

Calibration of LED displays

Content

We present how to calibrate LED displays using MURATest videocolorimeter. LED displays have now reached an unprecedented quality thanks to this type of calibration. We explain the calibration principle and the different steps. Practical results are also shown

Purpose

LEDs now deliver high luminescence, which make them suitable for information displays. An array of LEDs is not uniform because the LED characteristics suffer from dispersion. A LED wall requires a CALIBRATION step. The light level of each red, green and blue LEDs shall be adjusted to reach a uniform wall both in color and luminance. Generally a large LED display is composed of different independent tiles that must be calibrated separately. It is so needed to calibration color and luminance in an absolute way otherwise a tile not calibrated in the same conditions or with another instrument will appear different on the display.

Up-to-date LED tiles can now controlled separately the intensity of each LED through a dedicated electronics. The calibration procedure described hereafter explains how to provide the tiles sufficient information to get homogeneous color and luminance emission of each tile.

Calibration steps

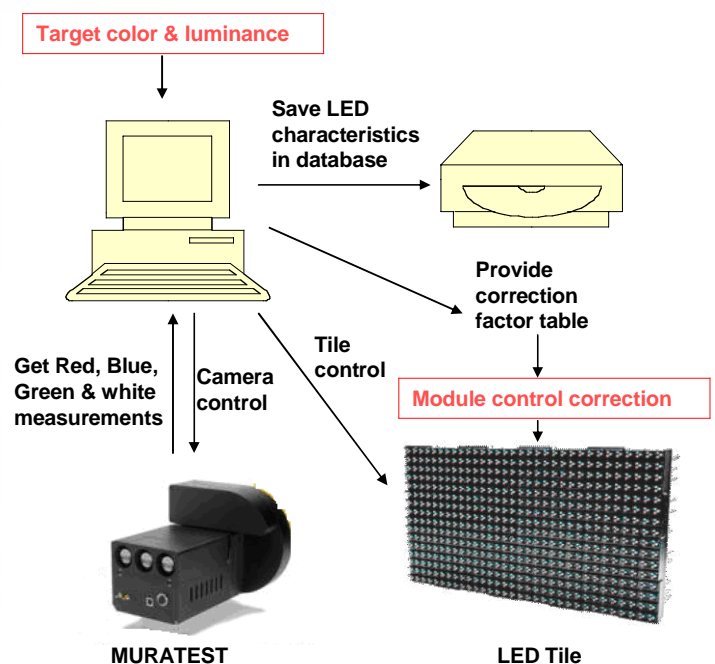
Customer must provide :

- Pixel configuration
- Target values for color coordinates
- Target values for luminance

ELDIM software realizes:

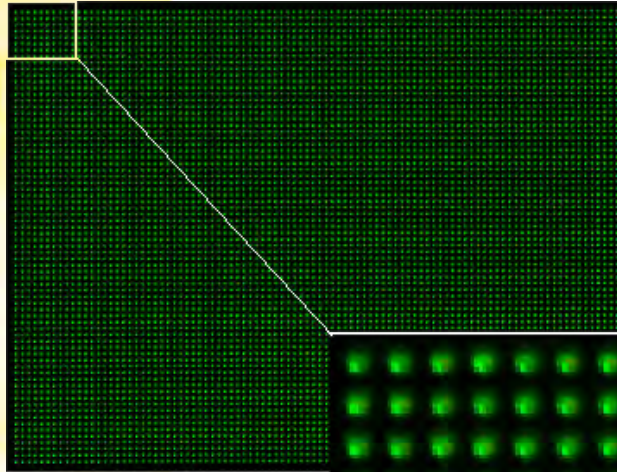
- 3 measurements in Red, Green & Blue
- Found automatically LEDs
- Extract individual color & luminance
- Calculate matrix correction
- Save Tile characteristics & calibration coefficients

Calibration check after correction possible



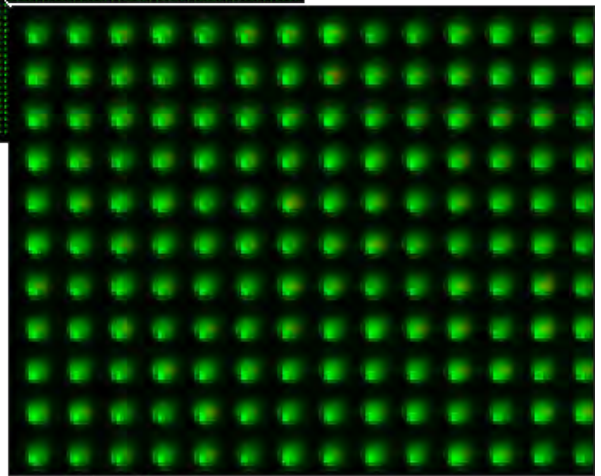
Measurements for calibration

Absolute high color measurement is needed. MURATest shows an unprecedented accuracy thanks to its 5 color filters dedicated to each CCD sensor and its telecentric imaging objective.



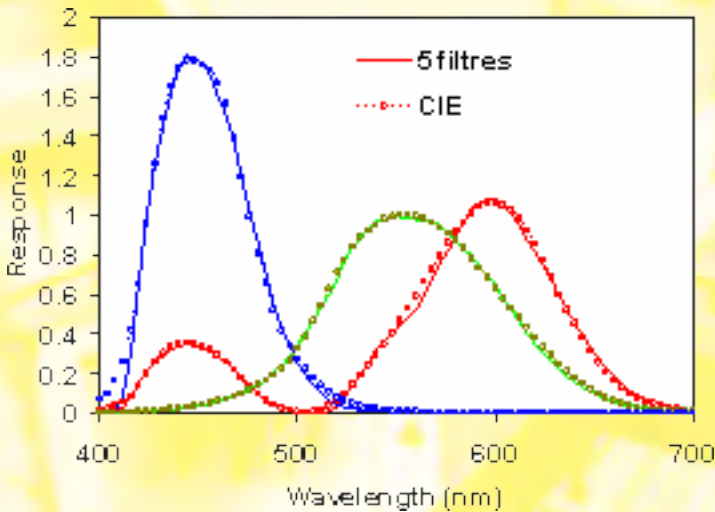
Green State for Panel 1

Measurement of the different colors is automatic. Both color and luminance of each LED are recorded and stored in excel or access format.



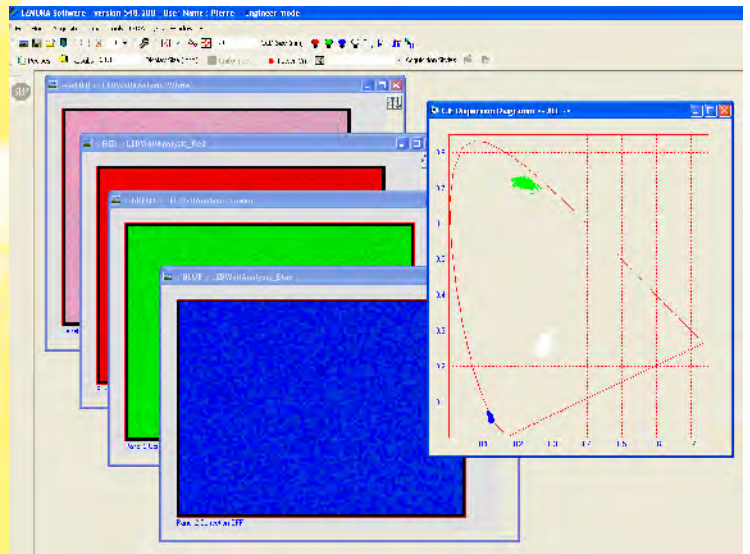
Green State for Panel 1

LEDs are located automatically and their luminance and color recorded



Adjustment of the MURATest response to the CIE curves

Each Tile homogeneity can be judged by eye or using different statistic tools. The color dispersion in the chromatic plane can be measured precisely.



Dispersion of the characteristics before calibration

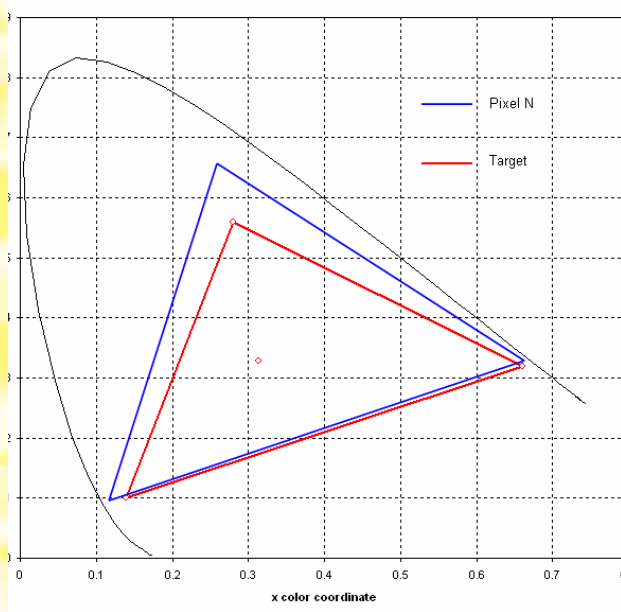
Calibration coefficients

For calculation the calibration coefficients it is necessary to define the geometry of the pixel. One red, one green and one blue LEDs are only necessary but sometimes additional white LED can be used.

The target color coordinate and luminance for each panel state is converted in tri-stimuli values X, Y and Z. For each pixel the correction matrix C is deduce in order to get:

$$\begin{bmatrix} X_{Red}^{T\ arg\ et} & X_{Green}^{T\ arg\ et} & X_{Blue}^{T\ arg\ et} \\ Y_{Red}^{T\ arg\ et} & Y_{Green}^{T\ arg\ et} & Y_{Blue}^{T\ arg\ et} \\ Z_{Red}^{T\ arg\ et} & Z_{Green}^{T\ arg\ et} & Z_{Blue}^{T\ arg\ et} \end{bmatrix} = \begin{bmatrix} X_{Red}^{Meas} & X_{Green}^{Meas} & X_{Blue}^{Meas} \\ Y_{Red}^{Meas} & Y_{Green}^{Meas} & Y_{Blue}^{Meas} \\ Z_{Red}^{Meas} & Z_{Green}^{Meas} & Z_{Blue}^{Meas} \end{bmatrix} \times \begin{bmatrix} C_1 & C_4 & C_7 \\ C_2 & C_5 & C_8 \\ C_3 & C_6 & C_9 \end{bmatrix}$$

The software computes automatically the different correction matrix by solving each set of linear equations and store them in different formats.



Correction in the chromatic diagram

The screenshot shows the 'LEDs Correction' software window. It includes fields for 'Serial Number' (Serial_Test) and 'Model' (Model_Test). There are checkboxes for 'Save as DataBase [Access format]' and 'Save as Workbook [Excel format]'. Below are four columns for 'RED LEDs', 'GREEN LEDs', 'BLUE LEDs', and 'WHITE LEDs', each with a color indicator and a '01' dropdown. There are also sections for 'Panel Pixel Resolution' (Columns: 12, Rows: 10), 'Panel Module Resolution' (Columns: 6, Rows: 5), and 'Module Pixel Resolution' (Columns: 2, Rows: 2). A section for 'RGB Color Coordinates and White Balance' has radio buttons for 'Automated detection' and 'Manual definition'. The 'Manual definition' section has input fields for RED, GREEN, BLUE, and WHITE coordinates (Small x, Small y, Luminance). At the bottom, there are 'Compute Analysis and Correction' and 'Simulation Target Parameters' sections with a 'Simulate' button.

Pixel geometry definition and color target definition

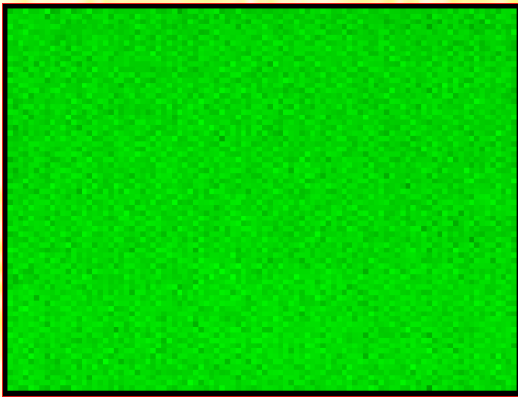
The screenshot shows a Microsoft Access database window with a table named 'Table1'. The table contains 21 rows of numerical data, representing calibration coefficients for different pixels.

ID	Col	Row	C1	C2	C3	C4	C5	C6	C7	C8	C9
0	0	0	0.2207336	0.1388525	0.0412316	0.215279	0.07721	0.220083			
1	0	1	0.2137206	0.146117	0.0177247	0.074750	0.184577	0.220561			
2	0	2	0.2037222	0.201355	0.0158693	0.0527398	0.2078125	0.2229235			
3	0	3	0.1935438	0.255191	0.0141381	0.0325251	0.207257	0.2249862			
4	0	4	0.1837212	0.301102	0.01240984	0.0222089	0.207442	0.224301			
5	0	5	0.204267	0.22663342	0.02263956	0.0535799	0.208322	0.2230054			
6	0	6	0.20251	0.210134	0.0120888	0.022388	0.204027	0.223051			
7	0	7	0.197773	0.242577	0.0117724	0.0225777	0.2037	0.2231615			
8	0	8	0.205278	0.181252	0.0170957	0.052254	0.202457	0.220567			
9	0	9	0.1928111	0.28912	0.011322	0.0101019	0.2017	0.2211215			
10	0	10	0.197712	0.271437	0.0225929	0.027723	0.20252	0.2201102			
11	0	11	0.202249	0.236017	0.0120882	0.022478	0.201627	0.2201452			
12	0	12	0.191100	0.300777	0.0225746	0.0224398	0.200174	0.220072			
13	0	13	0.194274	0.2727	0.0226964	0.0221568	0.20023	0.2200892			
14	0	14	0.20249	0.241242	0.0172506	0.022525	0.202557	0.220521			
15	0	15	0.201740	0.22127	0.0227067	0.022100	0.20207	0.22057			
16	0	16	0.2152	0.2239837	0.0226406	0.0225568	0.202459	0.2211215			
17	0	17	0.202249	0.235112	0.0120882	0.022478	0.201627	0.2201452			
18	0	18	0.197712	0.271437	0.0225929	0.027723	0.20252	0.2201102			
19	0	19	0.202249	0.236017	0.0220046	0.022478	0.201627	0.2201452			
20	0	20	0.2152	0.2239837	0.0226406	0.0225568	0.202459	0.2211215			
21	0	21	0.202249	0.235112	0.0220046	0.022478	0.201627	0.2201452			

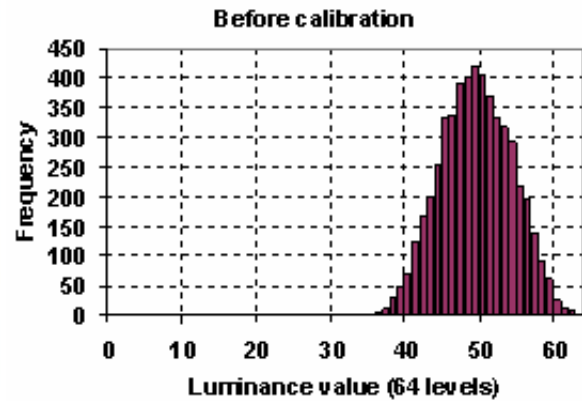
Calibration matrix in Access format

Calibration results

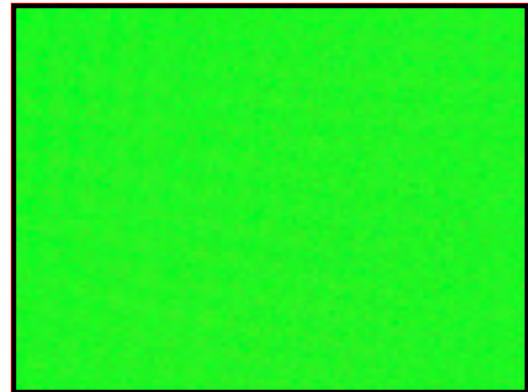
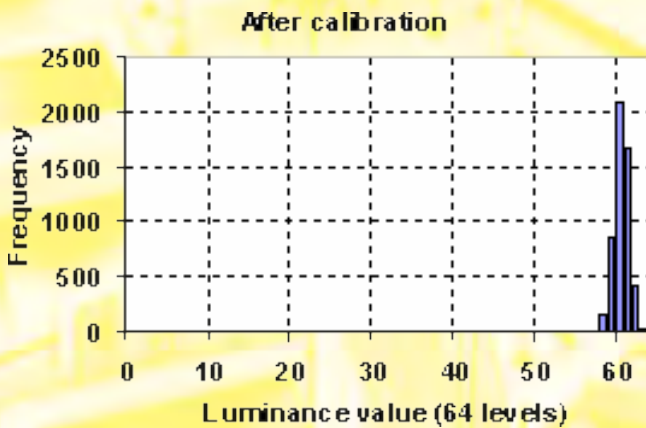
Once all the corrected coefficients have been written into the tiles, new measurement followed by color coordinates and luminance extractions can be realized in the same way as previously in order to check the efficiency of the calibration method. After correction the panels show a much better homogeneity both in color and luminance.



Panel 1 Correction OFF



Green color & luminance dispersion without calibration



Panel 1 Correction ON

Green color & luminance dispersion after calibration

Primary color		Target	Before calibration				After calibration			
			Average	Min	Max	Sdev	Average	Min	Max	Sdev
Blue	x	0.140	0.122	0.111	0.136	0.004	0.116	0.106	0.13	0.003
	y	0.100	0.054	0.039	0.074	0.006	0.108	0.099	0.12	0.003
	Y (normalized)			68.24%	132.17%	9.16%		95.34%	104.67%	1.30%
Green	x	0.280	0.22	0.179	0.27	0.014	0.269	0.259	0.277	0.002
	y	0.560	0.714	0.67	0.738	0.007	0.567	0.549	0.58	0.003
	Y (normalized)			62.65%	129.32%	9.71%		93.39%	105.32%	1.49%
Red	x	0.660	0.684	0.662	0.712	0.008	0.669	0.657	0.681	0.002
	y	0.320	0.316	0.288	0.338	0.008	0.331	0.319	0.343	0.002
	Y (normalized)			67.42%	113.26%	5.37%		92.19%	105.56%	1.47%
White	x	0.313	0.273	0.232	0.315	0.009	0.314	0.302	0.328	0.003
	y	0.329	0.257	0.203	0.315	0.015	0.34	0.325	0.358	0.004
	Y (normalized)			70.28%	123.32%	6.34%		94.43%	105.39%	1.46%

Tile characteristics before and after calibration

Equipment required: MURATest + EZMura Software