Everything you need to know about "fulldome", and some more

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3D -> 2D image mappings (projections)

Dome environments

Content creation

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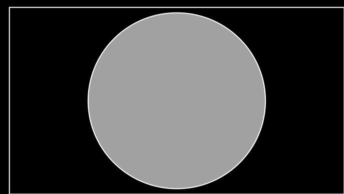
- Photography and filming
- Computer generated
  - Rendered
  - Realtime
- Other considerations
- Excluded: Stereoscopic dome projection

Photography and Filming

- Typical photographically derived content will be either
  - fisheye stills
  - fisheye time-lapse
  - panning fisheyes from high resolution equirectangular images
- Filming
  - traditionally very difficult to get sufficient resolution
  - aspect ratios of current video sensors are against us



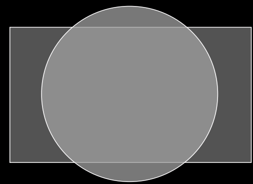
3840x2160

- Lots of traps and tricks to be aware of.
- There is a difference by some in the use of the word “fisheye”, for fulldome coverage we require a circular fisheye lens.

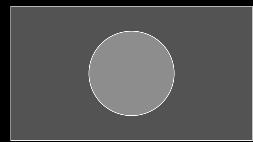
170 degree wide angle fisheye

180 degree circular fisheye

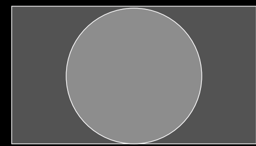
- Need to match the fisheye circle from the lens to the sensor.
- Noting the portion of the sensor actually used may vary depending on recording mode.



Truncated

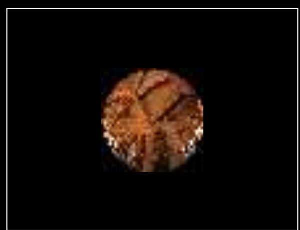


Inefficient use of pixels



Ideal

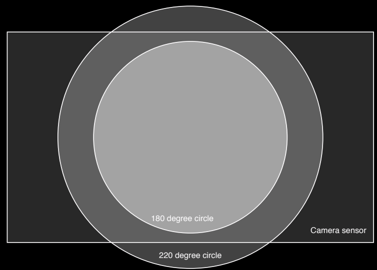
Example of a full frame fisheye on a MFT sensor



Example of a MFT fisheye on a full frame sensor

Ideal, MFT fisheye on a MFT sensor. (Or full frame fisheye on full frame sensor)

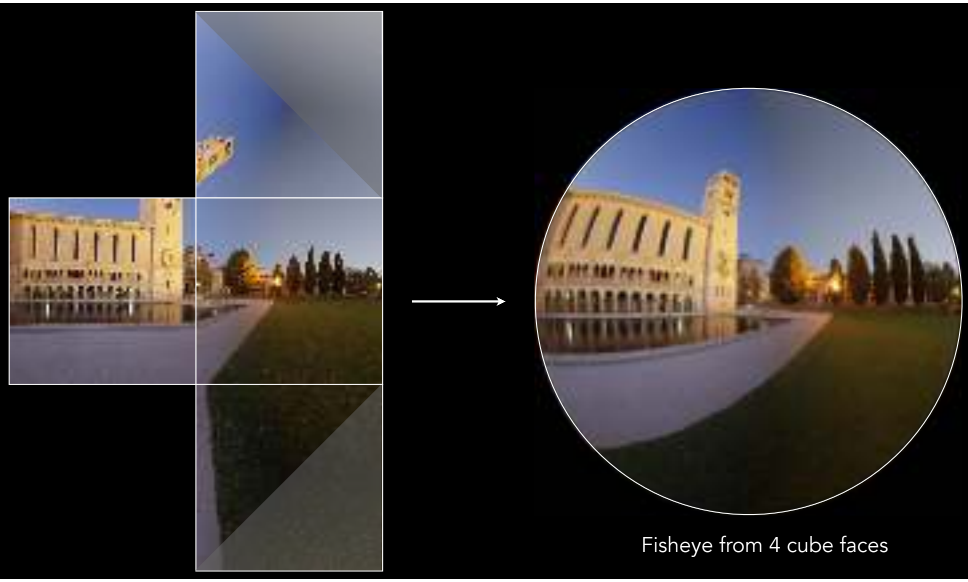
GH5 and Sigma fisheye



- One can extract fisheye frames in post production looking in any direction.
- For example, to deal with variable dome tilt.

Computer Generated - Rendered

- Fortunately most rendering packages these days have a fisheye camera model.
  - Maya, 3DStudioMax, Blender, etc.
  - It is essentially trivial to add for raytracing style rendering.
- Where they do not there is usually a plugin available.
- If that fails one may need to resort to recording cube maps which are just multiple perspective cameras, and assembling the fisheye from that.
- Rendering all 6 faces is required for an equirectangular, you only need 4 faces to reconstruct a fisheye. Noting that there is no need to create an equirectangular as an intermediate step, one can create the fisheye directly from the 4 cube faces.

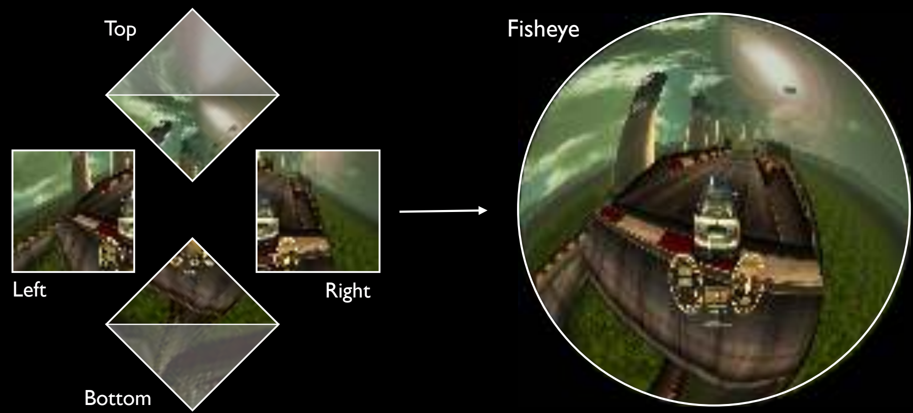


Fisheye from 4 cube faces

Computer Generated - Realtime

- Generally, current hardware accelerated realtime APIs do not support fisheye projection.
- Typically they only support orthographic (parallel) and perspective projections.
- The two most common approaches are:
  - Rendering cube maps using multiples rendering passes, followed by conversion to fisheye
  - Vertex shader
- Each has relative merits and disadvantages.

- Implementation for Unity and Blender Game Engine.
- The steps to create a fisheye are as follows:
  - A 4 camera rig arranged to create 4 faces of a cube map.
  - 4 crafted meshes to turn those faces into a fisheye.
- That is all that is required if the projection is a single fisheye or there is a media server performing the warp and blend.
- Further steps if warp and blend are required for N projectors:
  - N crafted meshes with fisheye applied to create a warped view for each projector.
  - Blending applied to those N views using shader or greyscale mask.



- Other approach to creating the fisheye is a single pass rendering and a vertex shader.
- A cunning trick: modify the position of each vertex such that the result when viewer with an orthographic camera is a fisheye image.
- Simple in concept but involves geometry tessellation which can be expensive.
- A straight line in a standard perspective projection only requires knowledge of the two end points. A straight line is not “straight” in a fisheye projection.
- The solution is to tessellate all the 3D geometry being drawn. The optimal algorithm to do this is not at all trivial, inefficient tessellation results in a high geometry load on the graphics card.

Considerations

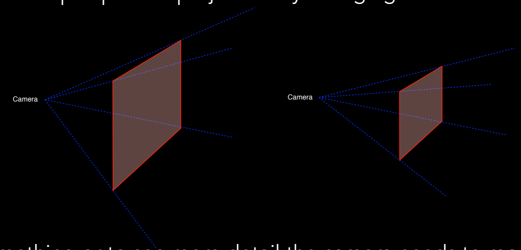
- Distances on a dome are larger than one might think.
  A 4m diameter dome has a length scale over 3 (π) times that of a 4m wide flat screen.
- An object moving from the left of a fisheye to the right of a fisheye is travelling 180 degrees, whereas on a flat screen it may be moving only 60 degrees.
- Tempting to treat movement on a fisheye the same as movement on a perspective frame.
- In addition to this the immersive nature of fulldome makes the audience more sensitive to fast movement.
- In particular pan the camera more slowly than usual.
- Due to the greater distances across a fisheye, at 30fps one may observe discrete time stepping for fast moving objects.

Considerations

- Dome experiences that are within confined spaces are more compelling.
  This is particularly so if there is insufficient resolution to resolve distant scenes.
- When creating 3D worlds for dome rendering it tends to be more expensive because one has to model more. For traditional animation one can limit detailed modelling to what the virtual camera will see.
- There is only position in a dome where the view is perfect.
  - At all other positions the view is distorted, for example, what should be straight lines will not be straight.
  - Fortunately we seem relatively tolerant of this.
  - Note that the correct position does not need to be at the centre of dome, it can be anywhere, but only one position at a time.

Considerations

- There is no such thing as a zoom.
  Zoom is achieved in perspective projection by changing the field of view.



- To magnify something or to see more detail the camera needs to move closer towards it.
- Actually it is the notion of zoom in traditional film that is the strange case, our eyes cannot zoom in real life. So when one creates displays that are closer to the way we see the real world, we lose some of the artificial devices … like zooming.

Considerations

- A number of considerations based upon the orientation of the dome and the position of the audience.
- For omnidirectional domes (no directional seating) one does not necessarily know where an audience member is looking.
- How to orientate the horizon on domes that may not have sufficient tilt.
- Important for camera motion to have momentum, avoid sudden movement/turns.
- If distributing to multiple domes how to optimise for the different configurations.

Standards

- Fulldome standards specify very little more than the orientation of the fisheye.
- 30 fps is the standard, note this is not the 29.97 of NTSC video.
- 5.1 audio is assumed to be the minimum capability of any system.

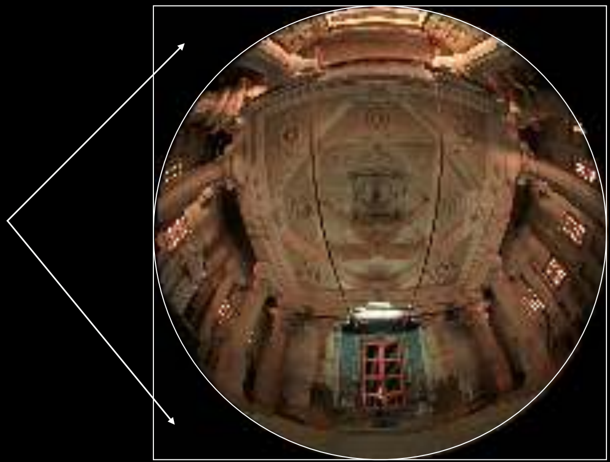
“Back”

Directly left

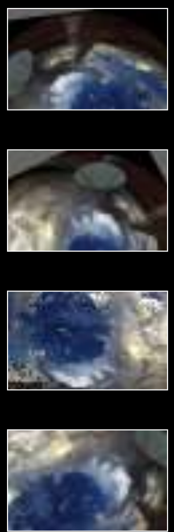
Directly right

“Front”

- The region outside the fisheye circle is not projected. Available for frame counts, time, logos, etc.



- Movies most commonly distributed as frames with separate audio track.
- The current default standard is 4K JPG or preferably PNG frames.
- Compiled into suitable playback format by recipient, for example, dicing for multiple projector/computer playback systems.
- Some of the playback systems for the major suppliers have custom/bespoke encoding standards.
- For smaller resolution domes MOV or MP4 may be supplied.



Example dicing a 4K fisheye for an 8 projector system

Considerations

- Common to oversaturate (add vibrance) to compensate for lack of contrast due to inter-reflections. cross bounce of light in a dome.

Considerations

- Straight lines are not straight on a fisheye.
- For example, adding text cannot simply be done as if it were in Cartesian coordinates.

Depth effects

- The question is often asked about stereoscopic 3D viewing in a dome environment. It can certainly be done and there are any number of stereoscopic capable domes. It is not easy!
- However, one often gets a strong 3D sense in a dome (with correctly created material).
- Reasons
  - If your periphery vision is filled with the virtual, there is no anchor to the real world.
    This is usually referred to as "removing the frame".
  - Similarly, if you cannot see the dome surface there is no connection to the real world.
  - Your brain really expects to interpret the world as 3D so it will use other depth cues.
    This is mainly relative motion, but also shading, occlusion, shadowing, etc.
- This depth from relative motion is why fulldome producers like to keep things (camera and objects) moving.

End of part 3

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Slides can be found here:
http://paulbourke.net/papers/epfl/