Engaging visual environments

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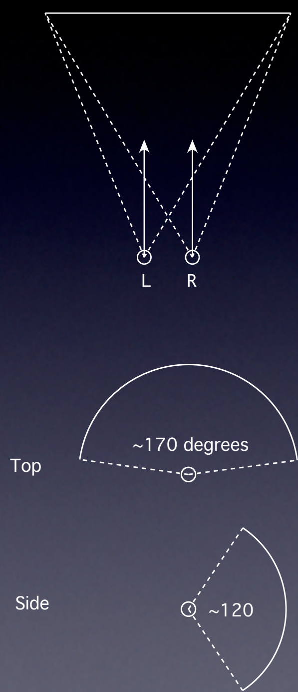
Human visual system

- Stereopsis: we have two eyes and each gets a slightly different view of the world. Most computer displays, like a photograph or painting, present each eye with the same image.
- Peripheral vision: almost 180 degrees horizontally and 120 degrees vertically. Most computer displays occupy as little as 20-30 degrees horizontally and vertically.
- Visual acuity: resolution and high dynamic range. Woefully inadequate dynamic range of existing display technology, also suffering from the legacy of using 1 byte per R,G,B per pixel.
- Will concentrate today on domes that engage our peripheral vision.



Stereoscopy - brief summary

- Irrespective of the technology, the fundamental requirement is that two correctly formed images (stereo pairs) are presented independently to each eye.
- Presentation technology
  - Anaglyph (red/blue): poor colour reproduction.
  - HMD: generally low resolution.
  - Polaroid: lowest cost, simplest, highest resolution, full colour stereo. (See demo)
  - Infitec: characterised by very low ghosting levels.
  - Shutter glasses: older technology, not common today.
  - Various autostereoscopic solutions: generally low resolution.
  - Holograms: only capable of displaying single images.
- Content creation
  - Realtime interactive generation well understood, generally OpenGL.
  - Still image capture straightforward.
  - Video capture still challenging, at least for stress free viewing.

Why bother?

- Assists with visualisation problems, especially those involving geometrically complicated structures or large data volumes.
- Allows one to get inside the dataset, something often difficult with stereoscopic projection.
- Provides an engaging environment for public outreach and education.
- Provides training benefits for exercises where depth perception is considered important.

Sydney Observatory

Sports training

Peripheral vision

- Contributes strongly to our sense of "presence", of "being there".
- Often gives a strong sense of 3D even though there isn't a stereo pair.
- Interesting that for gaming (and other activities engaged within virtual worlds) it can be argued that peripheral vision can givea higher gaming advantage compared to stereoscopy.
- Well established in the planetarium industry.
- Traditionally difficult to enage peripheral vision without a high capital expenditure.
- Many installations require head tracking and thus are inherently single person experiences.

Inflatable domes, David Carson & Paul Bourke

Upright dome, WASP

Projection options

- Multiple projectors: edge blending between projected images, multiple computers (genlocked). Horizon - The Planetarium as an example with 6 CRT projectors. Both expensive and usually unsuitable for smaller scale domes due to space requirements.
- With a single projector the goal is to scatter light across a wide angle.

  This is accomplished in two ways:
  - Fisheye lens
  - Spherical mirror (My invention)

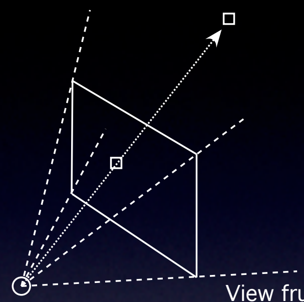
  Main difference between the above two options relates to the positioning of the hardware and the cost.

Elumenati

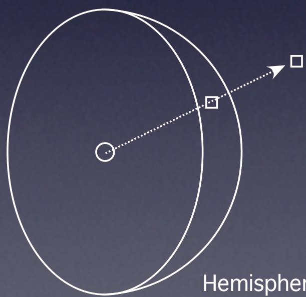
e-Planetarium

What is projected?

- Traditionally software that presents us with a view of a 3D world creates a perspective projection.
- This cannot create the visual field required for a wide field of view display, whether it is a cylinder or a sphere.
  - For a cylinder one creates panoramic projections.
  - For a sphere we need to create fisheye projections.

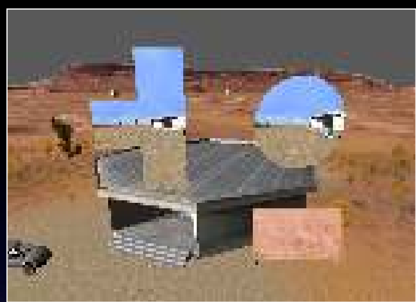

View frustum

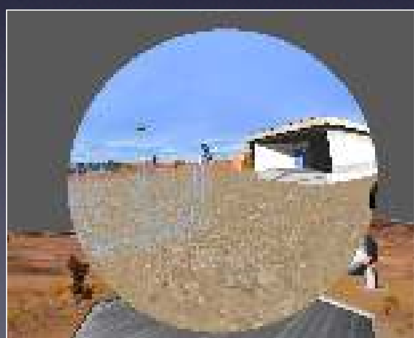
Dawn of the Space Age
Robin Sip, Mirage 3D


Hemispherical
Fisheye

Realtime generation

- OpenGL (or Direct3D) only support orthographic and perspective projections!
- Multipass cubic maps.
  - each field of view is 90 degrees vertically and horizontally.
  - "only" need 4 passes to reconstruct a fisheye.
- Vertex shader.
  - Shift all vertices so that when rendered with a orthographic projection the result is the same as if a fisheye projection.
  - While this is perhaps more elegant there are issues.
  - Primarily, a straight line in a normal perspective projection is formed by forming points in a straight line between the endpoint vertices. This is not the case for a fisheye projection, the lines between two vertices is not straight.
  - The solution is to tessellate lines and polygons, resulting in more geometry being sent to the card.

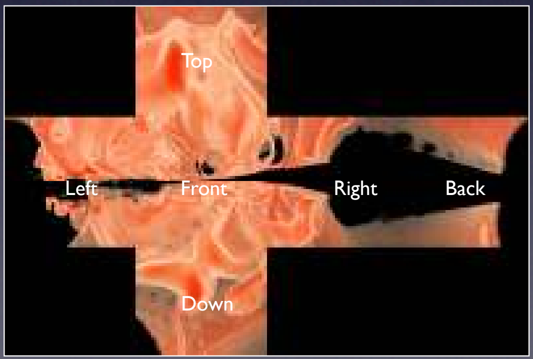

Example from Unity: 4 cameras in the scene each render to a texture. These 4 textures are applied to 4 meshs each with texture coordinates designed especially to create the required fisheye.



CG generation

- Render directly to fisheye.
  Most packages now either have a fisheye camera explicitly defined or there are fisheye lens plugins.
- Render to cubic maps and post process to fisheye.

Venus



Volumetric dataset, lizards head (Tim Senden, rendered with Drishti)

Still image capture

- Multiple photos and stitch to fisheye or spherical projection.
  Capable of extremely high resolution images.
  Only suitable for scenes with no movement.
- Single camera and fisheye lens.

Nikon D300 and 185 degree fisheye lens, 2800x2800 pixels

Video capture

- Still very challenging.
- Main problem is obtaining sufficient resolution.
  eg: A good digital planetarium "expects" fisheye images at least 3000x3000 pixels per frame and 30 frames per second.
- Multiple camera rigs are capable of high resolution but suffer from parallax errors.

Canon progressive HD camera and fisheye lens

iCinema, UNSW

Ladybug cameras

- 6 cameras, images stitched together to form 360 x 150 degree spherical projection.
- 15 to 30 fps.

Ladybug2

Ladybug3

Future projects

- Higher resolution, multiprojector iDome.
- High resolution tiled display, 5120 x 6400 pixels (33 MPixel display).
- Stereoscopic iDome.