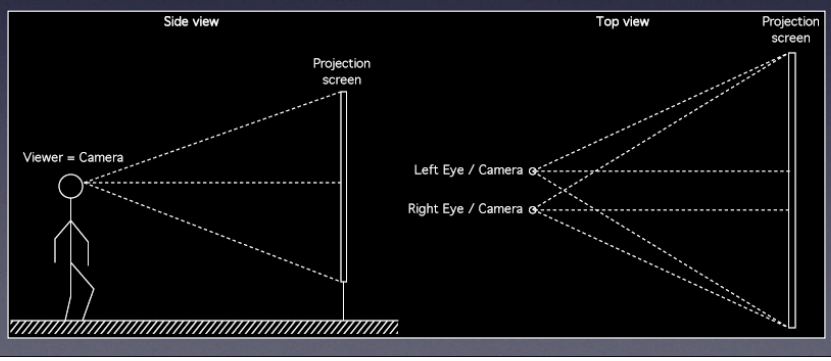
Omni-directional stereoscopy

Paul Bourke
(WASP, UWA)

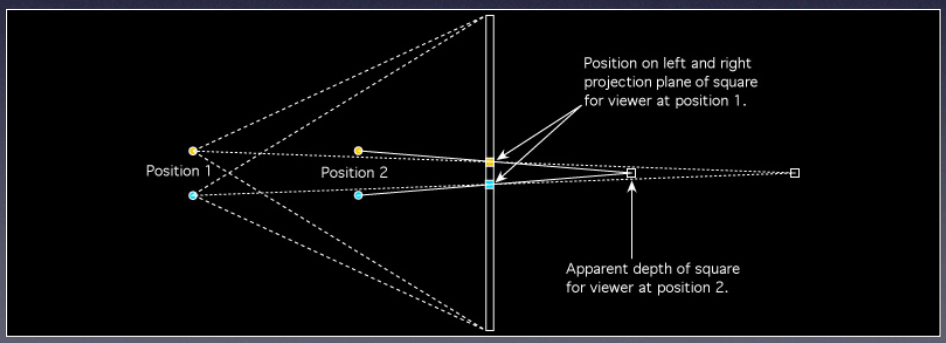
Motivation

- Correct stereoscopic views require a matching relationship between viewing geometry and rendering geometry. That is, viewer position/relationship to the display is identical to the virtual cameras position/relationship to the projection plane.
- Implications that apply to both flat and surround screen environments.
  - Correct depth and scale relationships only correct for a single viewing position, and hence single viewer.
  - For a non-stationary viewer, head tracking is required to maintain the correct frustums.
- To what extent can these be relaxed for surround stereoscopic projection environments, those intended for an audience.



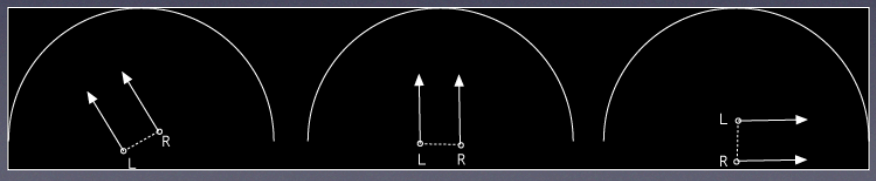
Example illustrating depth distortion

- In a non-head tracked environment it is easy to experience the distortions by moving left/right and forward/backward.
- Forward/back results in compression/dilation of space.
  Side to side movement results in shearing of space.
- Easy to see why this occurs. Consider the square on the far right in the below image and its projection onto the left and right projection plane. For a different viewer position the apparent depth of the cube changes.
  => Movement forward and backward results in a compression and stretching of space.



Example illustrating multiple observers

- A similar but more serious problem occurs for stereoscopic environments that surround a number of observers or even a single user.
- For a flat display the multiple observers receive increasingly distorted views as their distance from the correct spot increases. In a surround stereoscopic projection space they can receive a totally incorrect view, with zero or inverted stereoscopic image pairs.
- For example, in a cylindrical stereoscopic display an observer looking "forward" needs to receive totally different parallax information compared to an observer looking to the right.
- There can only be one image on the display so how can multiple observers be supported?
- Even a single observer needs different stereo pairs as they look in different directions, even though they may not move.



Question?

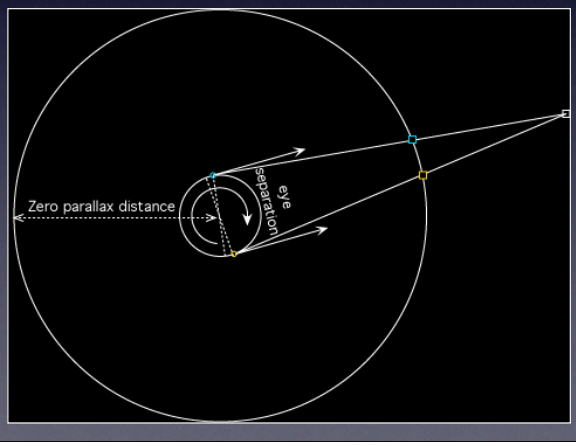
- Can one present strictly correct stereoscopic content to a number of observers within a large surround projection environment without distortion? Answer: no!
- Can one present stereoscopic content to a number of observers within either a large surround projection environment with an acceptable (unnoticed) level of distortion? Answer: yes!
- Will present the following cases that have been either installed or tested.
  1) 10m diameter cylindrical environment, first instance at iCinema, UNSW. This easily supports a dozen participants each optionally looking in different directions.
  2) Hemispherical dome, both large (multiple observers) and small (single person).

AVIE, iCinema, UNSW

iDome, WASP, UWA

Stereoscopic panoramic images

- Capturing stereoscopic panoramic images employs a slit camera pair separated by the inter-ocular distance. The camera pair rotate about their combined center.
- For continuous rendering no stitching errors. For a finite slit width of rendered material or for photography the stitching issues reduce as the slit width reduces. The stitching issues also reduce with distance.
- There are continuous rotating slit cameras, such as the Roundshot, multipass and vertex shader algorithms for OpenGL.

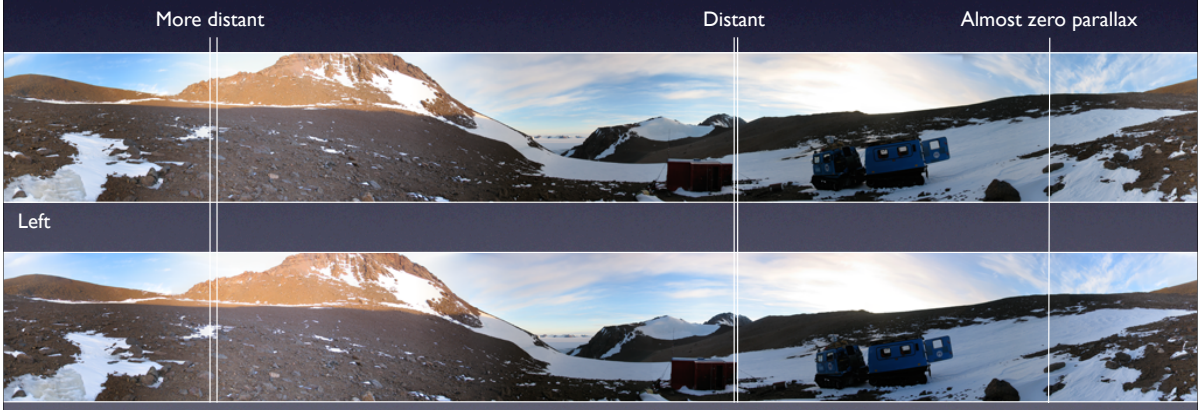


Roundshot camera

Raytraced stereoscopic cylindrical projection created for PovRay
Workflow developed for 3DStudioMax

Results

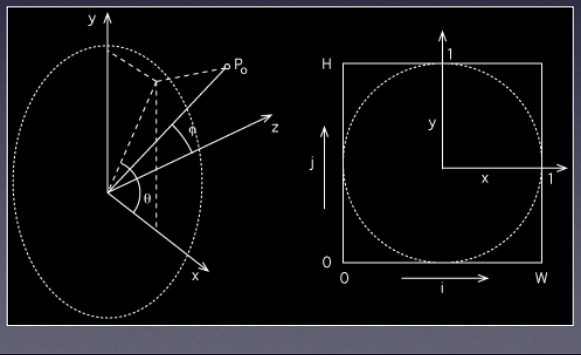
- Within a narrow region directly in front of an observer the stereo pairs are correct.
- As one considers the image left and right from that position the error increases.
- Saved by the limited FOV of the glasses! We don't experience stereo in our peripheral vision.
- Upshot is that multiple observers can be located within the cylinder and all see an acceptable stereo image irrespective of where they are looking.
- The distortions as one moves away from the center of the cylinder still exist but interestingly seem less noticeable compared to the equivalent flat screen shearing effect.

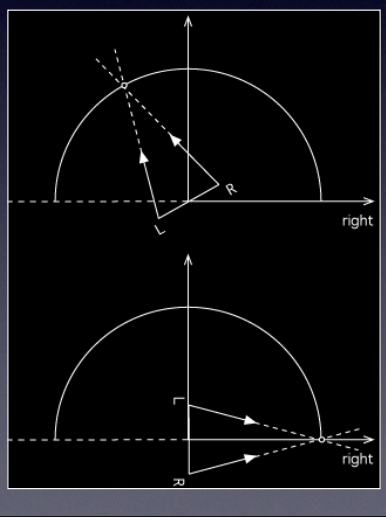


Images courtesy Peter Morse

Stereoscopic fisheye images

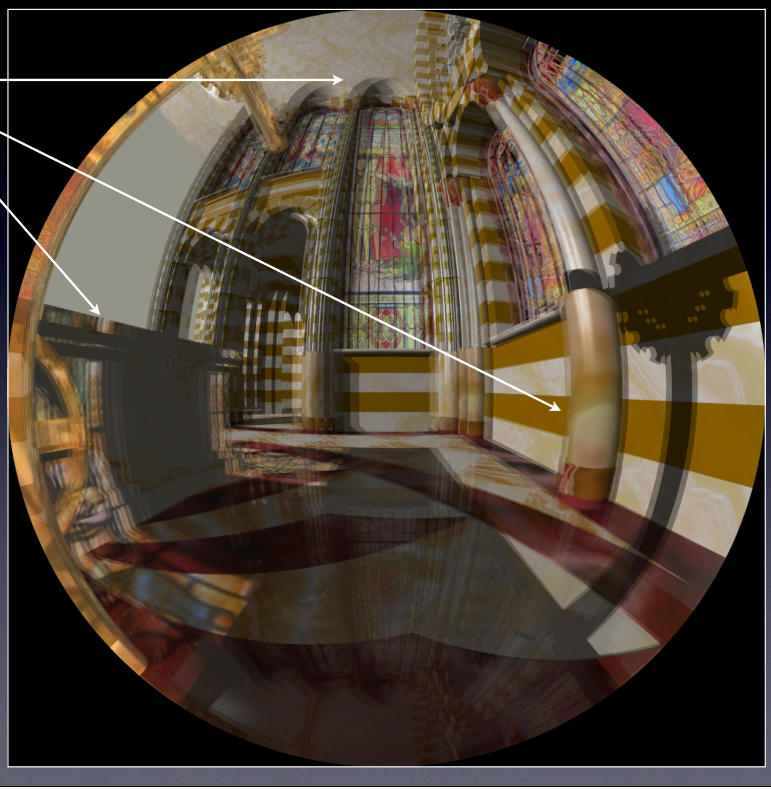
- Cast rays through each pixel (or subpixel) in fisheye space from each eye. Simulate head (and therefore eye) position as one pivots ones head about in the dome.
- Easy in a raytracer to arbitrarily define a initial vector for each point on the fisheye projection plane for each eye.
- Still image pairs can be generated by capturing stereo spherical projections.
- Currently implemented for CG and still photography.
- No clear solution for filmed material.





Example

Consistent parallax
across the fisheye



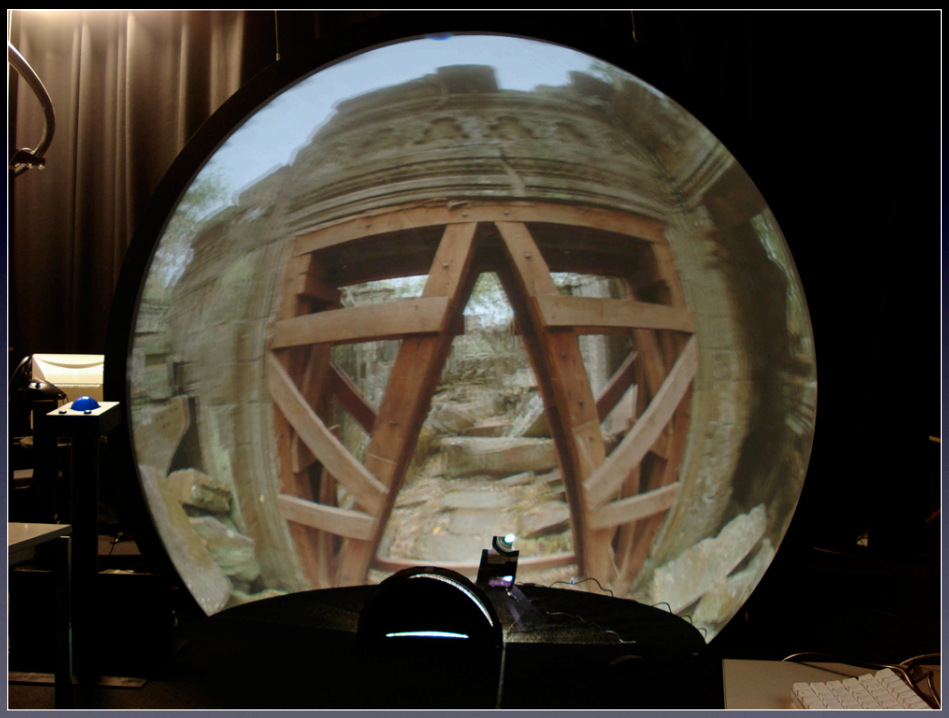
Raytraced with PovRay using
a custom camera type.

Redentore model courtesy
Nathan O'Brien

Example: iDome

Stereo fisheye pairs derived from stereoscopic spherical images by Peter Murphy

Example: iDome



Stereoscopic fisheyes calculated from stereoscopic spherical images, courtesy Sarah Kenderdine.

Concluding remarks

- Cylindrical stereoscopic movies are well established and working at iCinema, as well as other AVIE installations. Includes realtime, photographic, video, and CG content.
- Stereoscopic domes (two at the time of writing) are being deployed by planetarium installers, to-date they are not creating optimal stereosopic fisheye pairs as discussed here, but rather simply parallel fisheye projections with the expected errors as one looks away from the central direction.
- Successful tests have been conducted in the iDome using Christie 120Hz frame doubling stereo-capable DLP projector. (Further tests using anaglyph pairs.) Main problem at the moment is the unsuitability of the currently available lens from Christie.