Improving the Experience of Scenes with a Large Field of View using Shift Lens Perspective

A. Hoeben and P.J. Stappers

ID-Studiolab, Delft University of Technology, the Netherlands

Abstract
In interactive computer graphics such as games and interactive panoramic photos, users are often presented a view with a larger field of view than would correspond to the distance to and size of the screen on which the graphics are viewed. This makes looking at the scene a less claustrophobic experience, showing more of the environment than that which is strictly ahead. In many applications however, where the goal is to get a sense of presence and ambiance of the depicted scene, the large field of view distracts the observer with extreme converging lines when looking up or down. Even though these converging lines are perspectively correct, the resulting image does not match the way we normally perceive the world around us. In this paper we discuss modifying the perspective to reduce the distortions caused by the large field of view, to enhance the experience of these scenes.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 Three-Dimensional Graphics and Realism, I.6.8 Types of Simulation

1. Introduction

In today's high-end interactive computer graphics, engaging content and high fidelity graphics go hand in hand to deliver audiences a convincing perceptual experience. In games and simulations, audiences are captivated by what they see on (and hear from) the display. Advances in computer graphics are helping content developers deliver more realistic, engaging content. However, this near-photo realism also causes higher costs in content development; Photorealistic graphics require high amounts of detail.

Immersive panoramic photography has the potential to deliver a strong sense of presence and atmosphere of a scene, at low authoring cost. Panoramic photographers record the full 360 by 180 degree environment around the camera in a single environment map. By interactively selecting and unwarping part of the environment map [Gre86], a user can virtually look around in the depicted scene[Che95].The required photos can normally be taken within minutes. Post-processing the photos and delivering an interactive immersive experience of the captured scene is a matter of hours or even minutes – depending on the exact techniques and equipment used.

But paradoxically the – by definition photorealistic –

graphics of interactive panoramic photography may be the cause of additional problems. With more realistic graphics, an observer expects a more realistic experience. With photorealistic graphics, minor defects and subtle aspects of looking around that are missing from the experience start to show. In a previous study, we investigated ways to bring back subtleties of experiencing the physical world by incorporating the dynamic characteristics of human natural looking behaviour into the on-screen viewing condition [HS05].

One of the challenges of conveying a sense the spatial characteristics of a scene is the limited field of view provided by a computer screen when compared to the real environment all around us. The veridical (i.e., corresponding to the 'real' geometry) field of view for on screen depiction scene can be calculated from the dimensions of and distance to the screen:

$$vertical\ field\ of\ view = 2 * \arctan\left(\frac{screen\ height}{2 * screen\ distance}\right)$$

The veridical field of view for a person sitting in front of a 17" screen is around 10 to 15 degrees. While this calculated field of view results in a natural perspective on screen, it is inadequate to convey the same experience as looking around in an actual environment.

The resulting viewport is a narrow, claustrophobic view of the scene that can be best compared to looking outside through a tiny window from a distance. In our daily life we have been trained to use optical information from the corners of our eyes for orientation in our environment. With a limited field of view, we are missing these important stimuli. Dolezal showed that forcing someone to experience an environment through a limited field of view for prolonged periods can lead to an uncomfortable, nauseating experience [Dole82].

By depicting a larger field of view on screen beyond that which is strictly realistic, the observer can see more of his or her virtual surroundings. Apart from the view straight ahead, the observer can now see what would normally be more towards the corner of his or her eyes. The view is less claustrophobic and gives a more convincing impression of being *in* the scene rather than looking at a picture.

When the field of view of the display is increased too much, the observer sees the scene as if through an extreme rectilinear wideangle lens. At large viewing angles, vertical lines start to converge harshly as the camera is tilted over or under the horizon. Buildings seem to tip over and objects or people close to the camera but in the corner of the screen are distorted to unnatural extremes. While the converging lines are perspectively correct, they can be very distracting because we are not used to looking through extreme wide angle lenses in real life.

In [ZB85] a generalised method is discussed to adjust the perspective, resulting in a more looking image. In this paper we present a method that specifically targets the converging lines when looking up or down.

2. Shift lens perspective

When photographing buildings, architects often face similar problems with wide angle shots. Buildings often need to be photographed from nearby and from street level, requiring a wide angle shot with the camera tilted upwards.

To prevent converging vertical lines in the image, architectural photographers use *shift lens*, or *perspective control* cameras. Instead of tilting the camera, the lens is shifted up, parallel to the film plane. The resulting image is no longer strictly rectilinear. The optical centre of the projected image is not necessarily in the centre of the image plane. In other words, the horizon can be below the vertical centre of the image, while the image still retains parallel vertical lines.

A similar image can be obtained – in theory – by using an even wider angle lens on the camera while keeping the camera level at zero tilt. By cropping the wide angle image off-centre, resulting image has a similar perspective to the shift lens photo. Because the shift lens image is not cropped, it has a larger pixel- or film-resolution. Figure one show three different camera setups and resulting images.
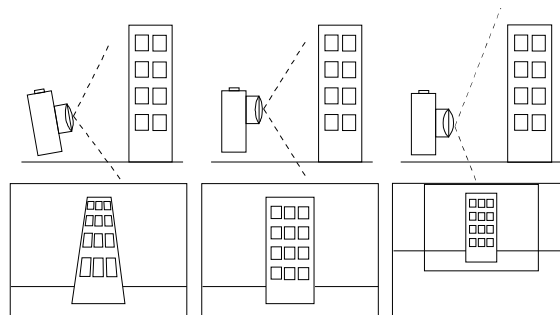
Figure 1: *Setup and resulting image from a tilted (left), shift lens (middle) and (cropped) extreme wide angle camera (right)*

Although the resulting images are not necessarily veridical, they are experienced as more convincing, especially in the appraisal of scenes which have strong vertical components, such as buildings and trees.

2.1. Limits of shift lens optics

A physical shift lens can only shift the perspective over a certain distance. Beyond that distance the lens starts suffering from vignetting, decreased optical resolution, and the resulting image starts to show unnatural distortions.

Likewise, a pure shift lens panorama viewer successfully prevents vertical lines from converging, but only for small shift values. When the shift values increase, the illusion of looking around in the scene starts to break. While there are no converging vertical lines, other extreme perspective distortions caused by the shift lens perspective start to become distracting and disorienting. These distortions are more evident when in a dynamic, interactive view then in an architect's still photo.

2.2. Shift lens panorama viewers

The original Quicktime VR component implemented unwarping of part of a cylindrical panoramic image using a two pass algorithm [CM95]. To conserve CPU power and compute more frames per seconds, the viewer could be set to only unwarp the image in the horizontal direction. This resulted in a viewer that was essentially using shift lens perspective instead of a tilting camera, although Chen doesn't mention this.

Macromedia Flash based panorama viewers are popular because of the ubiquity of the Flash player plugin on the web. Most of these viewers don't apply unwarping to the panoramic image, which leads to a poorer experience. Some viewers manage to implement the same partial correction as the original Quicktime VR viewer could apply [Ste04], but

the Flash player engine lacks functionality and performance to provide full correction.

Both these viewers are limited to showing cylindrical panoramas, i.e. panoramic images where the field of view has restricted vertical extent. These images are often displayed at a lower field of view than panoramic scenes that show the entire environment and are not affected by the converging lines issue as much as unlimited, *spherical* panoramas.

3. Implementation of a hybrid shift lens viewer.

In order to create a viewing experience where extreme converging lines are prevented but the observer can still look straight up and straight down, we implemented a hybrid shift lens viewer. When the viewer starts looking up from the horizon, it shows a shift lens perspective. Looking further upwards, we start mixing in tilt until the perspective is a pure tilted view like a normal spherical panorama viewer, when looking straight up.

The hybrid shift lens viewer is built as an extension to SPi-V, a hardware accelerated panorama viewing engine built on Macromedia Shockwave [Hoe04]. This viewer uses Shockwave 3d to display interactive panoramic images smoothly at full screen resolution. The underlying 3d engine does not provide access to the view transformation matrix. We can however apply a shift lens perspective using the same approach outlined before to emulate a shift lens camera by cropping an extreme wideangle view. By setting the rectangle for the camera larger than the area the 3d engine viewport, the view is cropped to the (shifted) camera rectangle automatically, at virtually no loss in performance. As argued in [HS05], finding a perceptually optimal value for this effect involves 'informed' tuning; veridical geometric computation does not lead to a satisfactory value.

Like other panorama viewers, SPi-V lets the observer change the camera pan and tilt value by dragging inside the unwarped display. For a pure shift lens system, we constrain the camera tilt to a level position. A tilt value is however still calculated, and used with the current vertical field of view and the current viewport height to calculate a shift.
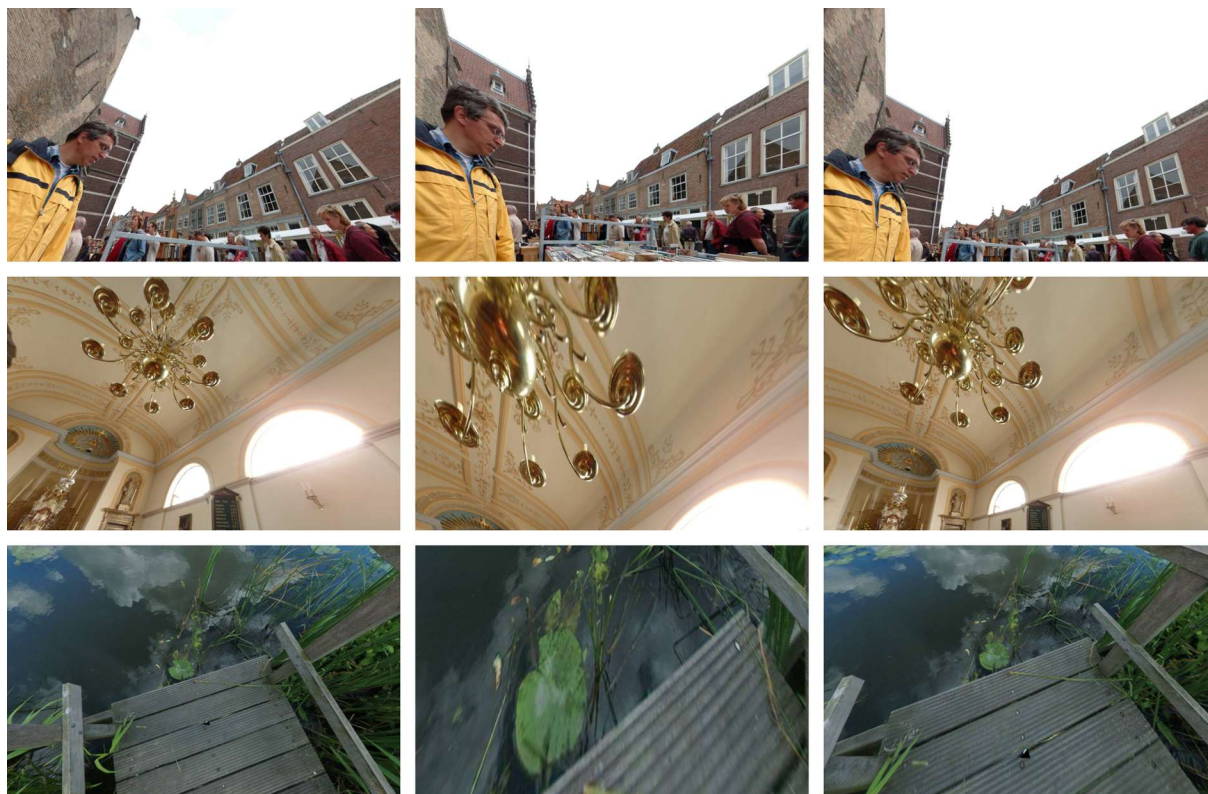
Figure 2: *Tilted (left), pure shift lens (middle) and hybrid shift lens perspective on three different scenes. The top scene shows straight lines in the pure shift lens view. When looking further up and down, the pure shift lens projections have extreme distortions.*

$$shift(px) = view\,height(px) * \frac{tilt\,value(°)}{vertical\,field\,of\,view(°)}$$

The hybrid shift lens perspective combines this camera shift with camera tilt, depending on the original tilt value.

$$factor = \left| \frac{tilt\,value(°)}{90°} \right|$$

$$camera\,tilt(px) = factor * tilt\,value(°)$$

$$camera\,shift(px) = (1 - factor) * shift(px)$$

The resulting view has a comfortable perspective that shows only minimal convergence of vertical lines when looking up from the horizon, but still allows the observer to look straight up and down without showing unnatural shift lens distortions.

Figure 2 shows a number of different views of a scene with different a tilting camera, pure shift lens camera and hybrid shift lens camera. The current implementation uses a linear factor to mix tilt- and shift lens perspective. While this implementation results in natural looking images for different types of scenes, some types of scenes may benefit from a more carefully adjusted function to provide a better mix between perspectives.

4. Evaluation

In an informal evaluation, we showed small a number of participants panoramic scenes through the hybrid shift lens panorama viewer. We did not tell them to pay particular attention to the perspective, but instead focussed on the panoramic scene. The participants did not notice or comment on the perspective or experience of looking around. When we turned off the shift lens effect, reverting the perspective to a normal tilt behavior, the participants were surprised to see the extreme converging lines and other wide angle distortions.

The effect that participants did not notice a difference in the experience until we took the enhancements away is similar to the results of our earlier study where we added subtle physical attributes such as inertia to the viewer [HS05]. It confirms to us that our enhancements to the experience of virtual scenes allows the observer to concentrate on the scene instead of the perspective or dynamics of looking around.

5. Discussion

The hybrid shift lens approach seems to fit the way we perceive the physical world around us. We are used to have the horizon as a reference, and the horizon is always at eye's height. When looking up or down at moderate angles we are still aware the horizon and the relation of the perspective of our view and the horizon. Because of this horizon-awareness we don't perceive extreme converging lines until we look straight up or down at extreme geometry such as skyscraper buildings. When looking straight up at such a high structure, we can loose the relation to the horizon. Even in real-life, loosing the horizon awareness and *seeing* the converging vertical lines lead can lead to vertigo and nausea with some people.

The hybrid shift lens viewer effectively mimics the horizon awareness. At low angles, when the horizon is in the view, vertical lines stay mostly parallel. When looking up or down at such angles that the horizon is no longer in the wide angle view, vertical lines start to converge.

Even though the effect of converging vertical lines is most obvious in scenes with strong parallel vertical lines such as scenes of small rooms or city scenes with buildings surrounding the observer, the hybrid shift lens did not introduce distracting distortions in wide open scenes. The hybrid shift lens viewer also prevents organic shaped such as people in scenes from being distorted in the corners of a normal wide angle view.

References

[Gre86]   GREENE, N. Environment Mapping and Other Applications of World Projections. *Computer Graphics and Applications*, *6* (11):21-29. November 1986

[Che95]   CHEN, S. E. Quicktime VR - an image-based approach to virtual environment navigation. *Computer Graphics, Annual Conference Series,* 1995, pp. 29–38.

[CM95]   CHEN, S. E. AND MILLER,G. S. P. Cylindrical to planar image mapping using scanline coherence. *United States Patent* number 5,396,583, 1995.

[Dol82]   DOLEZAL H. The restricted field of view: A neglected factor in adaptation research. *Living in a world transformed Ed*. New York, Academic Press, 1982. pp 57-79

[ZB85]   ZORIN, D. AND BARR, A. H., Correction of geometric perceptual distortion in pictures. *SIGGRAPH 95 Conference Proceedings*, pp. 257-264

[HS05]   HOEBEN, A. AND STAPPERS, P.J. Taking clues from the world outside: Navigating Interactive Panoramas. To appear in *Personal and Ubiquitous Computing, special issue.*

[Hoe04]   HOEBEN, A. fieldOfView | Spi-V engine. http://fieldofview.nl/spv [accessed 15 June 2005]

[Ste04]   STEHLE, C. FlashVR 360 Panorama Player for Macromedia Flash. http://www.flashvr.de [accessed 15 June 2005]