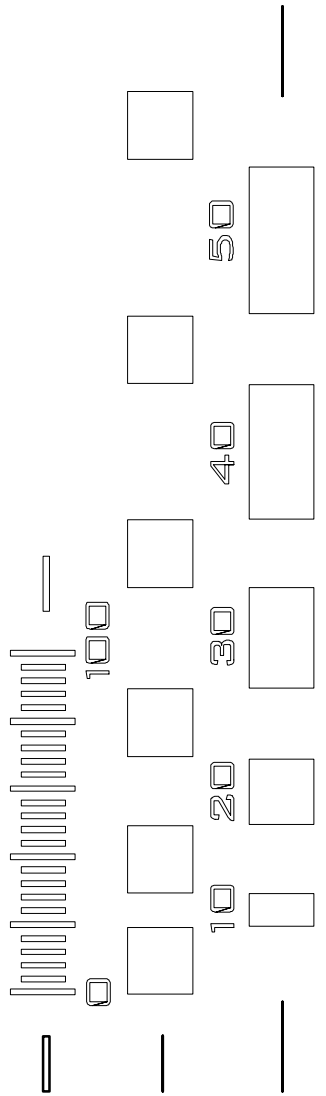
Accuracy of 3D Displays: Virtual or Reality?

Christine Wall

2001



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Overview

Introduction to display metrology at the NPL

What is a 3D display?

Some methods of creating 3D images

Why measure 3D displays?

Metrological requirements of 3D displays

NPL's work and current capability in 3D measurement

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Introduction to Display Metrology at NPL

NPL has been measuring 2D displays since 1985

We currently offer the following measurement services for reflective and self luminous displays:

- Luminance ± 4% (0.01 $cd \cdot m^{-2}$ to 10 000 $cd \cdot m^{-2}$)
- Chromaticity ± 0.002 (CIE 2 degree observer)
- Contrast
- Spectral radiance
- Spectral reflectance

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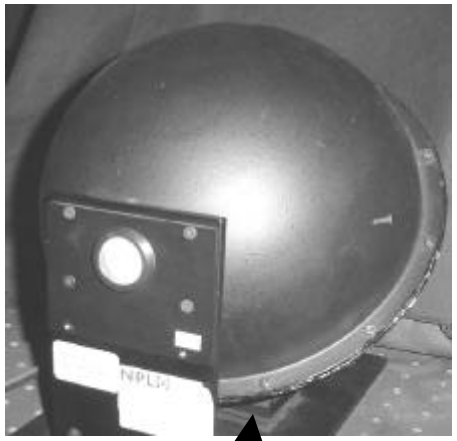
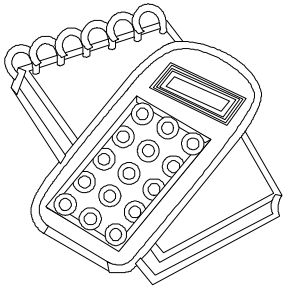
Introduction to Display Metrology at NPL

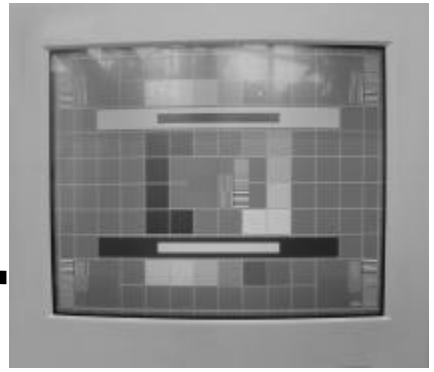


2. Measure a stable, well characterised light source



3. Make a correction file

4. Measure display



5.Apply correction file to find calibrated result

1. Select the instrument

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What is a 3D display?

“three-dimensional” according to Merriam Webster
adjective, circa 1891

1 : of or relating to three dimensions
2 : giving the illusion of depth or varying distances - used of an image or a pictorial representation especially when this illusion is enhanced by stereoscopic means
3 : true to life: lifelike

www.m-w.com

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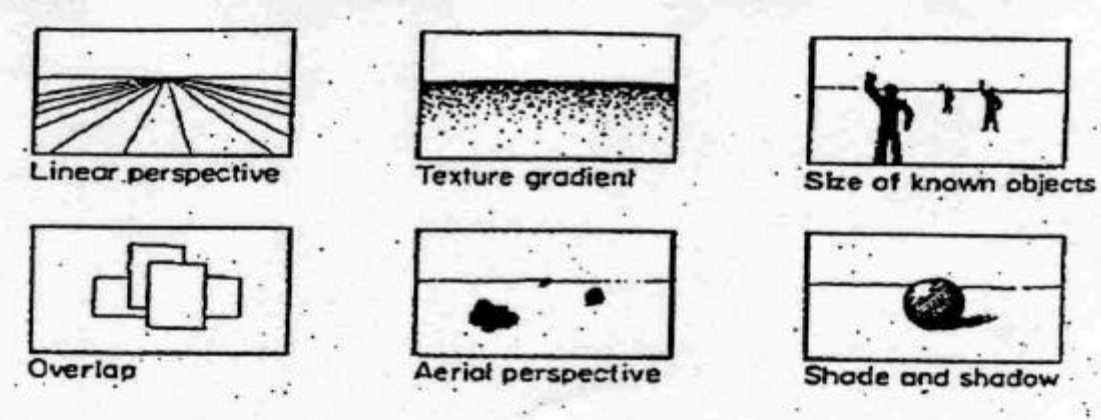
Cues for Depth Perception (Okosi)

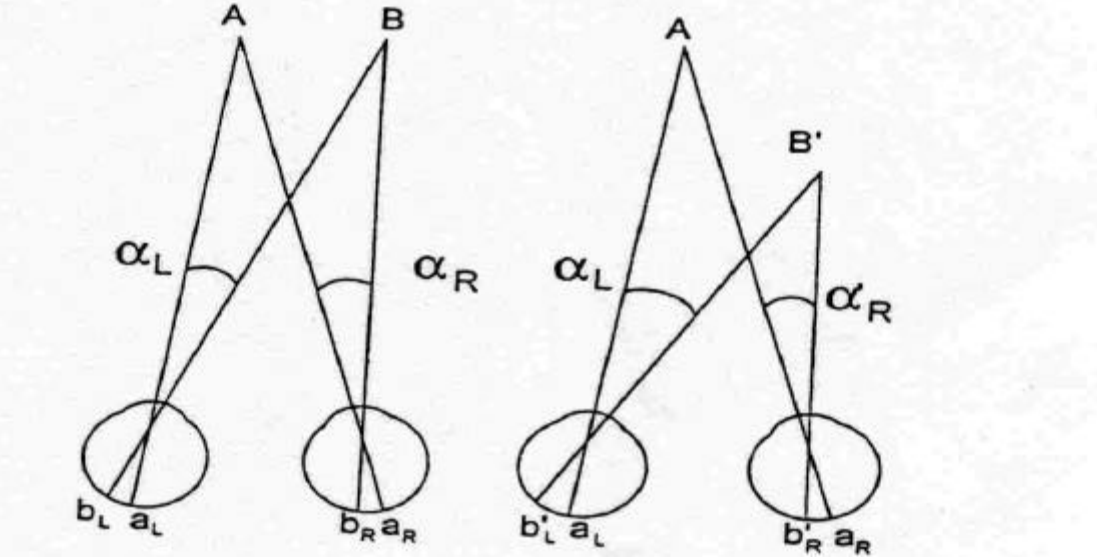
Physiological cues

Accommodation
Convergence
Binocular parallax

Psychological cues

Retinal image size
Linear perspective
Aerial perspective
Overlapping
Shading and shadow
Texture gradient





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What is a 3D Display?

To show a 3D image we can :

easy with a lens and a mirror (easy but not permanent)

create a real three dimensional image… (tricky)

or,

create the illusion of a 3D image by showing slightly different images to each eye… (simpler)

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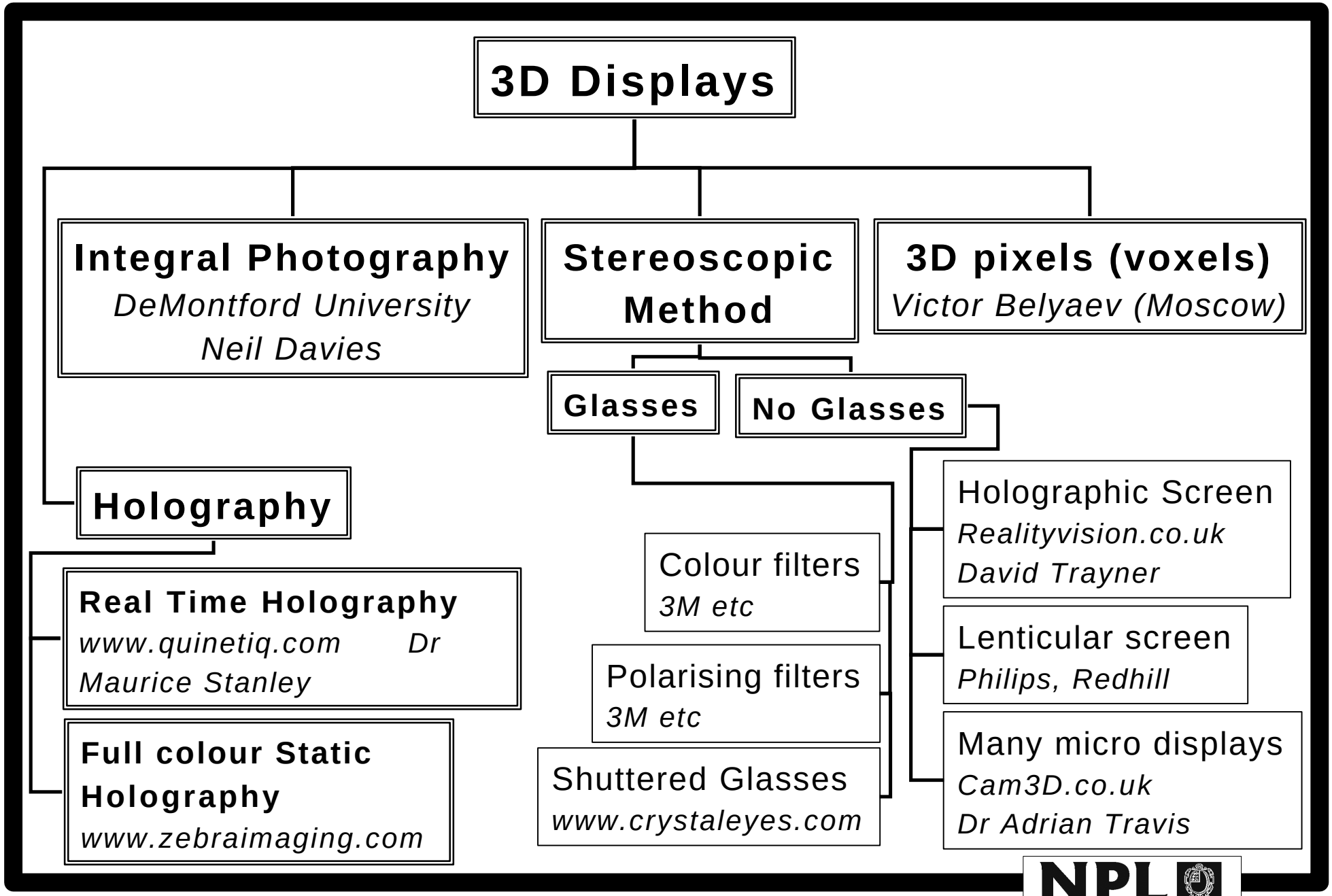
3D Displays
Integral Photography
DeMontford University
Neil Davies
Stereoscopic Method
3D pixels (voxels)
Victor Belyaev (Moscow)
Glasses
No Glasses
Holography
Real Time Holography
www.quinetiq.com Dr Maurice Stanley
Full colour Static Holography
www.zebraimaging.com
Colour filters
3M etc
Polarising filters
3M etc
Shuttered Glasses
www.crystaleyes.com
Holographic Screen
Realityvision.co.uk
David Trayner
Lenticular screen
Philips, Redhill
Many micro displays
Cam3D.co.uk
Dr Adrian Travis
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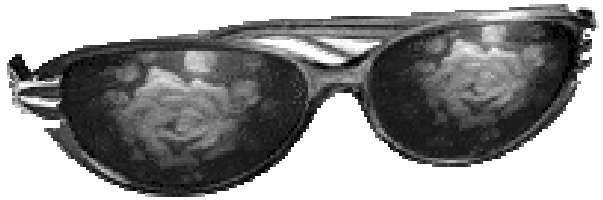
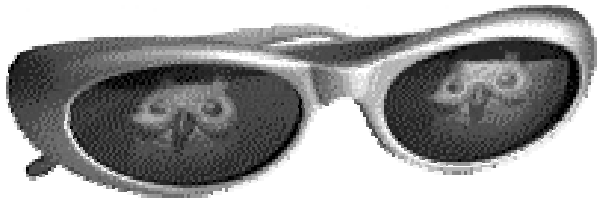
Creating 3D images with Holography

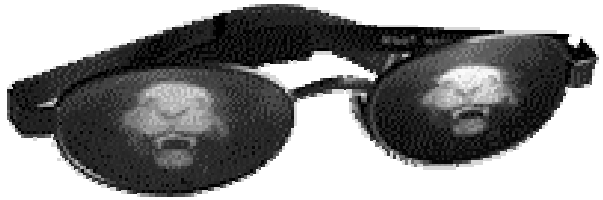
Holograms (c.1948 Dennis Gabor)

The optical wavefront which is reflected from the real object is recorded (amplitude and phase).

The original wavefront can then be reconstructed, hence you see an exact replica of the object.







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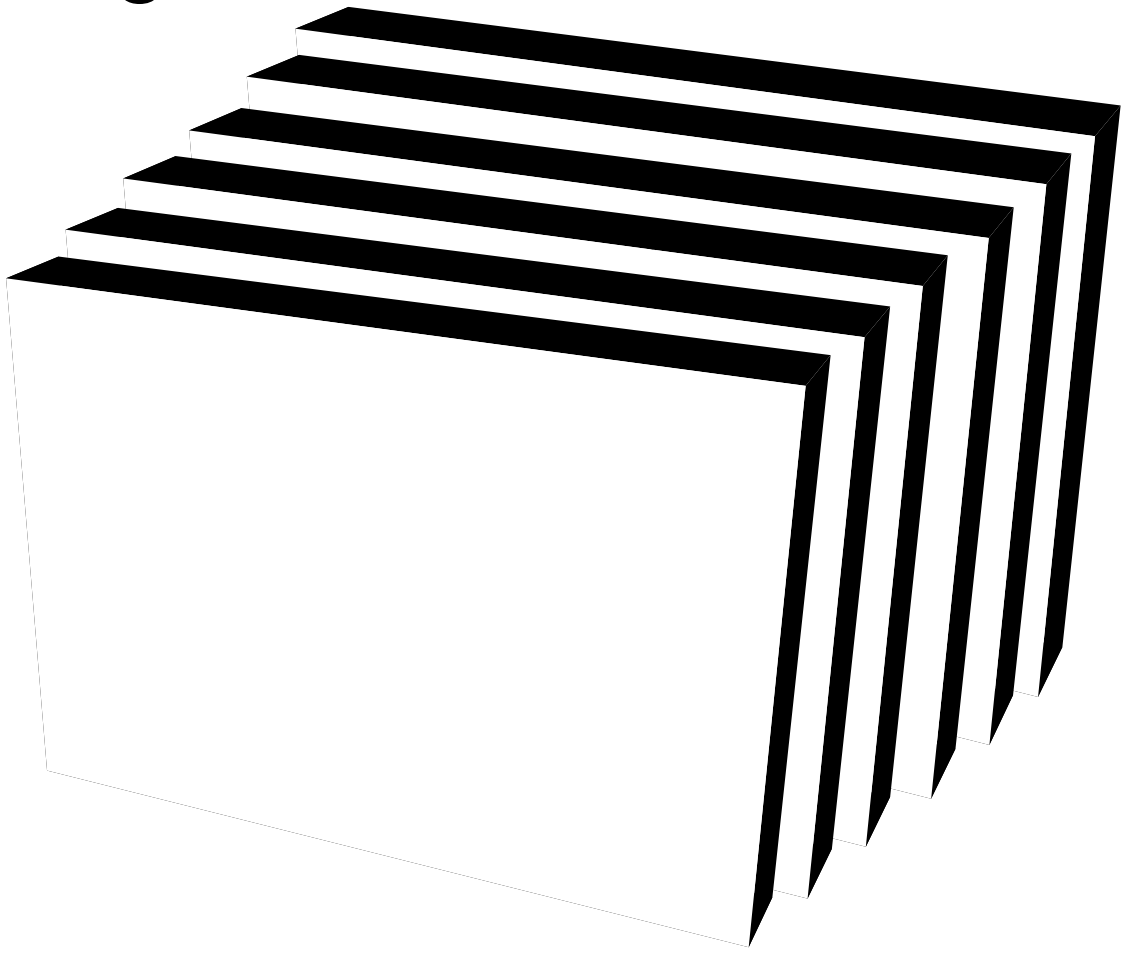
Creating 3D images with Voxels

A screen with three dimensions is used, with each pixel containing a finite volume. Each depth layer must be transparent when not in use.



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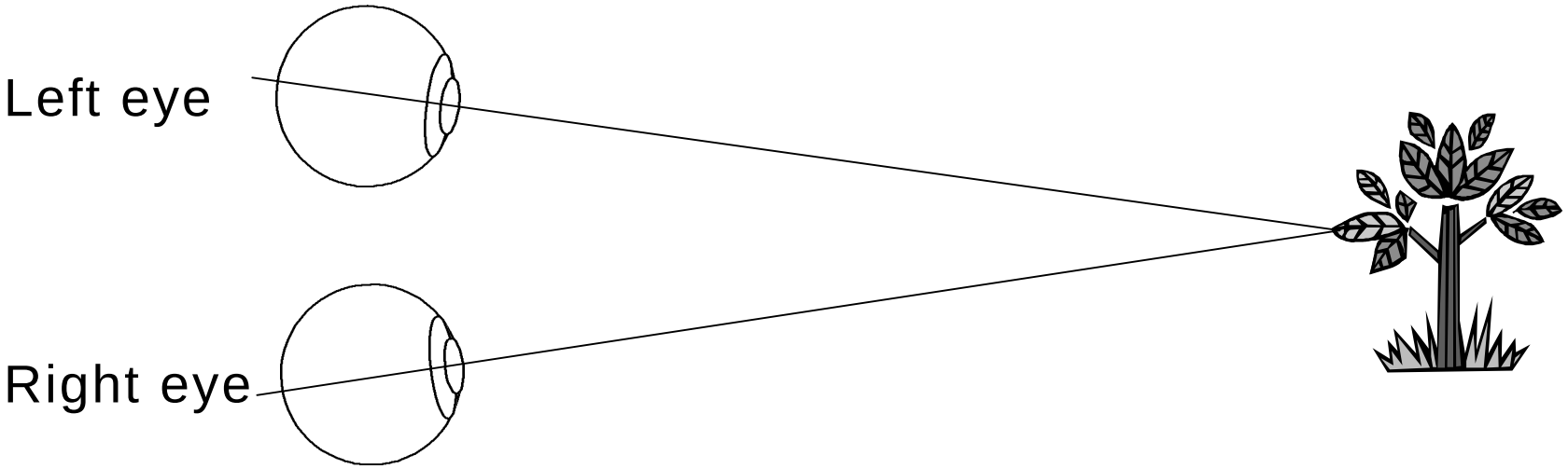
Creating Stereoscopic 3D Images



Real life: convergence and focus in same plane
Stereoscopic images: focus on display, convergence not always in the same plane.

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Creating Stereoscopic 3D images (1)

The Stereoscope (c.1830)

Two pictures are taken from a small distance apart. These can be recombined using a viewing device…. Or you can train yourself to see such pictures using a cross eyed technique.

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Creating Stereoscopic 3D images (2)

The Anaglyph (1930)

Two pictures are taken from a small distance apart and tinted red and blue

This works best for monochrome images

Red left, blue right

www.studio3d.com

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Creating Stereoscopic 3D images (3)

The Magic Eye (c. 1994)

This type of 3D image relies on the user focussing in a different plane to that of the image.

www.studio3d.com

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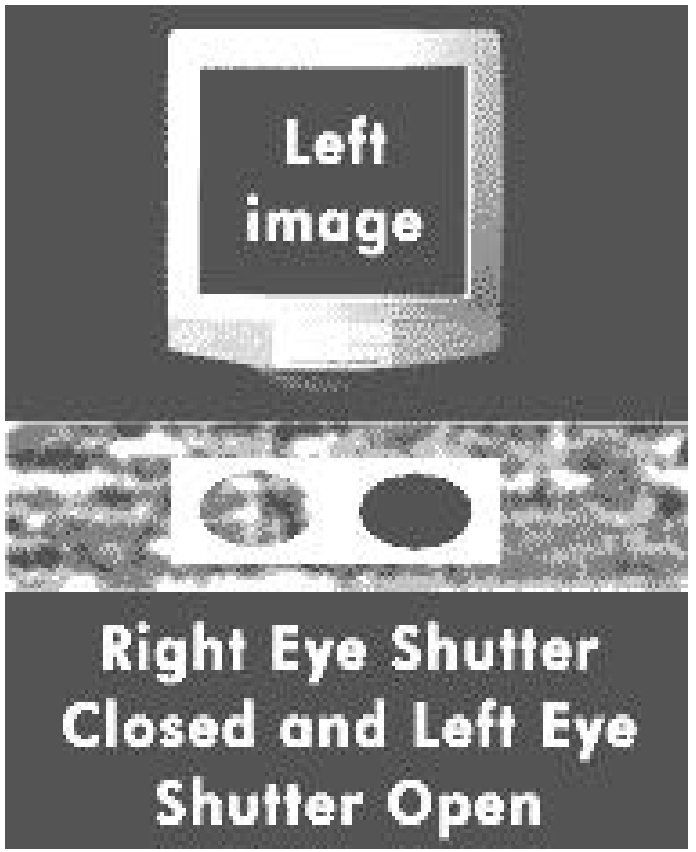
Creating Stereoscopic 3D images (4)

Shutter Glasses

The LCD shutters alternate to allow you to see a left and then a right image... this must be synchronised with the screen.



www.stereographics.com

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Creating Stereoscopic 3D images (5)

Shutter Screen (LCD)

If you don't like wearing heavy glasses you can attach the shutter to the screen, and wear featherweight polarising glasses. (you also don't see any effects when you look at an ordinary monitor.)

www.nuvision3d.com

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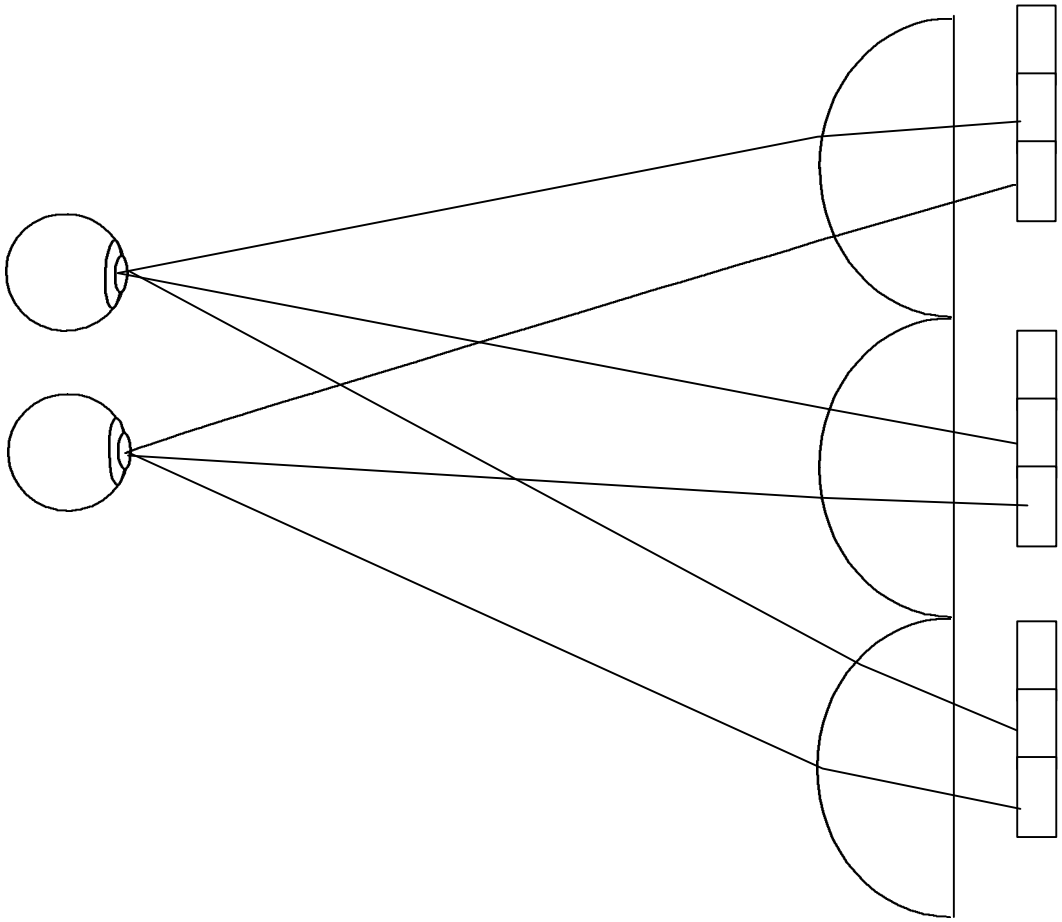
Creating Stereoscopic 3D images (6)

Lenticular Screen

The different viewing angle of the left and right eye causes them to access different images through the lenticular screen. The result is stereoscopic vision with motion parallax



www.stanford.edu/~matteoja/lent.html

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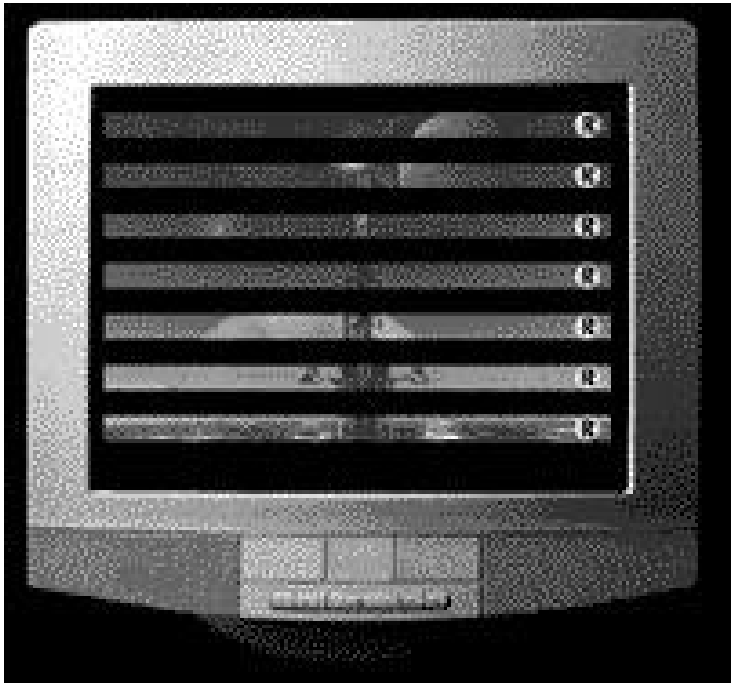
Creating Stereoscopic 3D images (7)

Interleaved Images

The screen is split into rows with alternate rows (or columns) destined for each eye. A holographic screen, lenticular screen or Venetian blind directs light to the eyes.



www.3dexpo.com

www.realityvision.co.uk

www.sharp.co.uk

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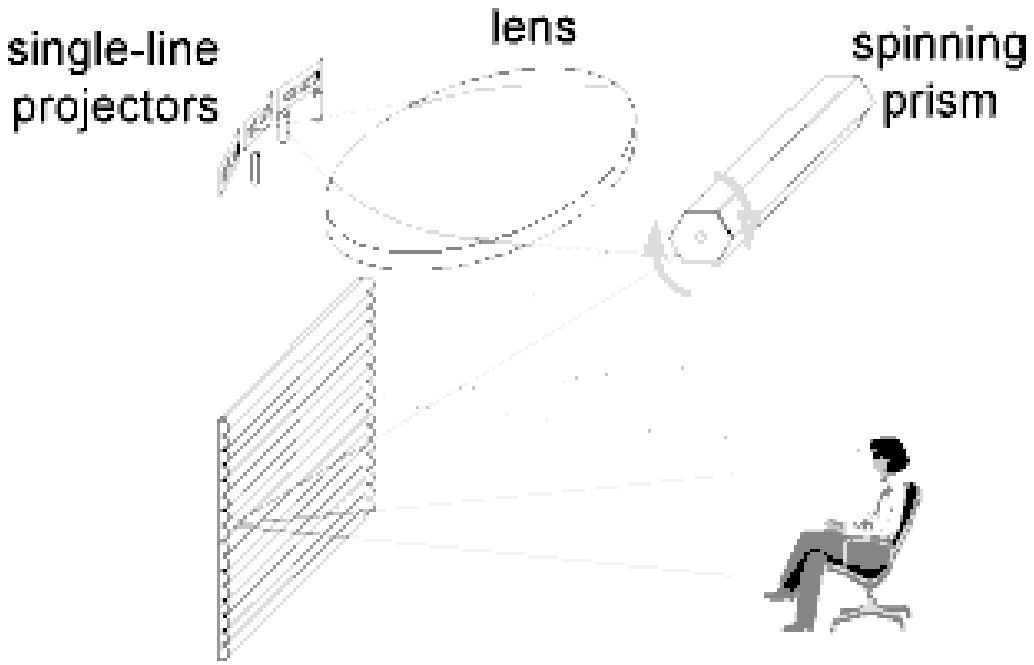
Creating Stereoscopic 3D images (8)

Multiple 2D Displays

Each display presents a different eye view. More displays means more viewers can see the 3D image



We use a spinning prism to line-scan a 3D image. This may be a cheap way of getting wall-sized 3D.

www.cam3d.co.uk

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Why measure 3D displays?

The realism offered by 3D images, makes them desirable for complex tasks, including:

- Design of jet engines
- Keyhole surgery

.... Do you want those images to be accurate NOW?

(oh.. it might make 3D games better too!!)

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Metrological requirements of 3D displays?

Different display types need different tests… in general manufacturers want:

Dimensional accuracy (VVV important…)
Colour
Contrast
Crosstalk between stereo images
Disparity between stereo images

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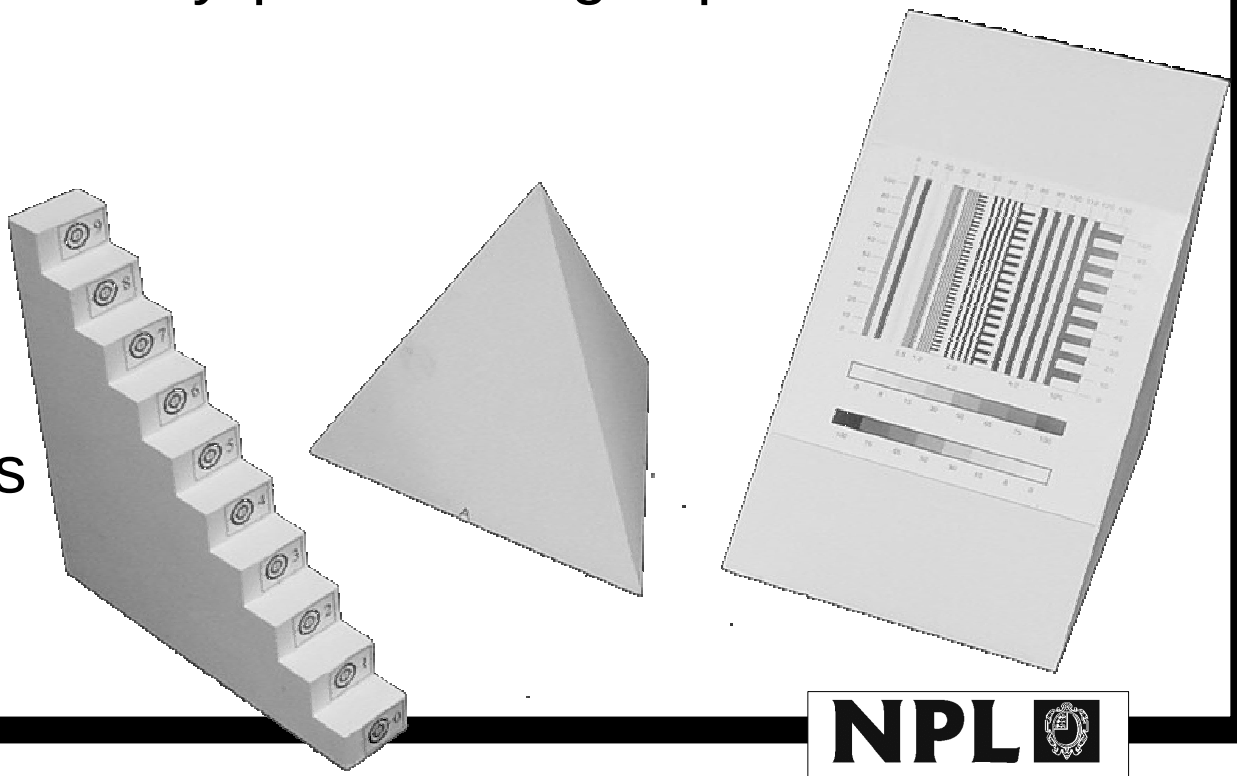
NPL and 3D measurement

Dimensional Accuracy

NPL has co-ordinate measuring machines, that can accurately measure 3D points to the nearest 0.001mm in X,Y and Z by positioning a probe on the surface of objects.

3 dimensional test artefacts were distributed among participants in a 3D study



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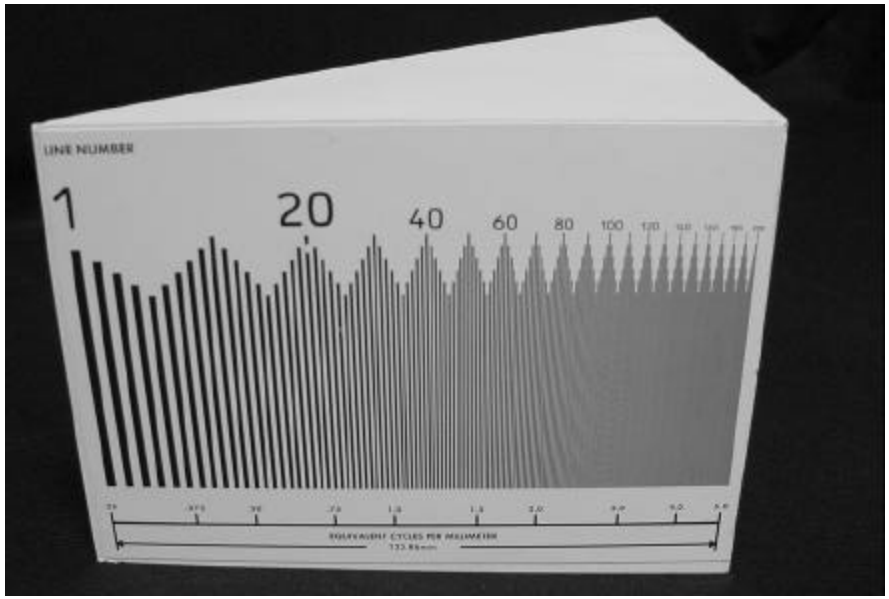
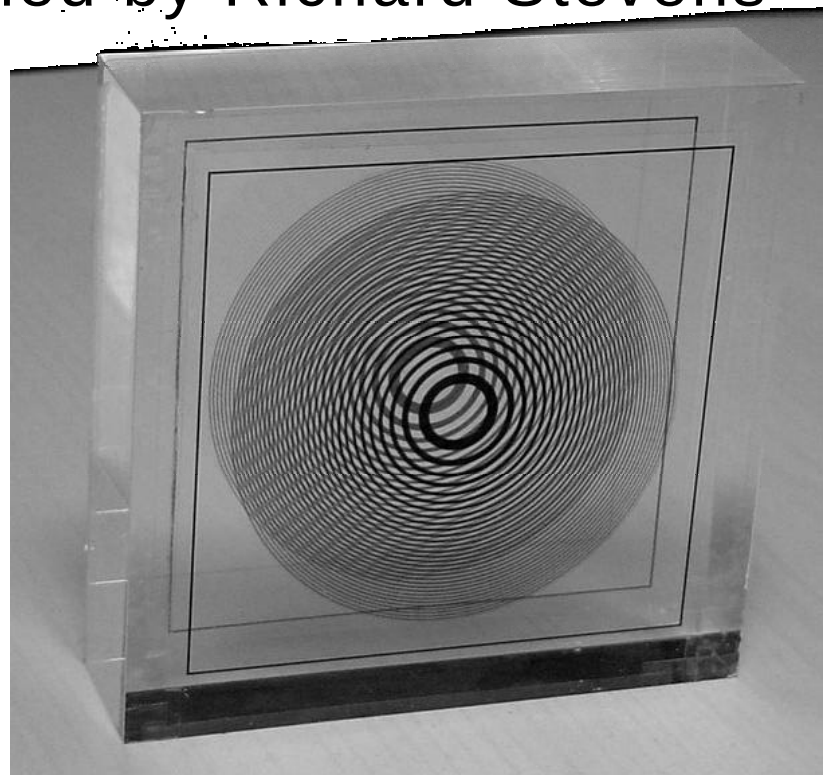
NPL and 3D measurement

Resolution testing
with a standard
test chart



Angular Parallax
using a moiré pattern
designed by Richard Stevens



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NPL and 3D measurement

Colour Rendering

Colour measurement in 3D environments is not defined.

Should the measured colour be the average the colour shown on each channel...or something more complex?

A self luminous 3D colour sample would be a useful artefact to begin such measurements.

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NPL and 3D measurement

Contrast

We had greyscale charts which allow a measure of contrast... BUT for stereo images, the contrast in each channel may differ, how this is perceived by the two eyes together isn't understood.

So we can make a measurement but it might not be useful?!

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NPL and 3D measurement

Crosstalk

Cross talk is the measure of how much of the signal destined for one eye, reaches the opposite one. It's a very complex measurement, but NPL are jointly looking at ways to achieve this.

Disparity

The two images are meant to be identical but seen from different angles, disparity is the measure of how different the images are

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NPL's Current 3D Capability

The NPL are currently looking at ways to expand our existing display measurement capability into the 3rd dimension. We are waiting news about funding for the development of a system to measure crosstalk.

We can measure resolution and parallax of 3D systems using the test artefacts we have developed.

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Questions

Thanks to Dr Richard Stevens and Julie Taylor

My colleagues on the 3D Project