

# Displays and immersion.

Paul Bourke

iVEC @ The University of Western Australia



# Introduction

- Immersion, “being there” ... around the extent to which one feels like one is really within an imperfectly mediated world (Mimetic Immersion).
- Werner Wolf describes immersion as :“... a feeling, with variable intensity, of being imaginatively and emotionally immersed in a represented world and of experiencing this world in a way similar (but not identical) to real life”.
- The focus for data visualisation is often around the extent to the digital delivery engages/ leverages the human visual system, and other senses.
- In the case of vision this is relates to:
  - stereopsis (depth perception arising from images from two positions, our eyes)
  - peripheral vision (for humans about 170 degrees by 120 degrees)
  - fidelity (spatial and temporal resolution)
- How do we rate the degree to which a display can support immersion?

# Visualisation laboratory, UWA

- Displays of different types, how to rate them? None are perfect.
- Can do this qualitatively (user surveys) but would be helpful to have a quantitative basis.

4K

iDome



Tiled display

Multiple high resolution panels

Stereo head tracked panels

# Plenoptic function: Light field

- Plenoptic: (optics) Of or relating to all the light, travelling in every direction in a given space.
- The “light field” is the infinity of 3D points through which innumerable light rays diverge and converge.
- The part of the light field we observe (in one eye) are the two spherical images located at the position of our eyes.
- The plenoptic function is a 7 dimensional function of position: (3 variables), polar angle (2 variables), wavelength and time.

$$L(x, y, z, \theta, \phi, \lambda, t) = i$$



Converging rays arriving at any single point of the light field can be imagined as a spherical image of the world seen from that single position.

# Requirements







- An ideal immersive display needs to represent this light field intensity “i”





$$L(x, y, z, \theta, \phi, \lambda, t) = i$$

- Any (current) display is only an approximation of the light field, display artefacts include:

Display artefact	Display Feature	Limitation of L()
Frame	Limited field of view	$\theta, \phi$
Pixels	Resolution	$\theta, \phi$
False colour	Colour gamut	$\lambda$
Colour banding	Colour depth	$\lambda, i$
Low contrast / brightness	Dynamic range	$i$
Noise	Signal to noise	$i$
Lag	Latency	$t$
Refresh rate / flicker / jitter	Frame rate	$t$

# Case 1: 4K desktop display







Light field parameter	Comments	Rating
$x, y, z$	Not stereo3D enabled. No head tracking.	
$\theta, \phi$	Framed view, angular field is limited.	
$\theta, \phi$	High pixel resolution so low angular discretisation	
$\lambda$	Standard display technology capabilities, would be improved by HDR display.	
$t$	Standard display technology of 60Hz	
$i$	Standard display technology capabilities.	

-  Good
-  Not ideal but current state of technology
-  Not ideal and limited by nature of system
-  Poor

# Tiled display



# Tiled display

Light field parameter	Comments	Rating
$x, y, z$	Not stereo3D enabled. No head tracking.	
$\theta, \phi$	Wider field of view by standing closer, still framed.	
$\theta, \phi$	High pixel resolution so low angular discretisation	
$\lambda$	Standard display technology colour capabilities.	
$t$	Standard display technology of 60Hz	
$i$	Standard display technology capabilities.	









# iDome

- 180 degree field of view, single person dome.



# iDome








Light field parameter	Comments	Rating
$x, y, z$	Not stereo3D enabled. No head tracking.	
$\theta, \phi$	Largely removes framing of human visual field.	
$\theta, \phi$	Most common variation has modest resolution, so high angular discretisation.	
$\lambda$	Standard projector colour specifications.	
$t$	Standard for projector, 60Hz	
$i$	Standard for projector but degraded by interreflections and imperfect optics.	

# Oculus Rift

- One of a number of low cost head mounted displays on the market.



# Oculus Rift

Light field parameter	Comments	Rating
$x, y, z$	Stereo support, position and view direction tracking.	
$\theta, \phi$	Entire human visual field not engaged.	
$\theta, \phi$	Low resolution, so high angular discretisation.	
$\lambda$	Standard projector colour specifications.	
$t$	Standard for panels.	
$t$	Poor head tracking latency.	
$i$	Standard for panels.	

# Stereo3D tiled display



# Stereo3D tiled display

Light field parameter	Comments	Rating
$x, y, z$	Stereo support and position tracking.	■
$\theta, \phi$	Significant portion of the human visual field engaged when close.	■
$\theta, \phi$	High resolution so low angular discretisation.	■
$\lambda$	Better colour than standard panels.	■
$t$	Standard for panels of 60Hz.	■
$t$	Head tracking latency. Stereo refresh of 30Hz	■
$i$	Standard for panels.	■

# Conclusion and future work

- Have introduced a formal method for rating display technologies by the extent that they represent the plenoptic function.
- This relates specifically to how they might support mimetic immersion (mimicking the real world) and maximise visualisation processes by leveraging the characteristics of the human visual system.
- User studies of immersion and visualisation experience can be compared to determine the relative importance of the parameters in the plenoptic function.