A stereoscopic movie player with real-time content adaptation to the display geometry

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Abstract

Content adaptation is solved by disparity mapping [LHW+10]. A linear transform (scale-shift) is not enough in most cases, and may result in卡式deck effect, divergence, or puppet theater effect [DVP10, DDRP11]. Shading and viewing geometries can be described using the same small set of parameters:

\[
\begin{align*}
&\mathbf{x}_d \quad \text{camera optical center} \\
&\mathbf{y}_d \quad \text{camera optical center} \\
&\mathbf{M} \quad \mathbf{H} \quad \text{plane of convergence} \\
&\mathbf{Wd} \quad \text{camera interocular} \\
&\mathbf{b} \quad \text{camera interocular} \\
&\mathbf{H} \quad \text{camera optical center} \\
&\mathbf{W} \quad \text{real depth} \\
&\mathbf{b} \quad \text{real depth} \\
&\mathbf{P} \quad \mathbf{b} \quad \mathbf{M} \quad \mathbf{W} \quad \mathbf{H} \quad \mathbf{b}
\end{align*}
\]

The scene depth (in the camera geometry) and the perceived depth (in the display geometry) are related by:

\[
Z' = \frac{H'}{\frac{W'}{W} \frac{b}{b'}} = Z = \frac{H}{1 - \frac{1}{\mathbf{W} \frac{b}{b'}}}
\]

A small object of dimensions \(\delta X \times \delta Z\) in the width and depth directions, placed at depth \(Z\), is perceived as an object of dimensions \(\delta X' \times \delta Z'\) at depth \(Z'\), and the roundness factor \(\rho\) measures how much the object proportions are affected:

\[
\rho = \frac{\delta Z'}{\delta Z} = \frac{\delta X'}{\delta X} = \frac{W' \delta Z'}{W \delta Z} = \frac{H'}{H} \frac{W'}{W} \frac{b}{b'}
\]

In the screen plane \((Z'=H, Z''=H')\), the roundness factor simplifies to:

\[
\rho_{\text{screen}} = \frac{W' \delta Z'}{W \delta Z} = \frac{H'}{H} \frac{W'}{W}
\]

From these equations, we compute a disparity mapping function that:

- has a roundness factor of 1 in the screen plane
- preserves depth proportions (and thus avoids divergence)

However, any disparity mapping function could be used in our implementation [LHW+10].

References


[DDRP11] Frédéric Devernay, Sylvain Duchêne, and Adrian Rame-Pena. Adapting stereoscopic movies to the display size and distance. This can lead to disturbing depth distortions such as the cardboard effect or the puppet theater effect. As more and more stereoscopic 3D content is produced in 3D (feature movies, documentaries, sports broadcasts), a key point is to get the same 3D experience on any display. For this purpose, perceived depth distortions can be resolved by performing view synthesis. We propose a real-time implementation of a stereoscopic movie player based on the open-source software Bino [Lam12], which is able to adapt a stereoscopic movie to any display, based on user-provided camera and display parameters.

Forward mapping uses OpenGL Shading Language (GLSL) to distort a trivial 3D mesh (one pixel center is a mesh vertex). The mesh (which is a quad strip) is built only once, and both images are forward-mapped in the same vertex shader. OpenGL’s Z-buffering is used to deal with self-occlusions. Vertices belonging to quads that are highly-distorted are assigned an alpha value of 0, meaning that the quad is transparent. This removes large elongated quads (usually at depth discontinuities) that produce highly visible artifacts.

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