

# 360 video

Paul Bourke

Presentation slides here  
<http://paulbourke.net/ecu360/>

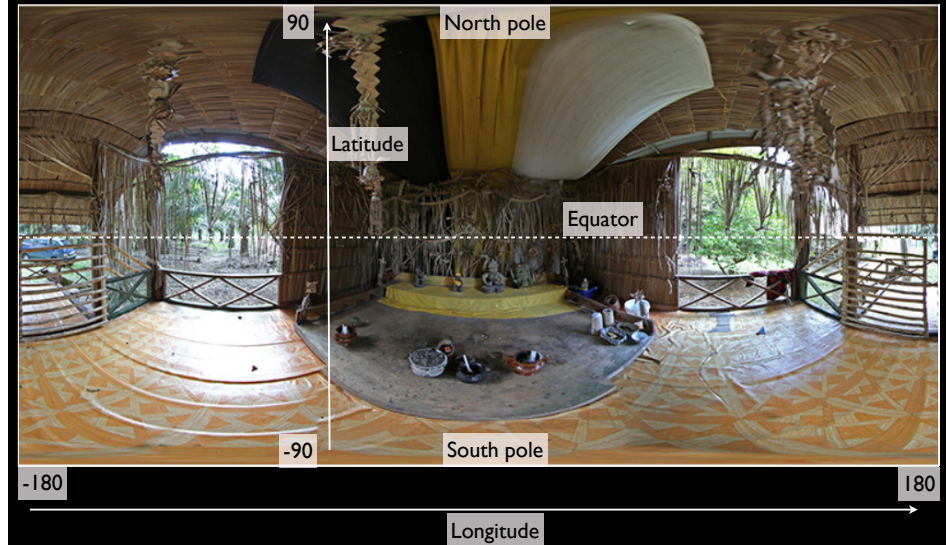
Mah Meri



Spherical panorama (equirectangular projection)



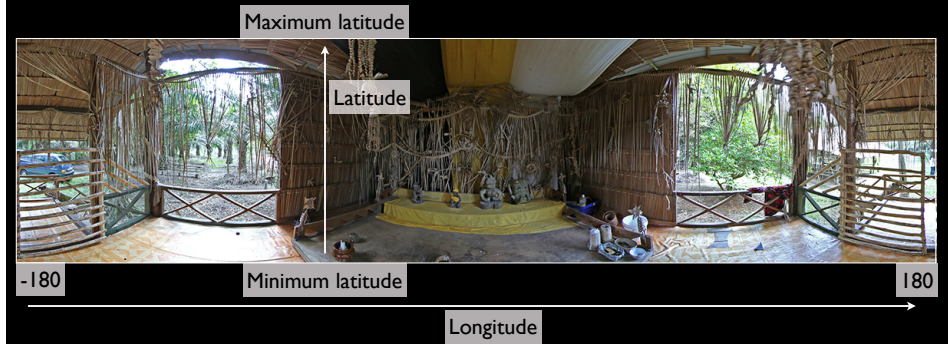
Spherical panorama (equirectangular projection)



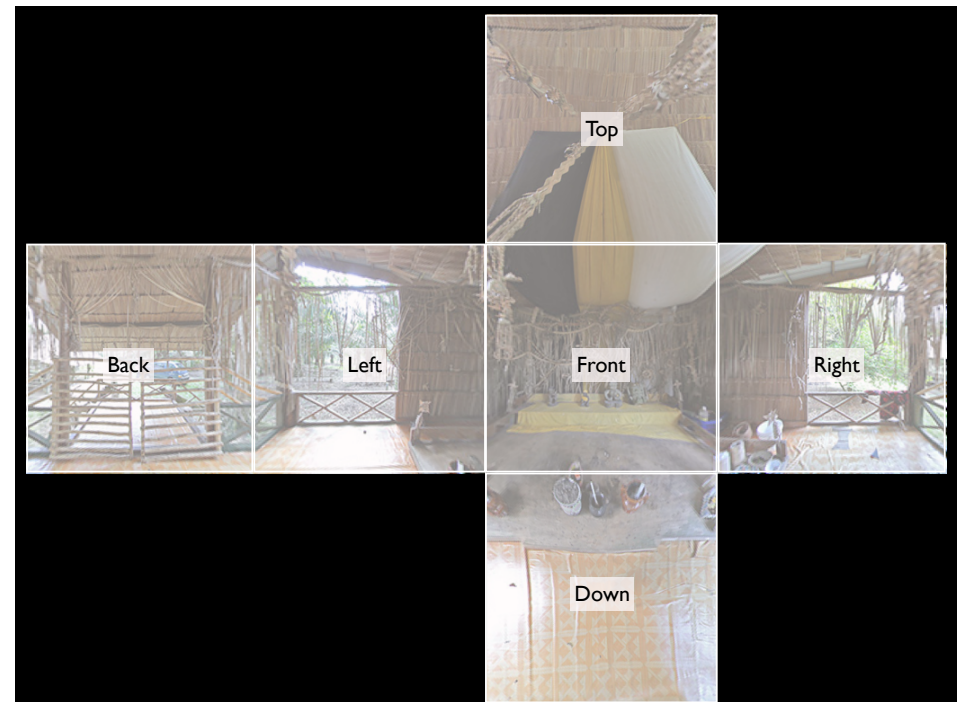
Cylindrical panorama



Cylindrical panorama

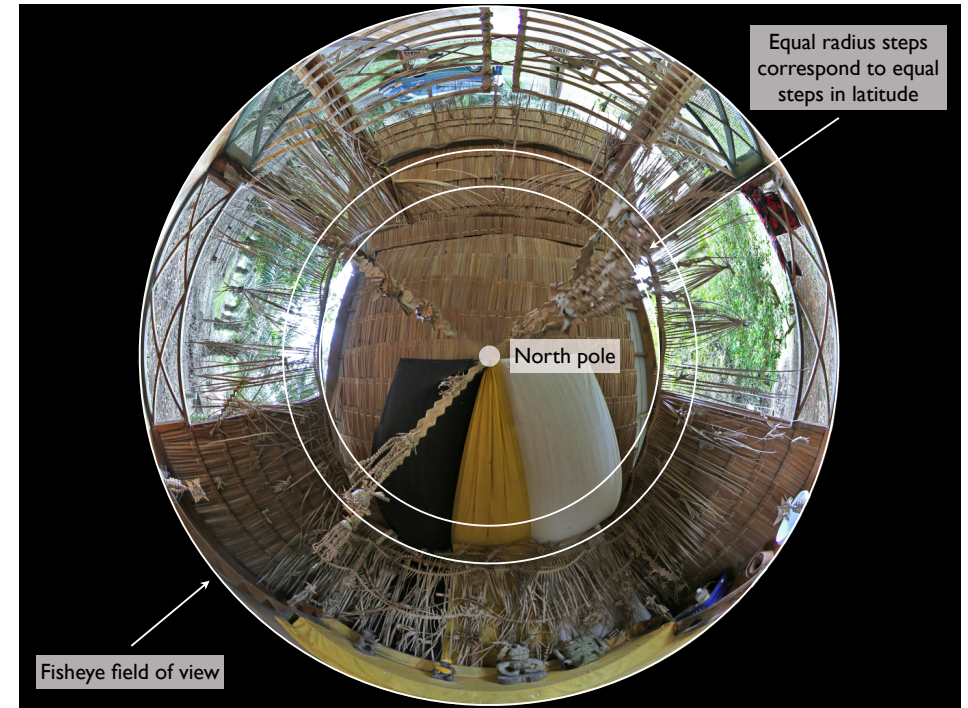


Cube maps





Fisheye



Wide angle perspective views inadequate









## Contents

- Tell you a story, introduce projections likely to be encountered.
- Examples of surround video recordings I've been involved in.
- 360 video, why it's hard. Why are there no perfect solutions.
- Stereoscopic panorama images and video, ODSP.
- Presentation of 360 video
  - Standard computer display, eg: YouTube, Vimeo
  - iDome
  - HMD, eg: Gear VR, Oculus, HTC Vive
- Post production challenges
- LadyBug-3 exercise



Sydney harbour bridge



iCinema



Volker Kuchelmeister  
iCinema



LadyBug-3



LadyBug-5





Borusan Group  
Place Turkiye, Sarah Kenderine and Jeffrey Shaw



Endeavour replica entering Perth



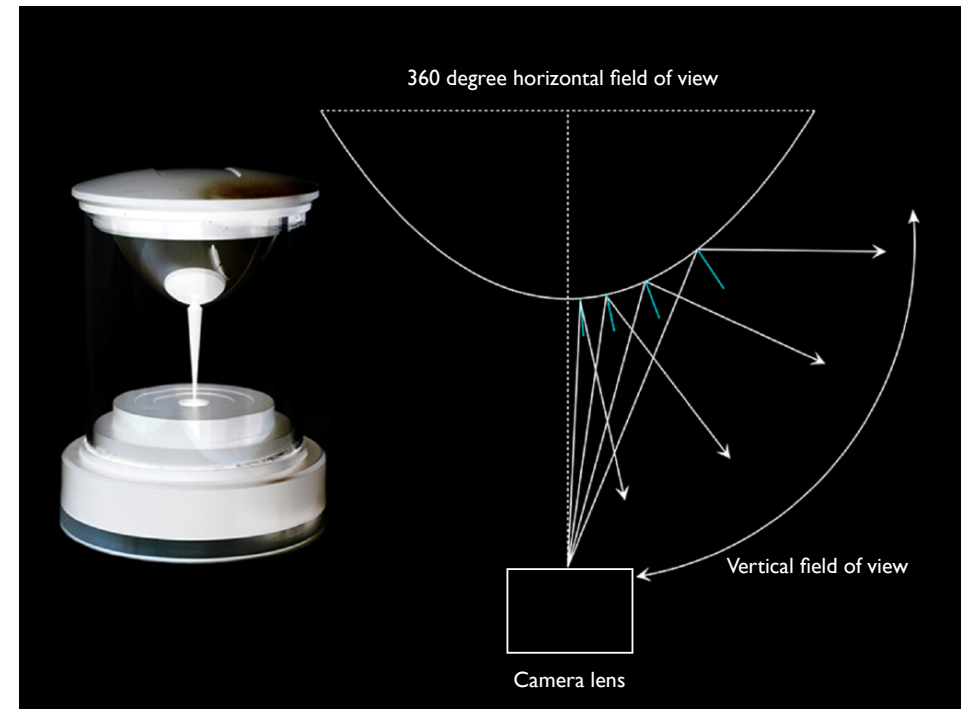
Veterinary course, CityU



## Why is it hard?

- Simplest is a single camera and mirror or wide fisheye.
- Next simplest is a twin fisheye. Processing example with Homido camera.
- Multiple (3,4,5,6 ...) cameras with wide angle lenses.
  - Controllable machine vision cameras
  - Commodity independent cameras

The fundamental problem: issue of parallax!





## 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

However there are 8k sensors being released!



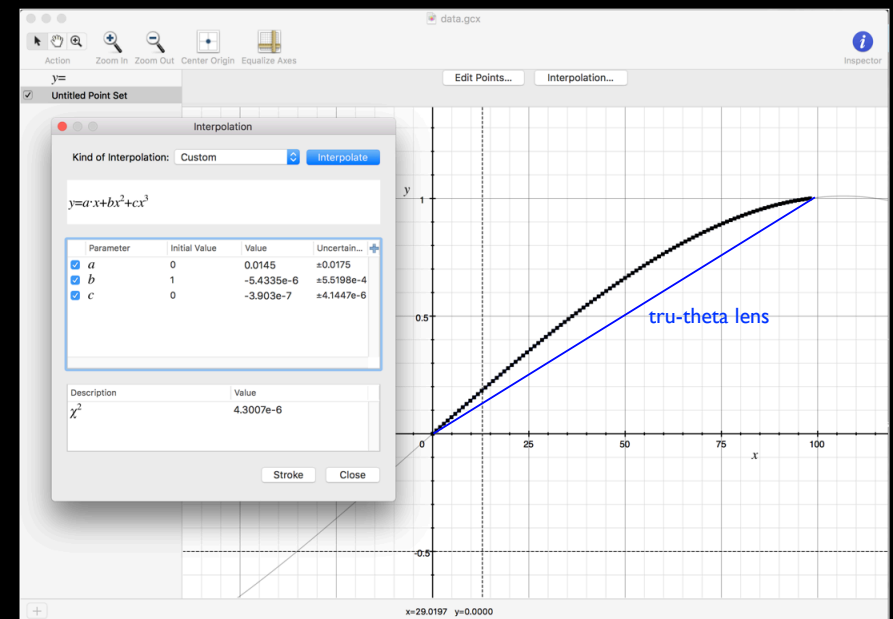
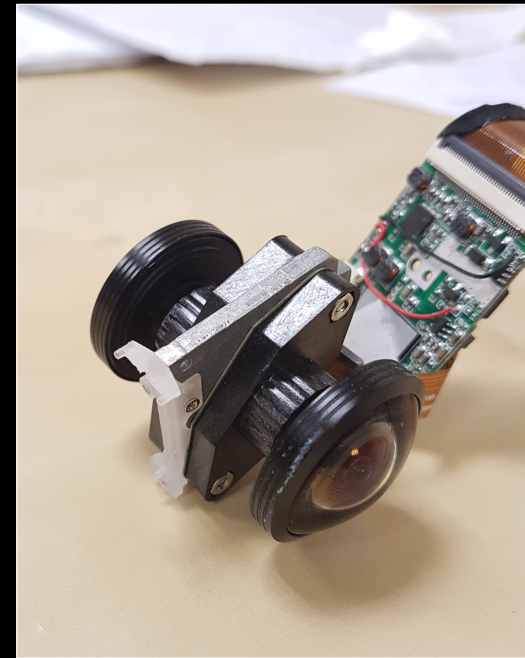
Ximea

## Dual camera rigs





# Homido workflow

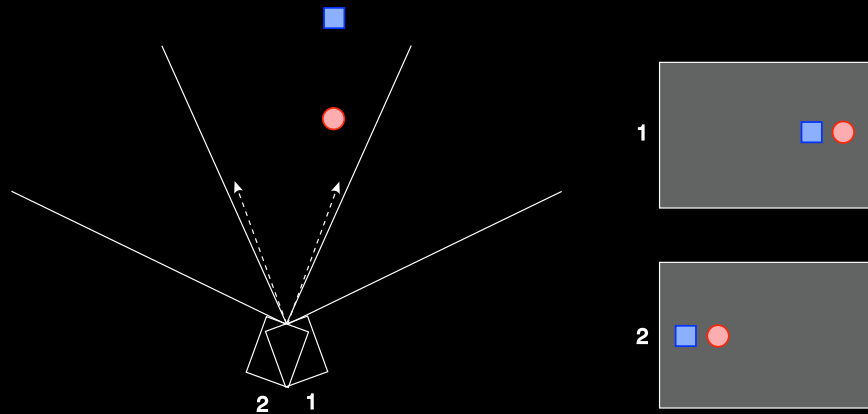
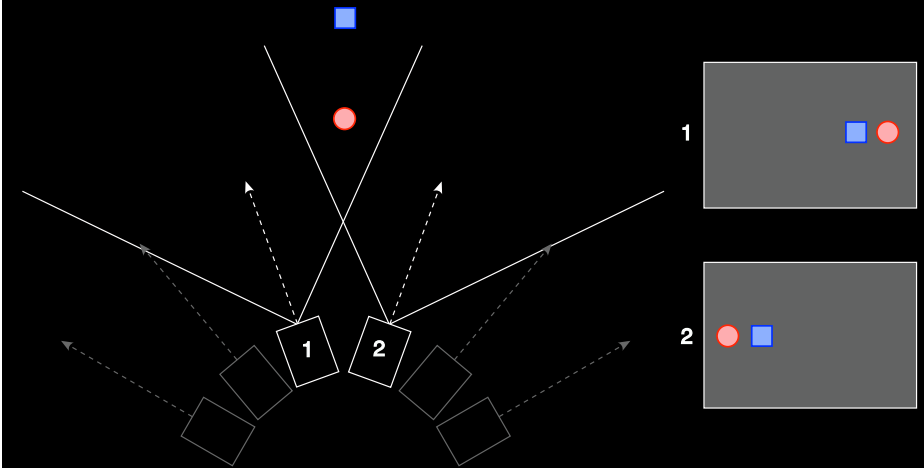








## The fundamental issue: parallax error



*A perfect stitch/blend is impossible.*

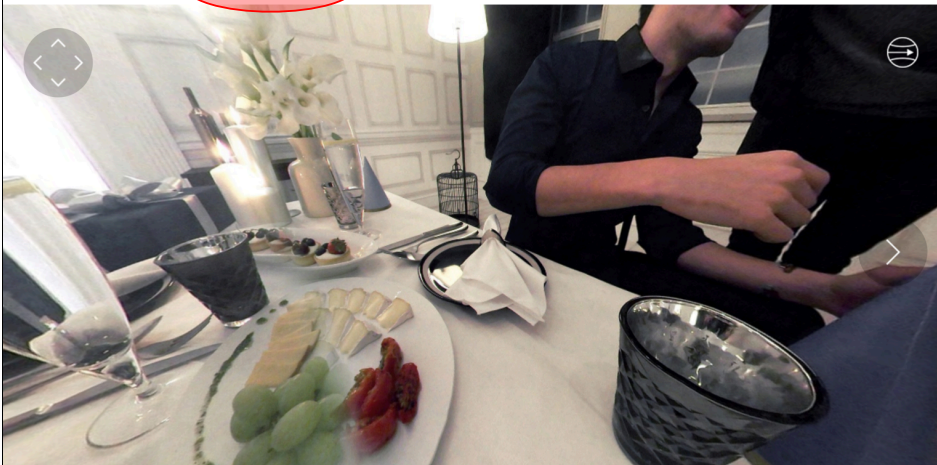
*No amount of cleverness can solve this.*

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



# The world through dual lens

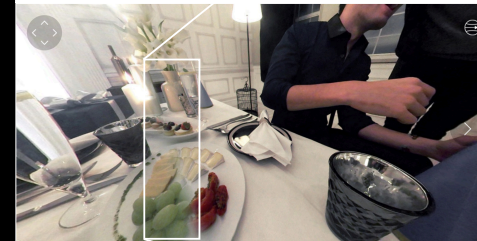
The front and rear lenses each capture 180 degrees horizontally and vertically, creating a seamless and complete 360-degree field of view.



<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.

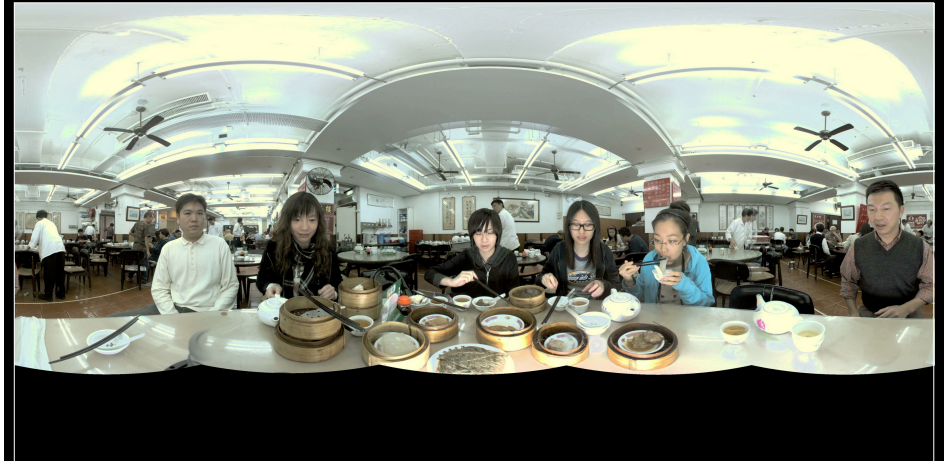




Corroboree, PixelCase Group

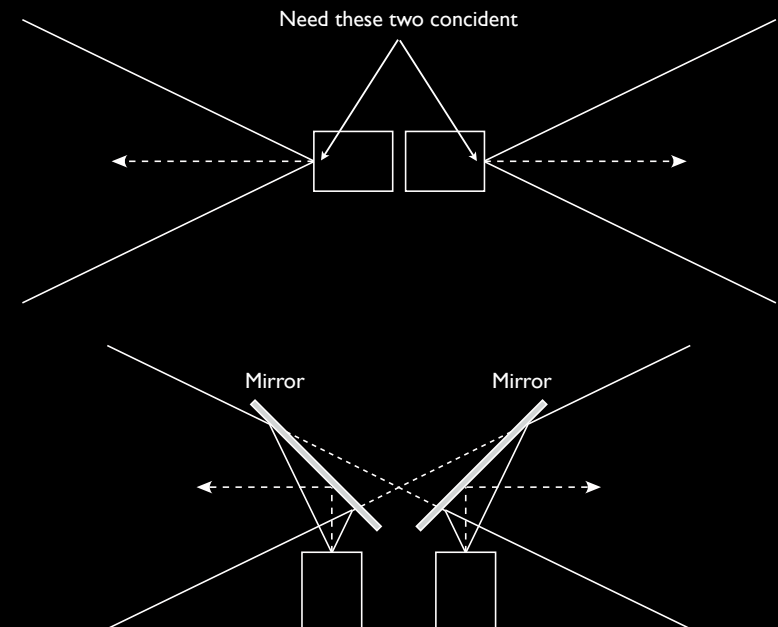


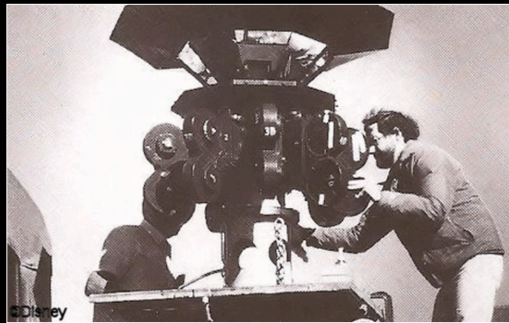
CityU, Hong Kong



*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)



(12) **United States Patent**  
**Masuda et al.**

(54) **IMAGING SYSTEM AND IMAGING OPTICAL SYSTEM**

(75) Inventors: **Kensuke Masuda**, Kawasaki (JP); **Noriyuki Terao**, Sendai (JP); **Yoshiaki Irino**, Kawasaki (JP); **Tomonori Tanaka**, Yokohama (JP); **Nozomi Imae**, Yokohama (JP); **Toru Harada**, Yokohama (JP); **Hirokazu Takenaka**, Kawasaki (JP); **Hideaki Yamamoto**, Yokohama (JP); **Satoshi Sawaguchi**, Yokohama (JP); **Hiroyuki Satoh**, Kawasaki (JP)

(73) Assignee: **RICOH COMPANY, LTD.**, Tokyo (JP)

(10) **Patent No.:** **US 9,201,222 B2**

(45) **Date of Patent:** **Dec. 1, 2015**

USPC ..... 348/36, 335; 359/725  
See application file for complete search history.

(56) **References Cited**

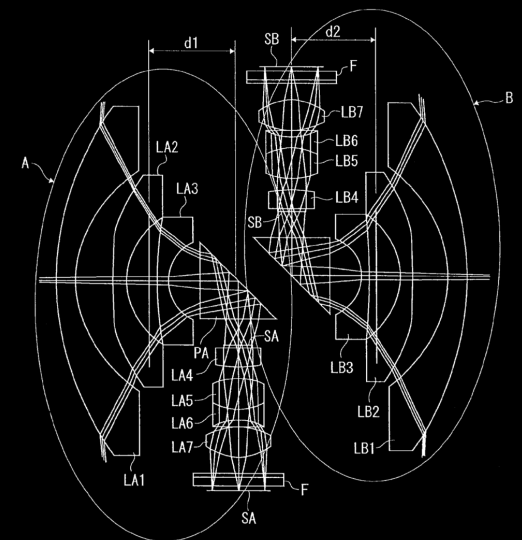
**U.S. PATENT DOCUMENTS**

3,283,653 A 11/1966 Tokarzewski  
7,154,551 B2 \* 12/2006 Kuriyama et al. .... 348/335  
(Continued)

**FOREIGN PATENT DOCUMENTS**

JP 2006-098942 4/2006  
JP 2007-164079 6/2007  
(Continued)

FIG. 1







## Stereoscopic panorama



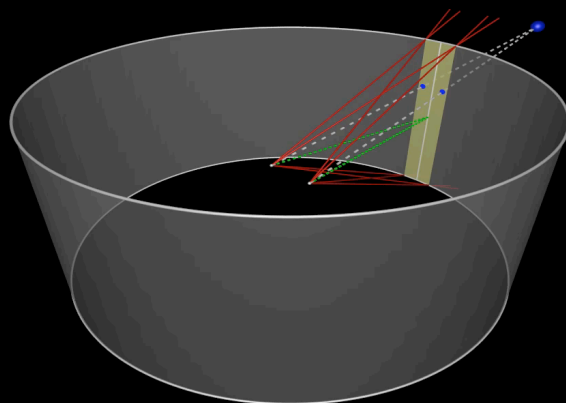
Peter Murphy  
Ankor Wat

Left eye



Right eye

## ODSP: Omnidirectional stereoscopic panorama



*But as with pretty much everything  
in optics and photography,  
it has all been done before.*



Barker's London panorama of 1792

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



Left eye



Right eye

Hampi, Sarah Kenderdine



Left eye



Right eye

Türkiye, Sarah Kenderdine



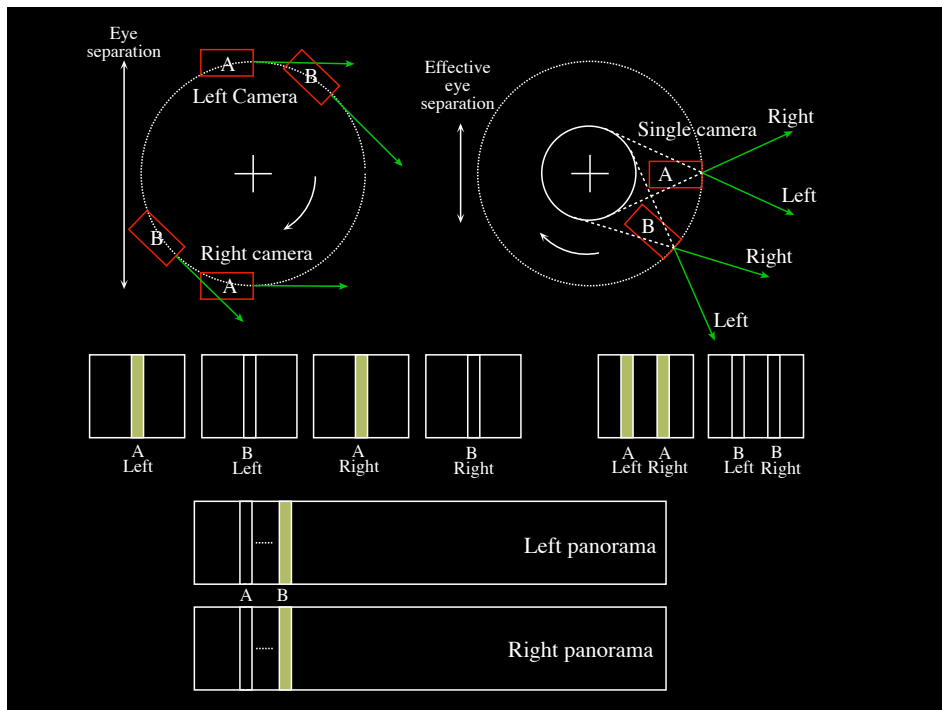
Left eye

Place Hampi



Left eye





Red Scarlet on Seitz rig



Sony (point and click) on Syrp rig



Left eye



Right eye

## Simplest stereo video rig



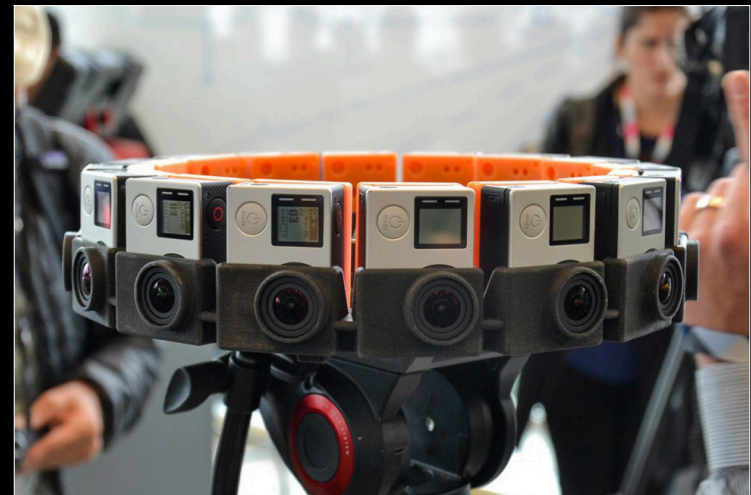
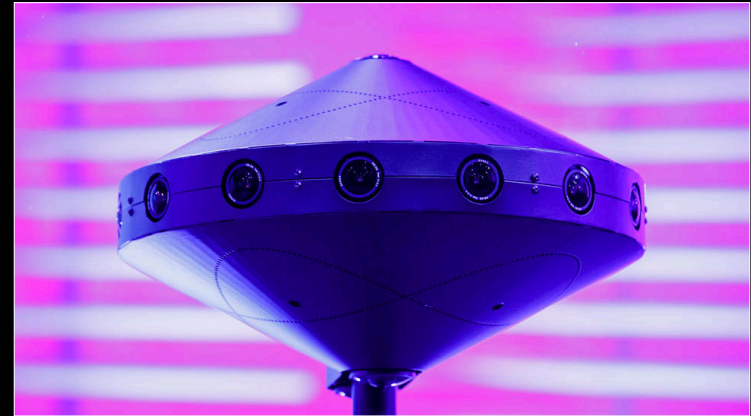
Still to be announced



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



Facebook 360







VokeVR

Home / Camcorders / VR & 360 Video / [360 Video Cameras](#) / JAUNT J1-24G


## Jaunt One - Includes 1-Camera Body - Jaunt One 24G Lens Cap

B&H # JAJ124G • MFR # J1-24G

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## 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!



Camera pairs side by side



Camera pairs top and bottom

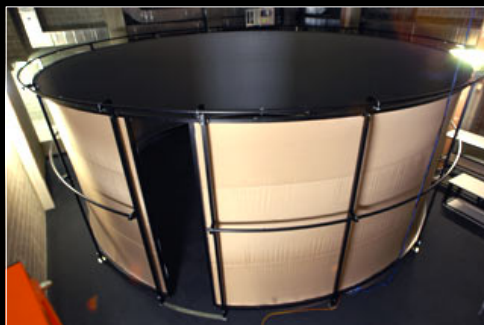
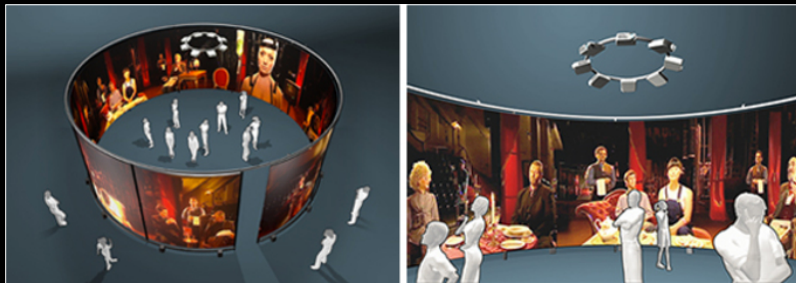
## The immediate future requirements

- The future of 360 video is largely about quality, quality of the capture and quality of the presentation.
- 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.

## Presentation: Computer display

- Large scale immersive environments.
- There are stand-alone 360 video viewers.
- YouTube introduced 360 video over a year ago.
- Vimeo added support just recently.

### AVIE (Applied Visualisation Immersive Environment)

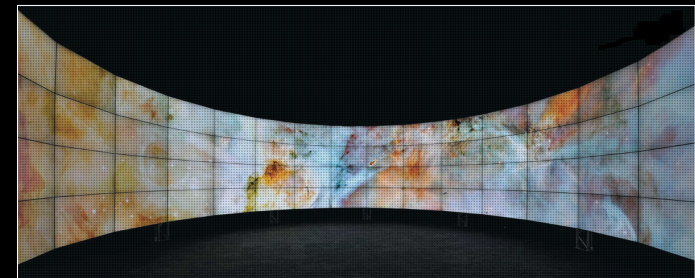


iCinema, UNSW

### CAVE-2



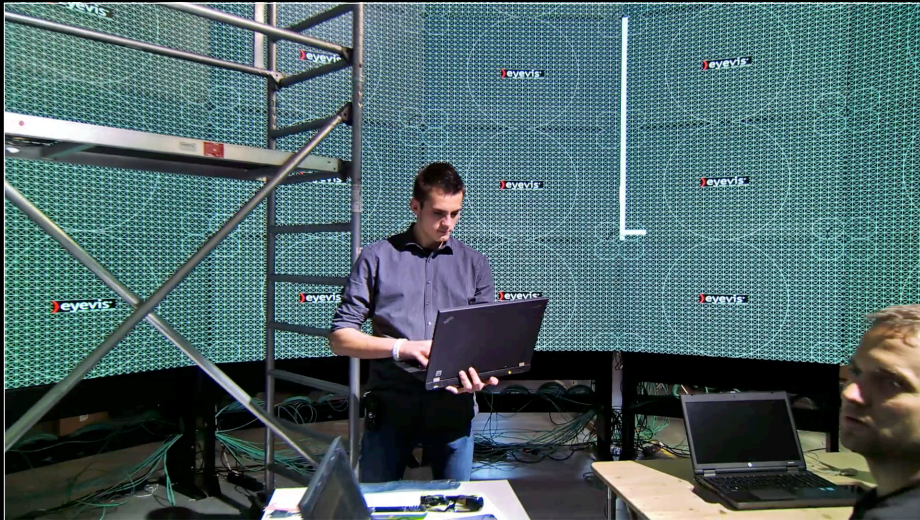
Monash



University of the Sunshine Coast



## EPICylinder



EPICentre - Enhanced Perception and Interaction Centre, UNSW

## Presentation: YouTube, Vimeo

- Unless you are recording with a couple of commercial devices that add the right EXIF data, you need to inject the EXIF data into your final 360 video. This ensures YouTube and Vimeo “knows” it is a 360 video.
- “Spatial Media Metadata Injector” (Mac and Windows)

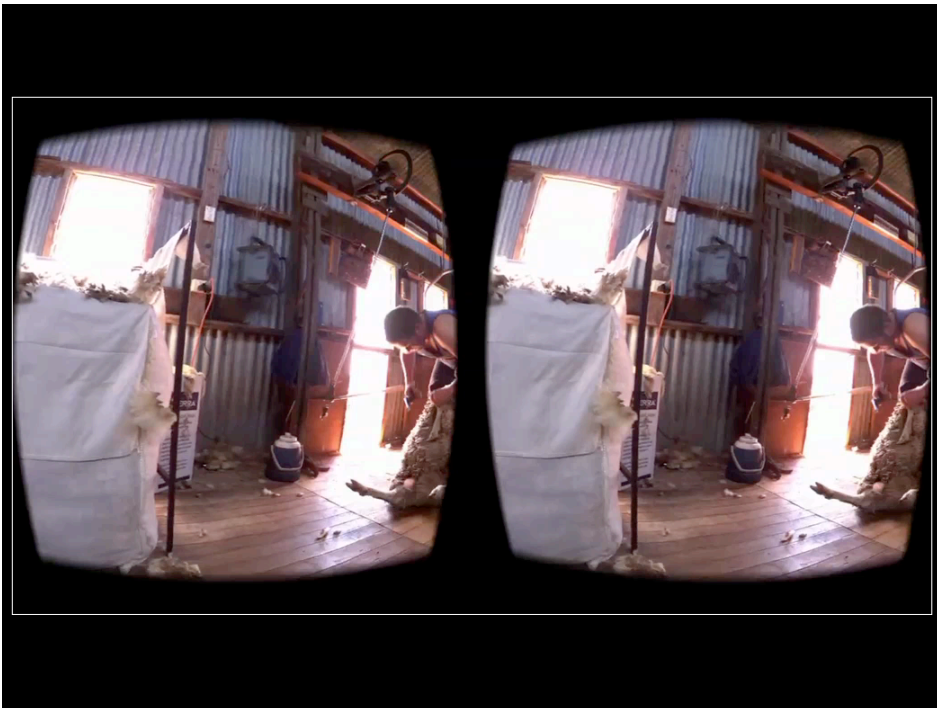


## Presentation: iDome

- The iDome is a locally developed “product”.
- There are a couple of bespoke 360 video players, based upon QuartzComposer or Vuo.
- Extracts a fisheye from the spherical projection.
- Warps that fisheye to compensate for the distortions introduced by the optics of the iDome projection system.
- Usually based upon standard QuickTime movies but other movie containers can be used.

## Presentation: HMD

- A plethora of apps available to play 360 video on head mounted displays.
- Most prefer to be based upon mp4.
- For mobile style devices (eg: GearVR) the challenge is playing 4K or 8K video.
- Still some “magic” with data rates for different devices.
- For tethered devices connected to a computer it is easier, (eg: VIVE).



## Post Production Challenges

- 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 doing support that.



2:1 aspect ratio

- 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.
- Currently I am not aware of compositing tools that “know” about circularly wrapping images.





- Straight lines are no longer straight.
- Currently I am not aware of compositing tools that operate in equirectangular space except for “fulldome” plugin from Navitar.



- Similarly, one cannot simply composite in and move rectangularly shaped objects as one can in a normal perspective frame.
- It took a few years for the stereoscopic editing tools to catch up with the recording technologies, same thing happening here.



Questions?

LadyBug, iDome, GearVR demonstration