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

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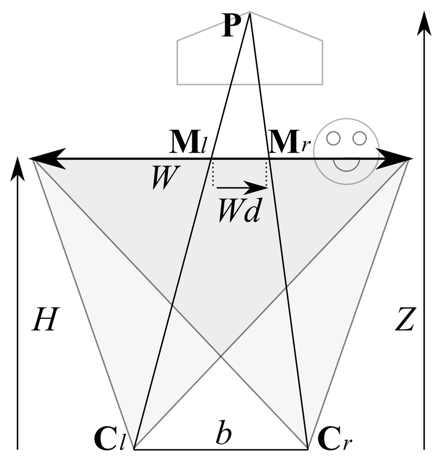
Abstract

3D shape perception in a stereoscopic movie depends on several depth cues, including stereopsis. For a given content, the depth perceived from stereopsis highly depends on the camera setup as well as on 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 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.

Content adaptation

Content adaptation is solved by disparity mapping [LHW+10]. A linear transform (scale+shift) is not enough in most cases, and may result in cardboard effect, divergence, or puppet theatre effect [DRP10, DDRP11]. Shooting and viewing geometries can be described using the same small set of parameters:



Symbol	Camera	Display
$\mathbf{C}_l$, $\mathbf{C}_r$	camera optical center	eye optical center
$\mathbf{P}$	physical scene point	perceived 3-D point
$\mathbf{M}_l$, $\mathbf{M}_r$	image points of $\mathbf{P}$	screen points
b	camera interocular	eye interocular
H	convergence distance	screen distance
W	width of convergence plane	screen size
Z	real depth	perceived depth
d	left-to-right disparity (as a fraction of W)	

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

$$Z' = \frac{H'}{1 - \frac{W'}{b'}(\frac{b}{W}\frac{Z-H}{Z})} \text{ or } Z = \frac{H}{1 - \frac{W}{b}(\frac{b'}{W'}\frac{Z'-H'}{Z'})} \quad (1)$$

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 ρ measures how much the object proportions are affected:

$$\rho = \frac{\partial Z'}{\partial Z} / \frac{\partial X'}{\partial X} = \frac{\partial Z'}{\partial Z} / \frac{W'/s'}{W/s} = \sigma' \frac{W}{W'}\frac{\partial Z'}{\partial Z} \quad (2)$$

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

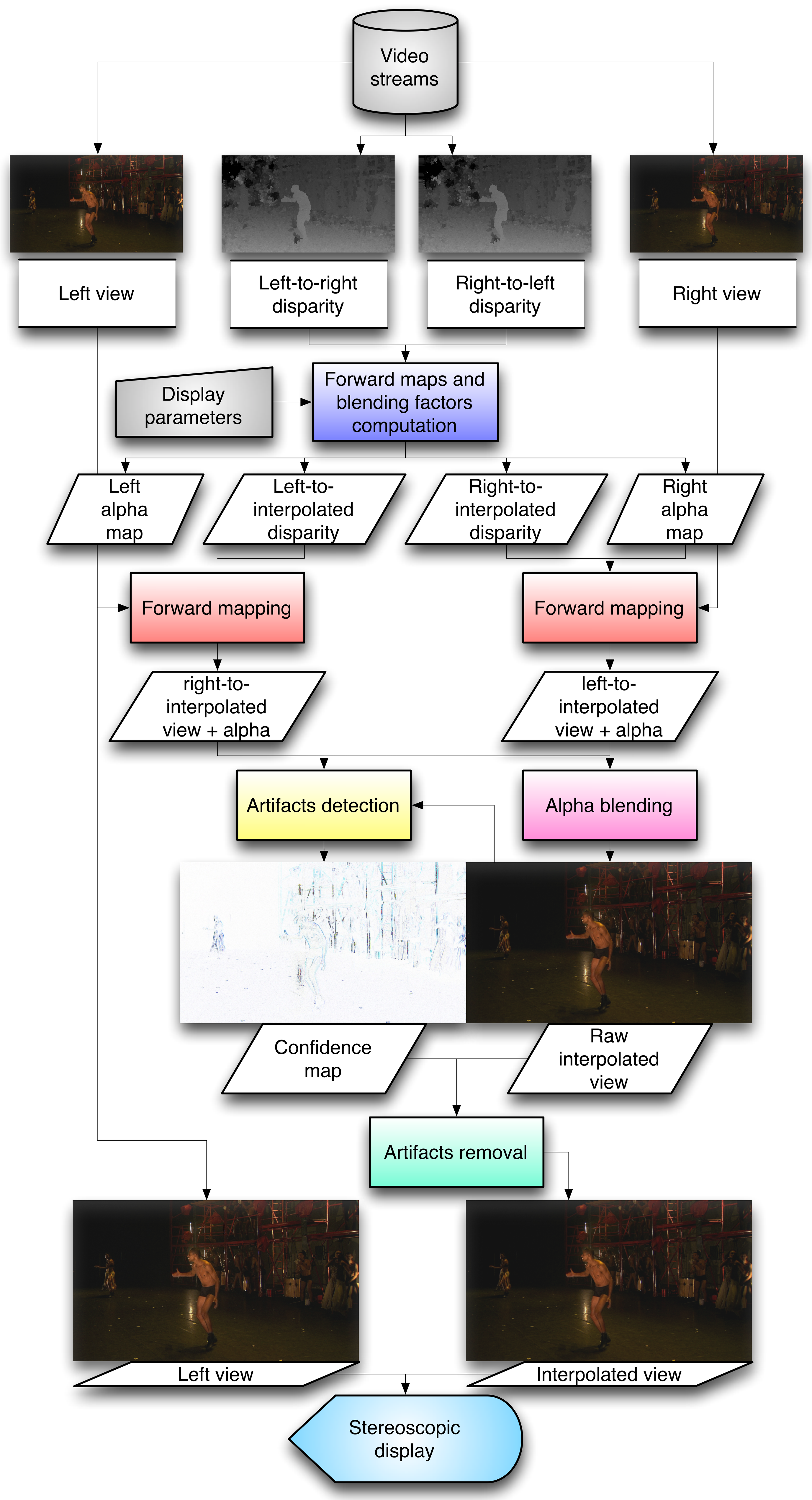
$$\rho_{\text{screen}} = \frac{W}{W'}\frac{\partial Z'}{\partial Z}_{(Z=H)} = \frac{b}{H}\frac{H'}{b'} \quad (3)$$

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)

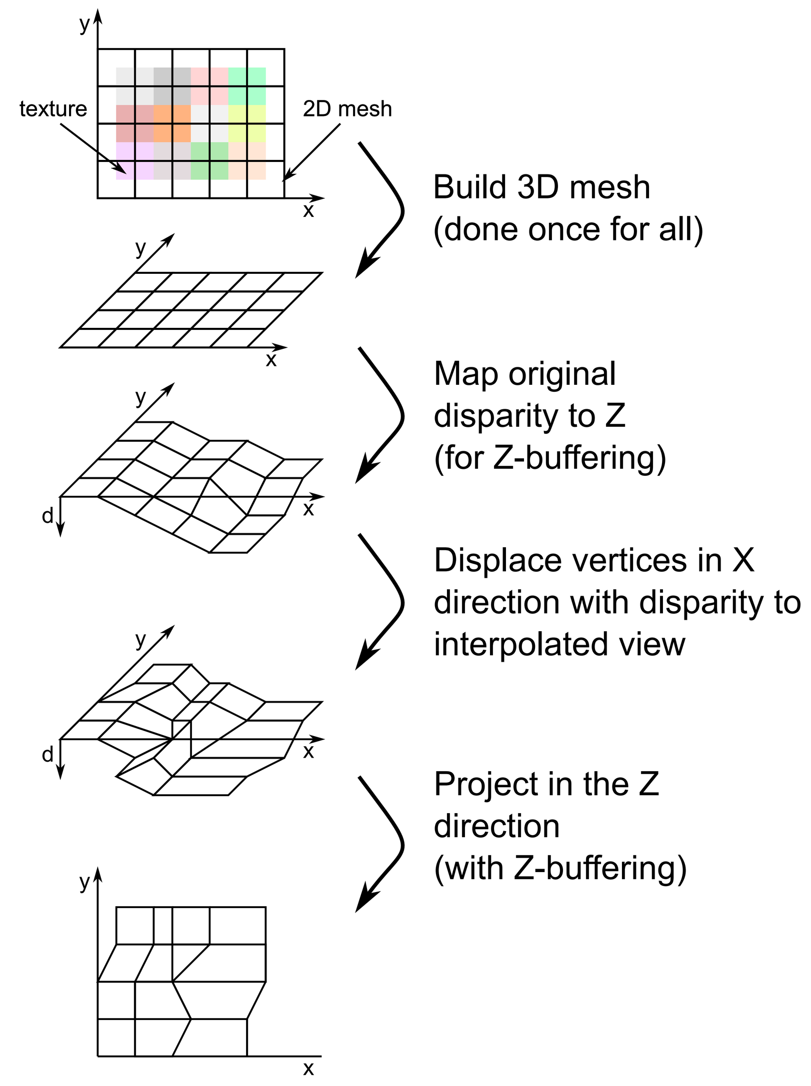
However, any disparity mapping function could be used in our implementation [LHW+10].

Algorithm Outline



Forward mapping

Forward mapping uses OpenGL Shading Language (GLSL) to distort a trivial 3D mesh (each 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.



Conclusion

- Uses a state-of-the-art open-source stereoscopic player, Bino, with multithreaded decoding and supporting many stereoscopic displays.
- Reasonable performance (1080p25 in real-time) on a quad-core 2.8GHz Xeon with a GeForce GTX480, without artifact removal (most time is spent decoding the four H.264 HD video streams).
- Real-time artifact detection and removal is being worked on.

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http://3dlive-project.com/