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ANALYZER by DXOMARK | Dynamic Range Measurement

Dynamic range defines a camera's ability to capture details in both very bright and very dark areas of a scene. In automotive applications, insufficient dynamic range can lead to loss of critical information, such as pedestrians in shadows or road signs against bright headlights.

DXOMARK has designed a dedicated measurement protocol to characterize the effective dynamic range of automotive cameras under controlled conditions.

These methods contribute to the IEEE 2020 standardization efforts for reliable and reproducible camera performance evaluation.

Key features

Designed for characterizing automotive cameras using dedicated HDR sensors

- Saturate any sensors currently available on the market, with adjustable maximum luminance up to 1,500,000 cd/m²
- Easy, fast, accurate and repeatable characterization of the dynamic range of the complete camera system (sensor + lens)
- All lights are flicker-free
- Measurement automation capability thanks to python API
- Software measurement, supports RGB & RAW images up to 32 bits/pixels
- Used for IEEE 2020-2024 standard definition and validation

Available measurements

- Evaluates camera dynamic limitations due to glare by comparing the sensor's linear response to the true luminance of the chart
- Contrast-to-noise ratio (CNR)
- Contrast dynamic range (CDR)
- Tonal contrast gain (TCG)

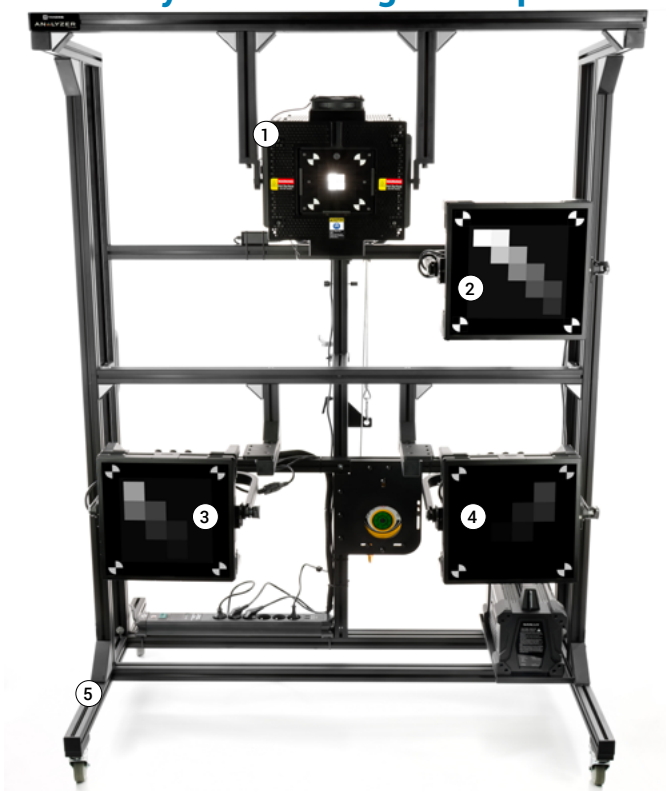
AUTOMOTIVE APPLICATION

DISTORTED CAMERA SUPPORT

The Dynamic Range measurement is compatible with wide-angle and fisheye cameras, with automatic adjustment of ROI definition.

DYNAMIC RANGE MEASUREMENT HARDWARE

170dB Dynamic Range Setup



① Brightest Light source for 1.5Mcd/m² chart, ② ③ ④ LED panels with dedicated charts to cover the 170 dB range, ⑤ Custom easel to ease chart adjustment

Required equipment

170dB Setup (DRP2020_001)

Recommended equipment

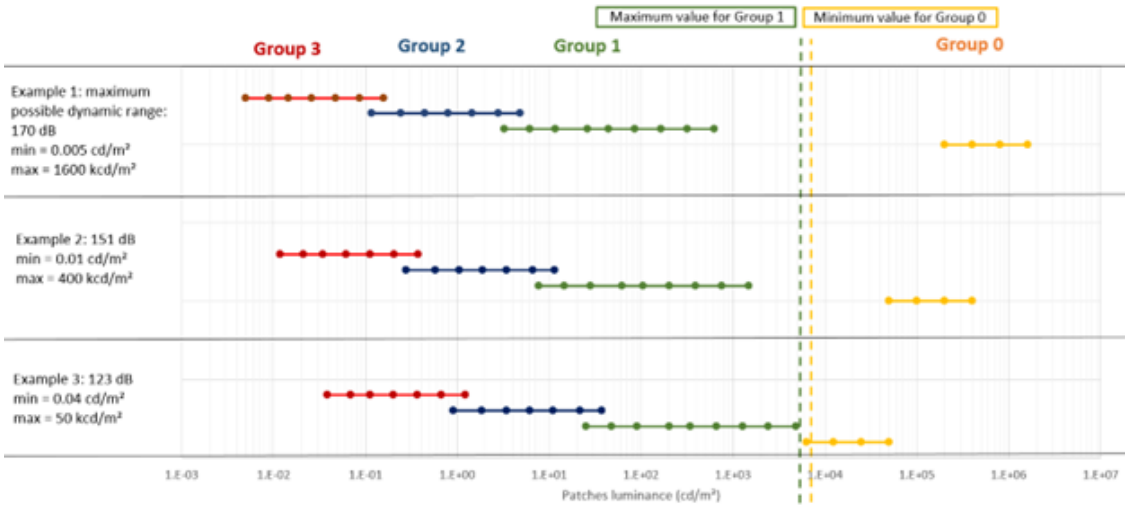
FRAMING & ACCESSORIES

Gossen Luxmeter - Mavomaster & Mavoprobe 5032B

General specification

- Size of the full setup: 1200 x 1200 x 800 mm
- Power supply: 100–240 V, 50–60Hz
- Total maximum power: 1800 W

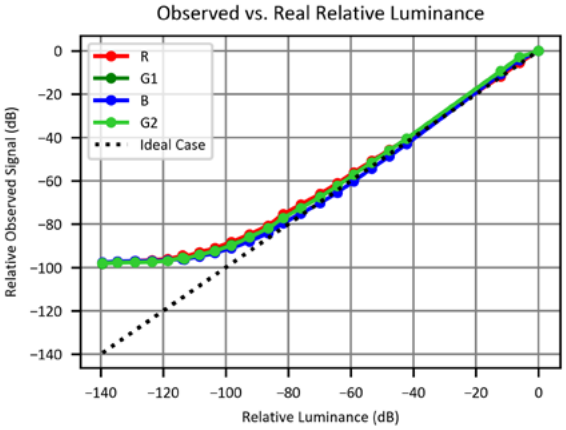
	Brightest Light source	LED panels
Light type	LED	LED
Color temperature	5600 K	[2700; 10000] K
CRI	96	97
Max luminance	1.5 Mcd/m²	65000 cd/m²
Patch size	10x10 mm	30x30 mm



The total dynamic range of the setup can be adjusted to the capabilities of the tested camera. The minimum dynamic range, in the setup, is 123 dB, and the maximum is 170dB.

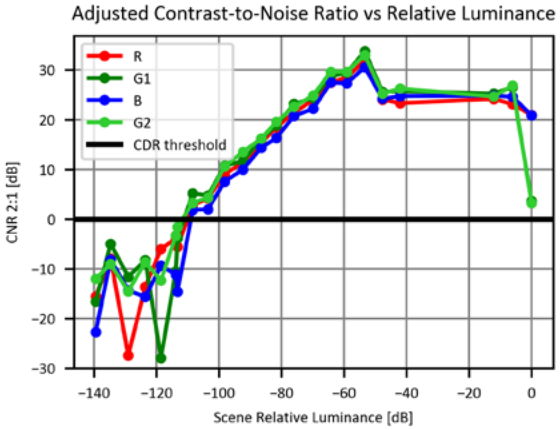
Analyzer Workflow Manager provides Python functions for processing image files

The measurement returns 3 main graphs:



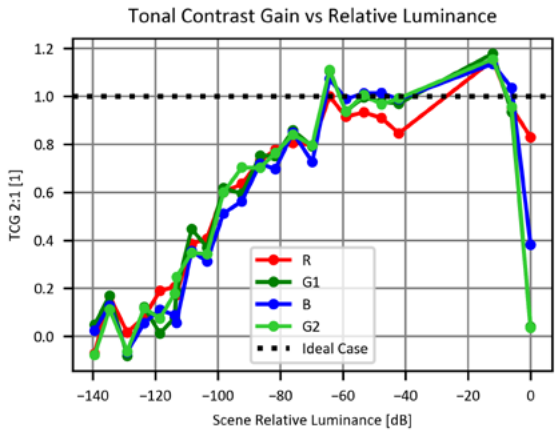
Observed & real relative luminance: To check lens limitations due to glare, this metric shows the sensor linear response compared to the true luminance of the chart.

In this example, the lens glare is around 120dB. Notice that the raw data is corrected from the dark level. If the lens was perfect and the sensor was linear , the measured grey level would follow the dashed line.



Contrast-to-noise ratio (CNR) is computed on all successive patches in the image captured by the camera and is compared with the limit under which the camera cannot see (0 dB).

CNR is affected by the sensor saturation in high-light, and by the lens glare and the noise in low-light. Contrast dynamic range (CDR) is the range of scene relative luminance for which CNR is above 0. Here, the result is a CDR of 121.8dB for the green pixels.



Tonal contrast gain (TCG) measures the contrast fidelity. In the case of nonlinear images, this metric is a better indicator of the quality of contrast reproduction.

TCG allows for a quantification of scene contrast preservation. The dashed line corresponds to simple contrast preservation.

DYNAMIC RANGE MEASUREMENT DEFINITION

CONTRAST-TO-NOISE RATIO (CNR)

$$CNR_{N:1}\left(A,B\right) = \frac{s_A - s_B}{\sqrt{\sigma_A^2 - \sigma_B^2}}$$

where

$A,\ B$	Two regions of interest (ROIs)
$s_A,\ s_B$	True signal related to A and B
$\sigma_A^2,\ \sigma_B^2$	Variance of the random noise related to A and B
N	Nominal simple contrast ratio between ROI A and ROI B, N=2

TONAL CONTRAST GAIN (TCG)

$$TCG_{N:1}\left(A,B\right) = \frac{log_2\left(\frac{L_{A,display}}{L_{B,display}}\right)}{log_2\left(\frac{L_{A,scene}}{L_{B,scene}}\right)}$$

where

N	Nominal simple contrast ratio between ROI A and ROI B, N=2
$A,\ B$	Two ROI
$L_{A,display},\ L_{B,display}$	Mean displayed luminance in ROI A and B
$L_{A,scene},\ L_{B,scene}$	Mean signal level of ROI A and B in the original scene

CNR CALIBRATION

$$CNR_{N:1,cal}\left(A,B\right) = CNR_{N:1}\left(A,B\right)\frac{C+1}{C-1}\frac{N-1}{N+1}$$

where

N	Nominal simple contrast ratio between ROI A and ROI B, N=2
C	Measured simple contrast of the scene

Specifications

CAMERA TESTING

Min resolution: 1920x1080
Max resolution: up to 50Mpix
FOV: up to 150°, with no limitation for the lens distortion
Sensor: Bayer filter sensor
File formats: jpg, bmp, png, tif, and any RAW format
Images: RGB and RAW formats (latest release notes provides a list of supported RAW formats)

PLATFORM REQUIREMENTS

PC-type computer with the following minimum configuration:
– **Intel Core i5 Fifth generation® processor**,
– A version of **Windows 11® 64 bits** operating system,
– **4 GB of RAM**,
– **64 GB of free disk space** to operate the software,

LABORATORY REQUIREMENTS

Laboratory minimum size: 2 x 2m
Temperature: 23°C ± 2°C (ISO 554:1976)
Humidity: 50% ± 20% (ISO 554:1976)

Black walls (reflectance < 5%) to ensure a good accuracy
When all the light panels of the DR 170dB are set off, the environment light level must be lower than 0.1lux

REFERENCES

- 2020-2024 - IEEE Standard for Automotive System Image Quality https://ieeexplore.ieee.org/servlet/opac?punumber=10935837
DOI: 10.1109/IEEESTD.2024.10935839