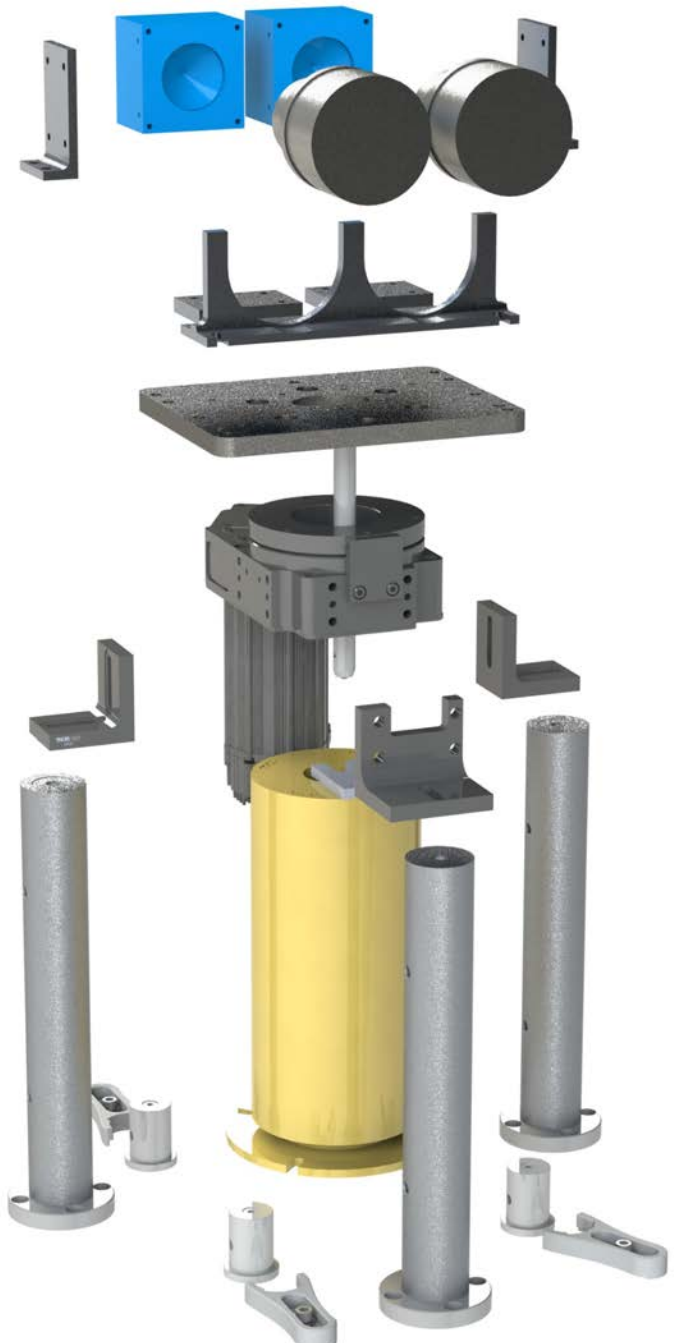
175° lenses

Rotary stage

Servo motor

Slip ring





Pipeline Comparison

Minimal capture BW

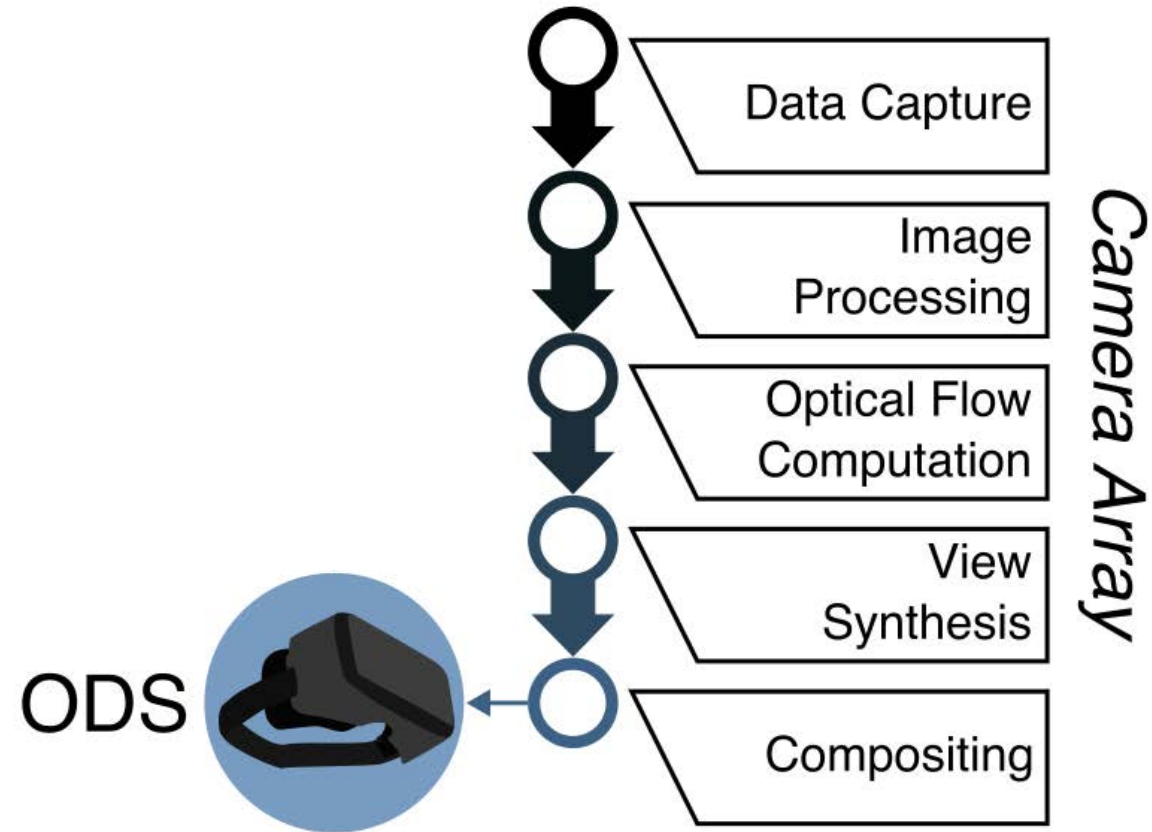
Minimal compute

→ Solves artifact issues*

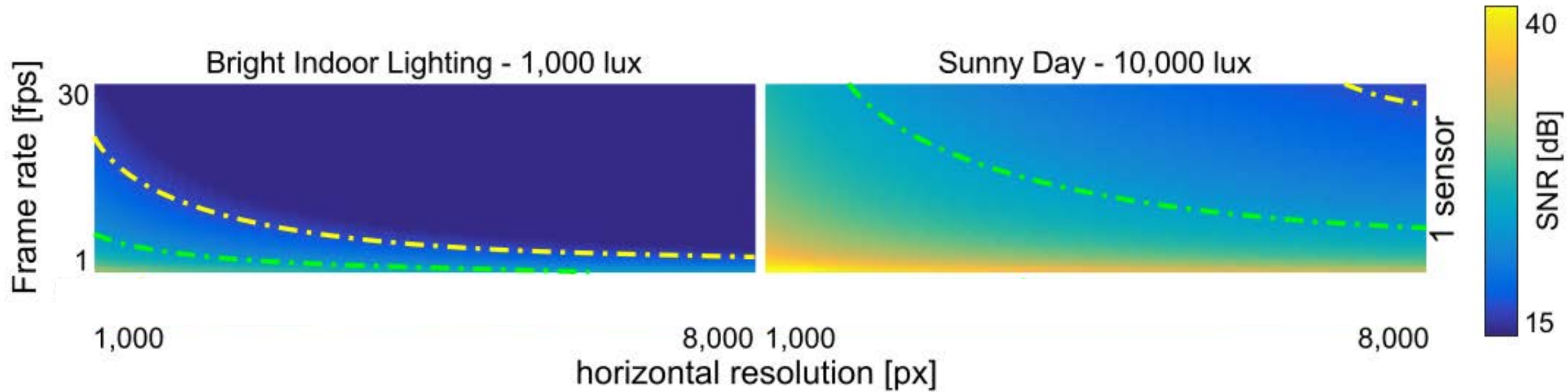
→ No calibration*

*Some new challenges

*New design space



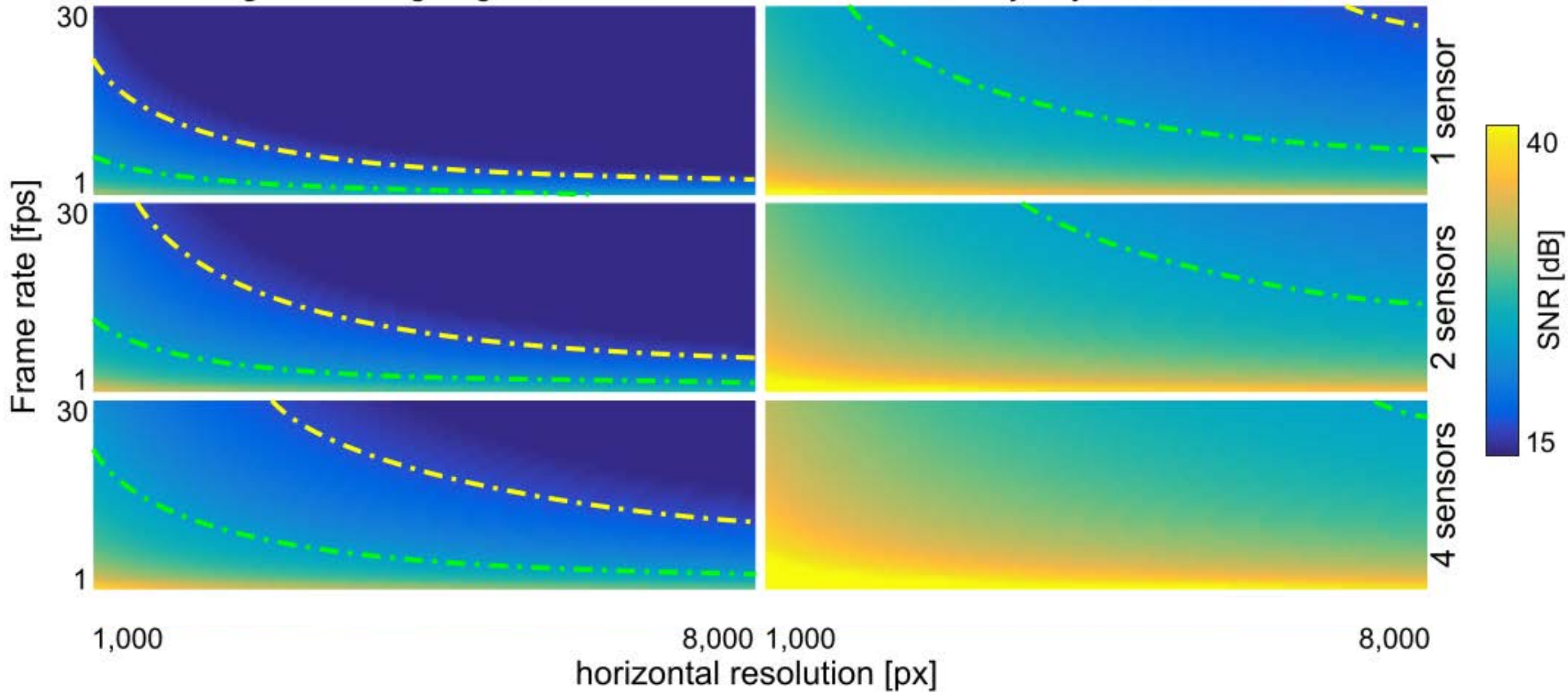
Design Trade-offs



Design Trade-offs

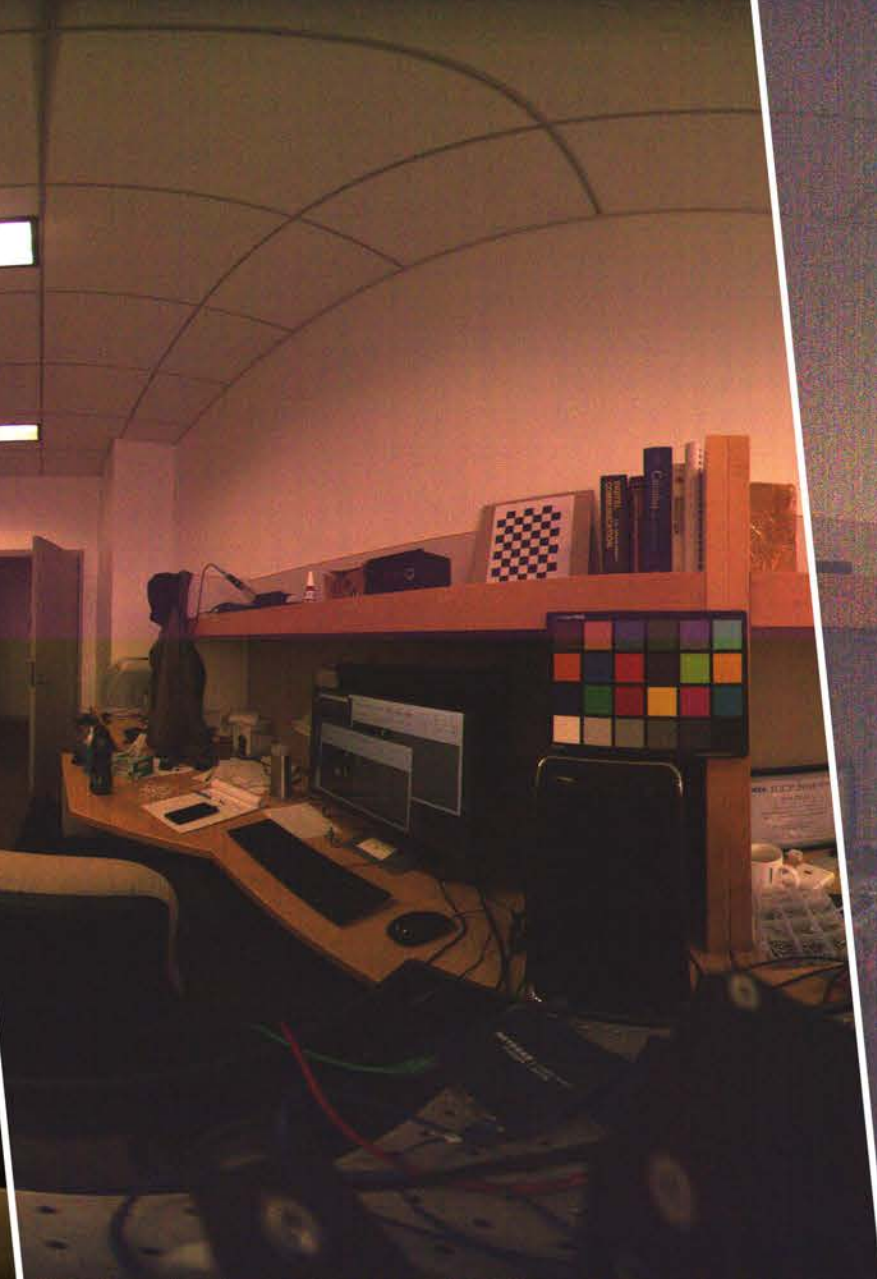
Bright Indoor Lighting - 1,000 lux

Sunny Day - 10,000 lux





8192 x 4096 x 1/26 fps



4096 x 4096 x 1.11 fps



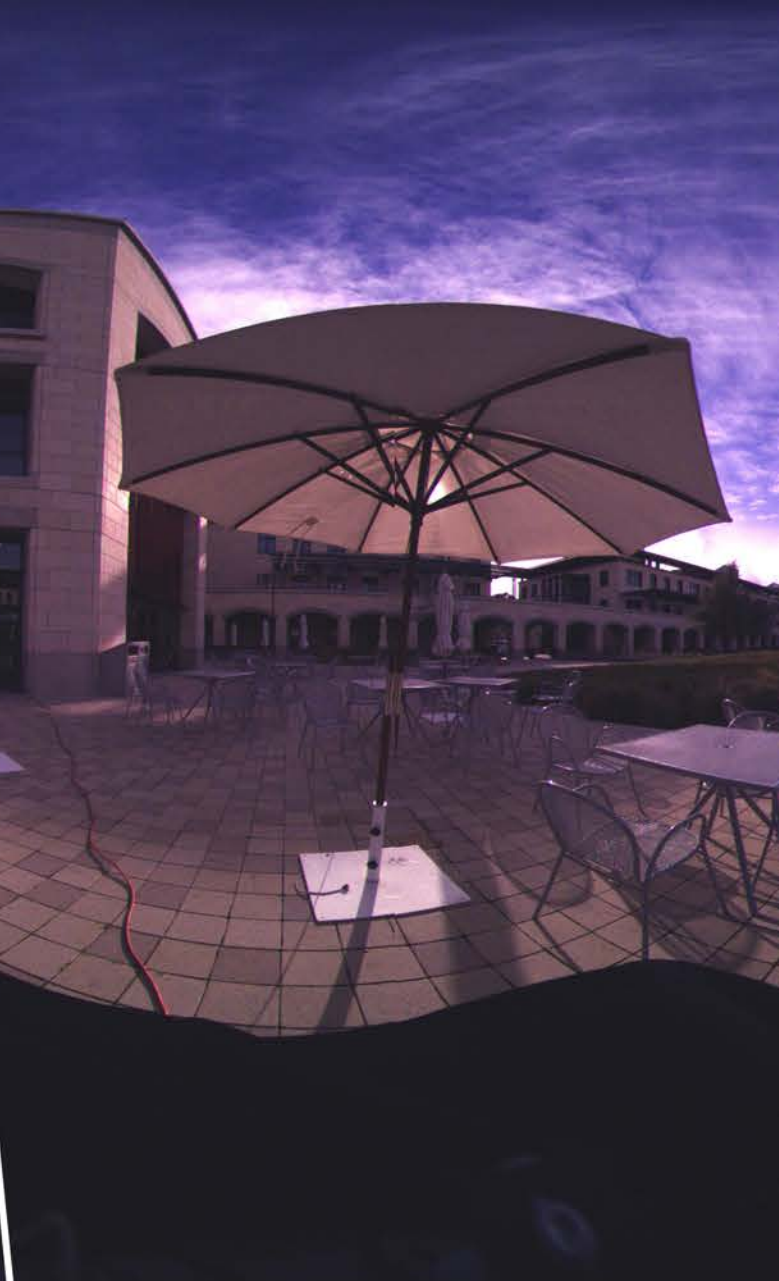
2048 x 4096 x 16.67 fps



8192 x 4096 x 1/26 fps



4096 x 4096 x 1.11 fps



2048 x 4096 x 16.67 fps



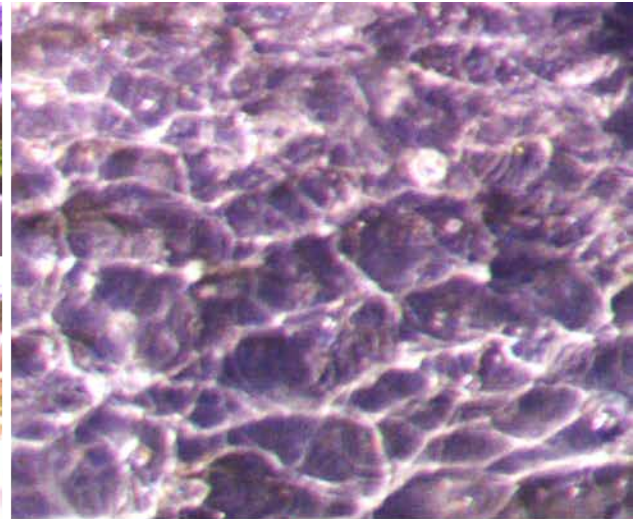
Challenging Scenes

Reflections

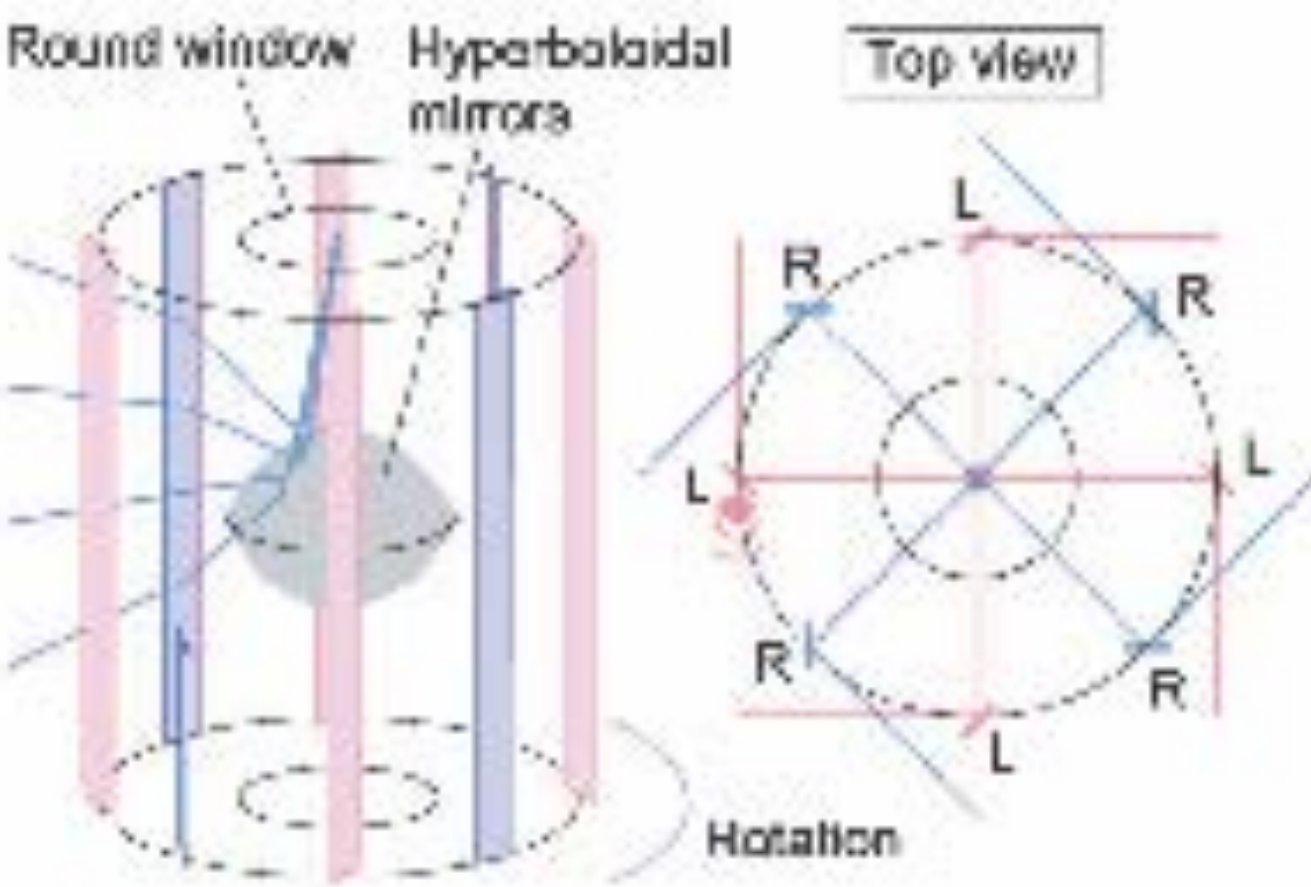
Transparency

Occlusions

Fine structure



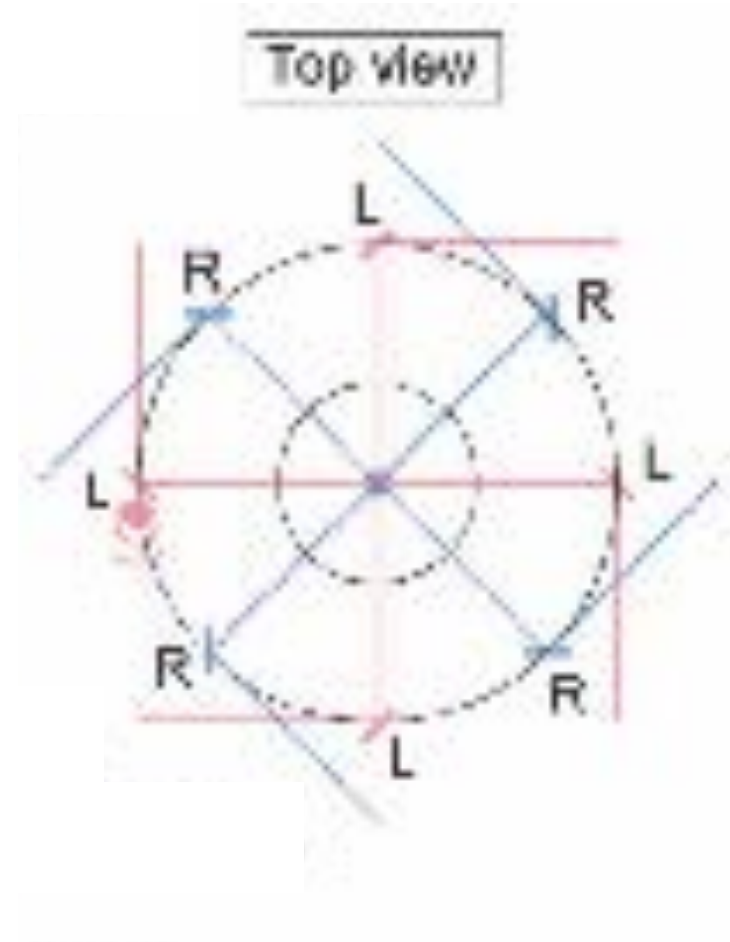
TORNADO



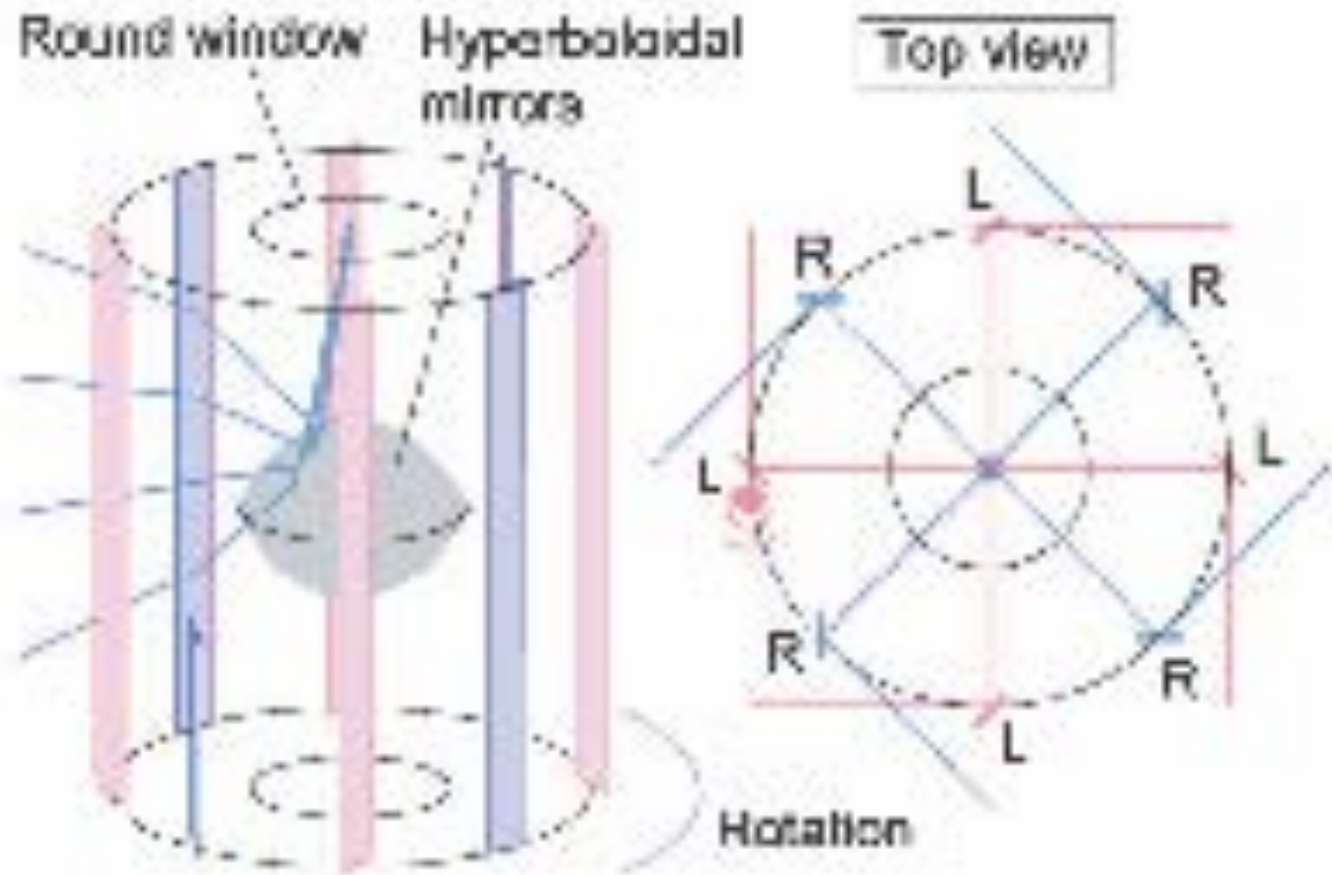
Live ODS Video (is hard)

Robert Konrad

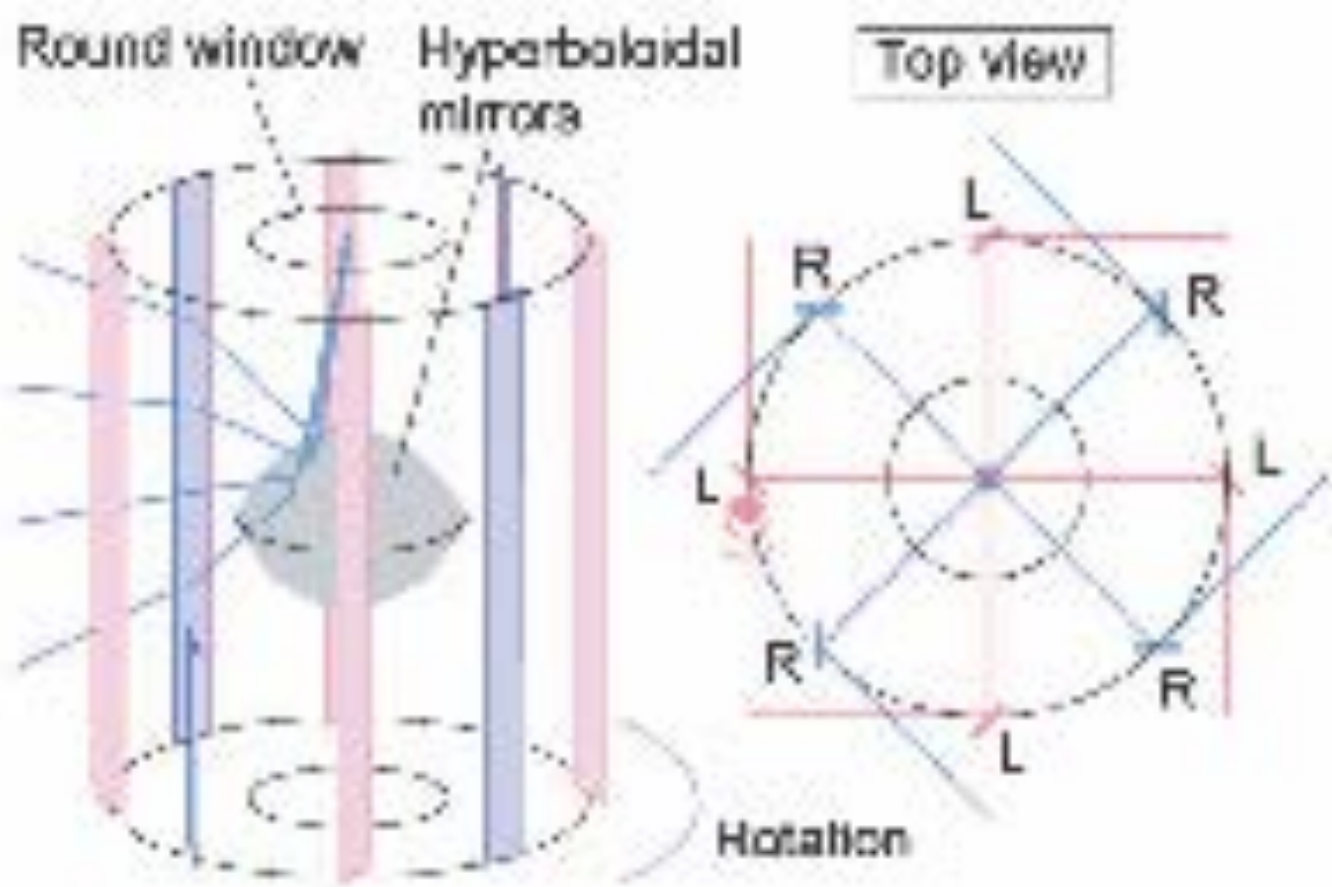
TORNADO



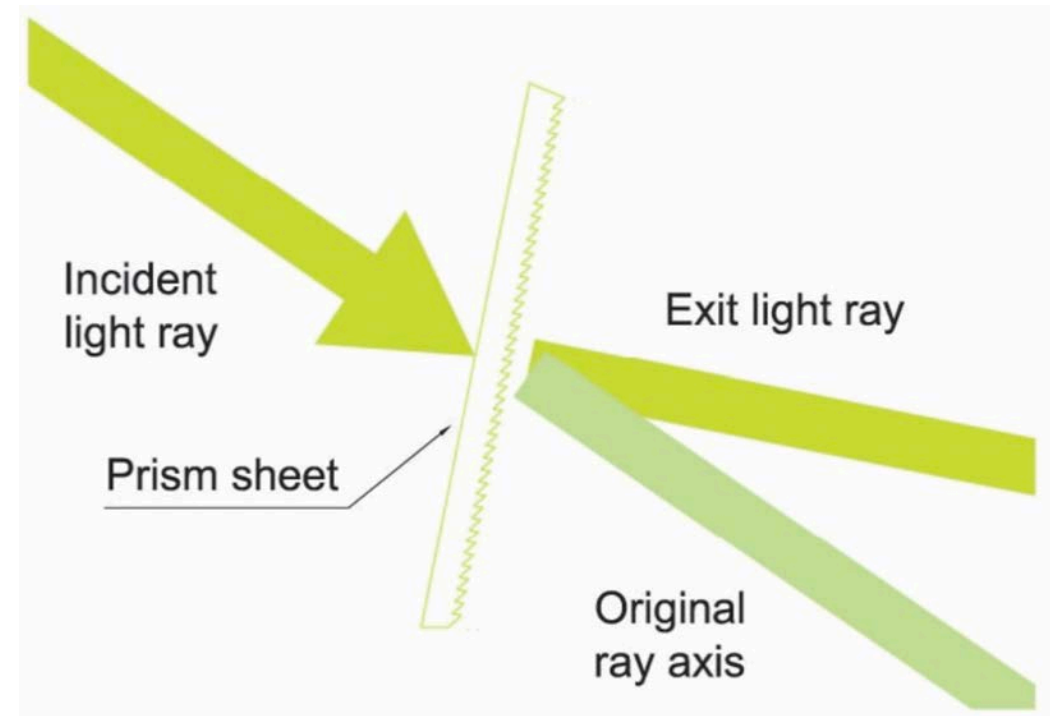
TORNADO



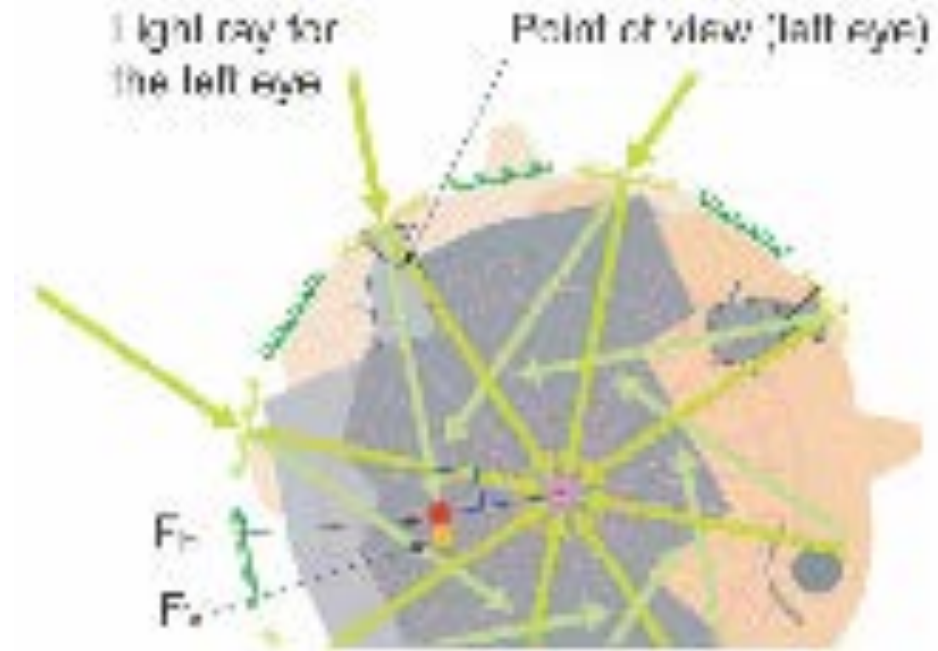
TORNADO



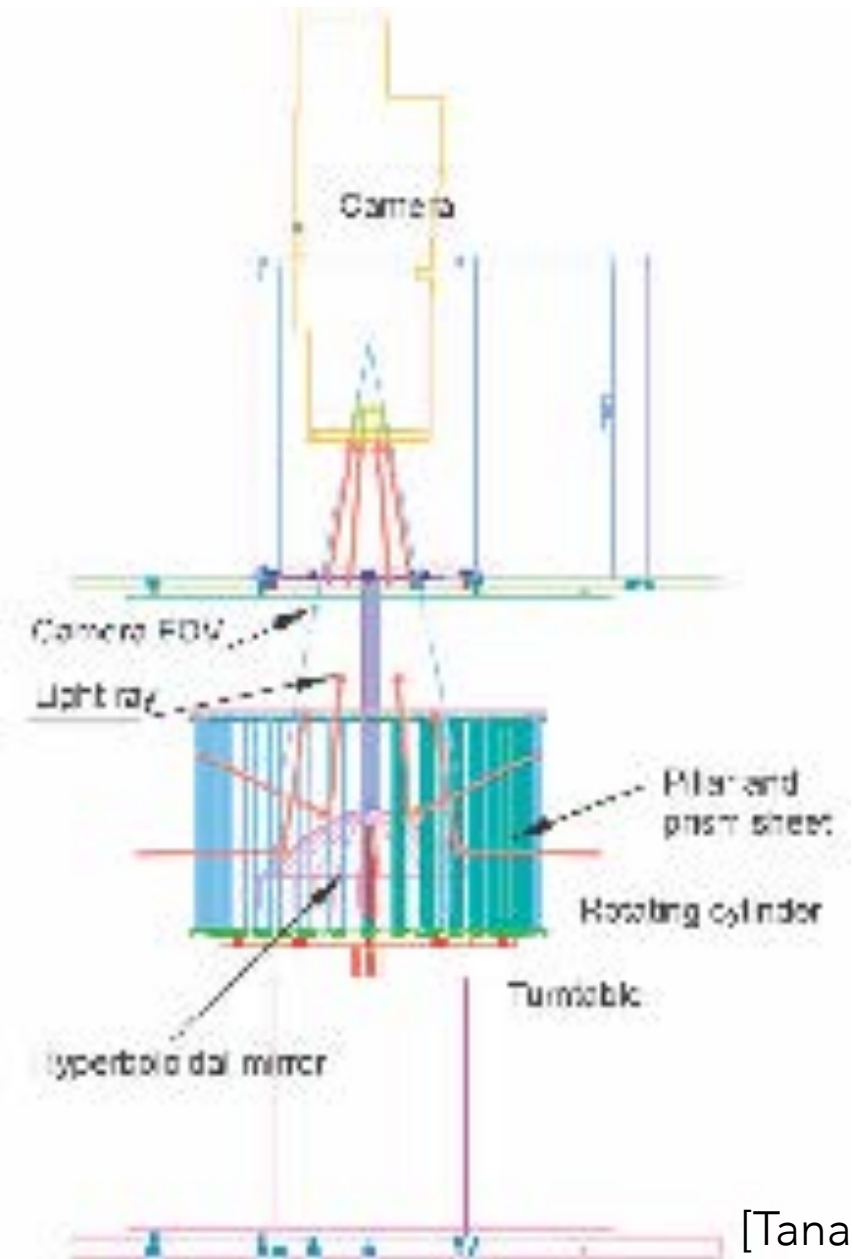
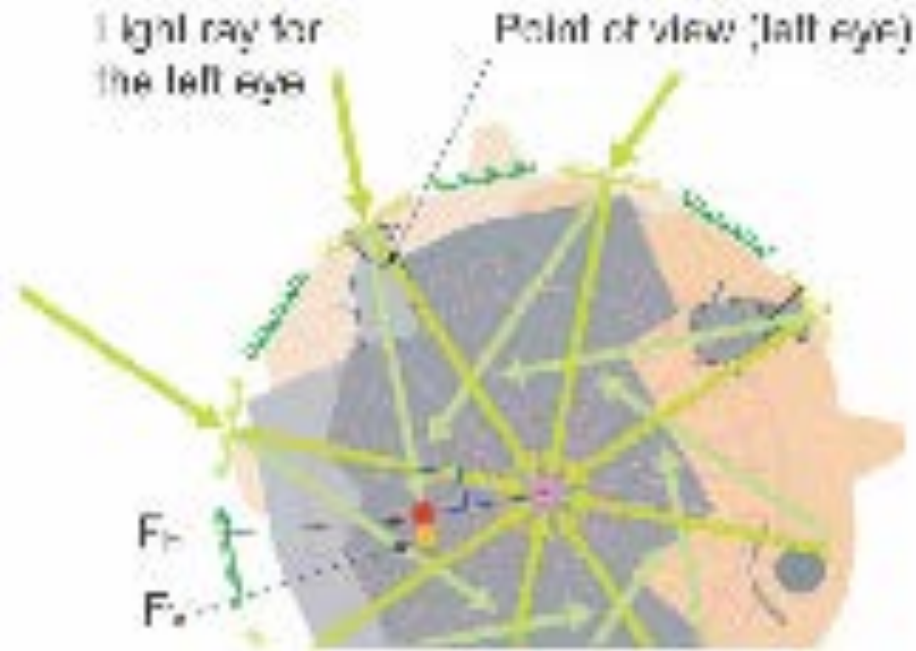
Prism Sheet Working Principle



TORNADO



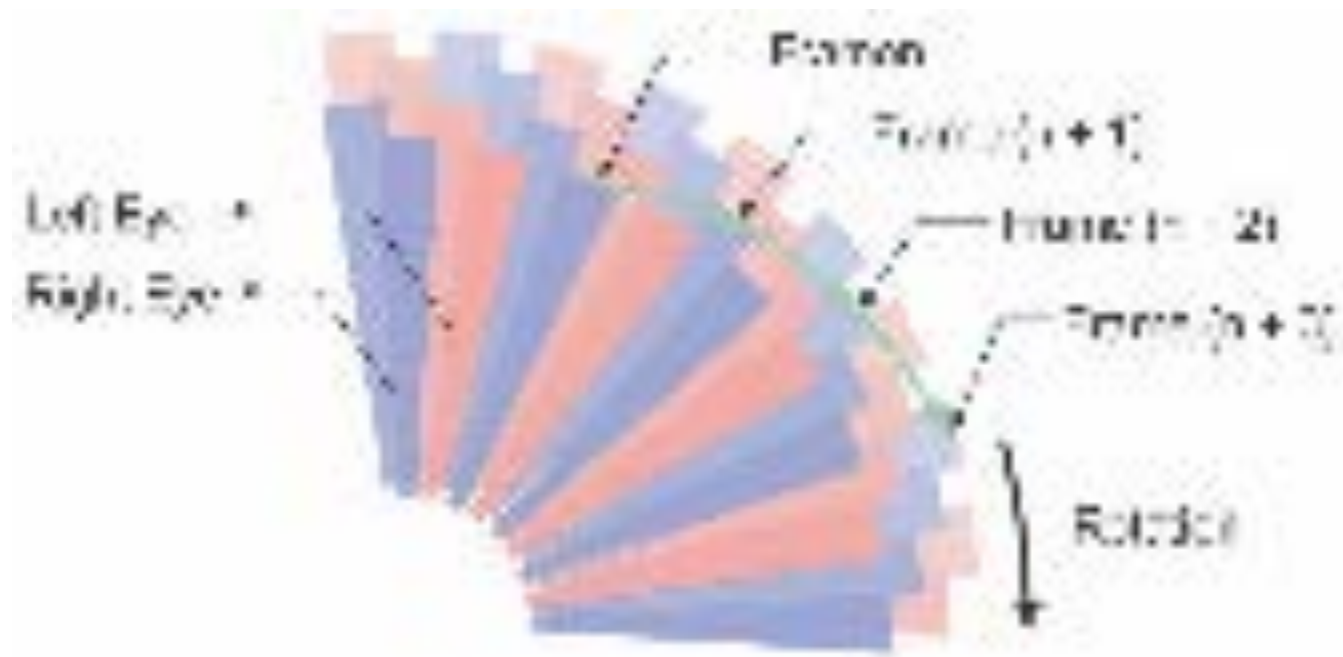
TORNADO



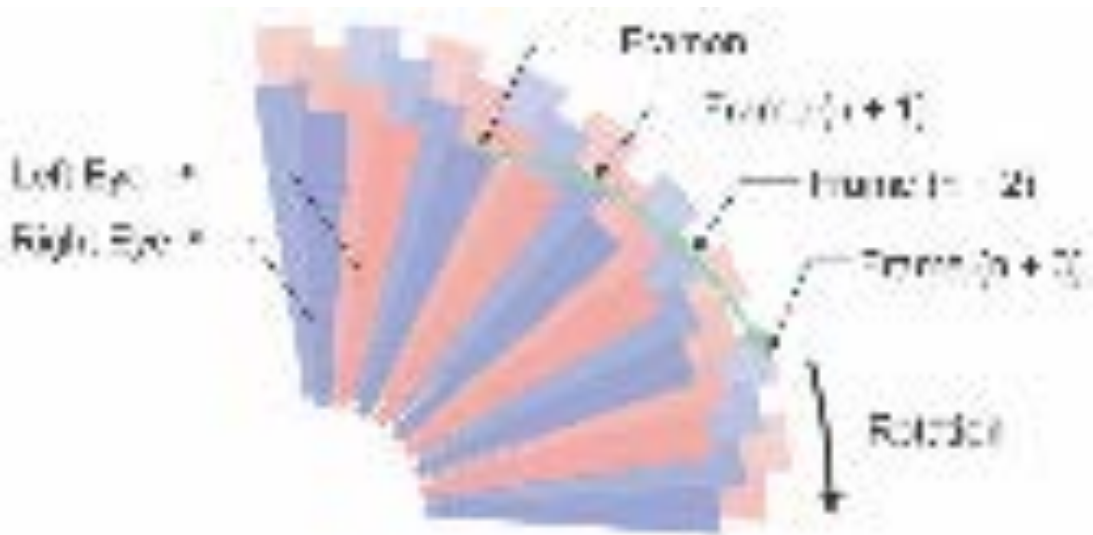
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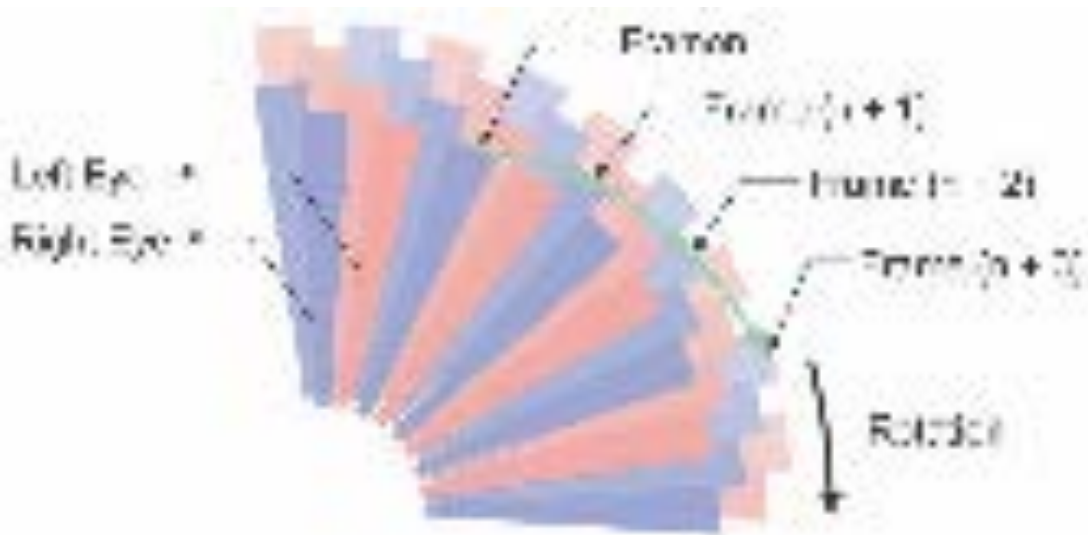
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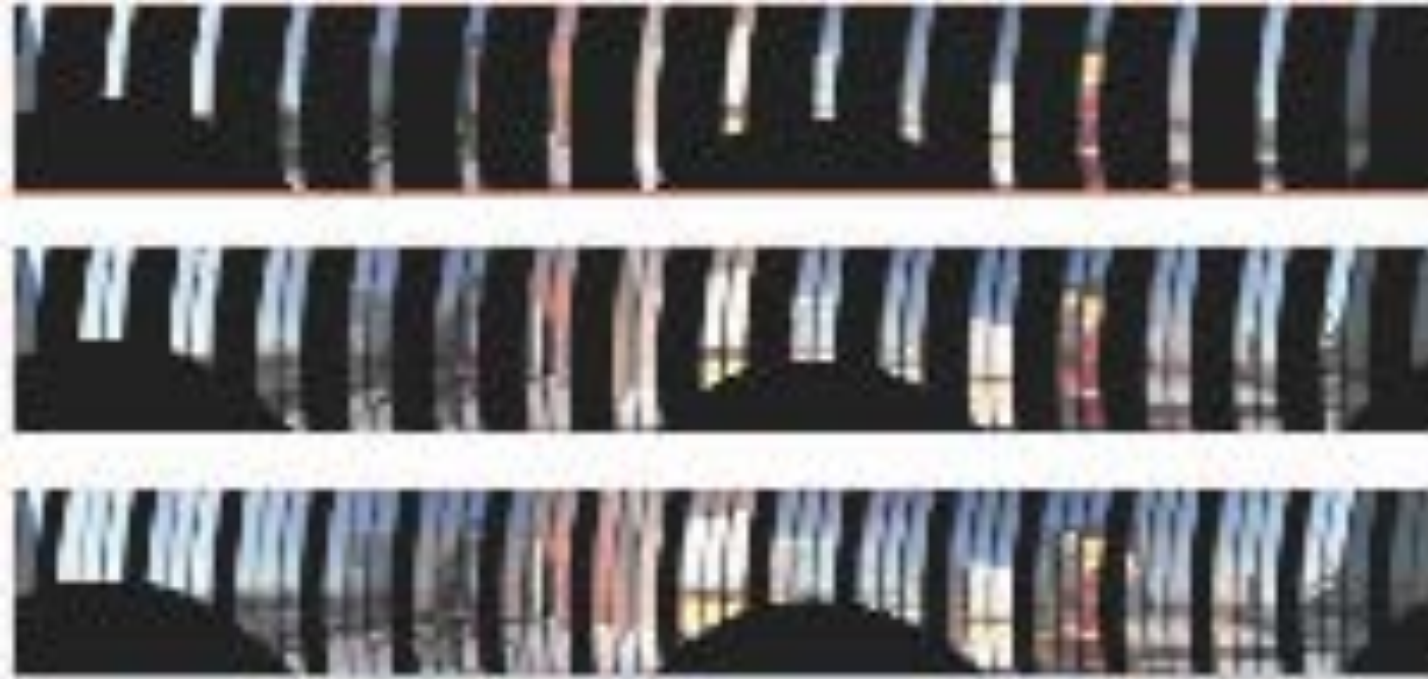
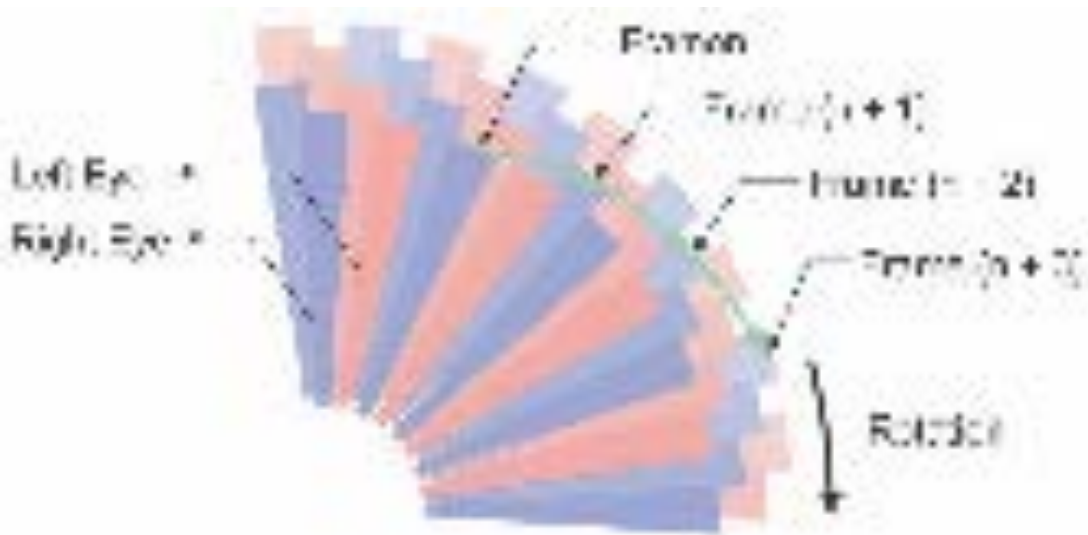
TORNADO



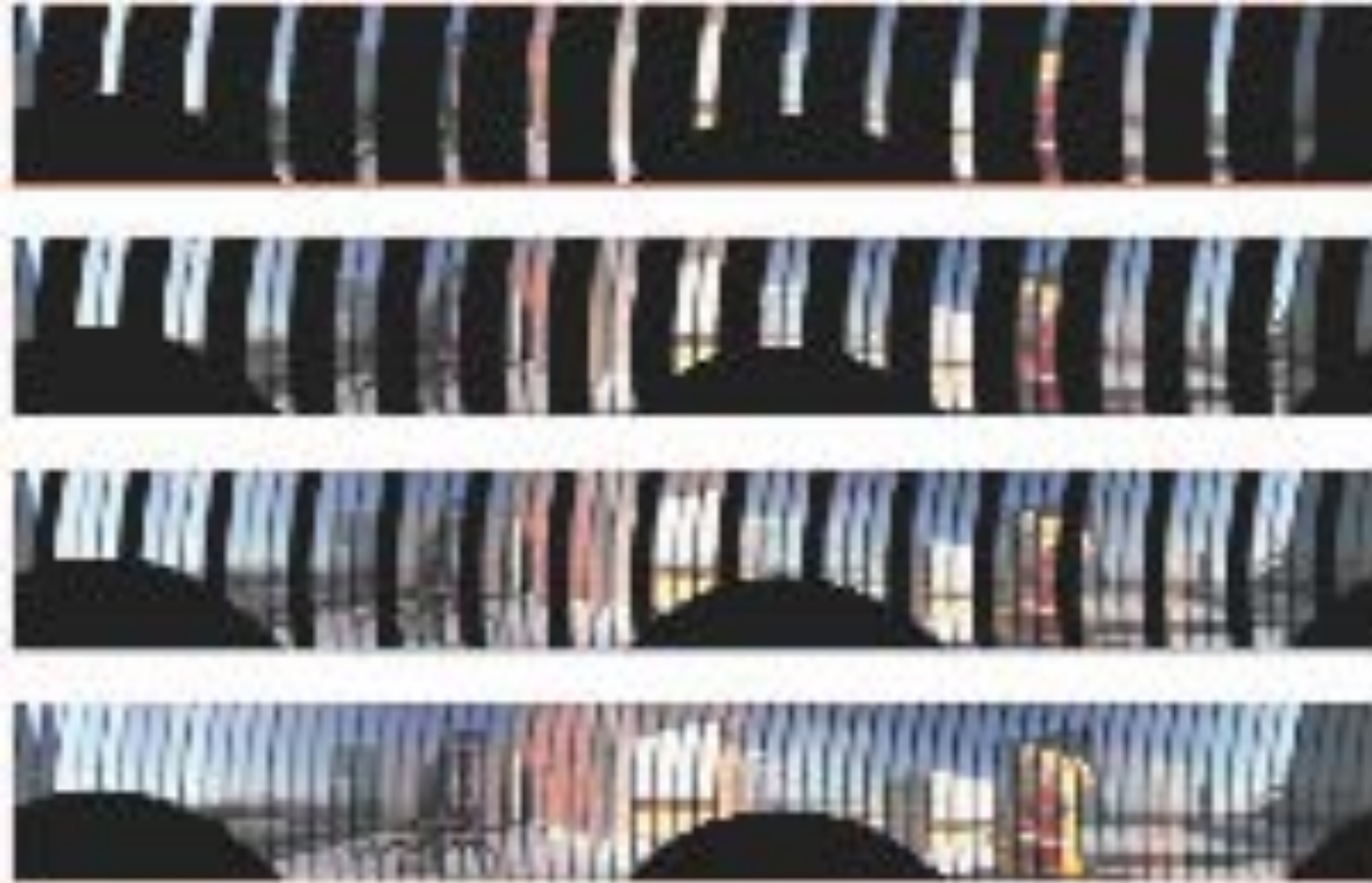
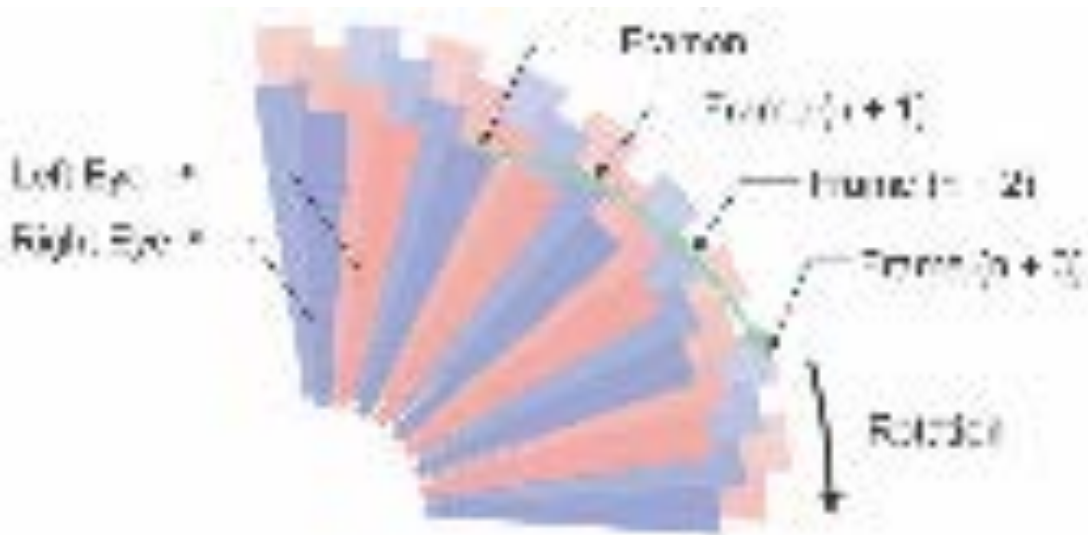
TORNADO



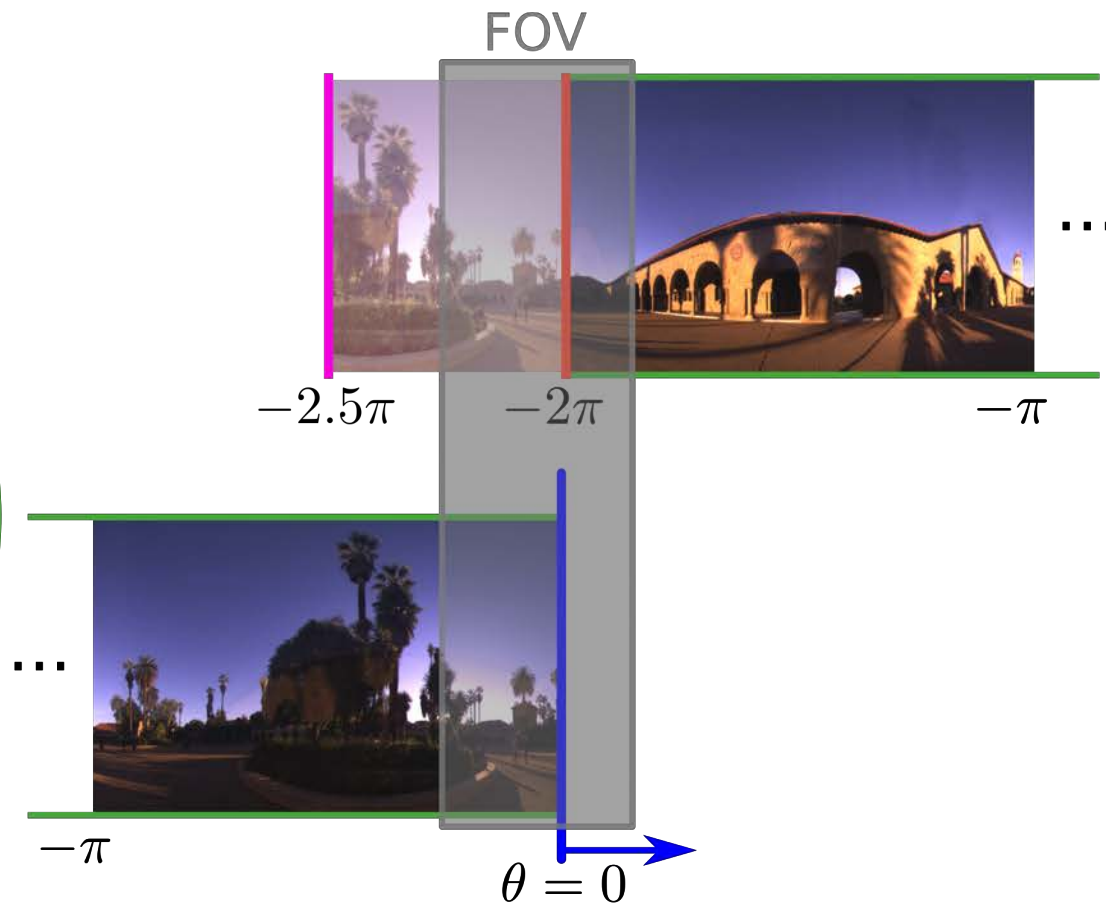
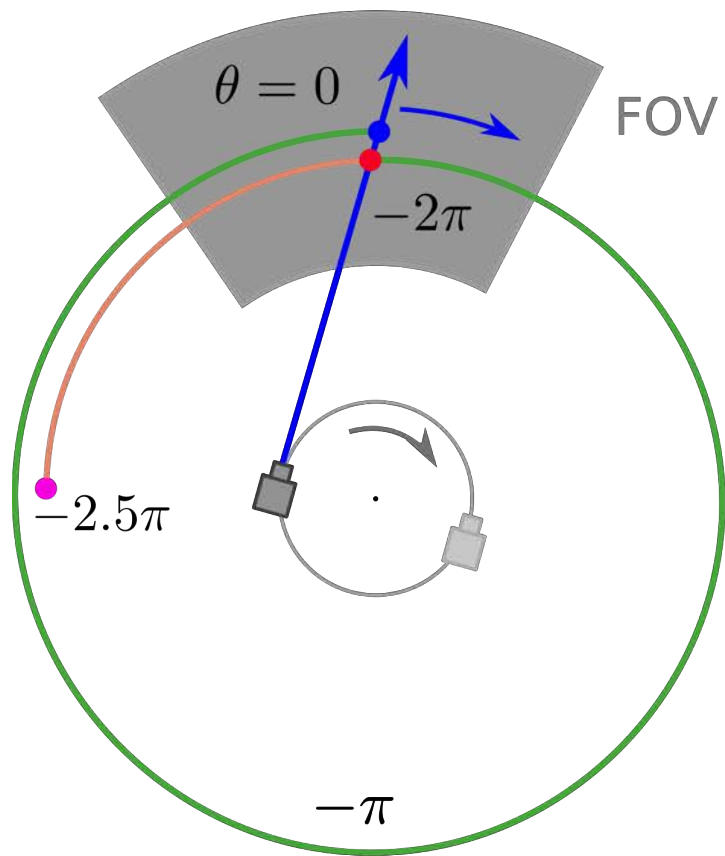
TORNADO



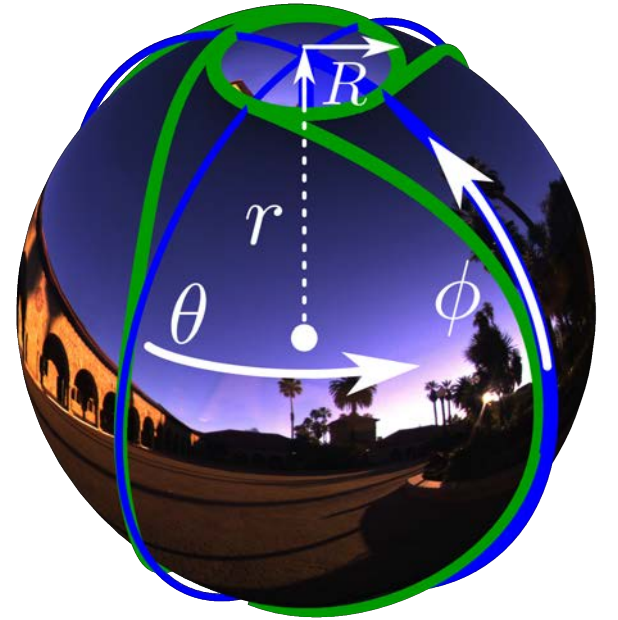
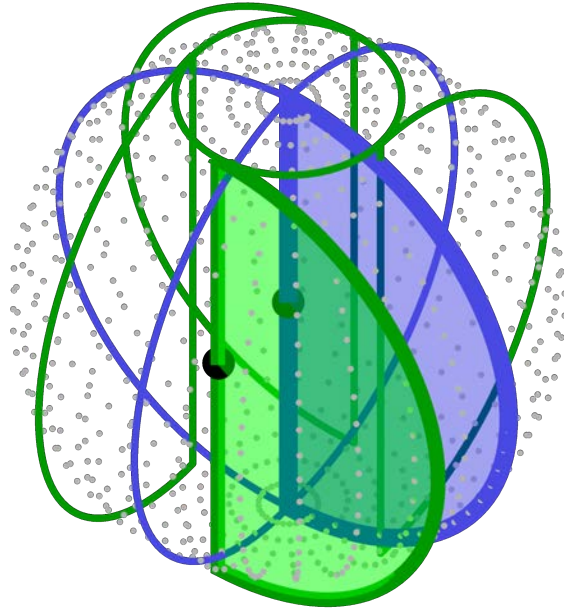
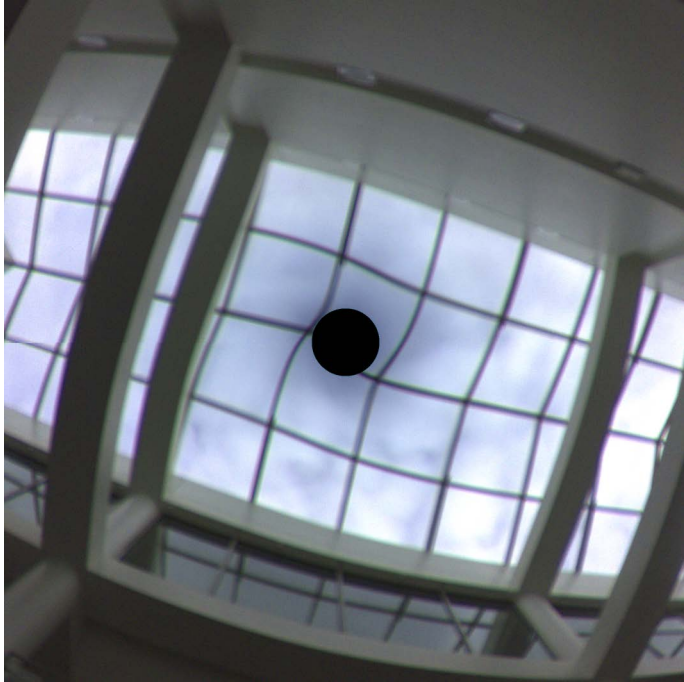
TORNADO



Seamless Rendering



Warping at the Poles



$$\Delta\theta = \tan^{-1} \left(\frac{R/r}{\cos \phi} \right)$$

$$\Delta\phi = \tan^{-1} \left(\frac{\sin \phi}{\sqrt{(R/r)^2 + \cos^2 \phi}} \right) - \phi$$

Warping at the Poles

