root6
technology for the creative

Metropolitan Police Video Training

Phil Crawley
@IsItBroke on Twitter

Video Measurement - Principals (4 days)

Course Aim

The aim of the course is to provide grounding in video fundamentals, compression and picture quality analysis for staff who work with video processing, detection and vision systems.

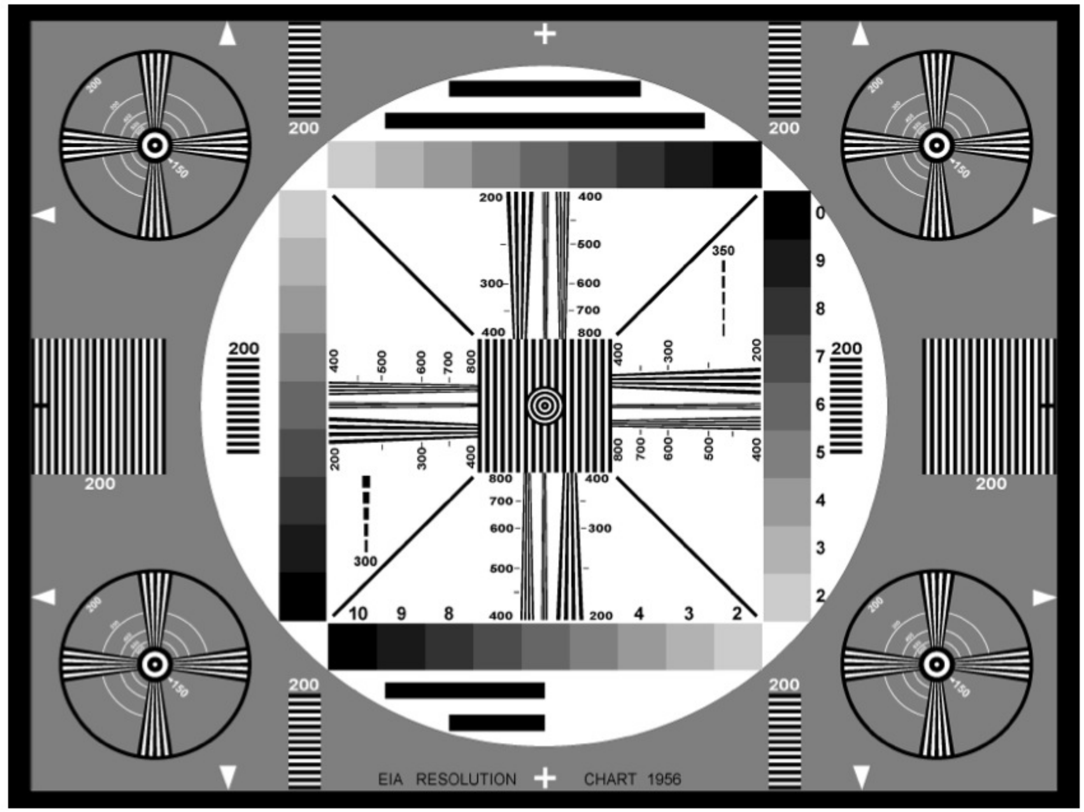
Course Structure

- Day 1 - TV Fundamentals; *Scanning and Sampling, Colour Systems, Analogue Composite Coding*
- Day 2 - TV Fundamentals; *Digital Component Coding, Conversion of Film to Television, High Definition*
- Day 3 - Compression; *DCT principles, Intra-Frame vs Inter-Frame Encoding, blocks and macroblocks*
- Video Tape Recording; *Magnetic recording principles, rotary recording, Simple VT maintenance.*
- **Day 4 -** Television Measurements; *Analogue, Digital*
- **Picture Quality Analysis in CCTV; *Analogue picture impairments, digital picture impairments, compression***
- **TV Displays; *CRT, LCD and Plasma displays. Problems with LCD and Plasma, Projection systems.***

www.root6.com +44 (0) 20 7437 6052

From Lens to monitor – image quality

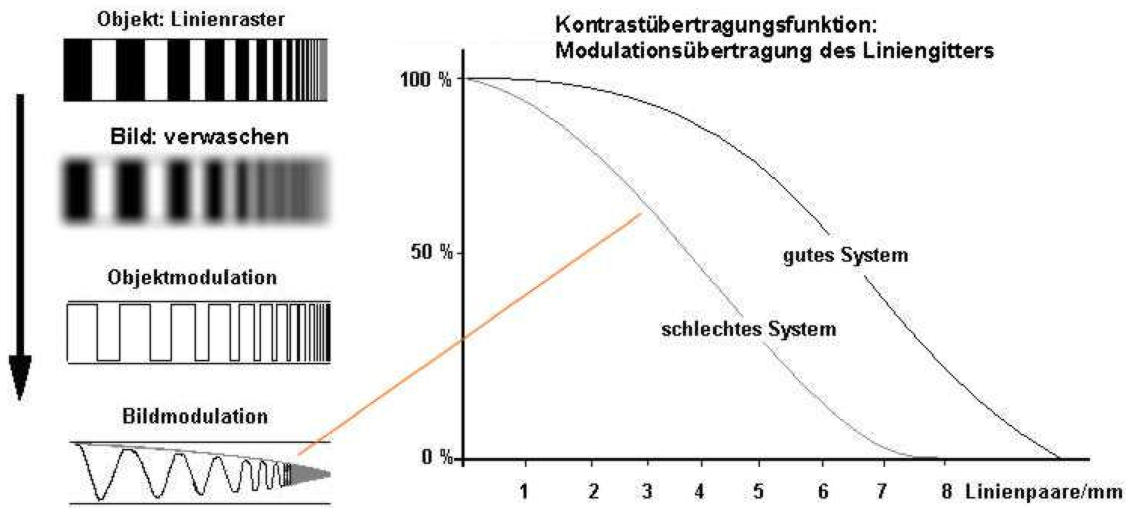
Television lines (TVL) is a specification of an analogue camera's or monitor's horizontal resolution power. It is alternatively known as Lines of Horizontal Resolution (LoHR), aka lines of resolution. The TVL is one of the most important resolution measures in a video system. The TVL can be measured with the standard EIA-1956 resolution chart. TVL also makes a variation on horizontal angle of display from a video camera, i.e. The more the TV Lines depending on the size of lens, the smaller/narrower the angle of coverage but better picture quality.



www.root6.com +44 (0) 20 7437 6052

The camera – optical transfer function

The optical transfer function (OTF) of an imaging system (camera, video system, microscope etc.) is the true measure of resolution (image sharpness) that the system is capable of. The common practice of defining resolution in terms of pixel count is not meaningful, as it is the overall OTF of the complete system, including lens and anti-aliasing filter as well as other factors, that defines true performance. The optical transfer function is roughly the equivalent of phase and frequency response in an audio system, and can be represented by a graph of light amplitude (brightness) and phase versus spatial frequency (cycles per picture width).



Sorry about the German text

They are the best optical people!

The whole chain

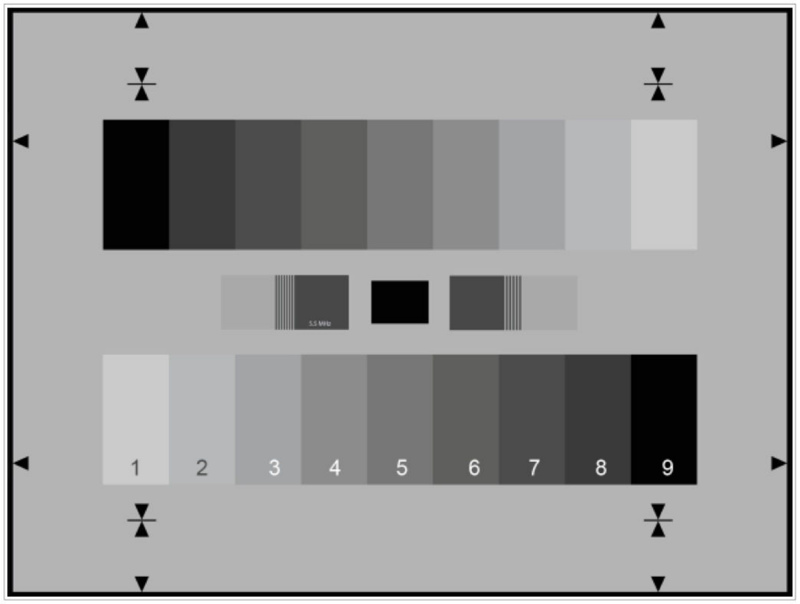
- The camera lens
- The resolution of the camera's sensor
- The encoding system
- The compression system
- The display system

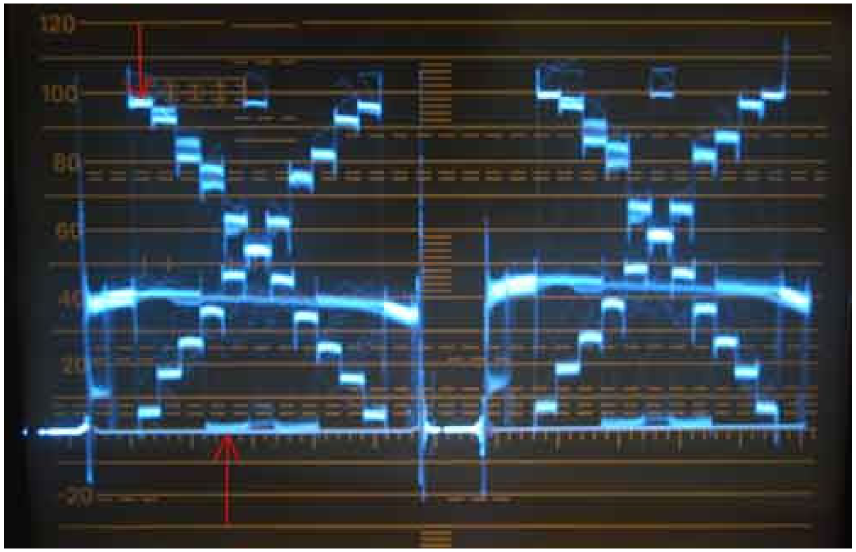
Clearly there would be a difference between;

- a pro-studio lens, a three chip camera, RGB output, uncompressed video and a broadcast monitor
- a domestic camcorder, single chip, PAL output, DVD compressed, domestic TV
- CCTV camera, single chip, PAL output, H.264 security recorder, PC monitor

To encompass the whole chain we refer to the *modulation transfer function*

Studio camera chip chart





Notice the high frequency gratings either side of the 'Gregory Hole'

Testing in the CCTV industry – Rotakin

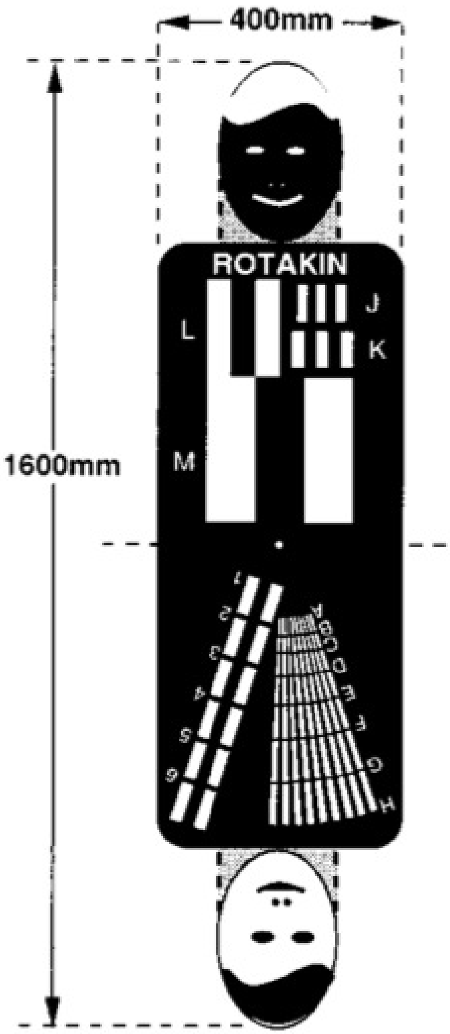
The security industry has its own testing standard. The Rotakin target was developed by HOSDB (Home Office Scientific Development Branch) as a means of auditing the efficiency of a CCTV system. It consists of a human silhouette target 1.6m in height. When the target fills the screen vertically it is said to be 100%R.

The target has various gratings for ensuring the modulation transfer function of the system allows footage to have the required resolution so that video material will stand up in court.

As well as lens, sensor, encoding/compression system the other factor that will affect how well each resolution grating is reproduced is lighting.

technology for the creative

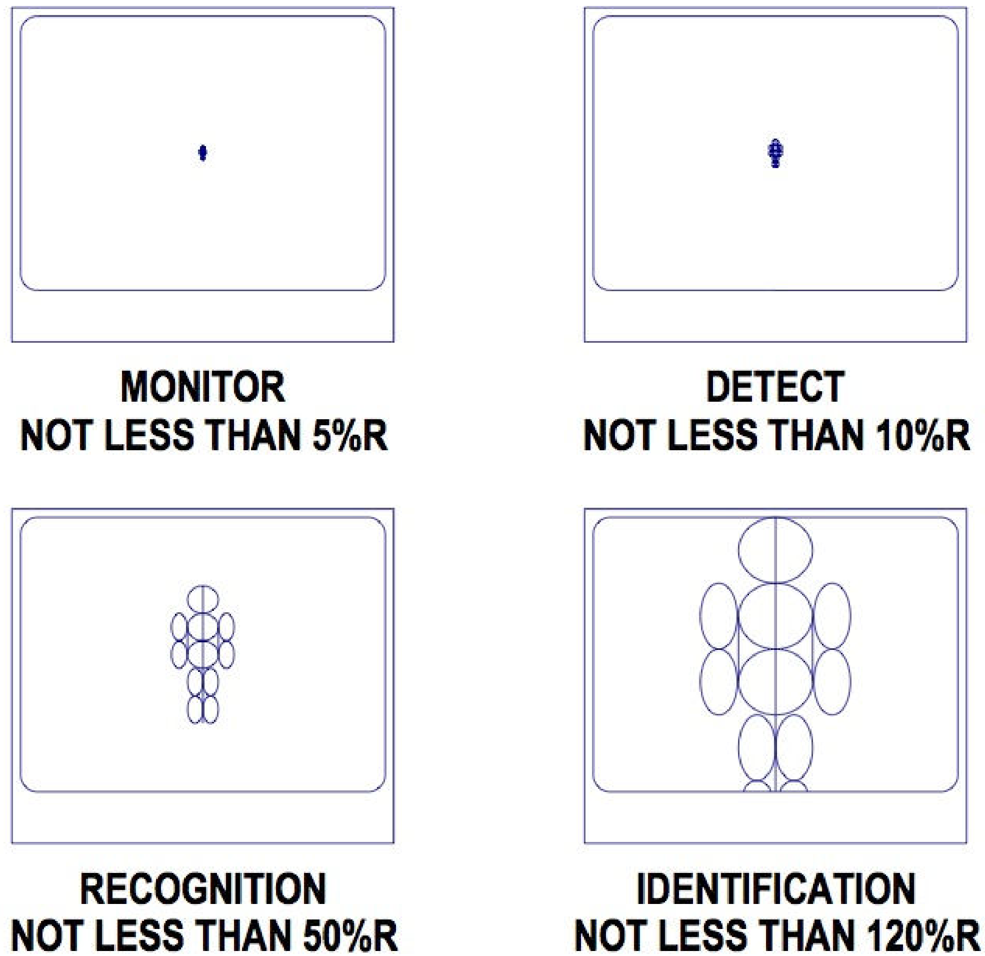
The Rotakin CCTV test target and scale markings



Rotakin Scale	mm/cycle on target	TV Lines/picture height for 100%R image
A	6,4	500
B	7,1	450
C	8,0	400
D	9,1	350
E	10,07	300
F	12,8	250
G	16,0	200
H	21,3	150
J	32,0	100
K	40,0	80
L	80,0	40
M	160,0	20

Levels of video evidence

- The requirement for identification is that the subject more than fills the frame (i.e. 120% R).
- At 100% R the A-grating should be discernible which implies the system has 500TVL resolution.



technology for the creative

CCTV & Rotakin – some more notes

- All cameras **must** produce colour images to enable accurate identification of offenders.
- All external public access doors must be fitted with cameras which enable clear, unobstructed images of all persons entering/exiting the premises. Where practicable, these cameras should be mounted internally. Such cameras must be mounted at a suitable height - looking towards, rather than down at the doorway. These cameras must be capable of producing HOSDB Identification standard images (a minimum of 450TVL resolution and 120% Rotakin screen target height) at the monitor.
- All internal cameras must be capable of producing HOSDB Recognition standard images (a minimum of 450TVL resolution and 50% Rotakin screen target height) at the monitor.
- CCTV Cameras are susceptible to interference and vandalism. Cameras should be fitted with robust anti-tamper housings to prevent such actions.
- All cameras must be a minimum standard of 450 TVL. They must have back light compensation, direct drive or amplification capability, and a sensitivity of a minimum of 1 lux.

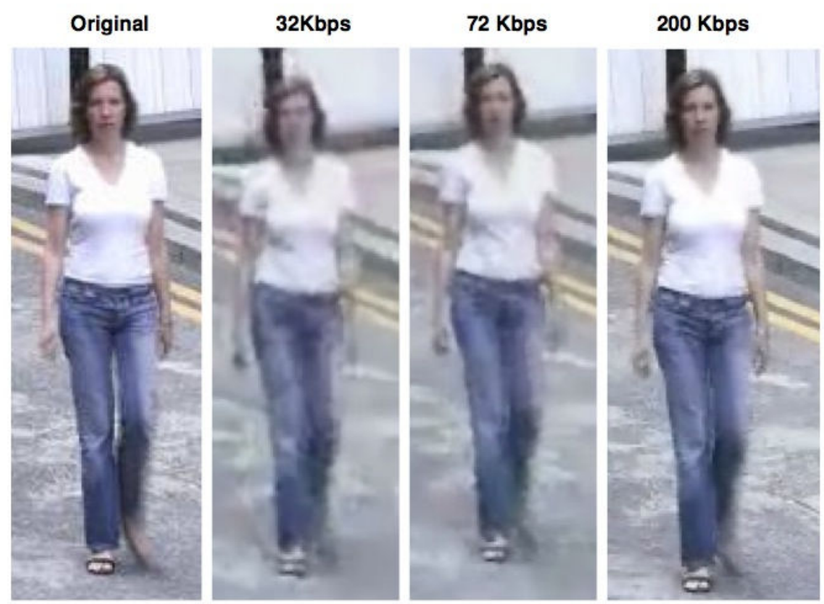
www.root6.com +44 (0) 20 7437 6052

Security recorders and compression

In the past CCTV footage would have been recorded on long-play VHS. Contemporary systems all use digital compression onto hard disk.

- Clearly low-data rate recordings compromise the retention of detail.
- H.264 is a contemporary compression system that out-performs MPEG2 for image quality at a given data rate.
- Typically 1Mbit/sec is reckoned to suffice for SD pictures to maintain enough resolution.

	Encoding Bit Rate (Kbps)	Compressed File Size (Kb)
	Original image file size	4, 200
MPEG-4	32	55
	52	57
	200	70
WAVELET	32	66
	52	75
	200	83



www.root6.com +44 (0) 20 7437 6052

root6

technology for the creative

1 camera x

1 million bits/second x

60 seconds/minute x 60 minutes/hour x 24 hours/day x 365/4 days divided by 8 bits/byte =

982,800 million bytes = 1 TB (approx)

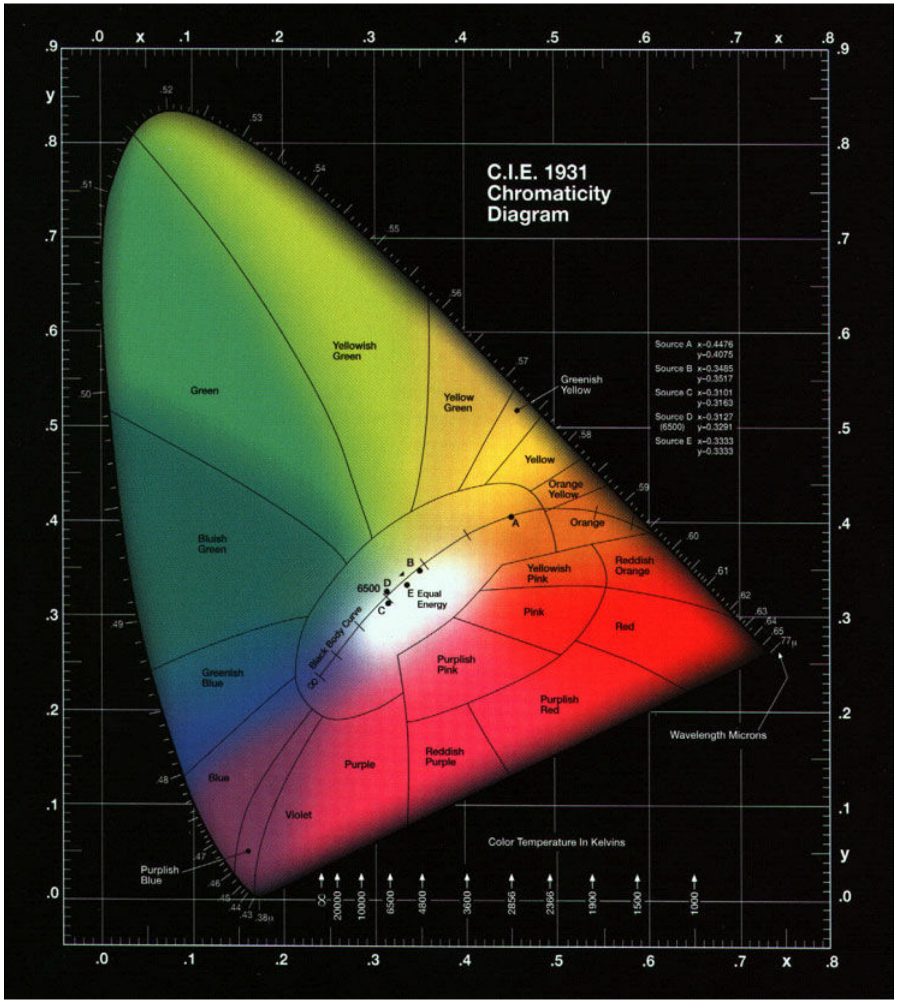
Overview and introduction to colour space and gamut including legalisers

An important aspect of the production/post-production chain is maintaining correct colourimetry. If the director of photography or the lighting-cameraman want that certain shade of red to be correctly delivered to the viewer then attention needs to be paid to the correct representation from the camera (be it standard or high definition or even film) through all transfer operations (potentially going between resolutions, YUV/RGB colour spaces and bit depths) to the final display surface (be it a CRT, LCD or even cinema screen).

Part of the problem is that all of our machines acquire images in the RGB space (TV cameras, Telecines, graphics workstations etc.) but for the most part we post-produce in a YUV space (with the exception of Sony's new HDCam SR format, an RGB high-definition VTR) which represents an immediate lowering of the colour space. This has been the case for a long time and is well understood.

www.root6.com +44 (0) 20 7437 6052

root6
technology for the creative



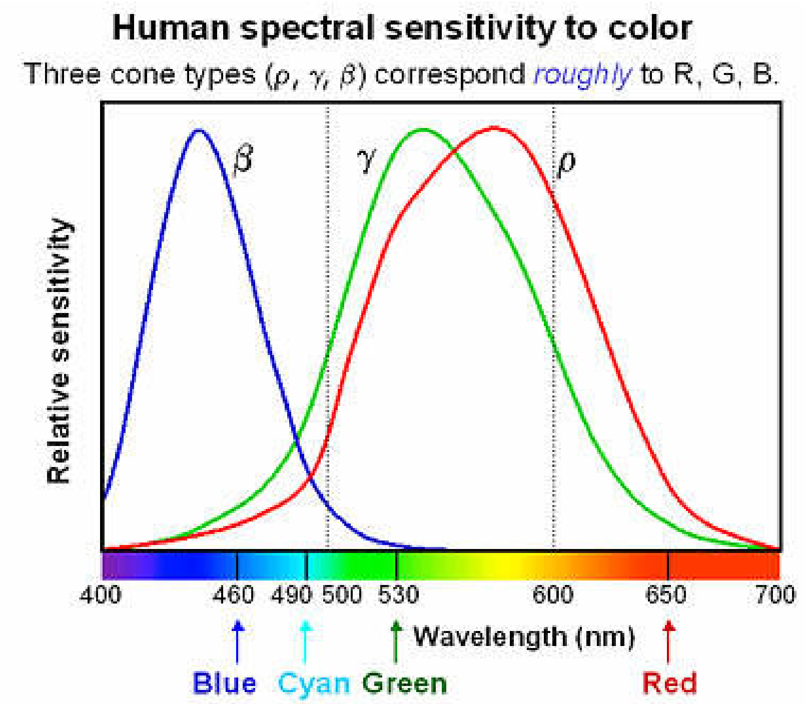
The CIE Chromaticity diagram (first published in 1931!) shows the gamut of human vision – essentially any display surface is a subset of this diagram and will be a triangle with red, green and blue apexes and white (actually monochrome – as the luminance of the image is reduced it tends through grey to black) in the centre. In the case of "illuminant D" (AKA "D6500" or "EBU phosphors") – the standard definition colour standard used since the sixties in Europe we enjoy a slightly wider red range than our colonial cousins but every gamut (television, film or print) is a poor compromise on what your eyes can handle. This is where the problem begins – you have a very critical instrument at your disposal to see these differences.

root6
technology for the creative

Legalisers

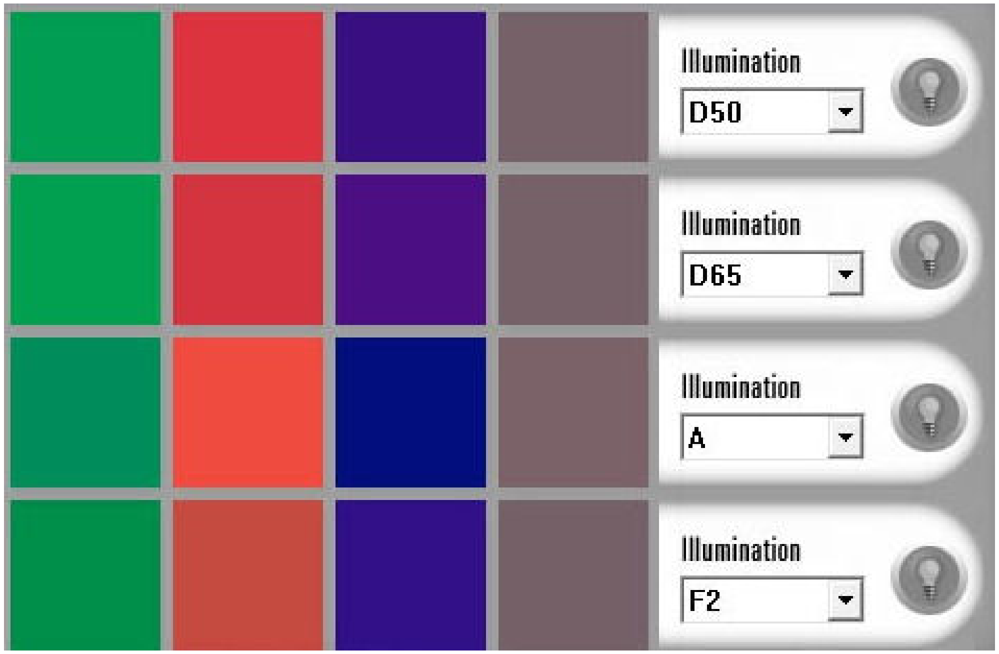
- Devices that auto-correct video so everything is 'street legal'
- Early models used to be quite brutal leaving pictures looking digitally manipulated
- Current models are much kinder to pictures – The Japanese Knee!

The nature of colour and light



Our eyes are sensitive to wavelengths from below 400nm (blue) through to over 700nm (red). Other creatures see different ranges of wavelengths, but as people our eyes start working just after (what we call) ultra-violet (where EM radiation has enough energy to start being called 'ionising radiation') through to just short of 'infra-red'. The light from the sun is broad-spectrum (i.e. at every wavelength we can see, and in fact extending far above and below where our eyes work). This mix of all frequencies from the sun illuminates our world and different objects absorb some frequencies and reflect others - the reflected light enters our eyes and depending on the mixture of reflected frequencies we perceive a certain colour - plants absorb all frequencies bar those around 550nm which is reflected and we call the sensation that we get from that set of frequencies 'green'. The same is true of objects that emit light (like TV and computer monitors).

The mechanics of human vision



There are several instances where (depending on the wavelength of the light) you may be getting similar amounts of response from different cones for different wavelengths - you can't distinguish between certain wavelengths because the cones are all stimulating the same signal for both wavelengths. These colours are referred to as metamers and your eye's inability to discern the differences is 'metameristic failure'.

This is best summed up by remembering that light is wide-spectrum but your eye us tri-stimulus and there will be some failures. The most pronounced is red-green colour-blindness suffered by some men. Also - all monitors are tri-stimulus but with a different set of peaks to the human eye; the manufacturers know this and they weight the red/green/blue response to try and match human vision as best as the technology allows.

technology for the creative

Metamerism and colour

The upshot of all of this is that we have different metameristic failures between different display technologies; CRTs (which with the benefit of history have had the chemistry of their phosphors refined to match human vision quite well), LCDs, plasma and projectors (of various flavours) all have different tri-stimulus RGB curves (all differing by different degrees to your eye and hence 'scaled' to try and best fit). It's amazing they cans be made to produce any kind of colour fidelity!

Colour Constancy

Edwin Land showed that colour is almost entirely relative. The paint on the back wall of the edit suite is as important as the colour on the monitor.

www.root6.com +44 (0) 20 7437 6052

technology for the creative

Calibrating monitors

Small side-note concerning units of luminance

- Lots of folks quote it in Foot Lamberts - terrible measurement!
- It assumes monitors are a point-source of light (they aren't)
- It is a mix of SI (Lambert) and Imperial (foot) measurements
- Far better to use the SI unit of the Candela per square metre.

Practical demo with CRT and LCD probes

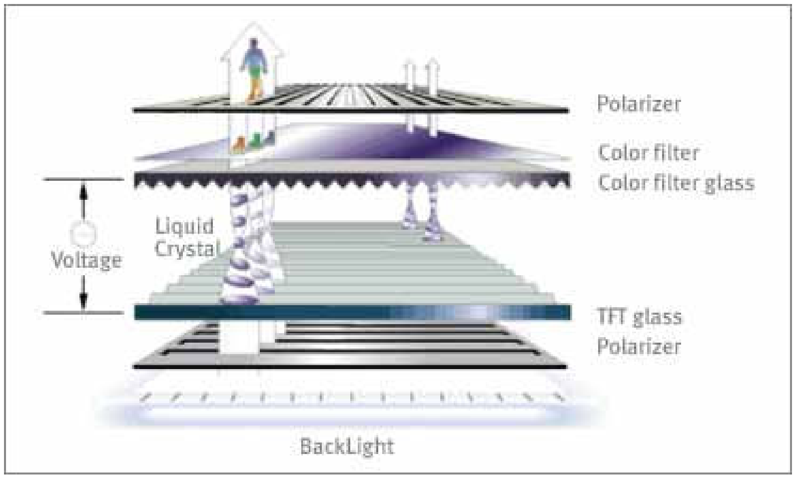
- Why 80Cd/m2?
- Why 6504K?
- procedure - remember to use the appropriate probe!
- What requires a test set and what can be done by eye?

technology for the creative

LCD monitors

Since LCD displays have largely displaced CRTs it's worth giving them special attention

- CF backlight or LED backlight?



But, for most LCD displays the colour white is made by the backlight and the two orthogonal display elements shut down red/green/blue sub-pixels.

Criticism of LCDs

- dynamic range
- black performance
- angle-of-view
- brightness

They tend to be for domestic applications where a lot more light is required (shop floor, living room etc) and that is why domestic LCDs are not suitable as grading display. Also - computer GUIs; everything is wrong - range (RGB vs YUV), illumination level etc.

Benefits of LCDs

- They hold their colour balance for 20,000+ hours until the backlight starts to fail

www.root6.com +44 (0) 20 7437 6052