# Data capture for immersive displays

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Presentation slides here
http://paulbourke.net/ecu2018/

## Contents

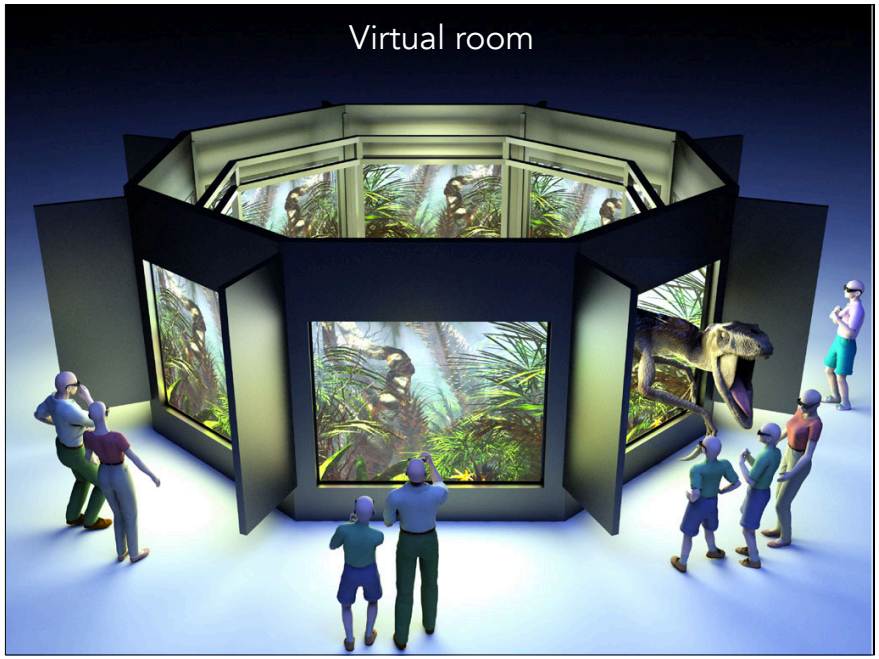
- Why?
- Some theory - Image projections.
- How? (Examples from my projects)
- Why is it so hard - Parallax issue.
- Various considerations, why immersive video is different.
- Discussion and demonstrations.

## Why?

- Why aren't we satisfied with a bounded flat monoscopic screen?
- Leverage the human visual system.
  Stereopsis - Peripheral vision - Fidelity
- Stereopsis provides depth perception from the two horizontally offset views are eyes provide to our visual cortex.
- Peripheral vision is largely attributed to providing the sense of immersion, of "being there", also called "presence".
- If we can leverage these capabilities of the human visual system then expect advantages, whether it is for science visualisation/communication, story telling, entertainment …
- Recent excitement is around commodity head mounted displays, but there is an older history. Circlerama in the 1960s, HMDs in the 1980s.
- There are other senses, particularly haptics, audio, touch. Generally considered supporting senses to increase engagement rather than primary.

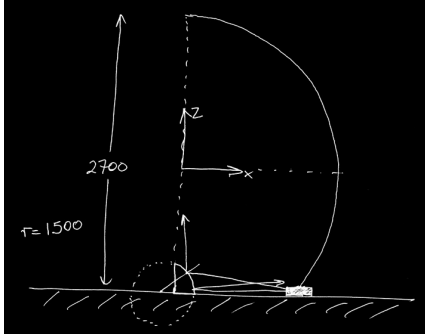
## Panorama 1453

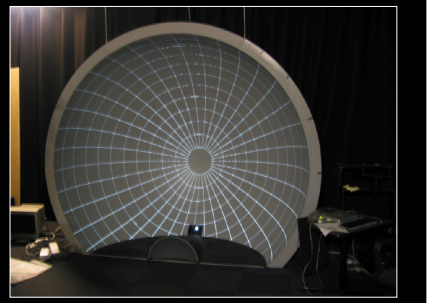
## Virtual room

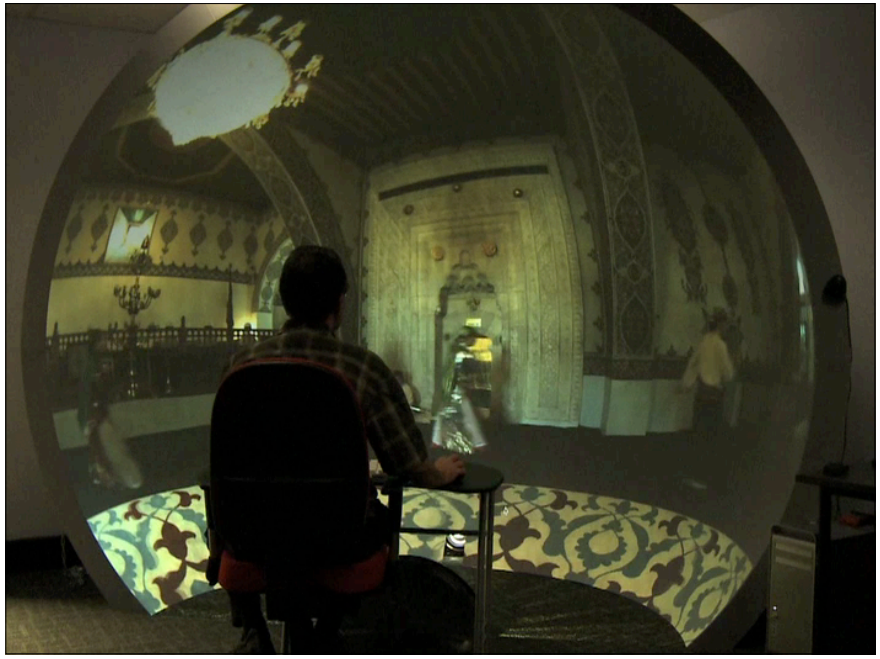


## iDome

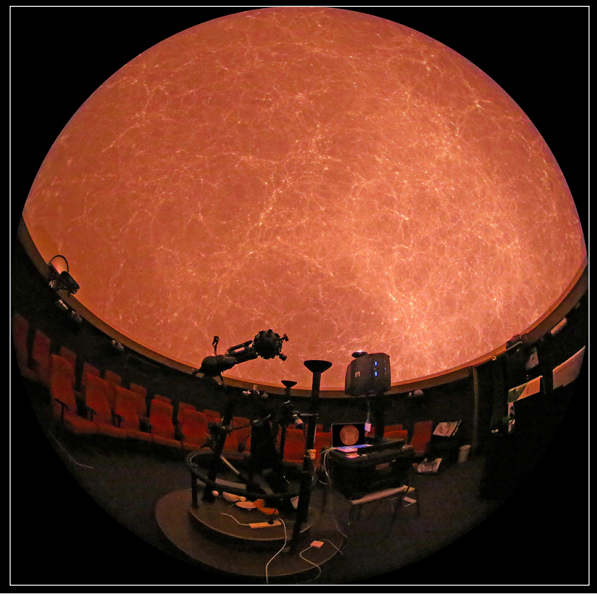
- "Invented" in 2002, iCinema (dome) and myself (projection).
- 180 degree horizontal field of view, 135 vertical field of view.



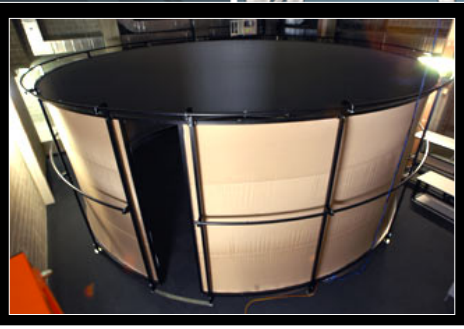





## Planetariums as immersive theatres



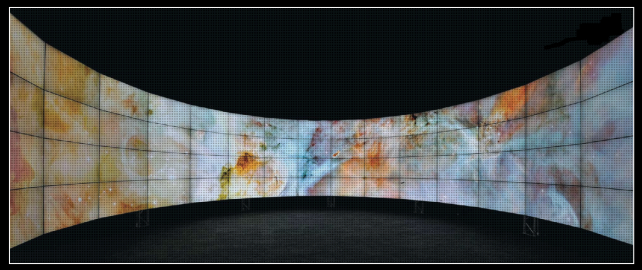
## AVIE (Applied Visualisation Immersive Environment)



iCinema, UNSW

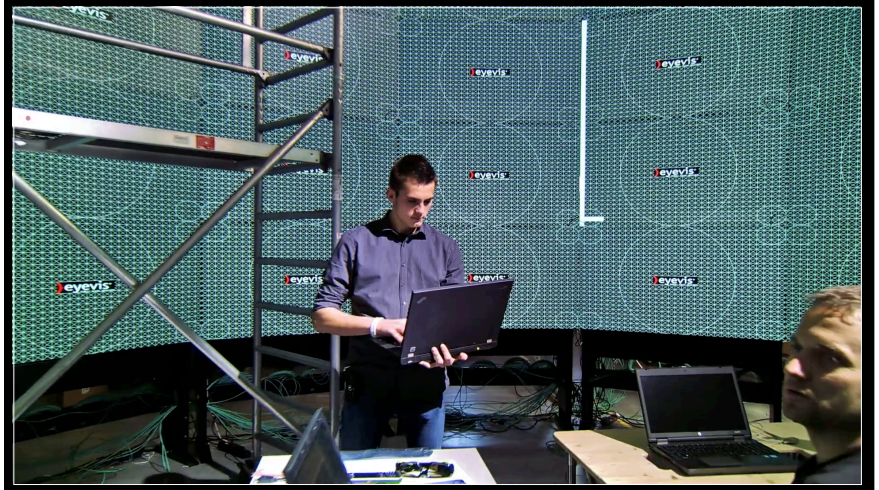
## CAVE-2

Monash



University of the Sunshine Coast

## EPICylinder



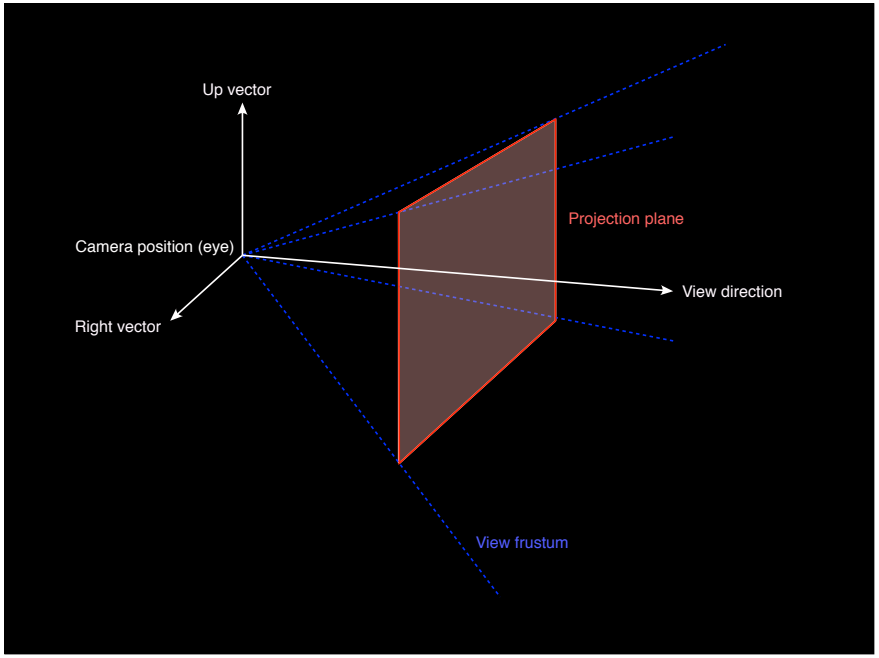
EPICentre - Enhanced Perception and Interaction Centre, UNSW

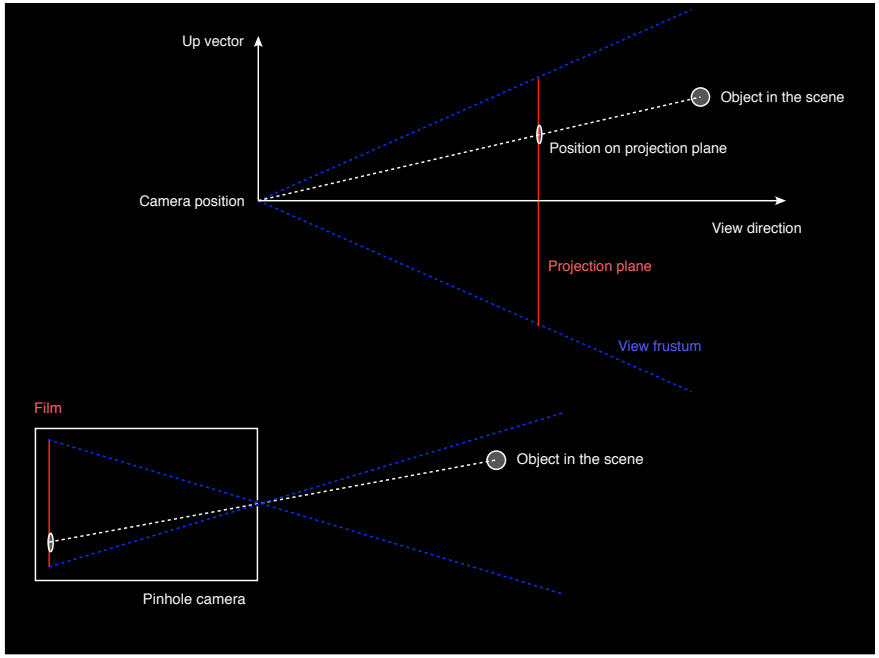
## HMDs

## Stereopsis - Peripheral vision - Fidelity

| | Stereopsis | Peripheral | Fidelity |
|---|---|---|---|
| 3D walls | | | |
| VROOM (Virtual room) | | | |
| Tiled displays (Planar) | | | |
| HMD (Head Mounted Display) VR headset | | | |
| Light table | | | |
| iDome | | | |
| Planetarium | | | |
| AVIE (Advanced Visualisation and Interaction Environment) | | | |
| EPICylinder (Enhanced Perception and Interaction) | | | |

# Image Projections




60 degree horizontal field of view

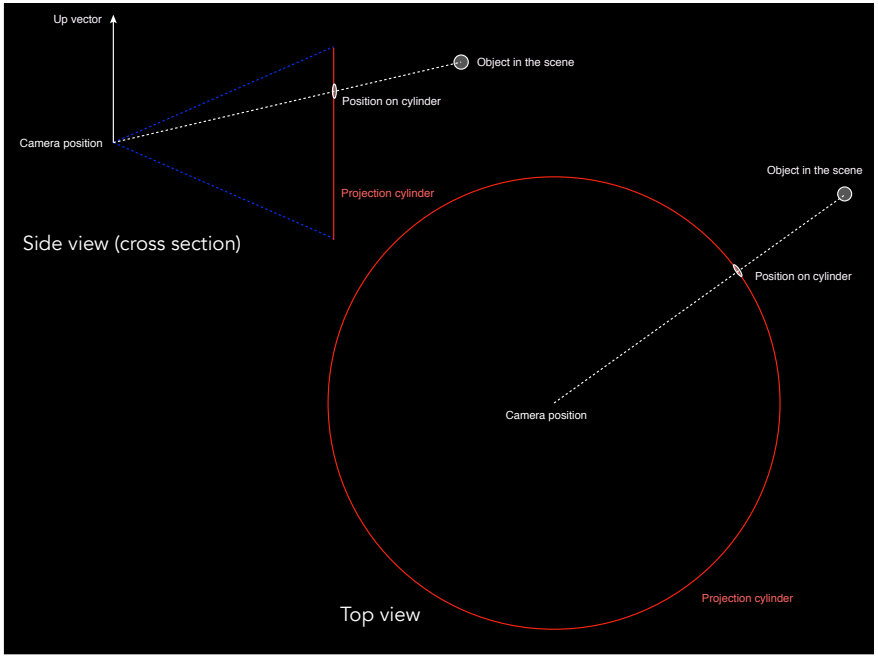
120 degree horizontal field of view

140 degree horizontal field of view

160 degree horizontal field of view

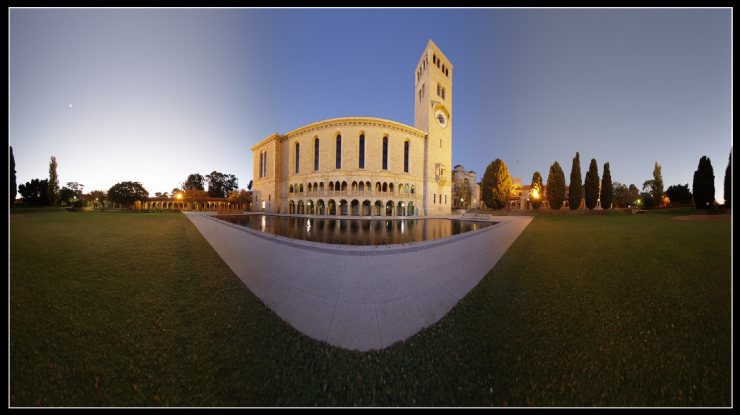
## Cylindrical Projection

45 degrees vertically




## Cylindrical Projection

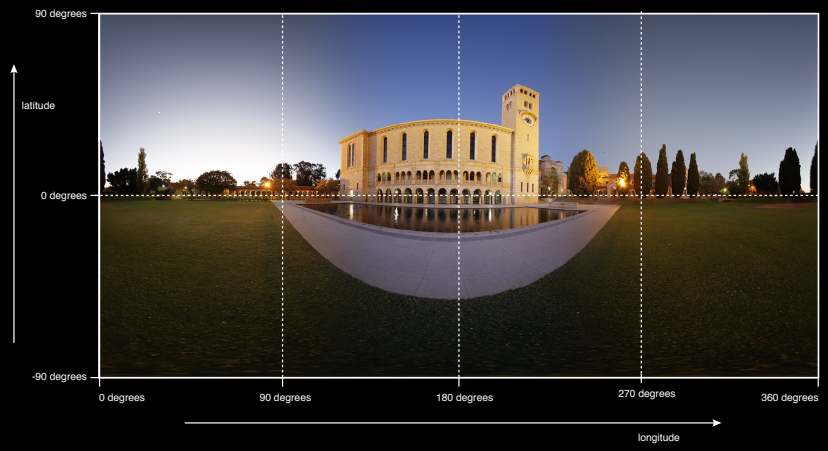
90 degrees vertically



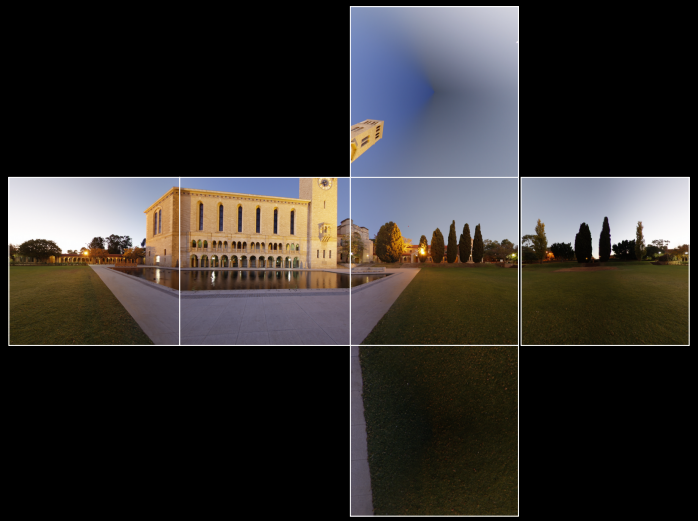
120 degrees vertically

## Equirectangular Projections

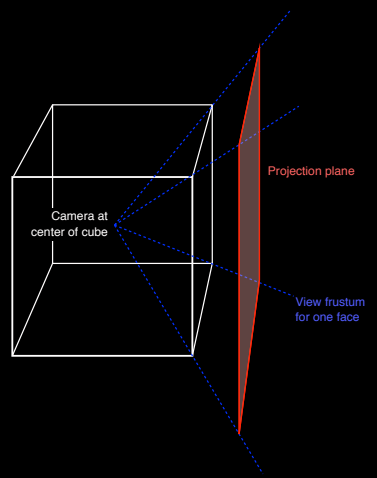
360x180 degrees




## Cube Maps



- Cube maps are 6 square view frustums through the vertices of each cube face.
- Each view frustum is 90 degrees horizontally and vertically.

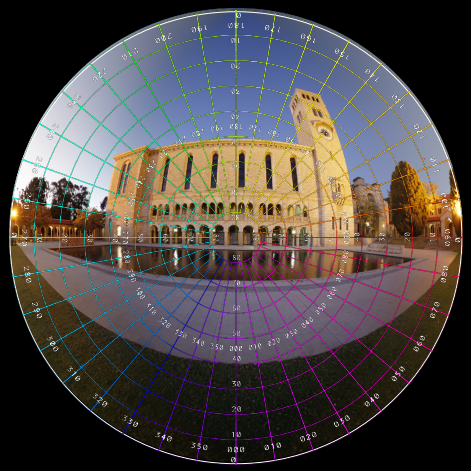



## Fisheye

180 degrees horizontally and vertically

(Actually 180 degrees through any axis passing through the center)

- Lines of longitude extend radially from the north pole.
- Lines of latitude (3D) create equal radius lines in the fisheye (2D).
- Put another way, there is a linear relationship between the distance from the centre of the fisheye to the age of the corresponding 3D vector.



Not limited to 180 degrees

180 degrees

220 degrees

## “Distortion”

- One is tempted to refer to the curved nature of what we expect to be straight lines as a “distortion”.
- Same applies to the spreading of objects towards the poles in an equirectangular projection.

## How?

- Simplest is a single camera and mirror or wide fisheye.
- Next simplest is a twin fisheye.
- In order to scale in resolution one needs to use multiple cameras.
- Multiple (3,4,5,6 ...) cameras with wide angle lenses.
  - Controllable machine vision cameras
  - Commodity independent cameras

Sydney harbour bridge

iCinema

Volker Kuchelmeister
iCinema

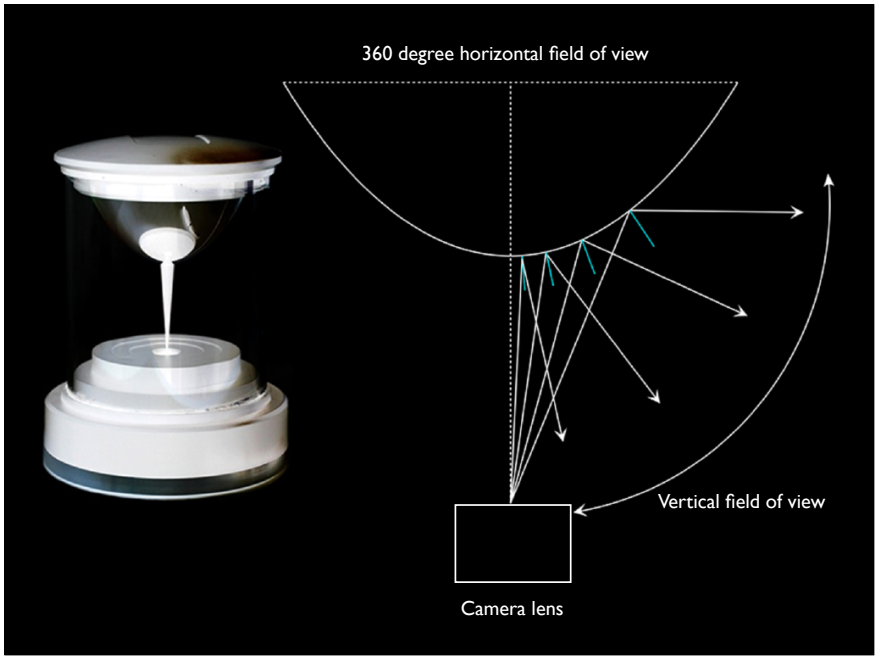
LadyBug-3

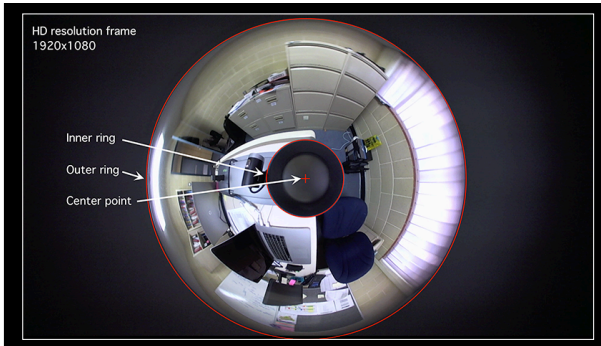
LadyBug-5

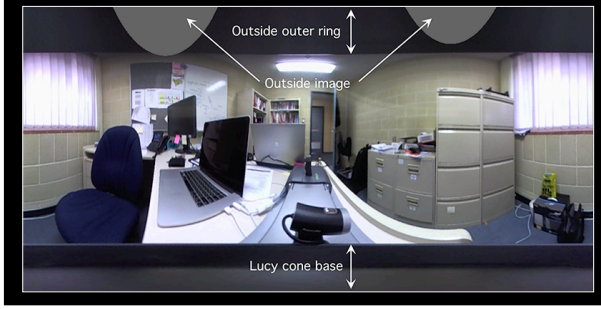
Borusan Group
Place Turkiye, Sarah Kenderine and Jeffrey Shaw

Endeavour replica entering Perth

Veterinary course, CityU






Entaniya 250 degree fisheye


## Single camera: relative merits

- Advantages
  - Simple
  - Small
  - No parallax errors, no blending
- Disadvantages
  - Doesn't (cannot) capture the whole vertical FOV
  - Doesn't scale in resolution
  - Not all pixels are equal size

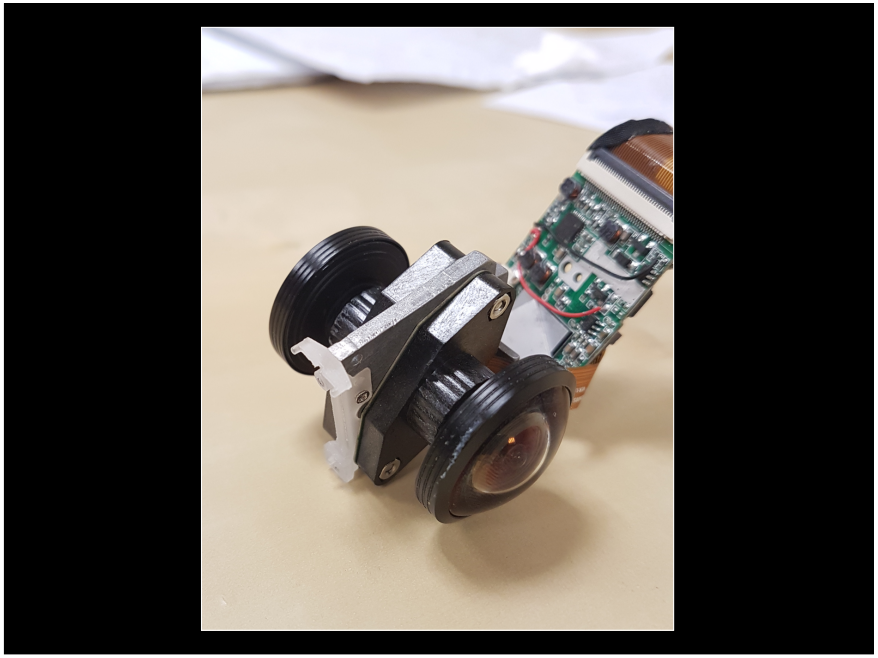

Ximea, 8K sensor

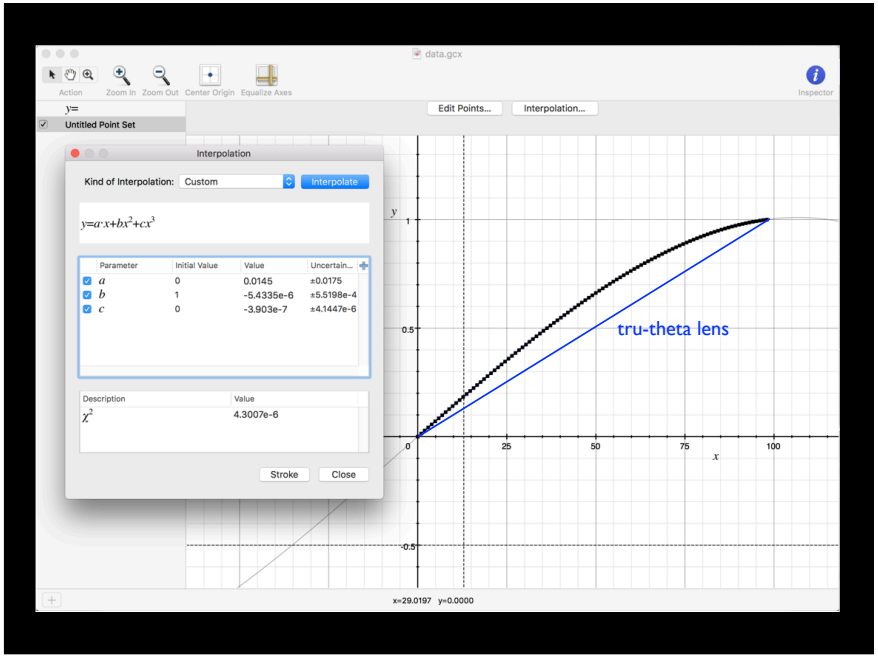
## Dual camera rigs

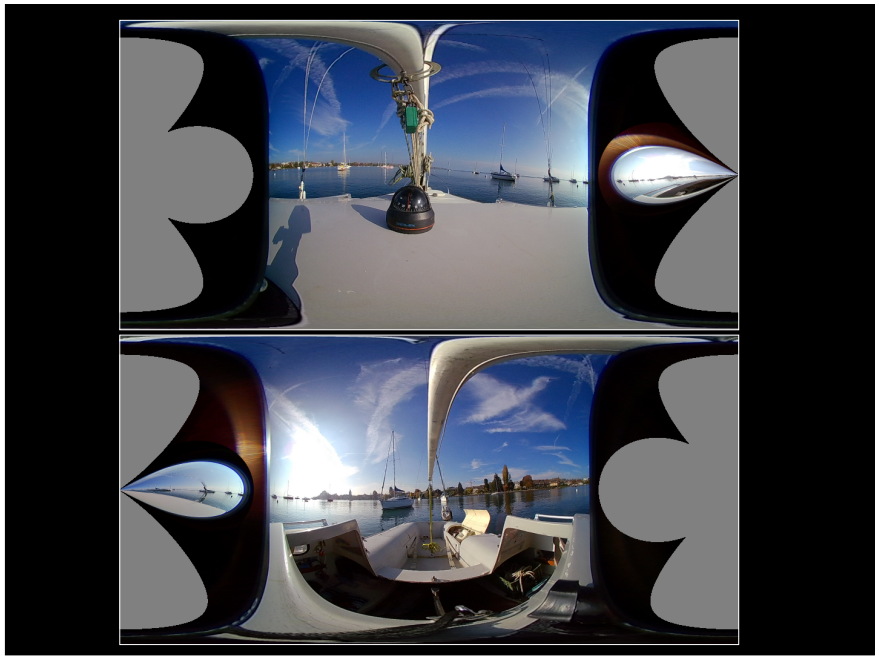


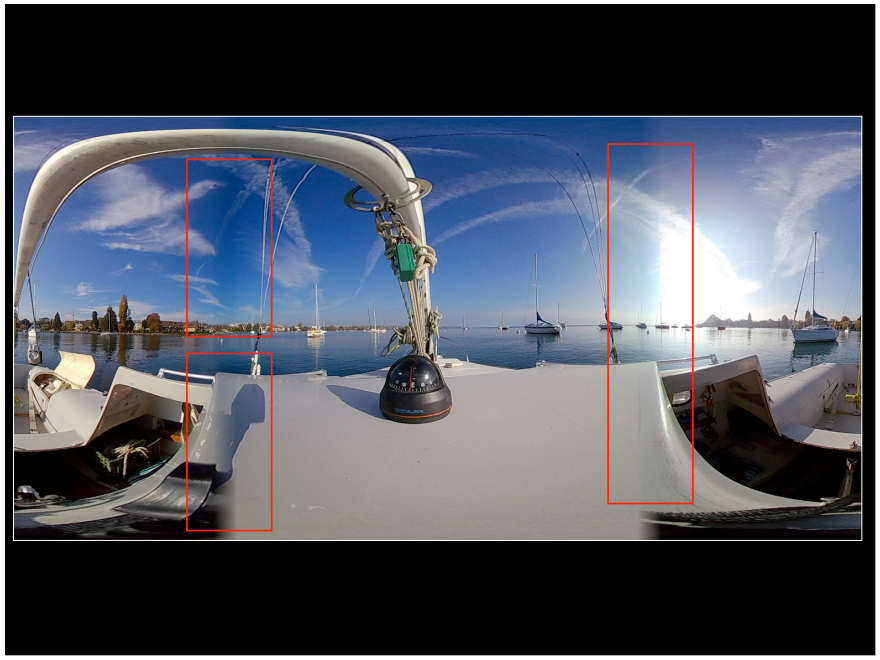



## Homido workflow



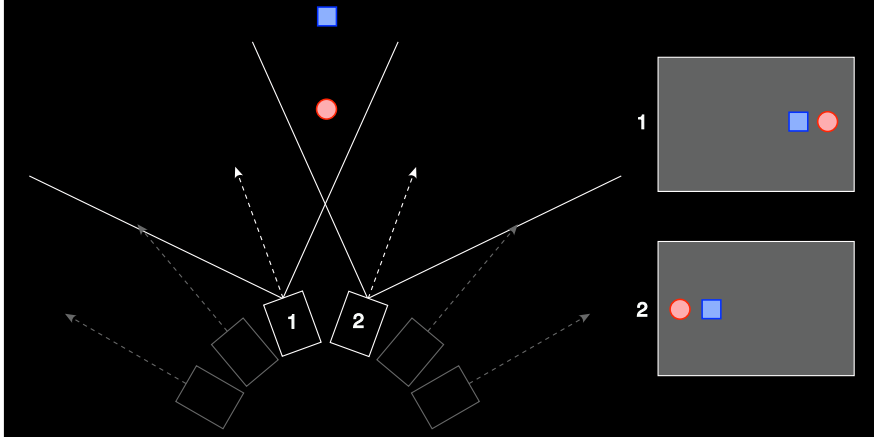

data.gcx
Action
Zoom In
Zoom Out
Center Origin
Equalize Axes
Inspector
y=
Untitled Point Set
Edit Points...
Interpolation...
Interpolation
Kind of Interpolation:
Custom
Interpolate
y=a·x+bx²+cx³
Parameter
Initial Value
Value
Uncertain...
a
0
0.0145
±0.0175
b
1
-5.4335e-6
±5.5198e-4
c
0
-3.903e-7
±4.1447e-6
Description
Value
χ²
4.3007e-6
Stroke
Close
tru-theta lens
x=29.0197 y=0.0000

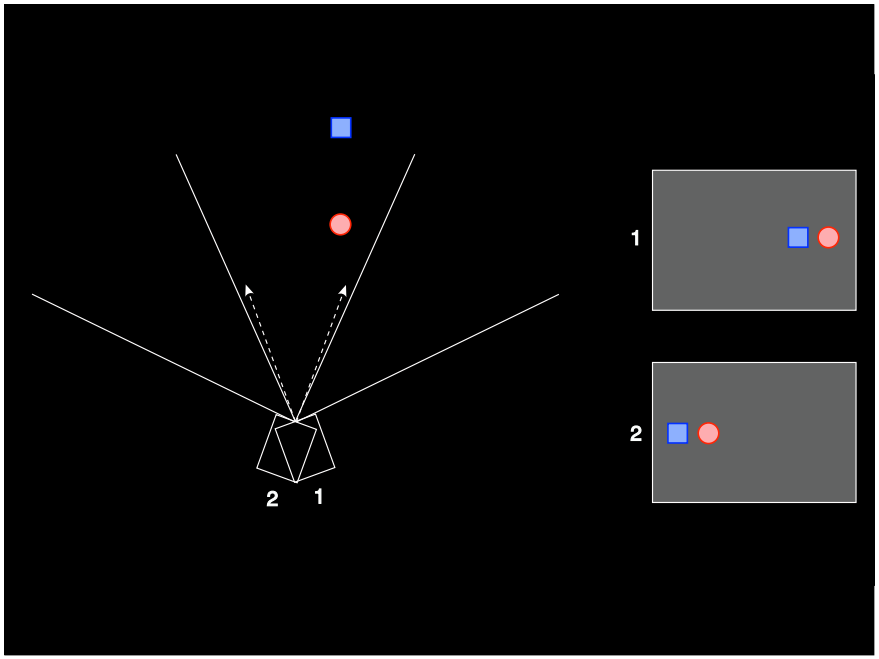




## Why is it hard?

**The fundamental problem: issue of parallax!**



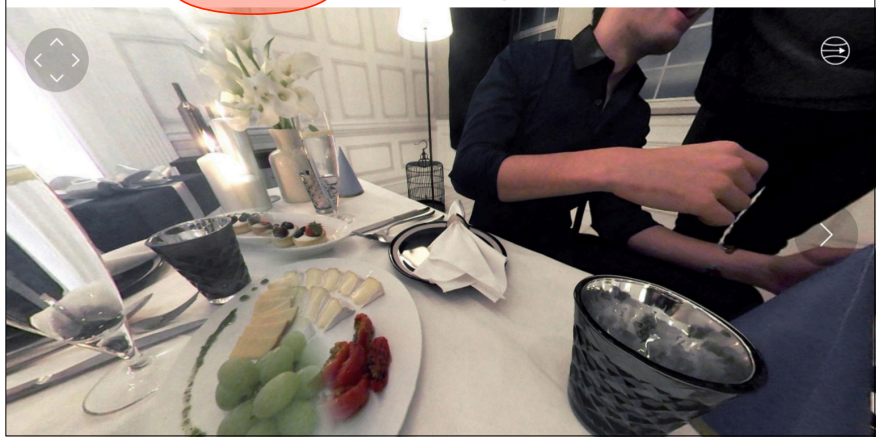

*A perfect stitch/blend is impossible.*

*No amount of cleverness can solve this.*

*One can stitch/blend perfectly for a single depth.*

# The world through dual lens

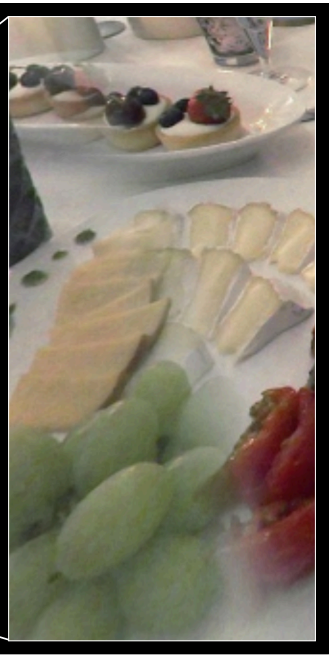
The front and rear lenses each capture 180 degrees horizontally and vertically, creating a seamless and complete 360-degree field of view.



http://www.samsung.com/global/galaxy/gear-360/

The world through dual lens

The front and rear lenses each capture 180 degrees horizontally and vertically, creating a seamless and complete 360-degree field of view.



Corroberee, PixelCase Group

Can get a perfect stitch at a particular depth.

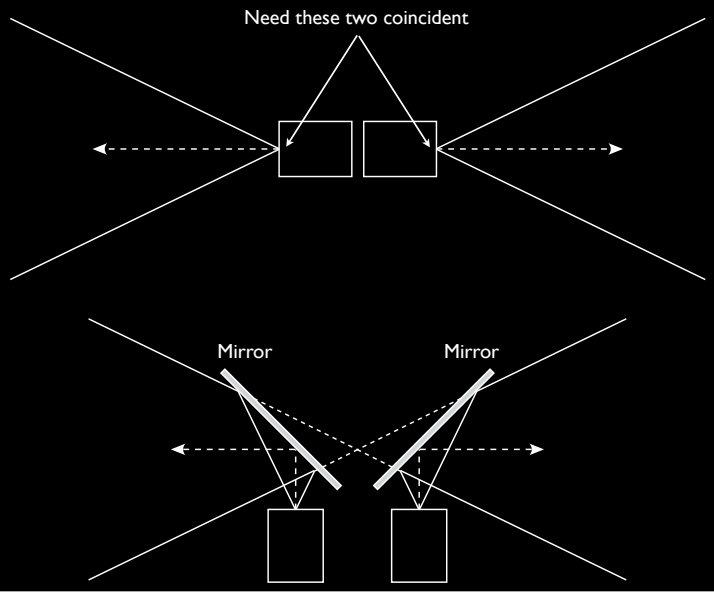
CityU, Hong Kong

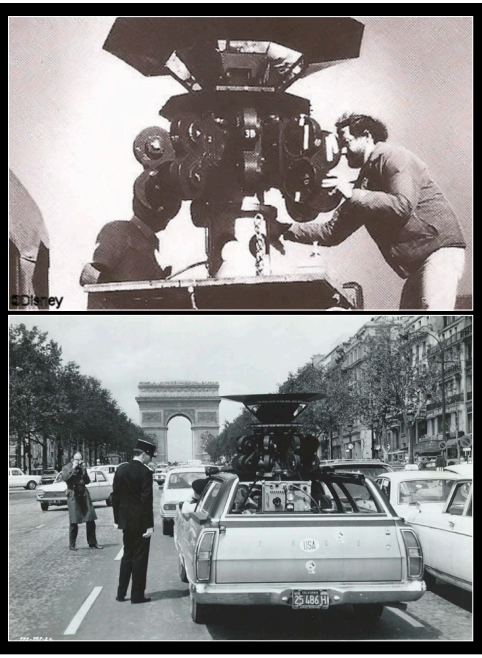
*But as with pretty much everything*

*in optics and photography,*

*it has all been done before.*

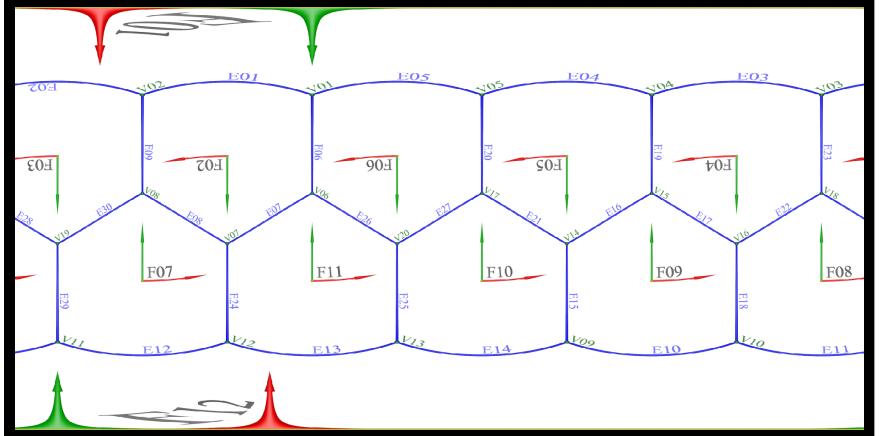
Consider two opposite cameras in a multiple camera rig



Circlorama camera #2
(Disney)

## Custom optics



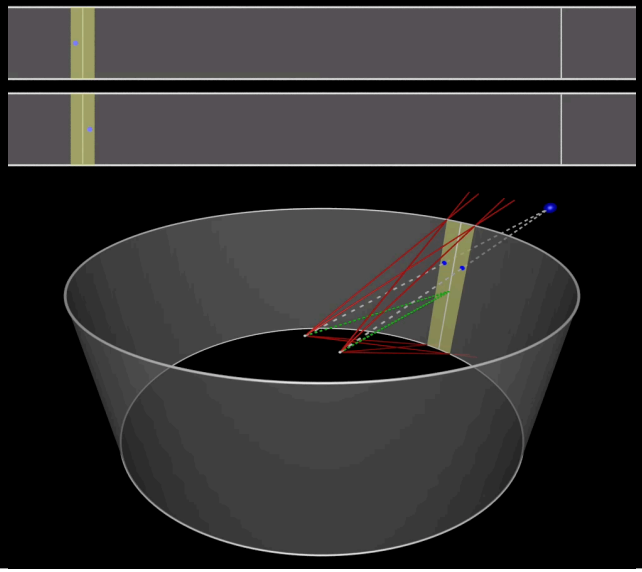
## Stereoscopic panorama

Peter Murphy
Ankor Wat

Left eye

Right eye

## ODSP: Omnidirectional stereoscopic panorama



Barker's London panorama of 1792

Omnidirectional stereo panoramas published by
H Ishiguro
in 1989 but reported by his colleague
K Sarachik
in 1979

Roundshot camera

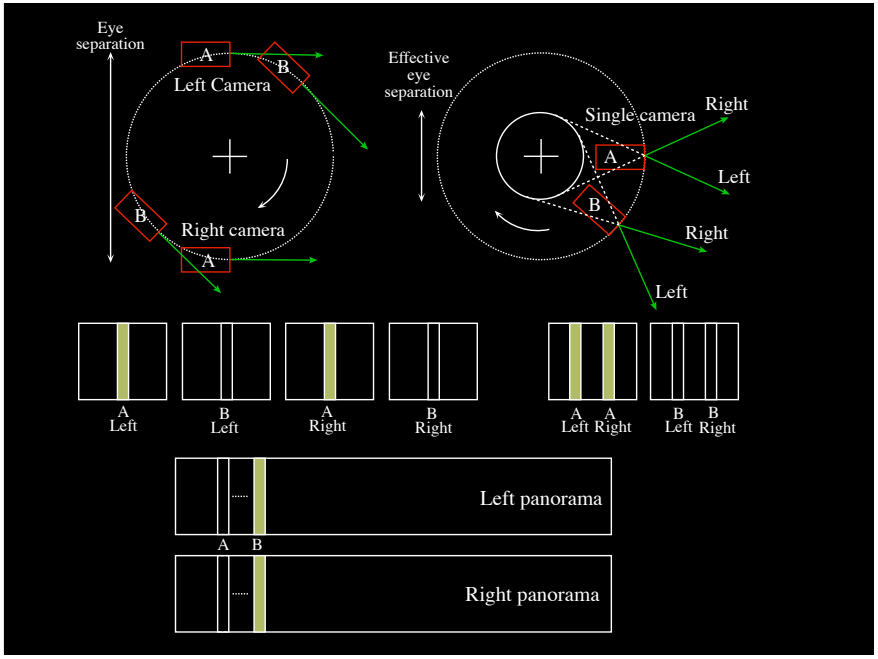
Left eye

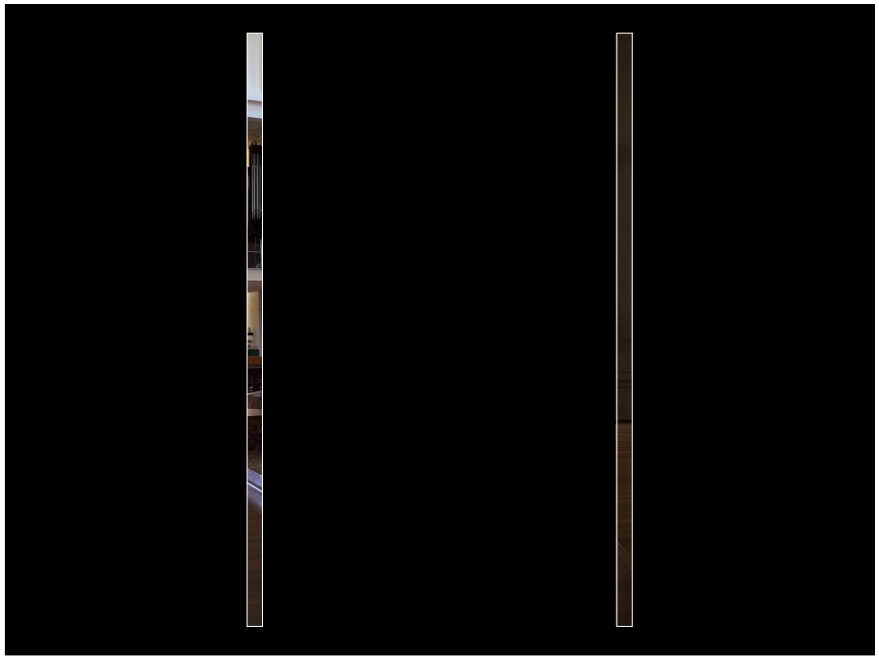
Right eye

Hampi, Sarah Kenderdine


Left eye
Right eye
Turkiye, Sarah Kenderdine


Left eye
Left eye
Place Hampi


Eye separation
A
B
Left Camera
B
Right camera
A
Effective eye separation
Single camera
A
B
Right
Left
Right
Left
A Left
B Left
A Right
B Right
A Left
A Right
B Left
B Right
Left panorama
A
B
Right panorama



Left eye

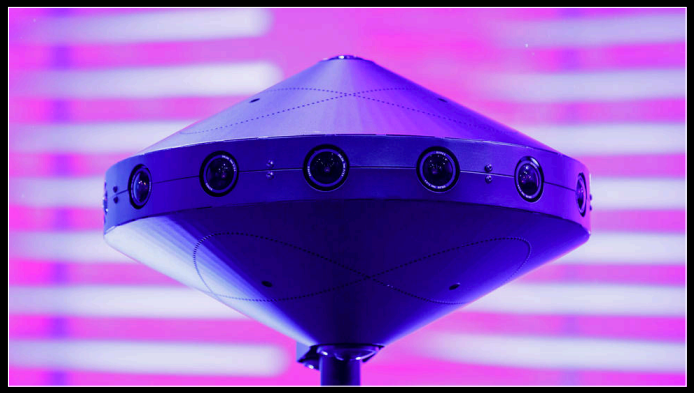
Right eye

## Simplest stereo video rig

Still to be announced

Based upon the zcam, smallest 4K camera with interchangeable lenses

Facebook 360

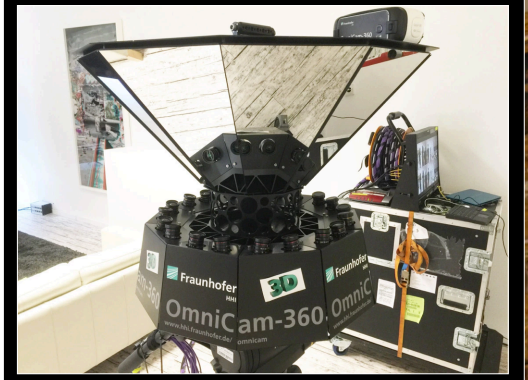


VokeVR


Jaunt One

## Relative merits

- Smaller number of cameras easier to manage.
  But create a cruder approximation to the ideal ODSP.
- Larger number of cameras give a better approximation.
  Potentially provide higher resolution.
  Become heavy and bulky.
  More involved post processing stage.
- Rigs made from commodity cameras easy to build.
  Suffer from colour matching, white point, lens calibration ...
  Higher post production cost to hide defects.
- Still have the same parallax problems!
  Despite very clever algorithms (optical flow, AI …).

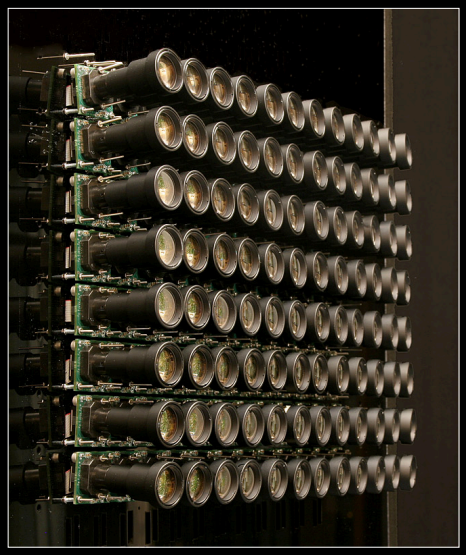


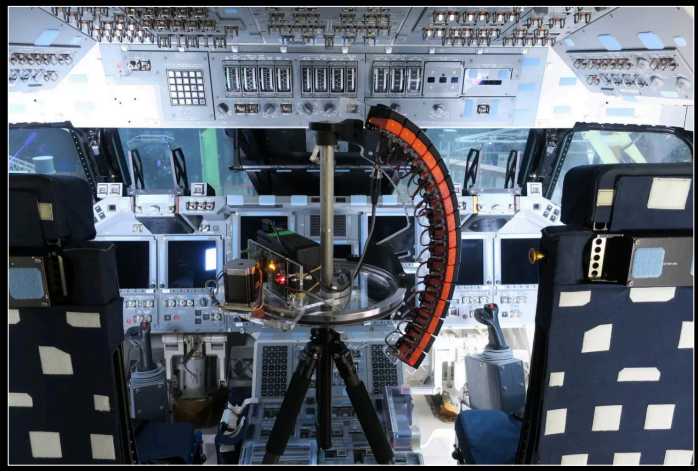

Camera pairs side by side

Camera pairs top and bottom

## Lightfield

- Instead of capturing just rays that focus on a sensor, capture the whole lightfield.
- Normally using an array of cameras or lens array.
- Not only allows one to refocus in post, and provide depth perception, also allows one to move ones head (within a limited range) and see around objects.
- Still very experimental, video rigs have limited field of view, 360 rigs are only for static scenes.





## Random considerations

- Frame resolution. 4096x2048 spherical frames now considered “low resolution”. 8192x4098 is currently most common, many rigs capture even higher.
- Dealing with non-standard aspect ratios, 2:1 typically. Some so called “professional” packages don’t support that.

2:1 aspect ratio

## Left-right edge

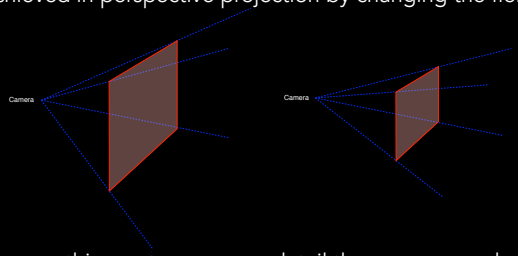
- Need to be careful with imaging effects that affect neighbouring pixels. For example, colour changes generally don’t, but operations like sharpening do. Remember these images wrap horizontally so pixels to the right of the right edge are actually on the left edge.
- Compositing also needs to occur across the wrapping zone.

## Rectilinear elements

- Straight lines are no longer straight.
- Cannot simply overlay text or gui elements.

## Zooming

- There is no such thing as a zoom.
  Zoom is achieved in perspective projection by changing the field of view.




- To magnify something or to see more detail the camera needs to move closer towards it.
- Actually it is the notion of zoom in traditional film that is the strange case, our eyes cannot zoom in real life. So when one creates displays that are closer to the way we see the real world, we lose some of the artificial devices … like zooming.

## The future

- The future of 360 video is largely about quality, quality of the capture and quality of the presentation.
- Monoscopic has a chance, stereoscopic is still very problematic.
- I claim "*If this medium is to survive it needs to deliver experiences that do not cause physical stress*".
- This is one of the reasons why stereo3D televisions are not in more widespread use, the hardware and content more often than not provided a negative physical experience.
- It's not just can you see artefacts, you may not consciously notice them through clever post production, but they will still stress the human visual system.

## Questions and demonstrations