HDR imaging – Automatic Exposure Time Estimation
A novel approach

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Motivation:

We want to estimate the exposure times for the LDR images that will be used to build a HDR radiance map of the scene. The method should work for any camera whatever the shape of its CRF is, and for any scene. We recover the full dynamic range of the scene with the minimum number of shots and without any known information about image content. The method works on-line as the capturing is ongoing.

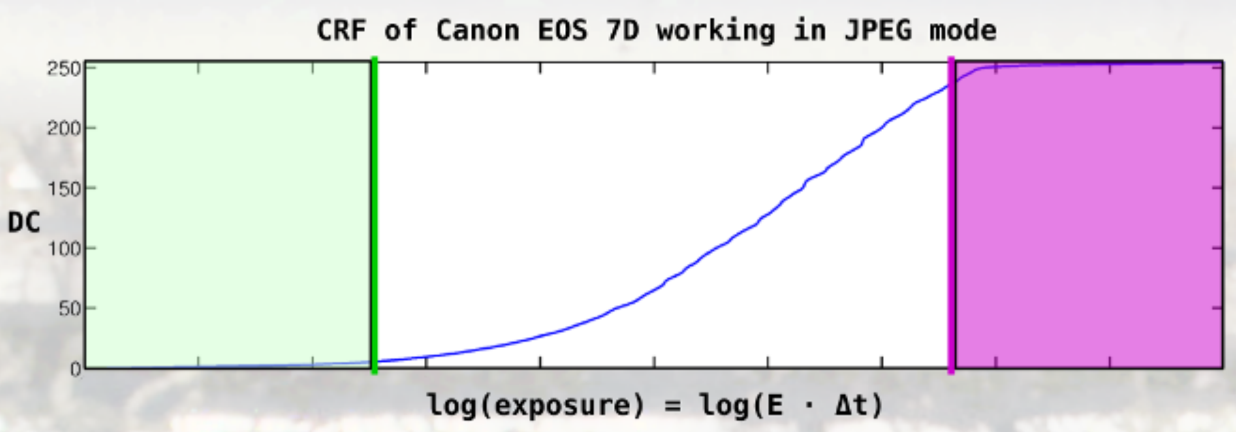

Figure 1: CRF of our camera with noisy and saturated ranges highlighted.

Step 1:

The user has to fix three parameters. The first two are NOISE FLOOR and SAT LEVEL on the CRF (fig 1). The third parameter is the % of total population we can afford to be lost (fig 2). This can be 0% for full range capturing.

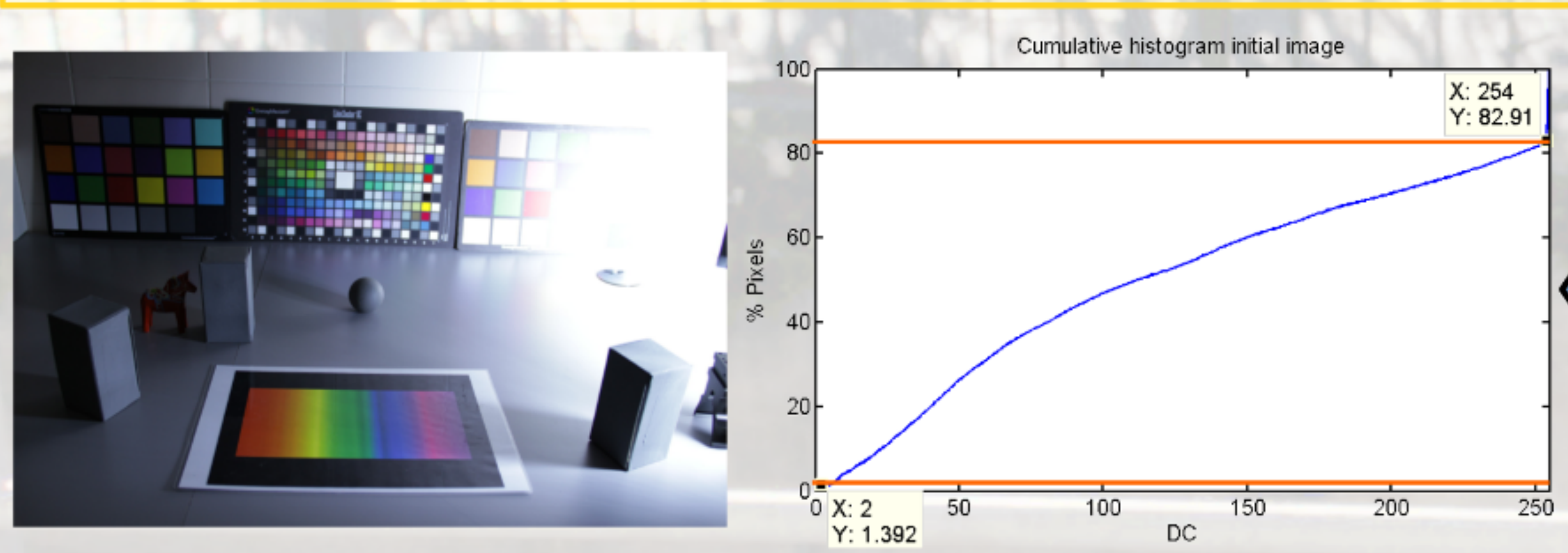

Figure 3: Initial image and its cumulative histogram. Noise and saturation limits are highlighted.

Step 3:

The method checks if the properly exposed pixel population is above the chosen threshold. Otherwise, longer and/or shorter exposures must be acquired. To calculate the new exposure times, we aim to shift the response from regions just saturated to a value just above noise floor, an vice-versa (see eq. 1 and 2).

SNR vs Capture time:

The closer NOISE FLOOR and SAT LEVEL are, the better SNR the final HDR radiance map gets, at the cost of higher number of shots and longer capturing times. Fig 4 presents the SNR histogram (from [1]) of a HDR radiance map comparing 4 tuning conditions of the method and a ground truth (GT) using all available exposure times of the camera

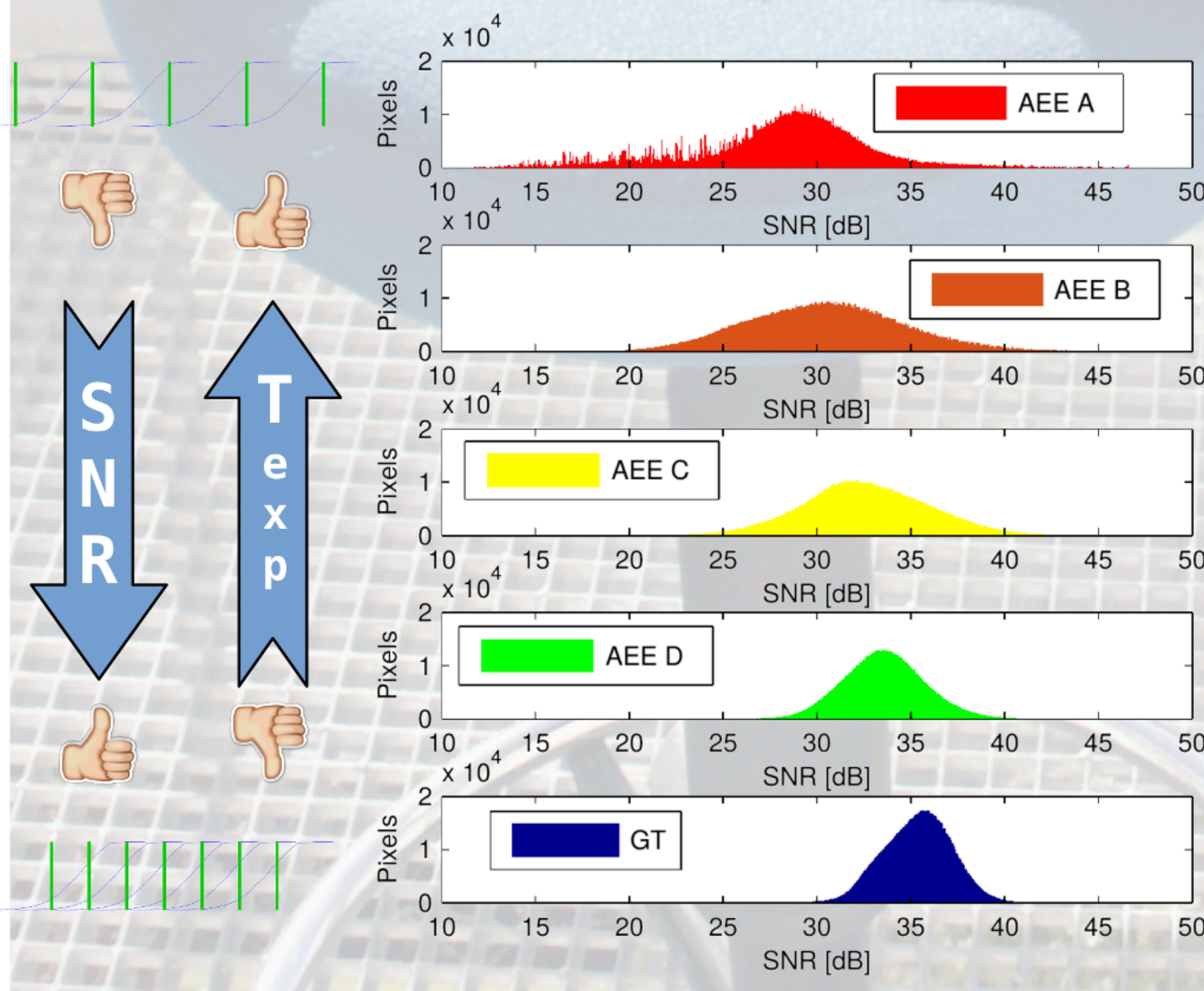

Figure 4: SNR histograms for different parameterizations of AEE and ground truth.

Method:

The method was presented in Martínez et al [1]. It is based on the CRF of the camera and the cumulative histograms of the incoming images. It is inspired by the way that Grossberg & Nayar [2] selected sample pixels to calculate the CRF. The CRF of the camera must be calculated in advance. This is also needed to build the HDR radiance map of the scene. We did it using the method explained by Debevec & Malik [3]. Here we present new data to test the method's efficacy for general HDR imaging.

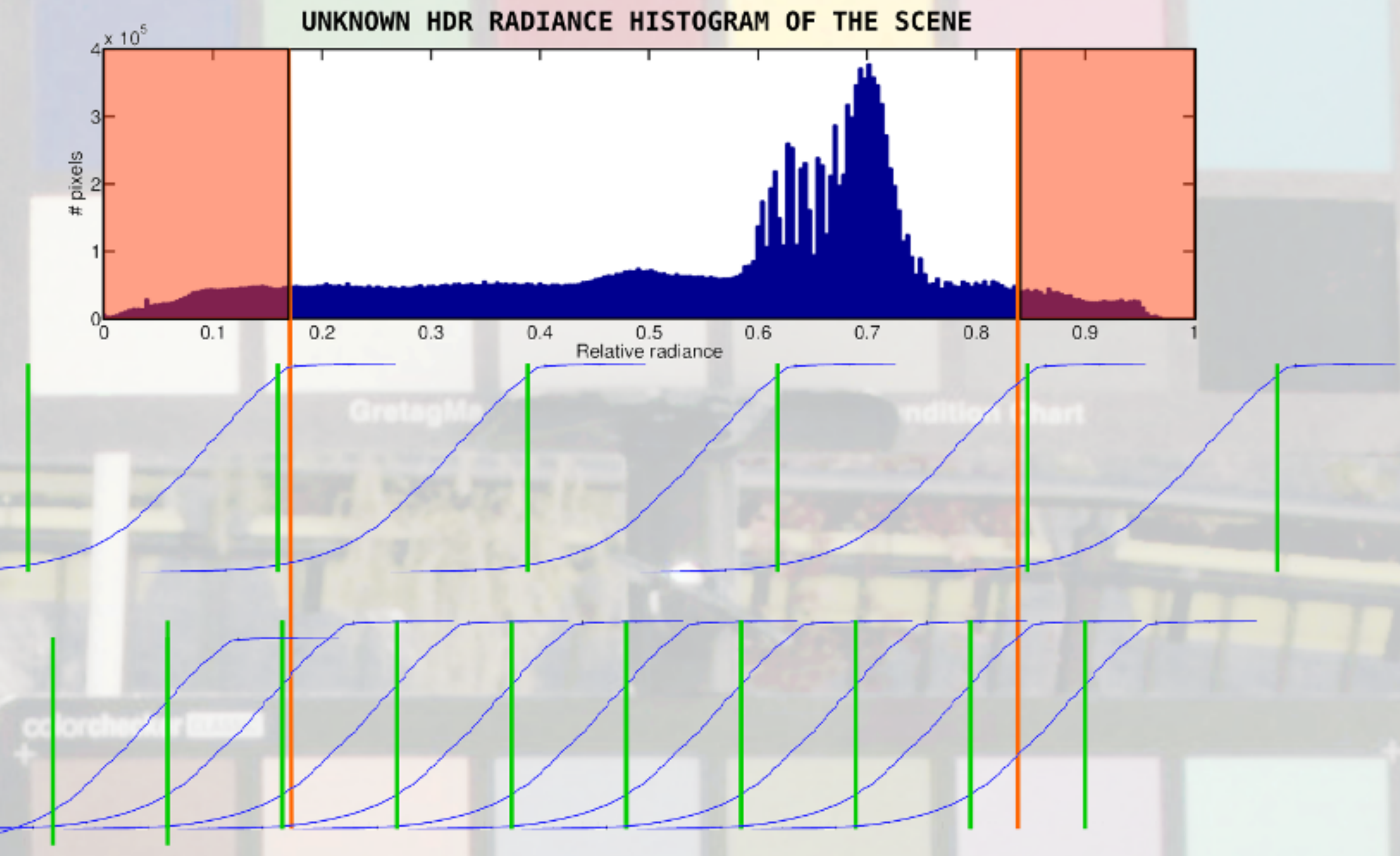

Figure 2: Unknown HDR relative radiance histogram of the scene (top). Effect of NOISE FLOOR and SAT LEVEL parameters on radiance sampling.

Step 2:

We start by capturing an image of the scene using an arbitrary exposure time (Δt_0). The auto-exposure setting of most consumer cameras works fine, but any exposure time could be used as long as some pixels in the LDR image are neither underexposed nor saturated. Then we calculate the cumulative histogram of this image (fig 3).

$$\Delta t_{longer} = \frac{CRF^{-1}(SAT_{level})}{CRF^{-1}(NOI_{floor})} \cdot \Delta t_0 \qquad (1)$$

$$\Delta t_{shorter} = \frac{CRF^{-1}(NOI_{floor})}{CRF^{-1}(SAT_{level})} \cdot \Delta t_0 \qquad (2)$$

Step 4:

With the new images acquired, go back to step 2 and repeat the cycle until the threshold stopping condition is met.

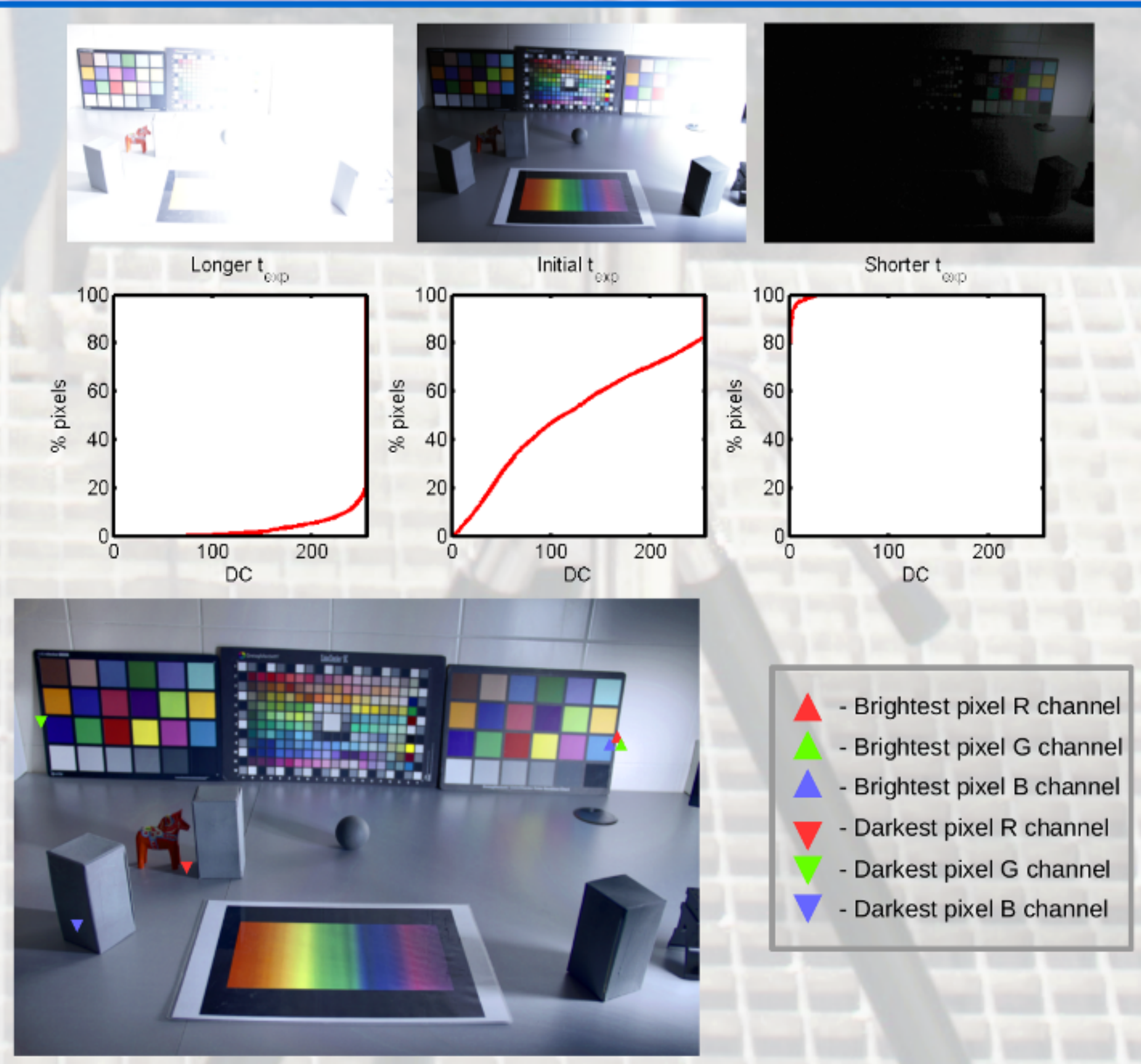

Figure 5: LDR pictures (top), with their corresponding cumulative histograms (middle). Tonemapped HDR radiance map highlighting brightest and darkest pixels for each color channel (bottom).

References:

[1]- Martínez, M. A. Valero, E. M. Hernández-Andrés, J. 2015. Adaptive exposure estimation for high dynamic range imaging applied to natural scenes and daylight skies. Applied Optics Vol. 54, No. 4, B241-B250.

[2]- M. D. Grossberg and S. K. Nayar, "What can be known about the radiometric response from images?" in Computer Vision ECCV (Springer, 2002), pp. 189–205.

[3]- Debevec, P. and Malik, J. 2008. Recovering high dynamic range radiance maps from photographs. In ACM SIGGRAPH 2008 proceedings 31.