

# A Virtual Reality Tool for Benchmarking Active Stereo Vision Systems in the Peripersonal Space

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## Motivation

In stereoscopic vision research, attempts of assessing the disparity cues in natural settings during active vision tasks yield to several studies on the disparity statistics [Liu et al., J. of Vision, 8:1-14, 2008]. Though, systematic analyses of this issue in the peripersonal space (large vergence angles) in real-world situations (i.e., 3D exploration of a *real* environment) are still lacking. A tool, that uses the virtual reality to simulate the actual projections impinging the retinas of an active visual system rather than to render the 3D visual information for a stereoscopic display, has been developed. The tool performs the stereo and vergence movements following the strategies adopted by different active stereo vision systems. The ground truth disparities can be computed for each different fixation point, thus allowing us to obtain disparity statistics in real-world situations.

## Active Vision Simulator

The simulator is based on Coin3D ([www.coin3d.org](http://www.coin3d.org)), an open-source implementation of Open Inventor, a C++ object oriented retained mode 3D graphics API designed to provide a higher layer of programming for OpenGL. Coin3D is a library of different building blocks, that can be used to create interactive 3D applications, by taking advantage of powerful graphics hardware features:

- Primitives, including shapes, properties, groups, etc.
- Interactive manipulators
- Components, including lights, viewers, virtual cameras, etc.

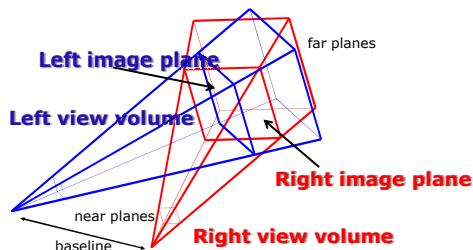
### 3D applications in a standard approach to virtual reality

Virtual reality is used for perceptual rendering of the visual information exploitable by a human user, that acts in immersive, highly visual, 3D environments (e.g. CAD software, video-games, 3D attractions, military or healthcare applications,...)

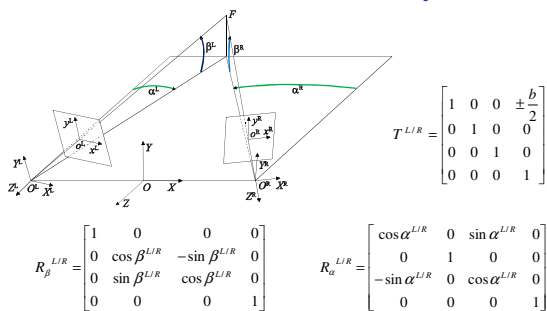
## A novel approach to virtual reality

Virtual reality as a tool to simulate the behavior of physical systems, in particular the simulation of robotic vision systems. In order to obtain an active vision simulator, we modified a component of the Coin3D library (the SoCamera node, that provide a view of the scene) to obtain a stereoscopic visualization of the scene useful to mimic an active stereo camera system, rather than to make a human perceive stereoscopy. This can be done by implementing the toe-in stereo technique.

### Toe-in stereo technique



### Pan-tilt stereo setup



### Ground truth horizontal and vertical disparities

From the z-buffer:

$$\lambda^{L/R} = \frac{fn}{w^{L/R}(f-n)-f}$$

$$\lambda^R \mathbf{x}^R = \mathcal{R} \lambda^L \mathbf{x}^L + \mathcal{T}$$

Horizontal disparity:  $d_x = x_L - x_R$

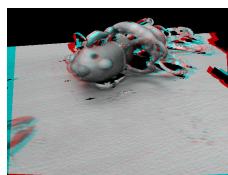
Vertical disparity:  $d_y = y_L - y_R$

## 3D data acquisition in real-world situations

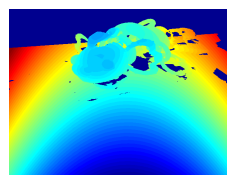
Laser scanner Konica Minolta Vivid 910



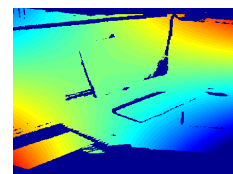
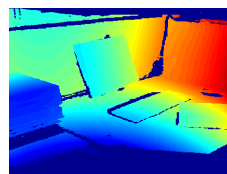
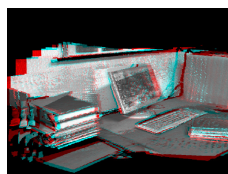
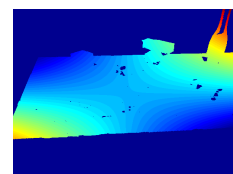
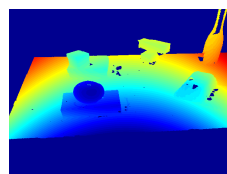
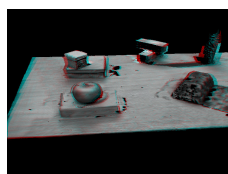
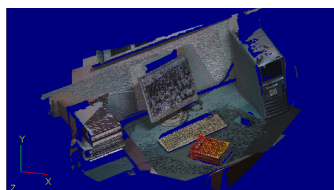
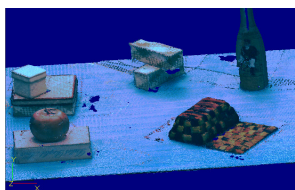
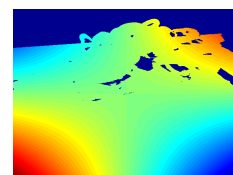
### Left/right view



### Horizontal disparity



### Vertical disparity



The stereo pairs and the ground truth horizontal and vertical disparities are available at:

[www.pspc.dibe.unige.it/Research/vr.html](http://www.pspc.dibe.unige.it/Research/vr.html)