iDome: Immersive gaming with the Unity3D game engine.

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Introduction

- Our visual system has three characteristics not exploited when viewing a single flat display.
- Stereopsis: Our visual cortex receives two horizontally offset view of the world that are used to give a sense of depth.
- Visual acuity: Resolution of displays is often not as high as our eyes can perceive, more importantly the dynamic range and colour space are lower than images from the world around us.
- Peripheral vision: Our visual field of view is almost 180 degrees horizontally and 120 degrees vertically.
- Many game support stereoscopic viewing. Due to eye strain issues very few players engage in stereoscopic gaming after the initial novelty has worn off. Additionally it can be argued there is very little gaming advantage especially since stereoscopic support in games only gives relative depth perception not true depth.
- Peripheral vision is credited with giving a strong sense of immersion, of being somewhere else. Our peripheral vision is very sensitive to motion detection, evolved for detecting predators and thus a likely gaming advantage.
- The goal here is to fill the players entire visual field with virtual imagery.

iDome

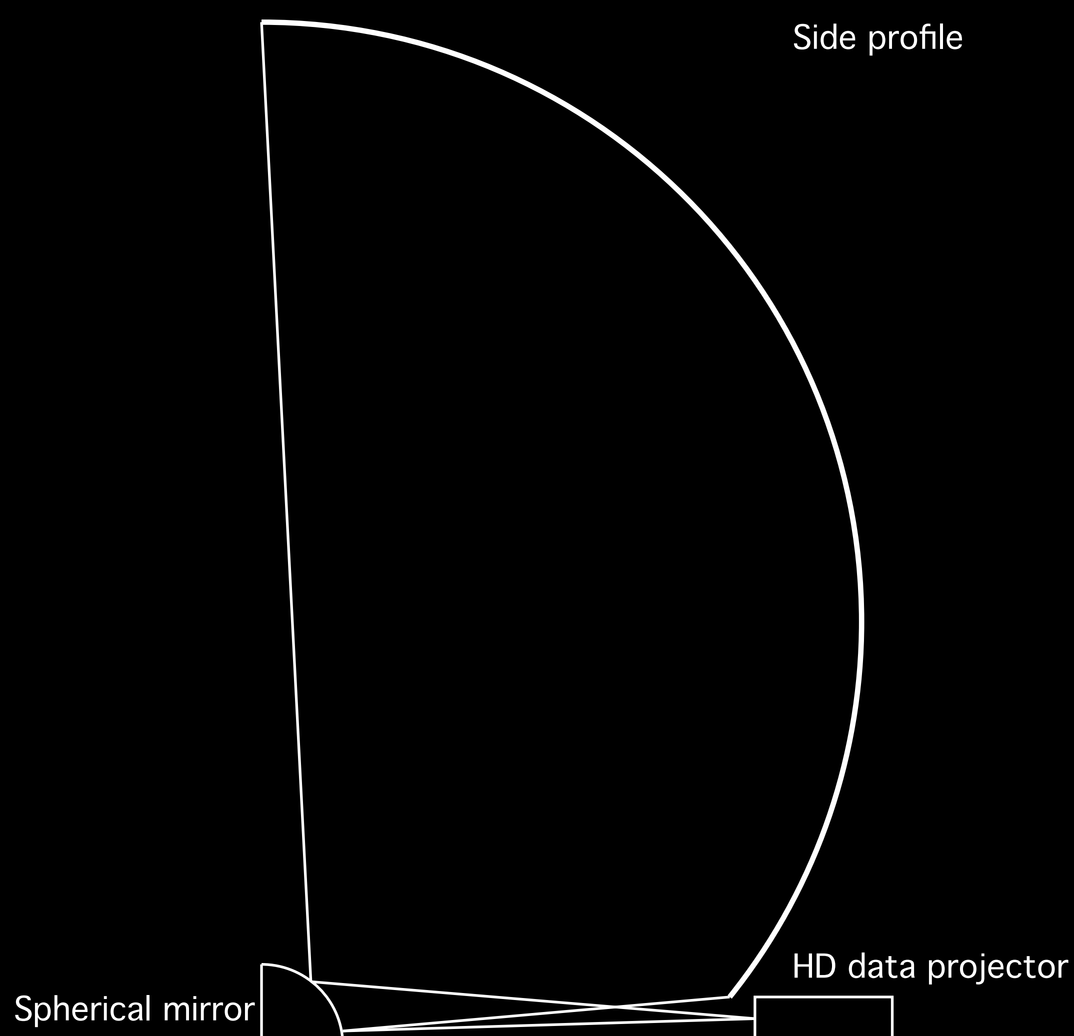
- 3m diameter hemisphere, truncated at the bottom at an angle of 45 degrees.
- Fibre glass construction, in 6 pieces bolted together.
- Attempt to create a seamless surface.
- Designed to be able to fit though standard doors and when assembled fit in a standard stud room.
- Employs a single HD projector and spherical mirror based projection system.

Angkor Wat - Courtesy Sarah Kenderdine

iDome at WASP, University of Western Australia

Projection optics

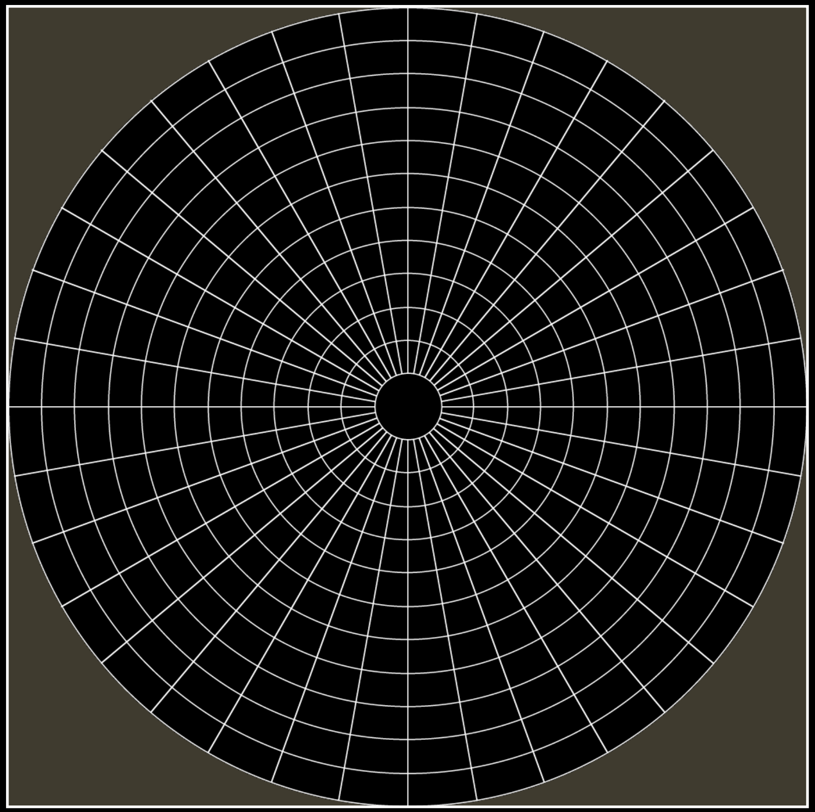
- Traditionally small domes use a fisheye lens as their projection system.
- These are both relatively expensive and occupy the ideal position in the dome for the user, namely the center of sphere from which the hemisphere is cut.
- iDome employs a spherical mirror to scatter light across the surface, opens up the front of the dome and the projection hardware is largely invisble.
- This requires an image warping stage to ensure the image appears natural in the dome.



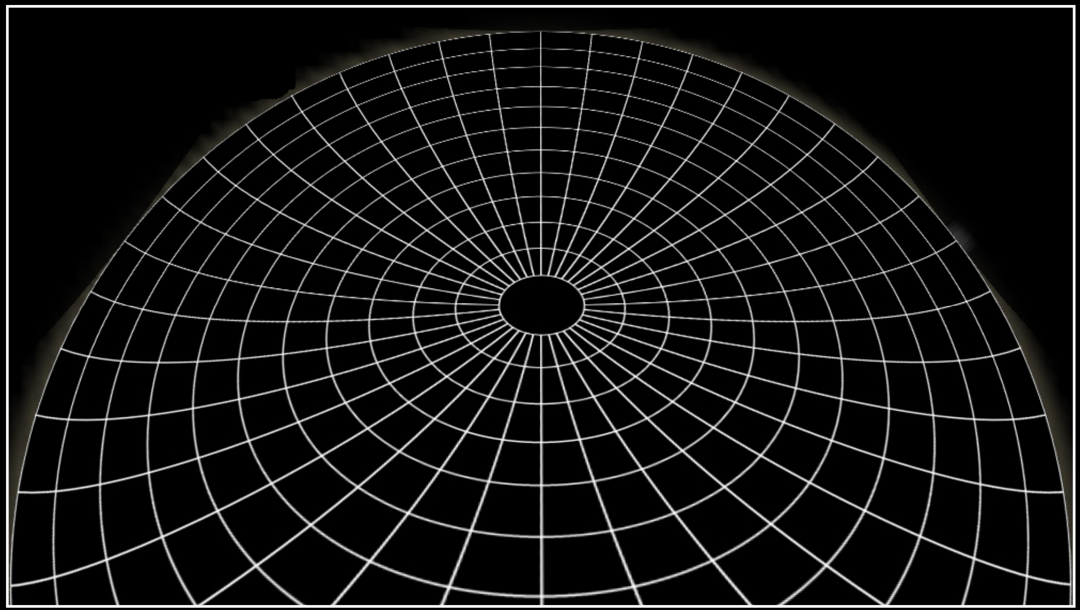
Mawsons hut - Courtesy Peter Morse

Fisheye warping

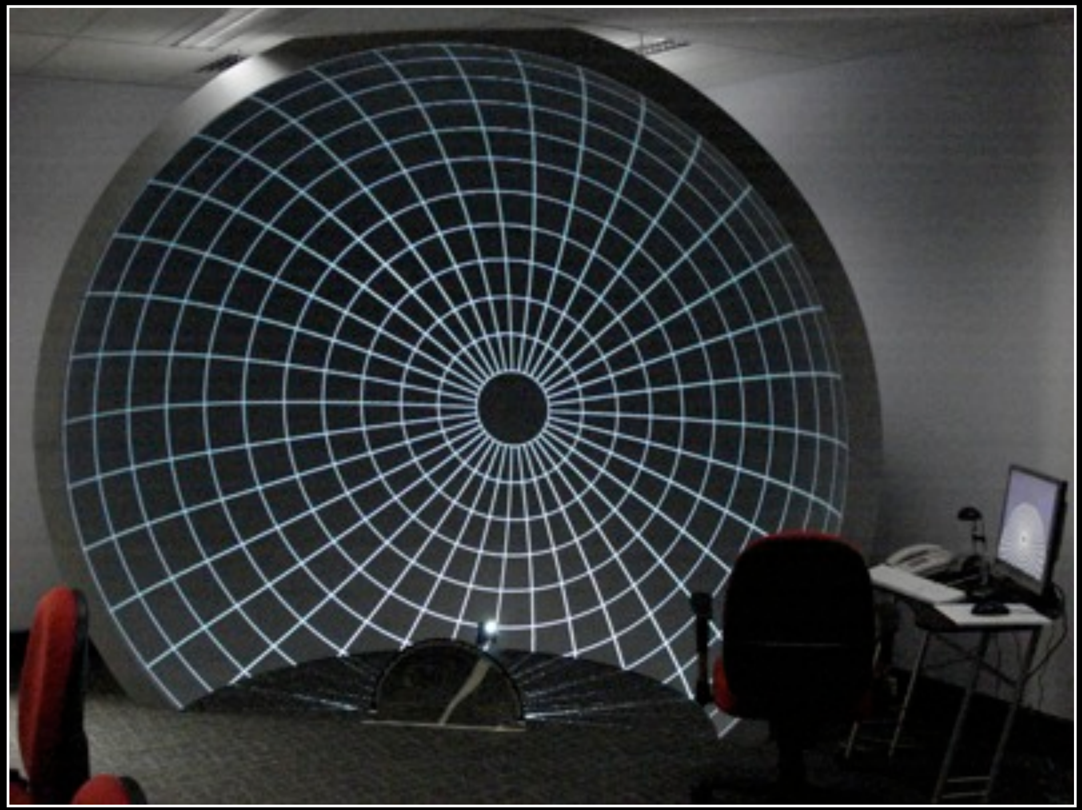
- All content for a hemispherical dome needs to be a fisheye projection. Only that has the visual information required.
- More precisely an “angular fisheye”. Radius in fisheye image plane is proportional to the latitude on the dome surface.
- The fisheye images are applied as a texture to a mesh that distorts it in just the right way so that the result on the dome appears correct.



Fisheye polar grid



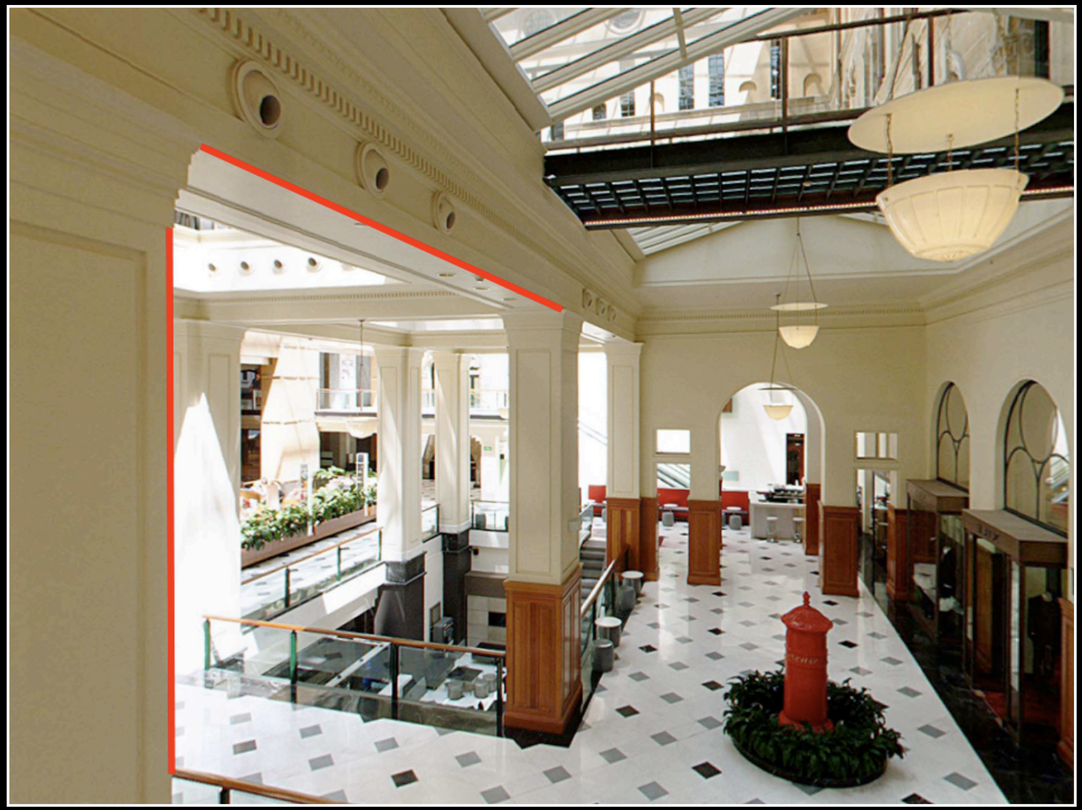
Warped fisheye



Result in iDome

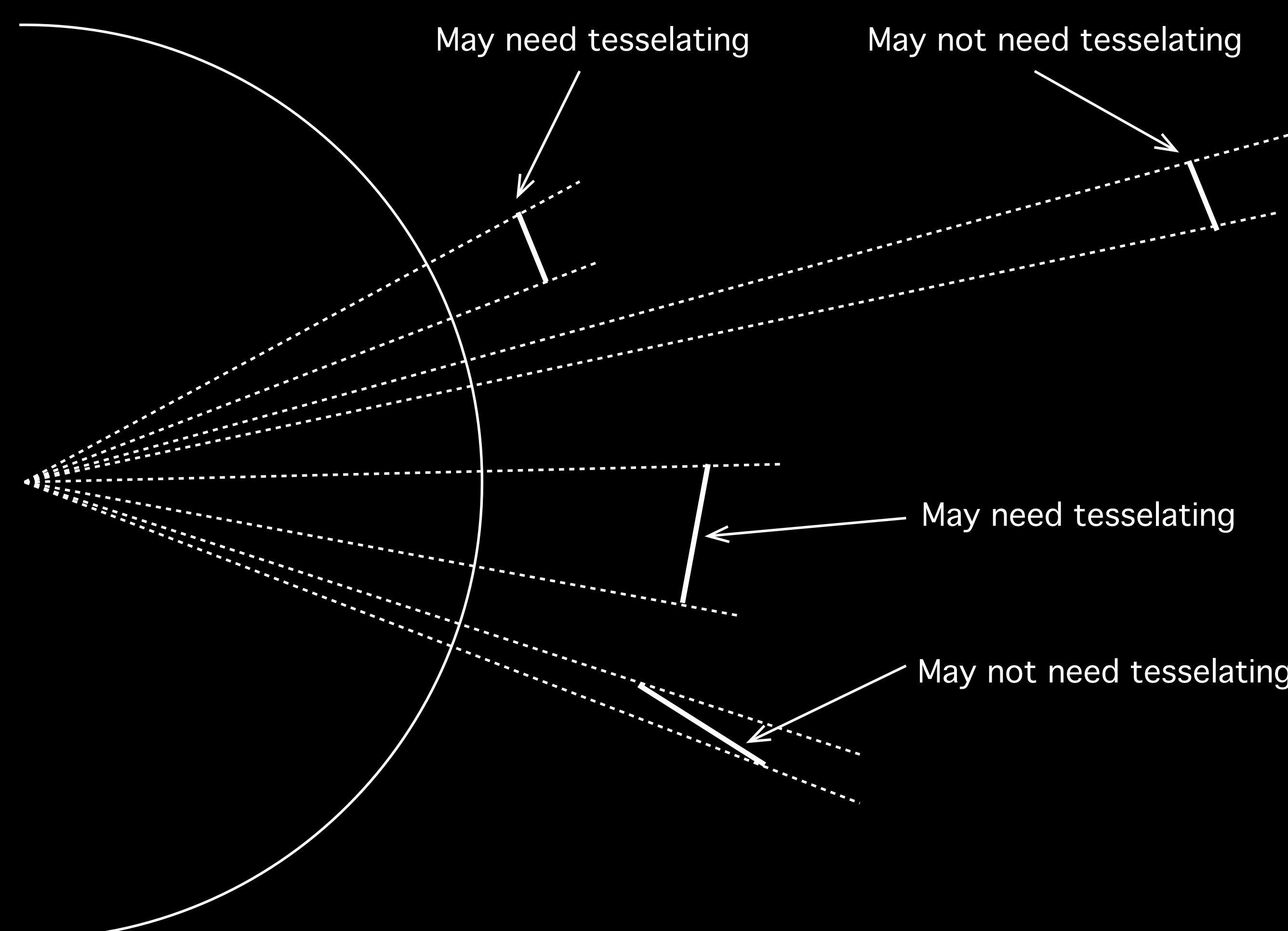
Realtime fisheye generation: Vertex shader

- There are two commonly used approaches for creating fisheye images: vertex shaders and multipass textures.
- Imagine repositioning each vertex in the model such that when the result is viewed with an orthographic camera the result is a fisheye projection.
- Not difficult and the rendering occurs as a single pass. Too good to be true?
- The problem is that a line between two points in a perspective projection is straight. But a line between two points in a fisheye image is not straight. The result is that geometry needs to be tessellated before drawing leading to a higher geometry rendering cost.



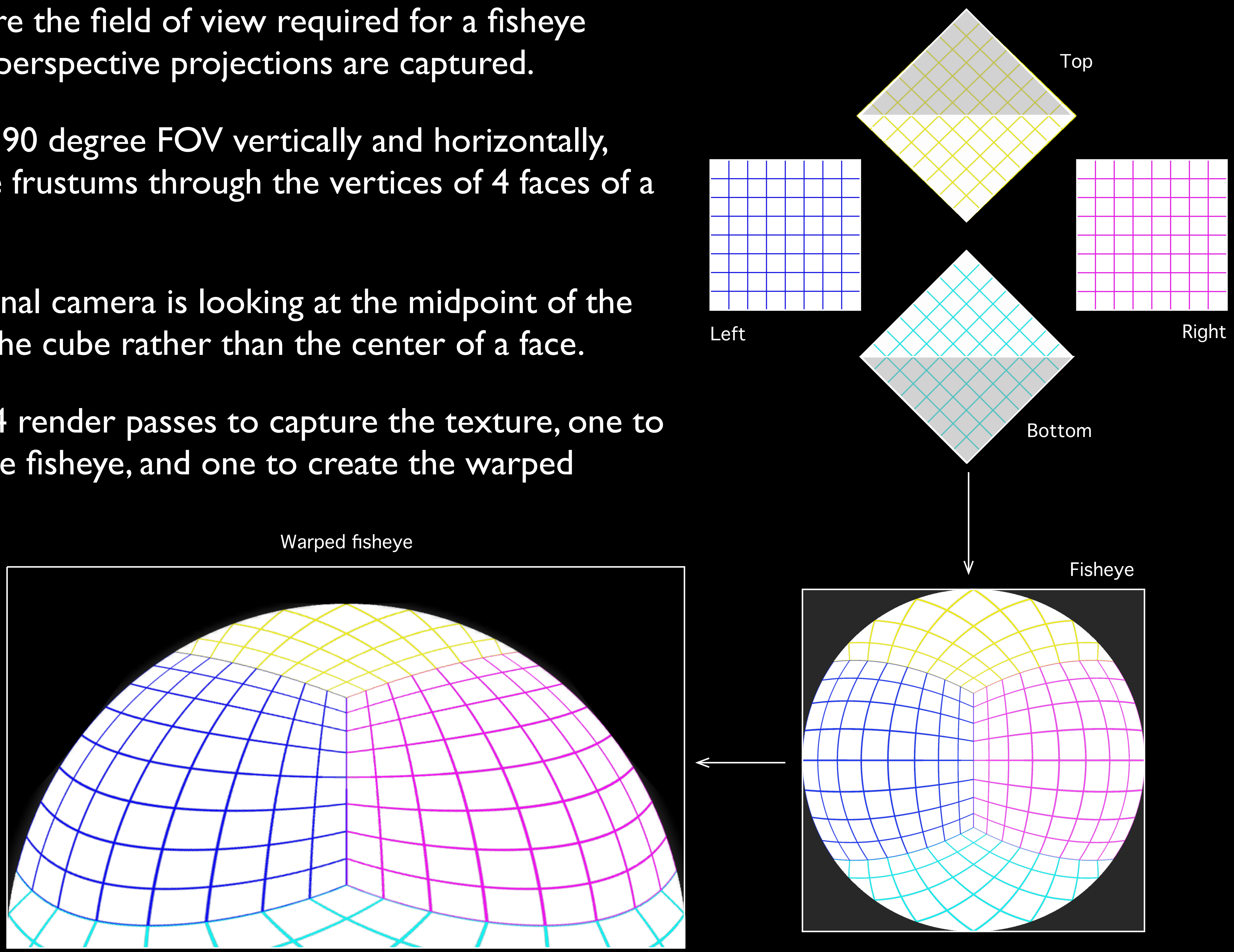
Vertex shader algorithm

- The optimal algorithm for when to tessellate and by how much is not trivial.
- Tessellation depends not only on the dimensions of the geometric primitives but their distance and orientation to the camera.
- For an existing game engine it would seem difficult to generalise and precisely calibrate for different projection arrangements.
- While lines introduce a linear increase in geometric complexity, planes (triangle and quads) introduce a squared increase. Hence the need for an optimal algorithm.



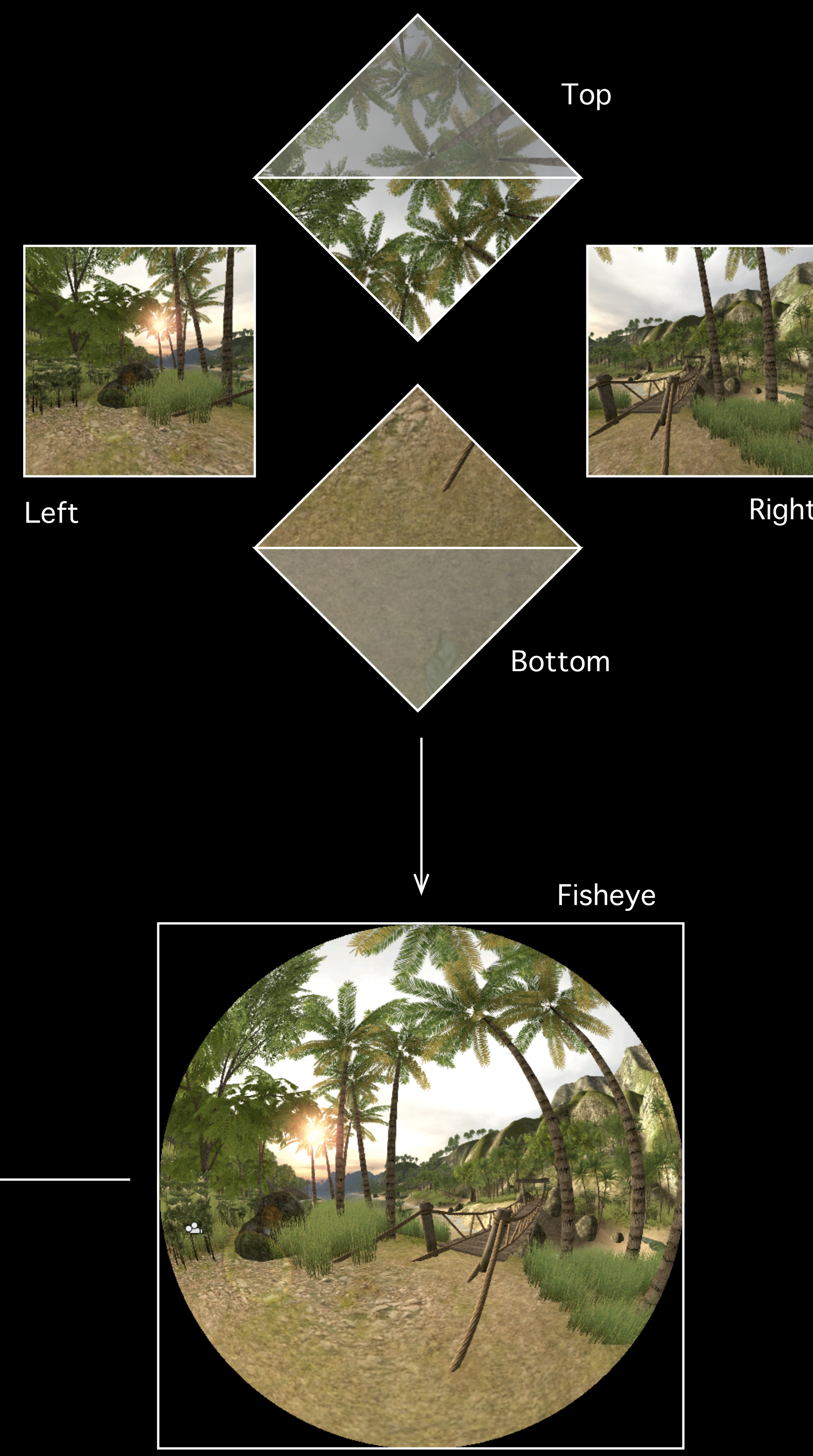
Realtime fisheye generation: Multipass rendering

- To capture the field of view required for a fisheye image, 4 perspective projections are captured.
- Each is a 90 degree FOV vertically and horizontally, these are frustums through the vertices of 4 faces of a cube.
- The original camera is looking at the midpoint of the edge of the cube rather than the center of a face.
- Overall: 4 render passes to capture the texture, one to create the fisheye, and one to create the warped fisheye.

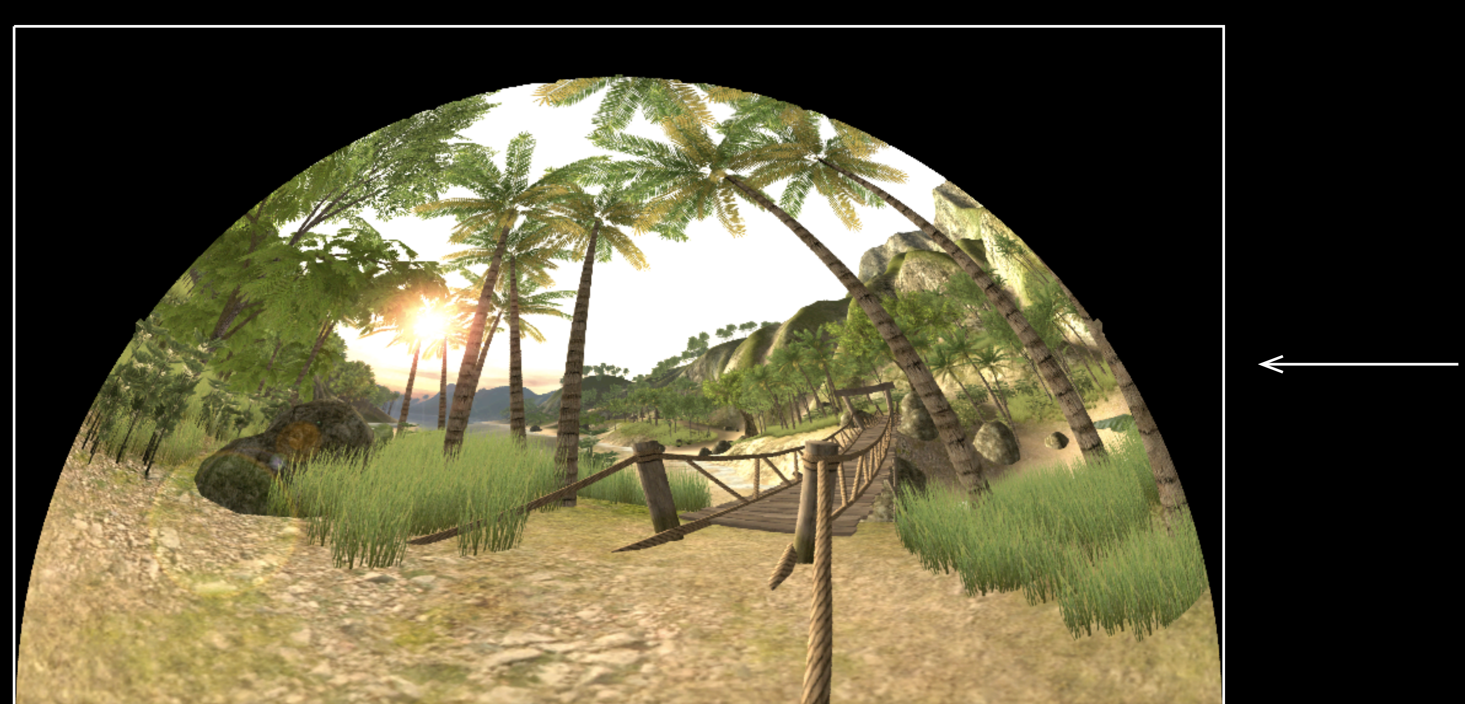


Unity Island Example

- Four initial passes implemented as "render-to-texture", so requires Unity Pro.
- Possible to skip the fisheye step and apply the 4 textures directly to the warped texture mesh but the performance for the texture warping phase is negligible, less than 1 fps. This direct warping has some tricky implications for the design of the required texture meshes.
- Having the fisheye has generality benefits for those with a projector with fisheye lens.

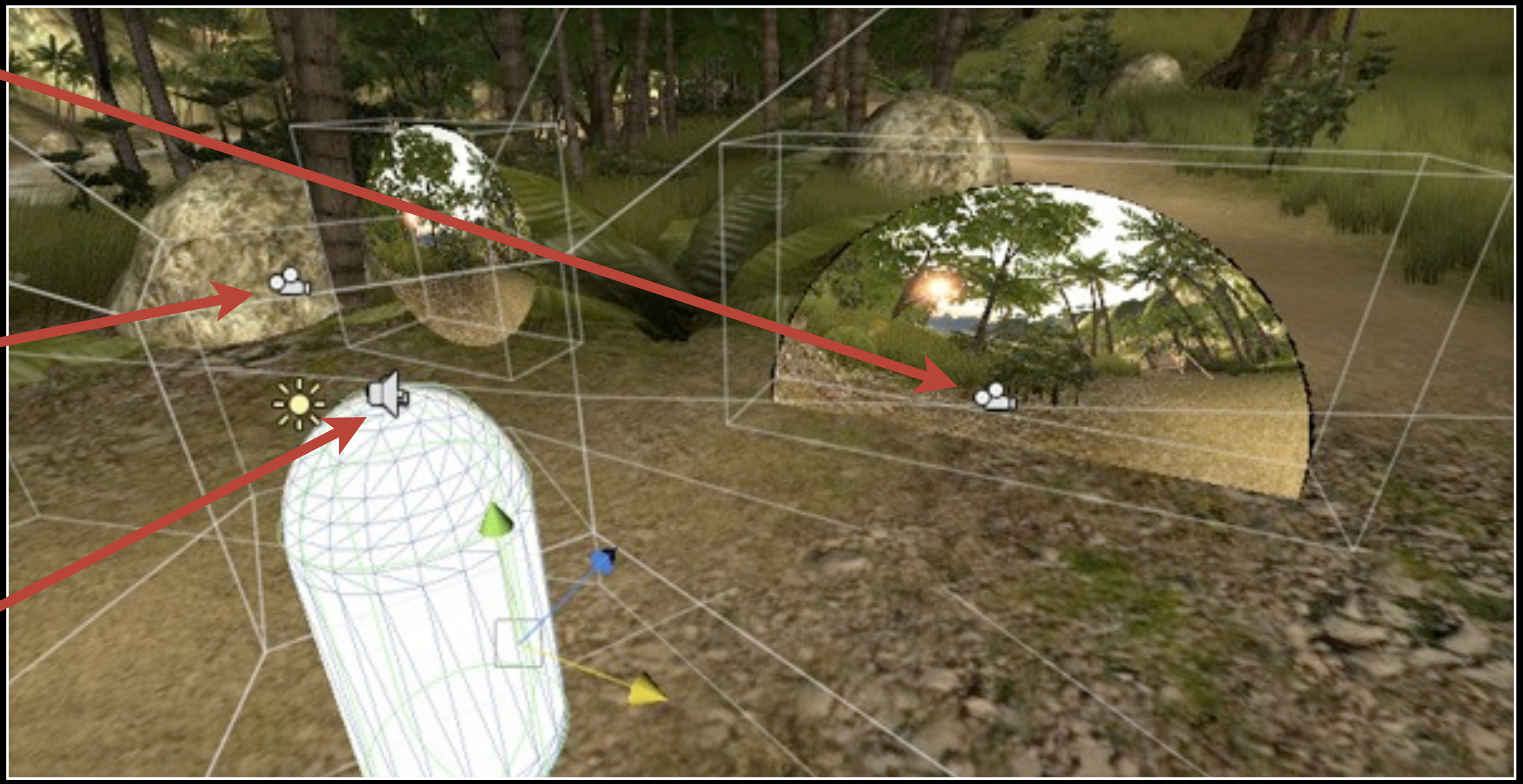


Warped fisheye



Texture dimensions

- What size textures to use in each stage? Two high and there are performance and aliasing effects. Too low and the full resolution of the iDome isn't being exploited.
- Cube face textures: 1024 pixels square. Fisheye texture is 2048 pixels square. Final image to be projected is HD, 1920x1080 pixels.
- Typical performance penalty: each cube face individually render at between 36 and 52 fps (old ATI X1900 graphics card). Combined to form fisheye: 24 fps. Warped fisheye (final frame rate): 23.2 fps.



Generality

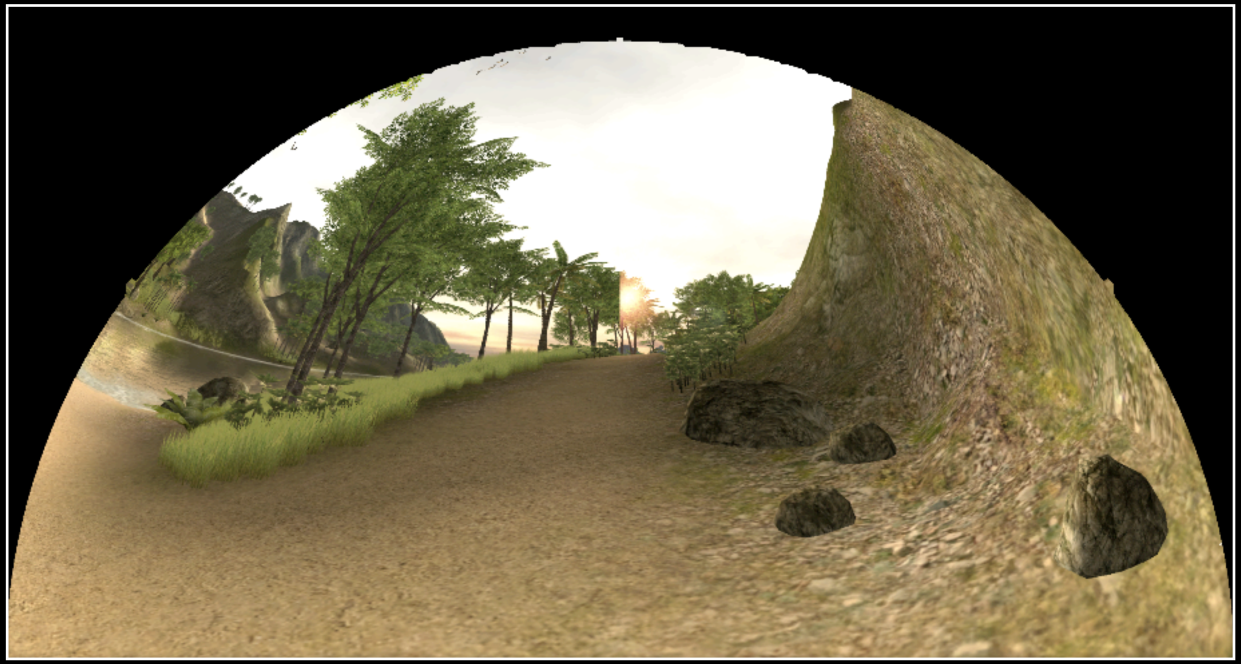
- Each hemispherical dome will have a slightly different fisheye warping. Depends on the exact projector used, relative positions of the components, etc.
- The precise warping mesh is created using an interactive calibration program and the result saved to a OBJ file. This is imported into Unity to do the warping for the particular site.
- Note that this is very general, it can support diverse projection environments such as standard planetarium domes and even rectangular rooms.

Art exhibition, Graphite 2005

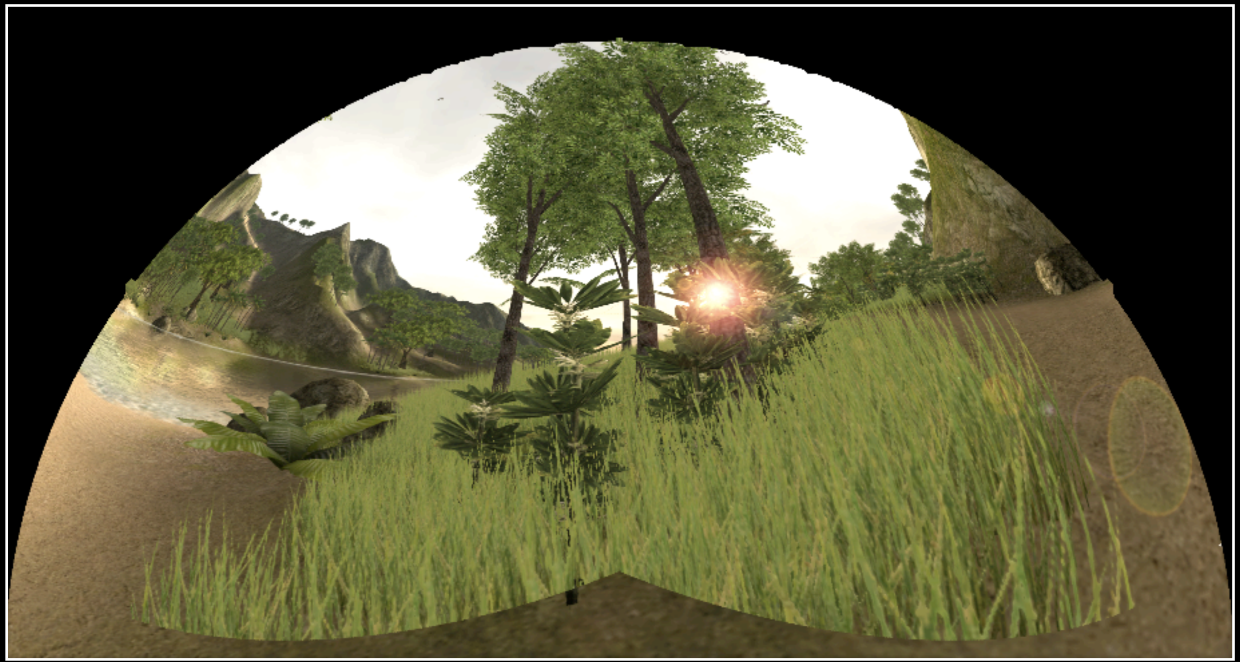
Courtesy Montreal Art School

Issues

- Effects that are essentially 2D effects on the image plane are problematic, for example, sun halos. The sun near an edge of the cube faces only appears in one face so that is the face the flares are added to and not the adjacent faces.
- These effects are also problematic with vertex shader approach since the effect will generally not be in fisheye coordinates.
- Another problem occurs with effects or geometry that have camera angle dependence. For example billboarded textures, the billboard will be at different angles between cube cameras leading to a discontinuity.
- Billboarding for grass is particularly noticeable since the camera for the bottom cube face is parallel with the grass billboards. [Grass billboarding can be turned off in the current release].



Sun effects as it crosses the cube faces.

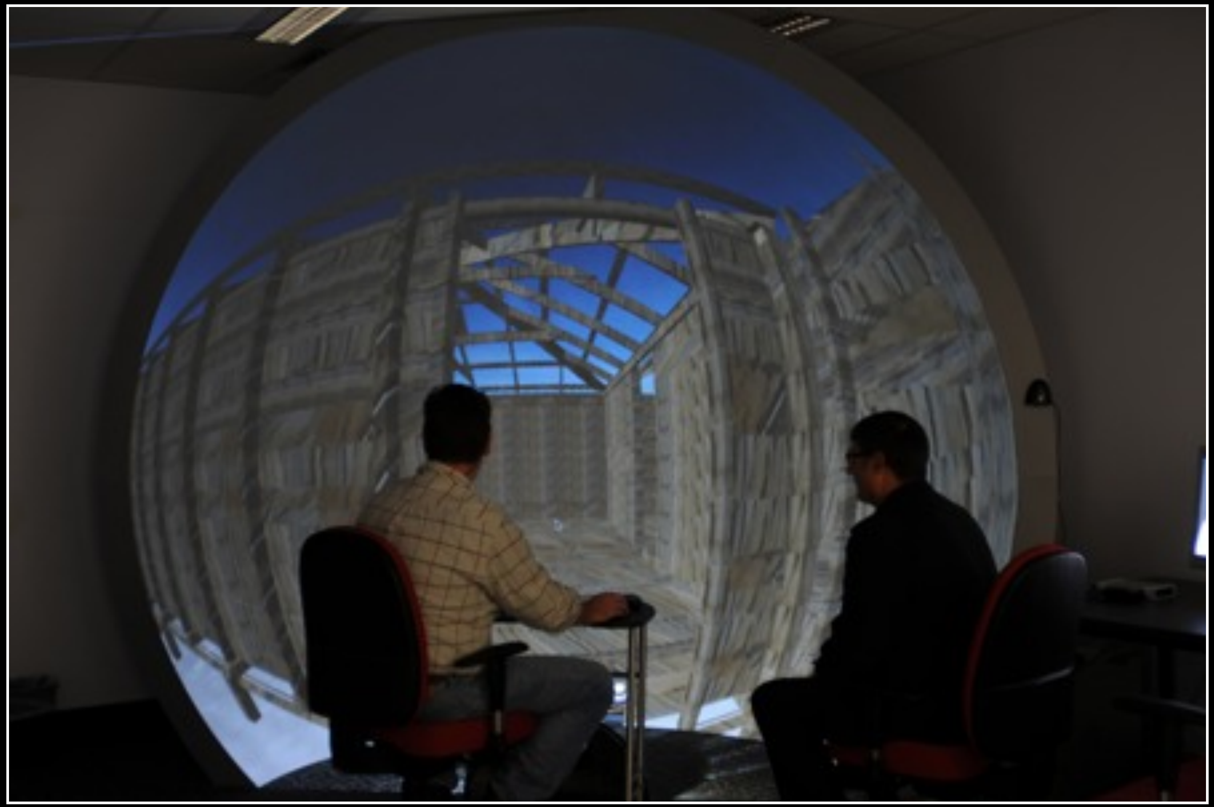


Billboarded grass.

Movie: Island

Example: Mawsons hut

- Virtual reconstruction of Mawsons hut, Antarctica.
- Hut is littered with spherical panoramic bubbles that can be entered.
- Research by Peter Morse.



Movie: Mawsons hut

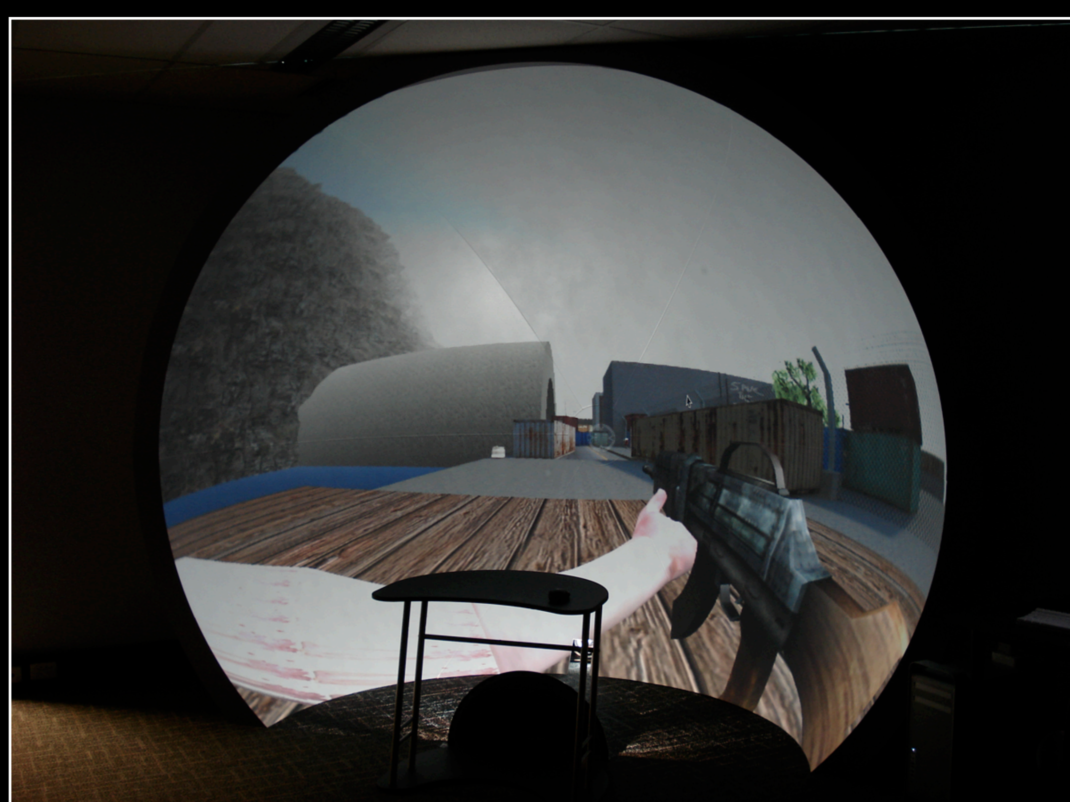
Example: ASKAP

- Public outreach project to educate the public on the SKA (Square Kilometer Array), the worlds largest radio telescope project.
- The “player” can walk or drive around the proposed ASKAP array, explore the local wildlife, see the telescope dish arrangement, etc.

Movie: ASKAP

Example: Save the Farley Mowat

- Political game "In 2009 280,000 seals and seal pups will be bludgeoned to death for their pelts on the ice flows of northern Canada."
- "As well as ignoring a global plea ... the Canadian government has stolen the Sea Shepherd Conservation Society Vessel, the Farley Mowat."
- Game by Aaron Cross.



Movie: Save the Farley Mowat

Questions?

Further reading by the author

- Using a spherical mirror for projection into immersive environments.
  http://local.wasp.uwa.edu.au/~pbourke/papers/graphite2005/
  Graphite (ACM Siggraph), Dunedin Nov/Dec 2005.
  Proceedings of the 3rd international conference on Computer graphics and interactive techniques in Australasia and South East Asia. pp 281-284.

- Low Cost Projection Environment for Immersive Gaming.
  http://local.wasp.uwa.edu.au/~pbourke/papers/jmm/
  JMM (Journal of MultiMedia), Volume 3, Issue 1, May 2008, pp 41-46.