5th BAM-DIN-Workshop on Image Technology,
Berlin, 2005

Production method for analog ISO/IEC-test charts according to ISO/IEC 15775

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Introduction

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The ISO/IEC 15575 standard for colour copiers was issued by ISO/IEC JTC1/SC28 “Office Systems” in December 1999. The Japan Business Machine and Information System Industries Association (JBMIA) published test charts compliant to these standard described in ISO/IEC 15775: 1999/FDAmd 1: 2005. The production of test-charts according to this standard requires a method for the reproduction of colours given by absolute CIELAB values.

This poster presentation compares the accuracy of the following printer calibration methods:

- Postcript rip colour rendering
- ICC calibration
- MTL calibration (according to ISO/IEC TR 19797)
- Look-up table (LUT) interpolation with different LUT sizes

Two test charts are used for this research. The first uses 557 test colours choosen stochastical from the printer gamut. The second one is test chart 4 of ISO/IEC 15775.

This poster also shows a method, how high accuracy for ISO/IEC test charts in reflection and transmission can be reached. The method uses a CIELAB camera to measure a complete test chart in 2 minutes.

The test charts produced with this methods will be available by BAM this year.

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Setup

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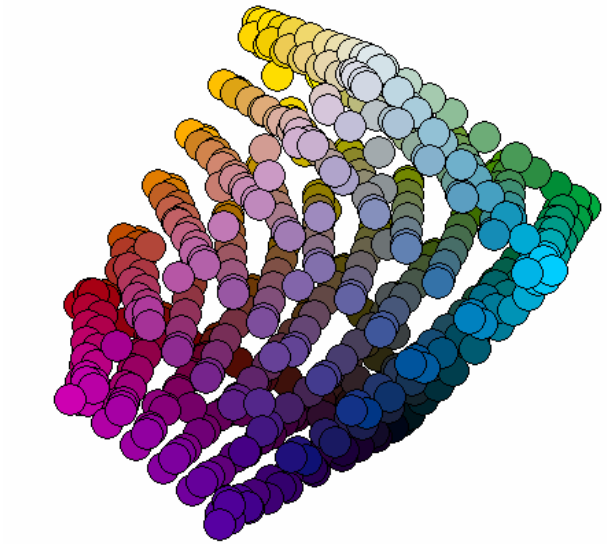
Colour Space:	All CIELAB colours are calculated with D65 standard illumination / 2° observer.
Output device:	Fuji Fujix Pictrography 3000 photographic printer / PG-SG/ER W paper, default settings, disabled colour management.
RIP:	Raster Plus 2.0.6
Measurement device:	Gretag MacBeth SpectroscanT. Spectral measurement between 380nm and 730nm (10nm steps).
Accuracy:	CIELAB values are calculated according to the method descriped in CIE 15.3 A printout with subsequent measurement provides a typical repeat accuracy of $\Delta E=0.6$ with a maximum of about $\Delta E=2.0$.
Test charts:	All charts are directly programmed in Postscript using a D65 CIELAB colour space. The first test chart uses 557 test colours choosen stochastical from the printer gamut. The second test chart is test chart 4 of ISO/IEC 15775.

Setup

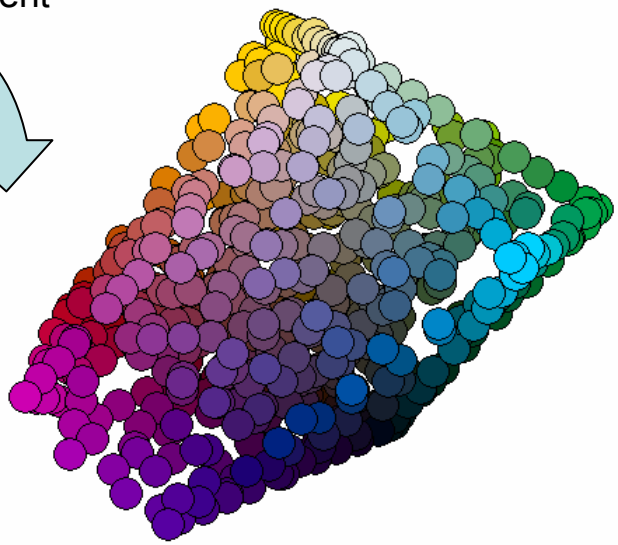
Test chart with 557 CIELAB test colours:

1. The 8 basic colours (RGBCMYNW) of the printer are measured in CIELAB.
2. Using a interpolation technique test colours are calculated arranged in a regular grid.
3. To avoid side effects the test colours are stochastically change.



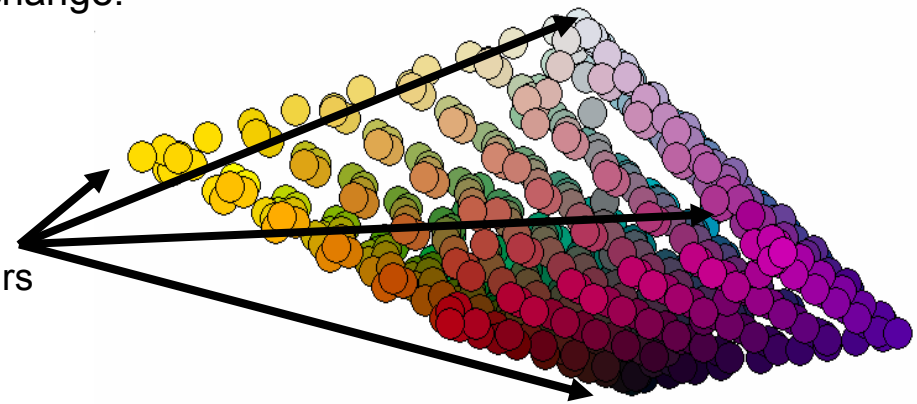
Viewing angle 1:
Test colours in L*a*b* space

Rearrangement

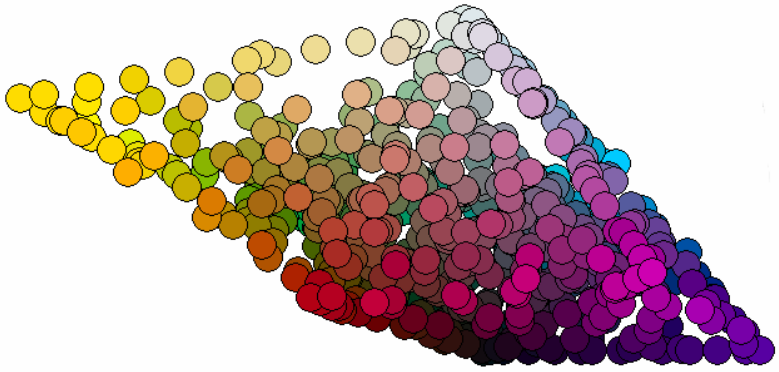


Viewing angle 1:
Rearranged Test colours in L*a*b* space

Basic colours



Viewing angle 2:
Test colours in L*a*b* space



Viewing angle 2:
Rearranged Test colours in L*a*b* space

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Methods

Postscript rip colour processing:

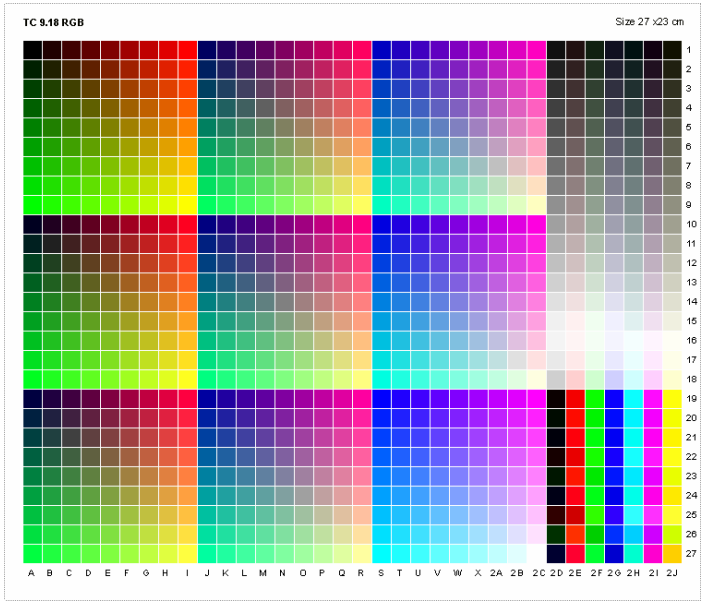
The test charts are rendered directly by the rip.

ICC calibration:

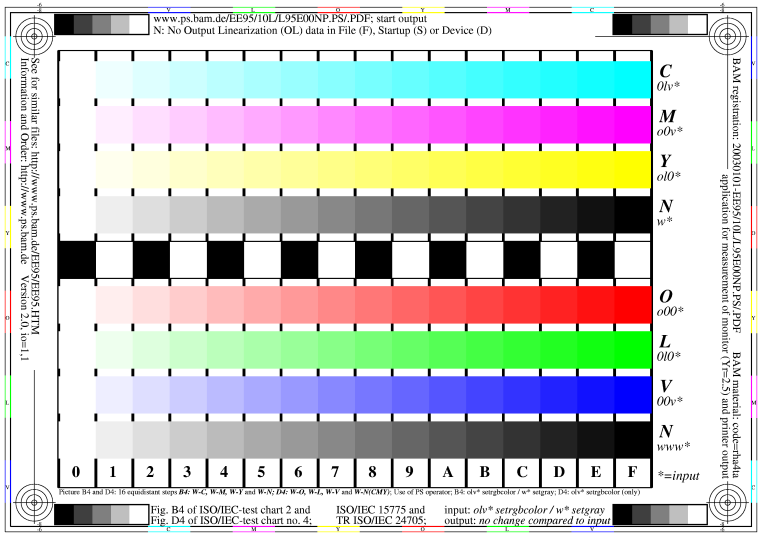
1. Creation of an ICC profile. The printout of a TC 9.18 test chart with 918 RGB patches is measured. Using *ProfileMaker* 4.1.5 an ICC-profile is calculated. The settings in *ProfileMaker* are optimized for D65 and maximal quality.
2. The test chart is imported into *Photoshop* 7. Using the ICC profile a RGB version is calculated.
3. The RGB version is printed.

MTL code (ISO/IEC TR 19797:2004-09):

1. A printout of a test chart with 8 16-step equally RGB-spaced test patches is made. The measurement data of this test chart is used as calibration data for the MTL code.
2. The MTL postscript code is integrated into the test chart.
3. The test chart is printed via the rip.



TC 9.18 RGB test chart

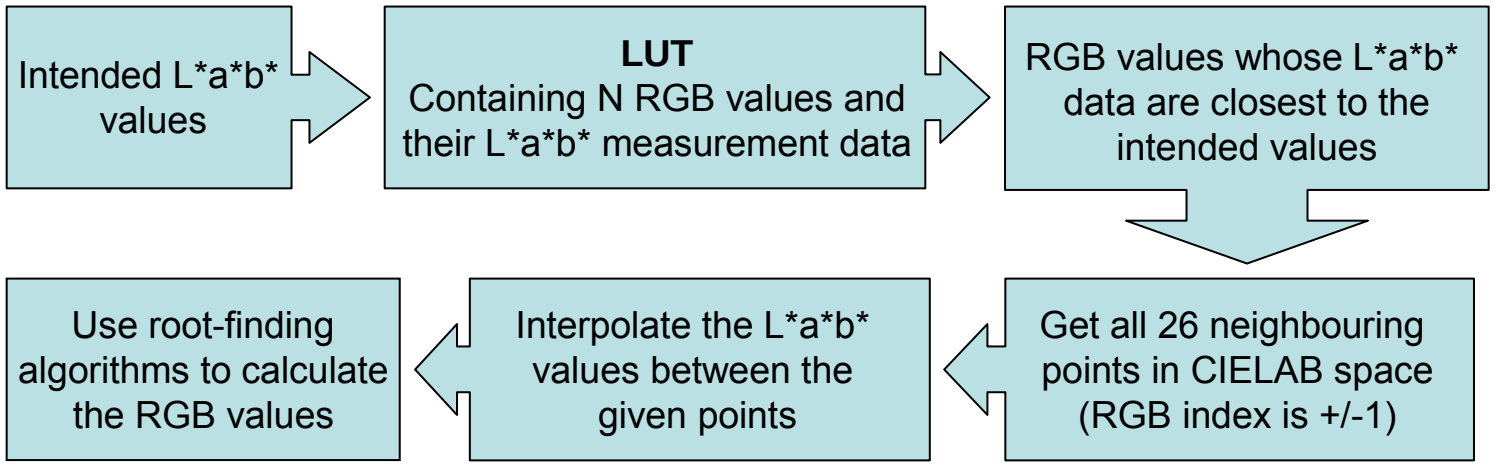


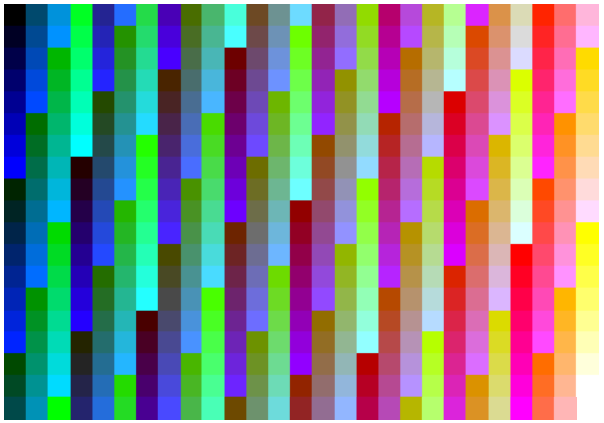
ISO/IEC TR 19797:2004-09 test chart

Methods

Look Up Table (LUT) calibration:

1. A printout of a test chart with N = n*n*n RGB test patches is made. The measurement data of this test chart is used for a LUT combining the RGB input values and the CIELAB output values.
2. The interpolation postscript code including the LUT is integrated into the test charts. The code calculates for every CIELAB colour the corresponding RGB LUT values with the smallest ΔE compared to the reference.





RGB test chart with 8x8x8 patches for printer profiling

RGB test chart measurement data in CIELAB space

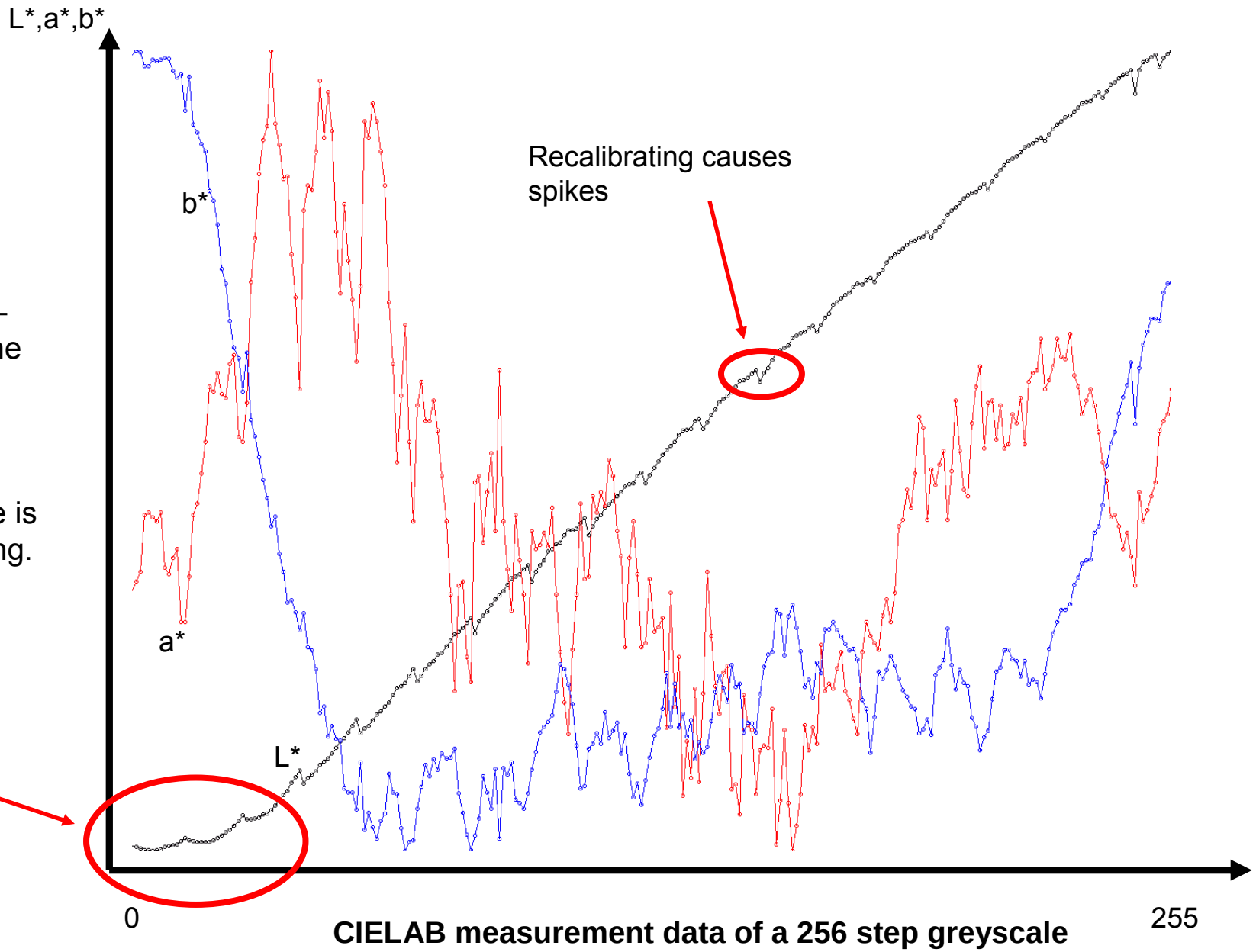
3. Using the 26 surrounding points in the LUT the LAB values are interpolated inside this volume. Using a Newton Raphson method the RGB values with the smallest ΔE compared to the reference are found.
4. The test chart is printed via the rip.

Results

Measuring a 256 step greyscale shows two Problems:

1.The printer goes into saturation at about RGB 18-18-18. If the step width of the calibration algorithm is too coarse an increasing error results.

2. The Measurement device is recalibrating while measuring. This causes spikes which produces additional errors.



CIELAB measurement data of a 256 step greyscale

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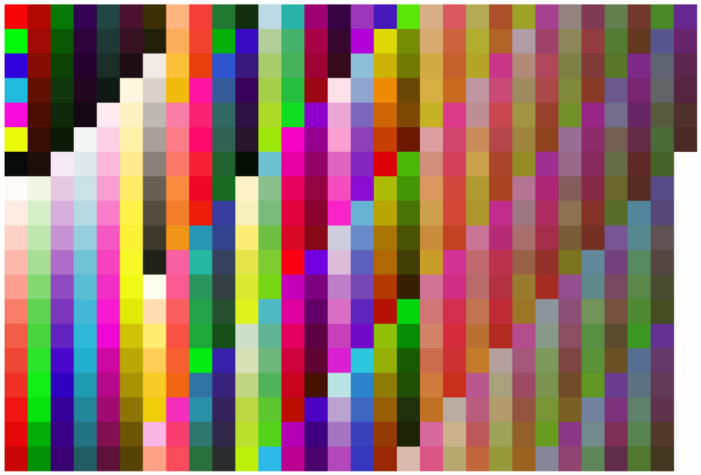
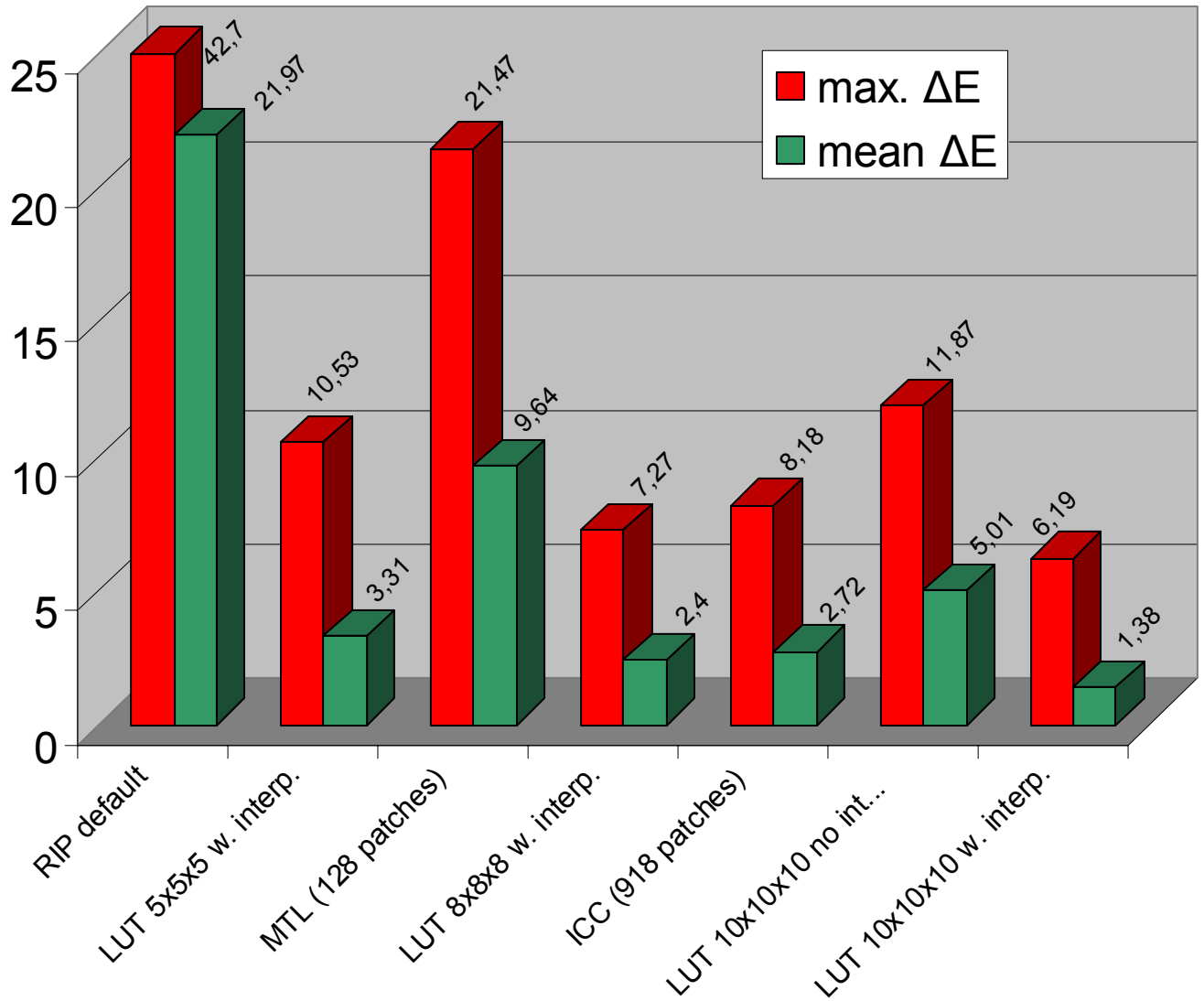
Results

Absolut CIELAB colour reproduction of 557 test colours

The 557 CIELAB test colours have been printed with the 7 different calibrating methods. The figure shows the average and maximal ΔE between intended and measured values.



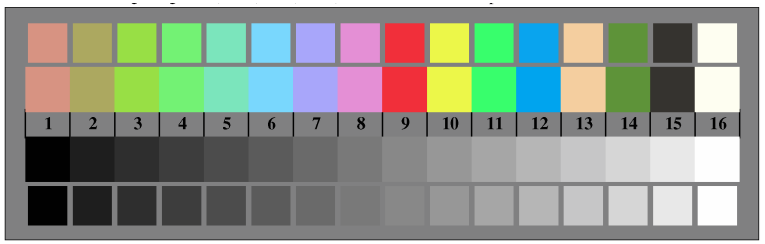
Test chart with 557 CIELAB test colours



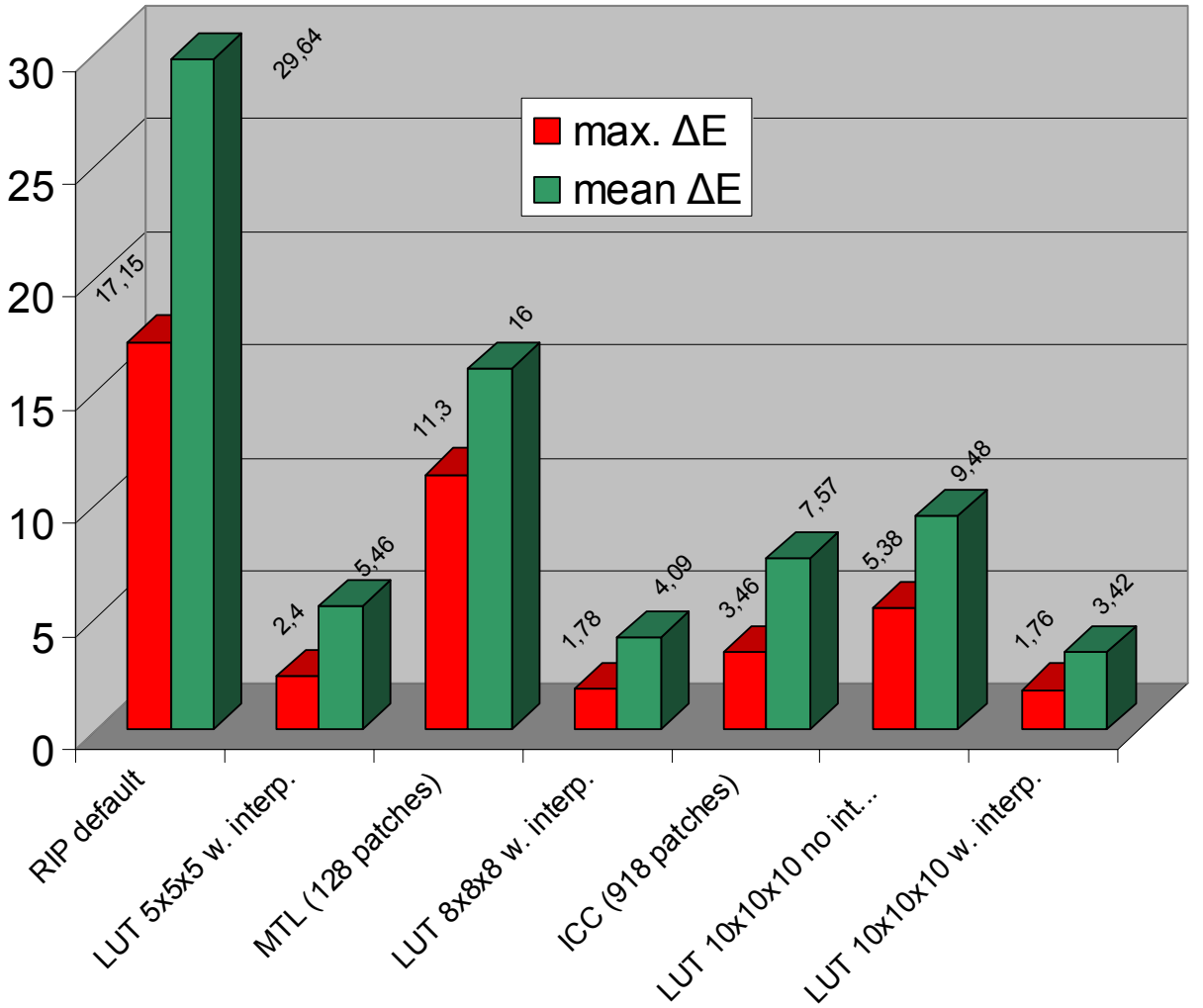
Results

Absolut CIELAB colour reproduction of 14 CIE test colours

This figure shows the average and the maximal CIELAB colour difference between the intended and printed 14 CIE test colours of ISO/IEC 15775 test chart 4. Compared are the 7 different calibrating methods.



14 CIE test colours of ISO/IEC 15775 test chart 4



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Results

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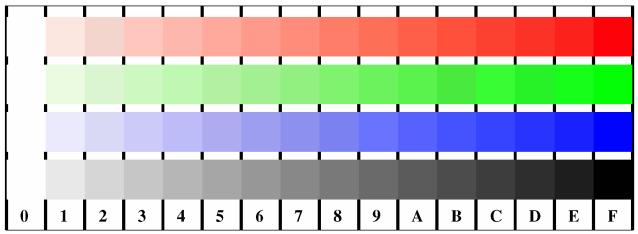
Average regularity g* of 4 16-step colour scales

This figure shows the regularity of the 4 16 step colour scales of ISO/IEC 15775 test chart 4 for the 7 different calibrating methods.

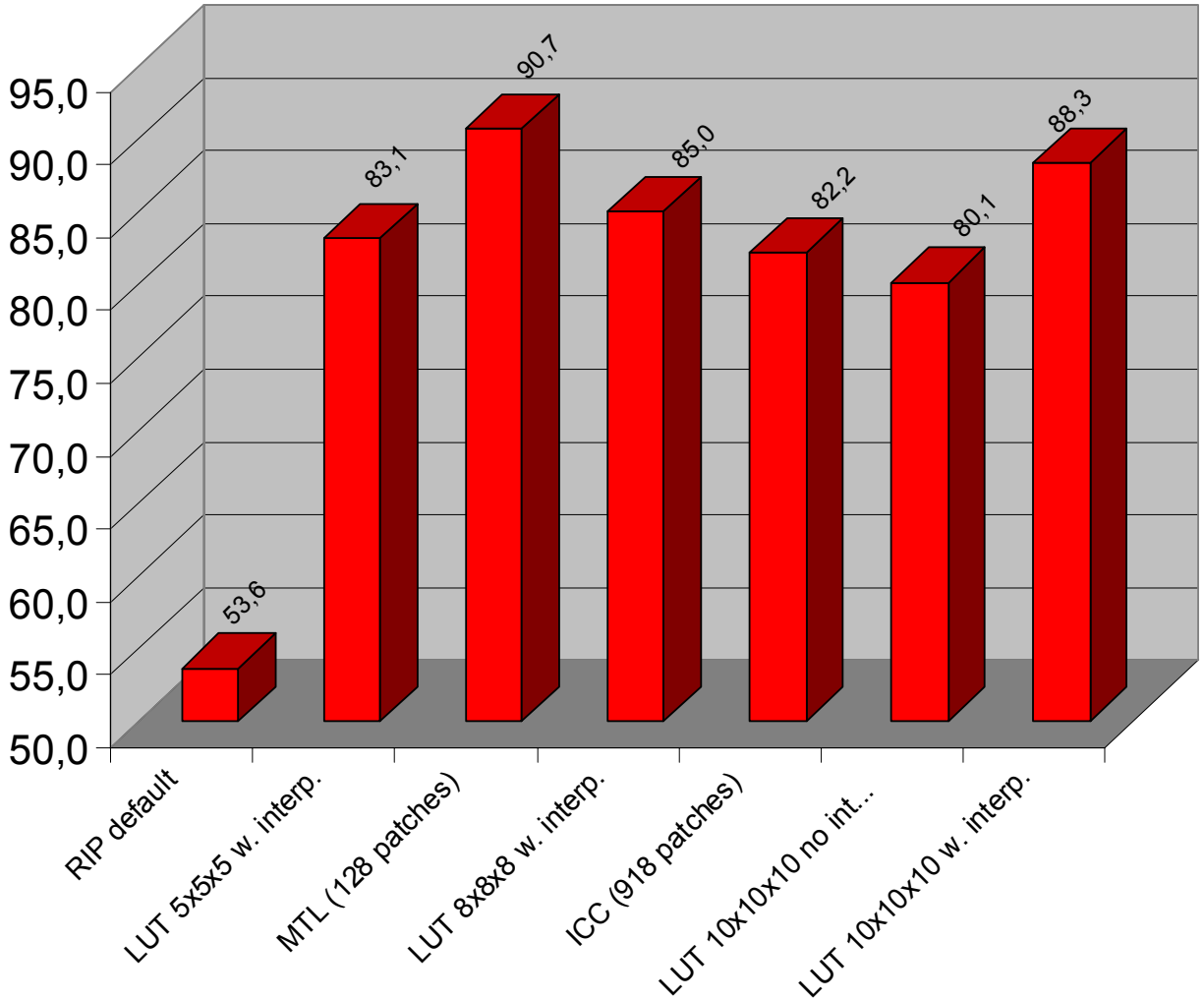
The regularity of a colours scale is defined as:

$$g^* = 100\ \Delta L^*_{min} / \Delta L^*_{max}$$

Where ΔL^*_{min} and ΔL^*_{max} are the minimal and maximal CIELAB colour difference between two colour scale steps.



16 step colour scales of ISO/IEC 15775 test chart 4



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Results

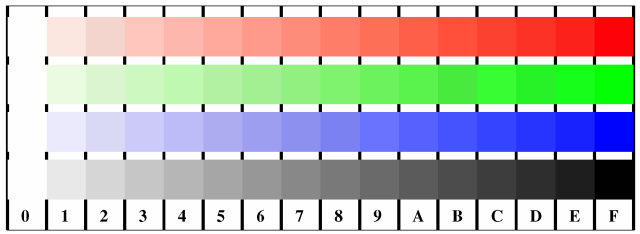
Mean colour reproduction index $R^*_{ab,m}$ of 4 16-step colour scales

This figure shows the mean colours reproduction index of the 4 16 step colour scales of ISO/IEC 15775 test chart 4 for the 7 different calibrating methods.

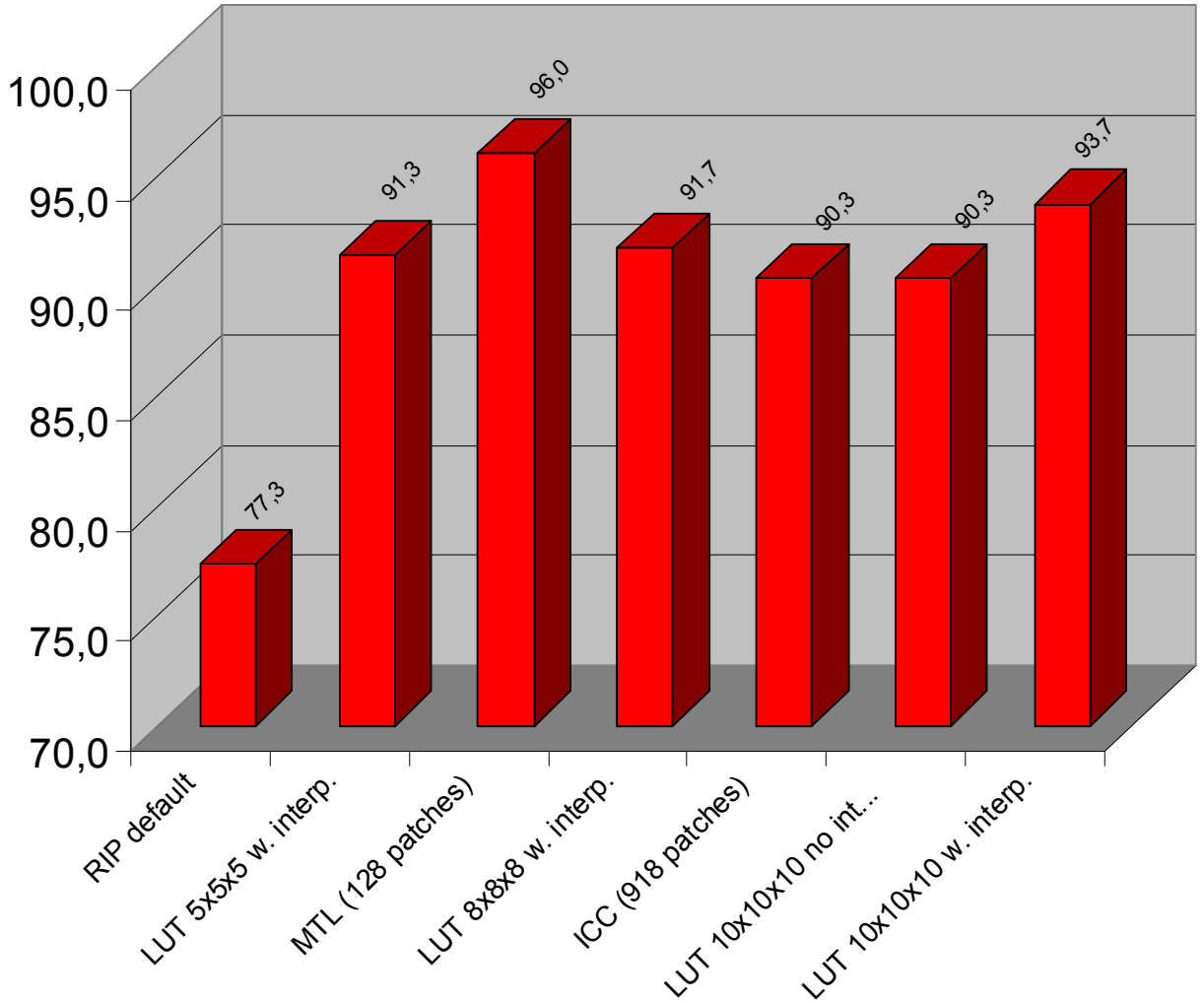
The mean colour reproduction index is defined as:

$$R^*_{ab,m} = 100 - 4{,}6\,(0{,}263\,\Delta L^*_m + 0{,}737\,\Delta E^*_{ab,m})$$

ΔL^*_m and $\Delta E^*_{ab,mx}$ are the mean lightness and chroma difference between two colours steps.



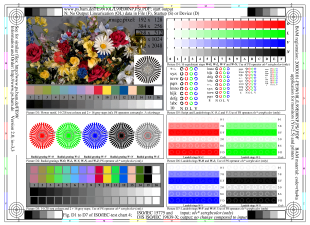
16 step colour scales of ISO/IEC 15775 test chart 4

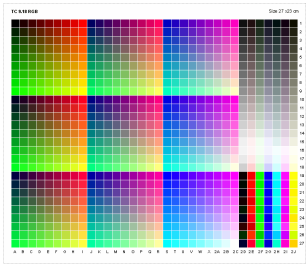


Outlook

Test chart production with a CIELAB camera

L*a*b* test chart data

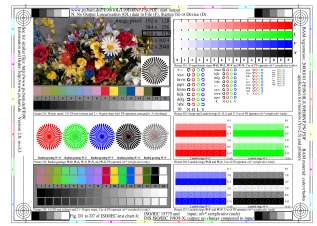




RGB/CMYK test chart

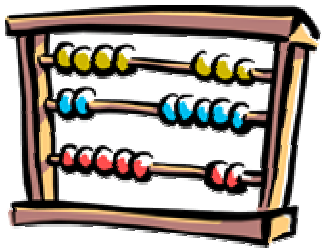
LUT

Test chart in device colour space



Printed test chart

1. Measurement



Recalculating and improving LUT

Measurement approx. 90 sec.

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References

DIN

- ISO/IEC 15775:1999-12: Information Technology - Office machines - Method of specifying image reproduction of colour copying machines by analog test charts - Realisation and Application, 50 pages
- ISO/IEC 15775:2004-XX: Information Technology - Office machines - Method of specifying image reproduction of colour copying machines by analog test charts - Amendment, see document number N648 at the URL
- http://www.jbmia.or.jp/sc28
- ISO/IEC TR 19797:2004, Device output for 16-step colour scales, output linearization method (LM) and specification of the reproduction properties
- ISO/IEC TR 24705:2004, Method of specifying image reproduction of colour devices by digital and analog test charts, see document number N670 at the above URL
- DIN 33866-1 to -5:2000-07 – Information technology - Office machines - Colour image reproduction equipment - Method for specifying image reproduction of colour devices by digital and analog test charts, Classification and principles. (This standard includes four analog DIN-test charts no. 1 to 4 equally spaced in CIELAB).