iDome: Immersive Visualisation

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The human visual system has a number of characteristics that are not generally exploited when one is viewing a standard computer display. Applications of visualisation and virtual reality are intimately reliant on the sense of vision and therefore benefit from using the full capabilities of that sense. As such, the sense of depth that results from the human eyes being slightly offset is often used to add a perception of depth to the visualisation of datasets and virtual environments. The other characteristic of the human visual system that plays an important part in daily experience is the wide field of view, almost 180 degrees horizontally and about 120 degrees vertically. It is this wide peripheral vision that is accredited with a strong sense of being some somewhere else, of being immersed in an virtual environment.

Various solutions have been proposed that fill the human visual system with virtual imagery, for example, multiple flat walls that may partially or completely surround the observer. One problem with these is that the corners are very hard to hide and as such one is aware of the projection surface which in turn reduces the illusion of being somewhere else. Another option are cylindrical displays, which while they may wrap around the viewer they generally have a limited vertical field of view.

The iDome attempts to solve these limitations by using a hemispherical surface, this totally surrounds the viewer and an attempt is make to create a seamless surface.

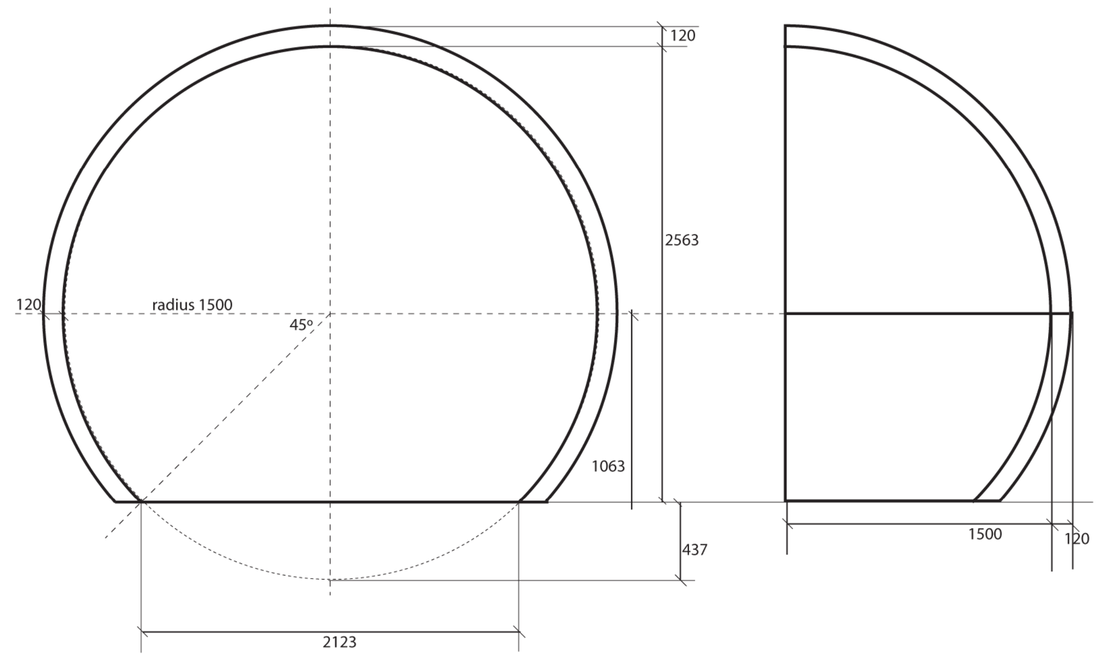

Figure 1. Dimensions of the iDome, a section from a 3m diameter sphere.

One of the challenges is the digital projection onto a hemispherical surface. The traditional approach is a projector with a fisheye lens. There are two issues with this, the first is the projector (which may be large) with the fisheye lens ideally needs to be located at the centre of the hemisphere, this is also unfortunately the best position for the viewer. Secondly, the engineering and optics of fisheye lenses for projectors is non-trivial and they typically are prohibitively priced. Multiple projectors are commonly used for digital projection in planetariums. These have the advantage of giving a higher resolution result on the dome surface. Multiple projectors are less attractive for a small person dome due to space requirements, it is difficult to arrange the projectors in a way that doesn't interfere with the viewer, and the alignment and edge blending associated with multiple projectors is often problematic.

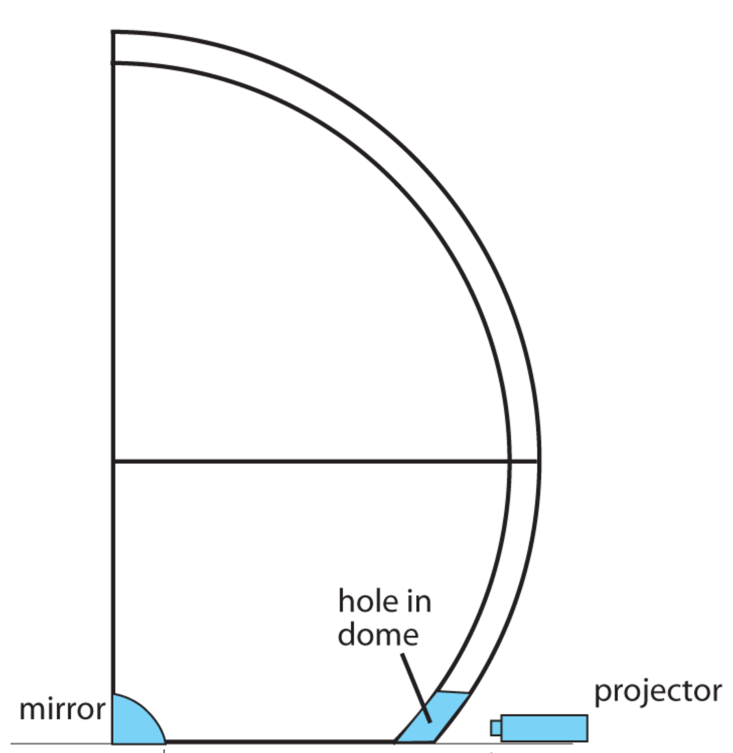

Figure 2. Illustration of the projection geometry. This does place restrictions on the suitable projector models, not all projectors can meet the focus requirements.

The approach used in the iDome is to employ a first surface spherical mirror. This mirror is located out of the way at the base of the dome and the projector is almost completely hidden at the base and behind the dome. The purpose of the spherical mirror, like a fisheye lens, is to scatter the light across the surface of the hemisphere.

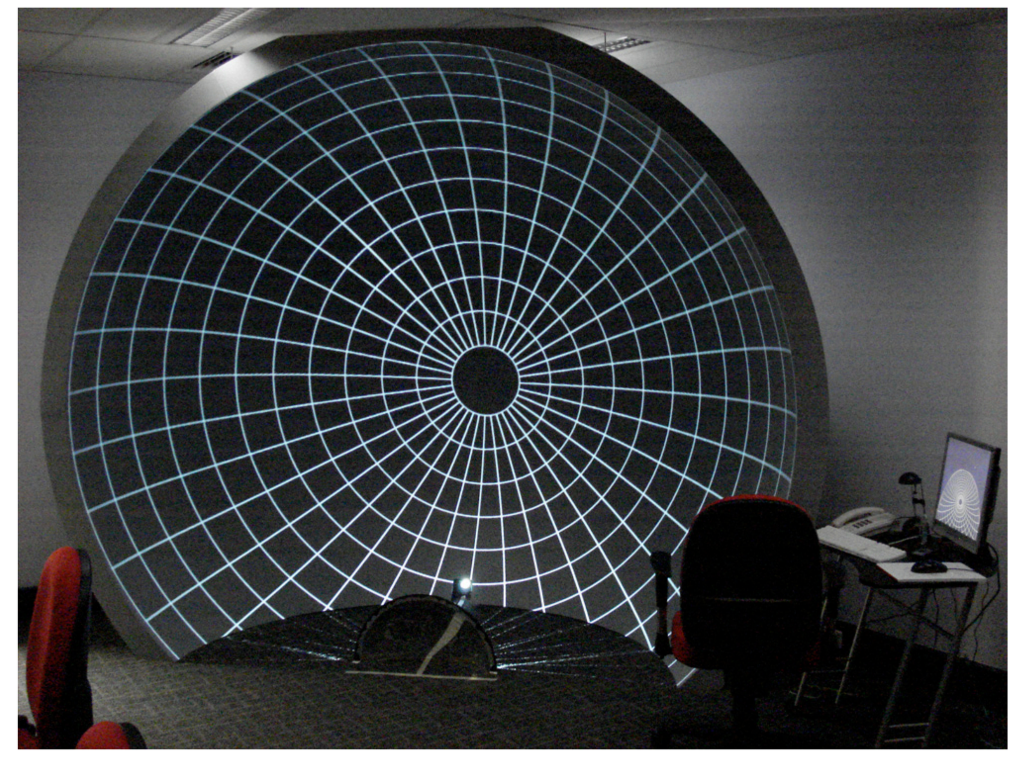

Figure 3. Polar mesh used for projection calibration. Note the position of the spherical mirror which frees up the opening of the dome and the largely hidden projector.

The difference between this projection system and a fisheye lens is that the image is distorted by the spherical mirror. It is however relatively straightforward to distort the projected image such that it appears undistorted on the dome surface. This distortion is potentially different for the hardware configuration of each installation, a calibration process allows a precise image warping to be created.

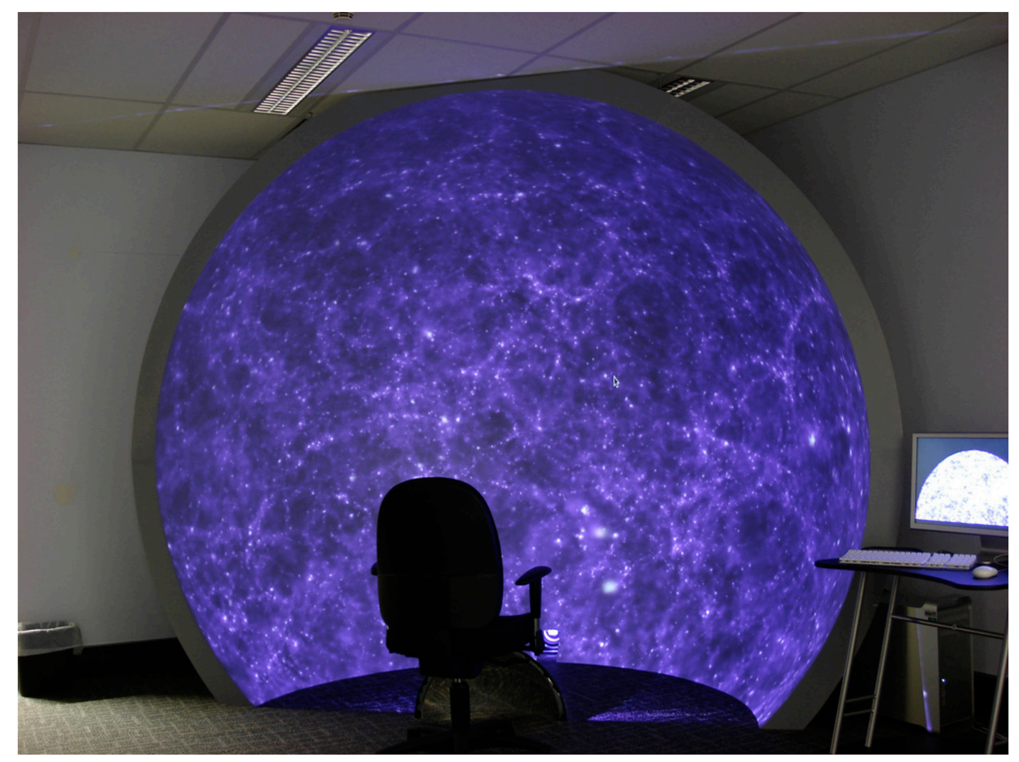

Figure 4. Astronomy visualisation. Flight through a cosmological simulation showing the large scale structure of the universe.

The power of modern graphics cards ensures that this distortion can occur in real time, this is true for interactive software as well as for movie playback applications.

Figure 5. Exploration of molecular datasets. Since the dome surface is largely invisible, other cues such as motion convey a surprising sense of 3D depth.

In the application to science visualisation the strength of the iDome is the ability to view the data from the inside. On a traditional flat display one would be continually panning in order to view the surrounding structures, in the iDome the surrounding structure is immediately visible and presented in a natural and undistorted fashion. Traditionally immersive environments have been used for the exploration of built spaces, for example in architecture and virtual heritage applications.

Additional application examples.

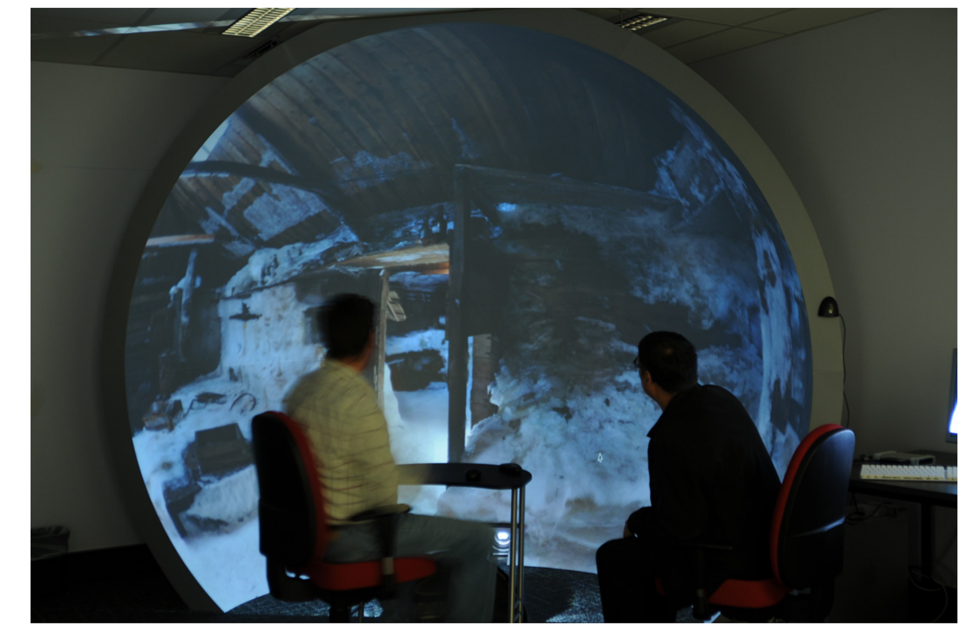

Figure 6. Mawsons hut, an example of virtual heritage. Courtesy Peter Morse and developed with the Unity engine.

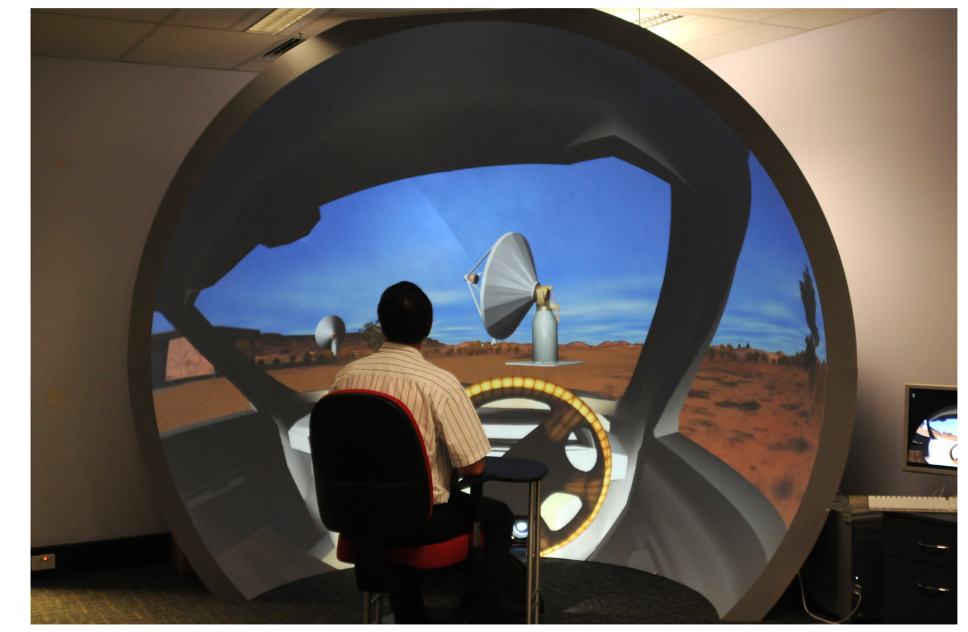

Figure 7. Driving simulator as part of the ASKAP (Australian Square Kilometer Array) site exploration "game". Developed with the Unity engine.

Figure 8. Example of architectural visualisation. Models created in Google Sketchup and converted into an environment developed with the Unity engine.

Figure 9. Car driving simulator used in the quantitative analysis of the effects of alcohol on driver performance. Developed with the Blender realtime engine.

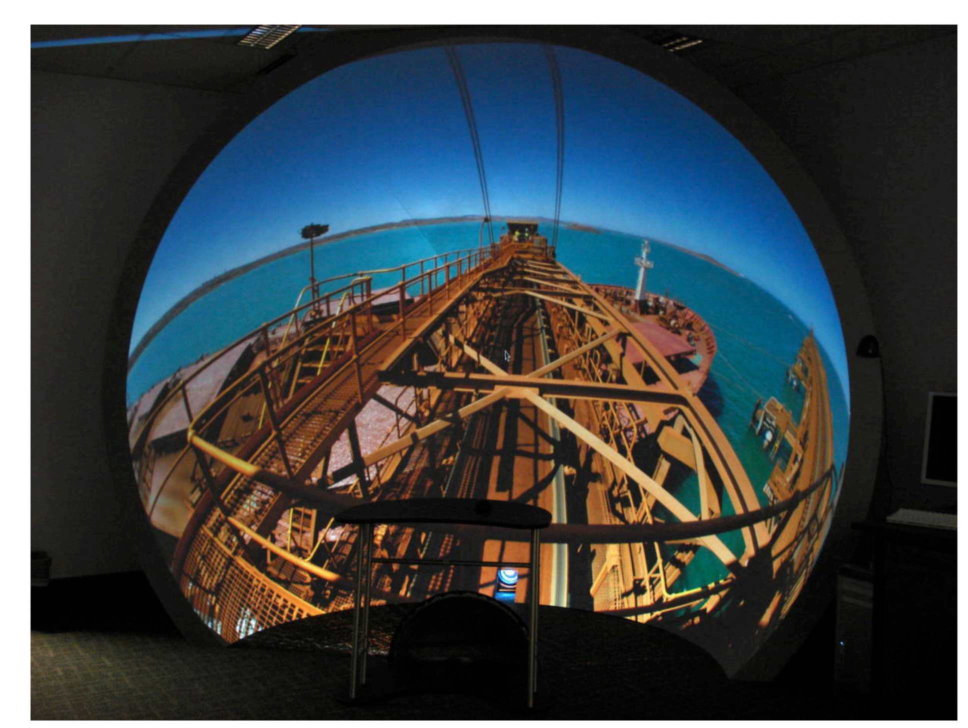

Figure 10: Remote operations using realtime footage captured with a 360 degree video camera, the LadyBug-3.