Test Lab Services Report

Consumer Video Camera Comparison

Report ID: SAMPLE01

Requested by:

Customer

Prepared by:

Imatest, LLC

Contents

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About Imatest

Imatest is a leader in image quality testing that has been headquartered in Boulder, Colorado since 2004. Imatest team members include a range of engineering disciplines including imaging science, computer science, physics, electrical, and mechanical engineering.

Imatest software, test charts, equipment, and services enable the imaging industry to develop the best products possible. We serve customers across many industries, including automotive, mobile, consumer electronics, security, aerospace, and medical. We provide the tools, resources, and knowledge to test all types of imaging systems, from satellites to camera phones, in visible light or infrared. Imatest helps eliminate bias by providing independent, impartial image quality testing for both design and manufacturing. Our clients can be confident they are testing the aspects of their systems that matter most to their customers. Our team is dedicated to enabling the imaging industry to provide accurate measurements that will help them improve the quality of their imaging products.

Overview of Test Lab Services

As experts in the field of image quality testing, leave the IQ lab work to us. We know that each test lab setup is unique to the needs of your company:

- We help create a customized service that achieves the testing objectives of your organization while working within your budget.
- Trained consultants will spend time with your team to better understand your needs and create a test plan to meet your project goals.
- Our detail-oriented engineers will test your equipment using our hardware, charts, and software to analyze images and interpret results—saving you time and resources.
- Provide consistent, repeatable, and trustworthy results through rigorous testing protocols, allowing you to build a portfolio of reports.

Service Offerings:

- Sensor evaluation
- Camera hardware design
- ISP tuning
- Benchmarking

Example Image Quality Metrics we provide:

- MTF (modulation transfer function)
- Dynamic Range
- Low light performance
- Temporal noise
- Motion blur
- And more

For more information, visit www.imatest.com/test-lab-services or contact us at LabServices@imatest.com

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Device Details

Table 1: Device Summary

Spec	Device 1	Device 2
Sensor	SONY IMX577	SONY IMX677
FOV	138.5°	83°
MP	12	24
F/#	f/2.2	f/2.8
Focal Length	9 mm	15 mm
Pixel Pitch	1.55 µm	1.12 µm

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Summary

Consumer devices were assessed for the IQ (Image Quality) Factors listed below. "I" frames were extracted from the captured fully processed video streams and analyzed for various image quality factors. Highlights of the analysis observations include:

- Extreme oversharpening was noted in the tuning of Device 1 (with peak MTF at 2.29), exhibiting strong ringing.
- The dynamic range results indicate that Device 1 had a higher range than Device 2.
- Both devices exhibit good SNR and uniformity.
- Both devices show strong levels of saturation applied but are accurate along hue directions. While their mean chromas were over 30% above an accuracy aim, their mean ΔE2000 values are low.

Table 2: Video Frame Test Summary

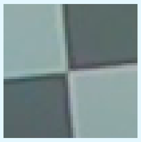
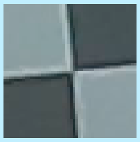
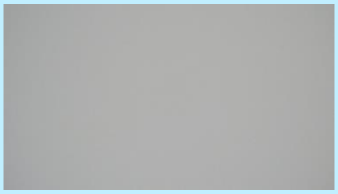
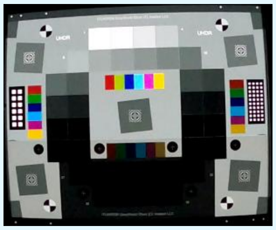
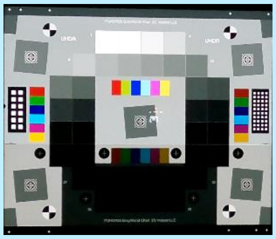
Chart	IQ Factor	Capture Conditions	Camera	Results Summary		Example ROI
SFRreg	SFR	Distance: 5 m CCT: 6073 K Illum. level: 995 lux	**Device 1**	Video MTF50P:	0.314 cy/pxl	
				Oversharpening (freq domain):	55.8 %	
				Overshoot (spatial domain):	26.5 %	
				Area under curve MTF:	0.307 cy/pxl	
				Peak MTF value:	1.56	
			Device 2	Video MTF50P:	0.3519 cy/pxl	
				Oversharpening (freq domain):	117.0 %	
				Overshoot (spatial domain):	65.6 %	
				Area under curve MTF:	0.315 cy/pxl	
				Peak MTF value:	2.29	
Flat Field	Uniformity	Distance: 1.27 cm Illum. level: 5.59 W/m^2	**Device 1**	Left Relative Illumination:	0.913	
				Right Relative Illumination:	0.885	
			Device 2	Left Relative Illumination:	0.982	
				Right Relative Illumination:	0.986	

Chart	IQ Factor	Capture Conditions	Camera	Results Summary		Example ROI
Spilled Coins	Texture MTF	Distance: 5 m CCT: 6073 K Illum. level: 976 lux	Device 1	Video Peak Texture MTF:	1.1	
				Video Computer Monitor Acutance:	1.731	
			Device 2	Video Peak Texture MTF:	1.21	
				Video Computer Monitor Acutance:	1.94	
36-Patch UHDR	SNR, Dynamic Range, OECF	Distance: 0.25 m Illum. level: 66.9 W/m^2	Device 1	Video DR:	57 dB	
				Gamma	0.587	
			Device 2	Video DR:	69.6 dB	
				Gamma	0.542	

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Test Capture Setup

Edge SFR

Lighting Conditions: Thouslite LED Cube system, 6073K, 99.5 and 995 lux
Test Distances: 5m
Timing box: IQL Camera Timing Test System
Chart: Imatest SFRreg, size 3x (600mm diameter), 4:1 contrast ratio (SKU: Reg-R-3x-4)

The DUT was placed on a Manfrotto tripod with a geared head. The test chart was placed in the Modular Test Stand chart holder with the Linear Motion Blur Test Module. The Thouslite LED Cubes were arranged at approximately 45º relative to the target on either side. Once the setup was complete, the DUT and tripod were positioned normal to the test chart at the nominal test distances. Captures were made with the test module in both static and moving conditions (1.83 m/s maximum velocity for a range of ± 25.685 mm from the center position). The captures included a timing box in the image for quantifying exposure time in each frame. Each vertical LED is on for the amount of time specified beneath and to the left of the row in each image, which enables easy counting of the LEDs to determine the exposure time.

Texture MTF

Lighting Conditions: Thouslite LED Cube system, 6073K, 976 lux
Test Distance: 5m
Chart: Imatest Spilled Coins chart (large)

The DUT was placed on a Manfrotto tripod with a geared head. The test chart was placed in the Modular Test Stand chart holder. The Thouslite LED Cubes were arranged at approximately 45º relative to the target on either side. Once the setup was complete, the DUT and tripod were positioned normal to the test chart at the nominal test distances.

Color

Lighting Conditions: Thouslite LED Cube system, 6103K, 1002 lux
Test Distance: 0.31m (not critical to measurement)
Chart: Calibrite ColorChecker Classic

The DUT was placed on a Manfrotto tripod with a geared head. The test chart was placed in the Modular Test Stand chart holder. The Thouslite LED Cubes were arranged at approximately 45º relative to the target on either side. Once the setup was complete, the DUT and tripod were positioned normal to the test chart at the nominal test distances.

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SNR and Dynamic Range

Lighting Conditions: Imatest LED Lightbox, 66.9 W/m^2 from brightest patch
Test Distance: 0.25m (not critical to measurement)
Chart: Imatest 36-Patch Ultra High Dynamic Range Test Chart (SKU: ITUHDR36)

The DUT was placed on a Manfrotto tripod with a geared head. The test chart was placed in the Imatest LED Lightbox, and the lightbox was placed on a table. The DUT and tripod were positioned normal to the test chart at the nominal test distance.

Flat Field

Lighting Conditions: Imatest LED Lightbox, 5.59 W/m^2
Test Distance: 1.27cm (not critical to measurement)
Chart: None (lightbox-only)

The DUT was placed on a Manfrotto tripod with a geared head. The lightbox was placed on a table. The DUT and tripod were positioned normal to the lightbox diffuser panel, as close as physically possible to the lightbox (<5 mm; required because of the extreme wide-angle nature of the individual cameras).

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Summary Results and Observations

Slanted Edge MTF Metrics and Observations

The relative contrast at a given spatial frequency (output contrast/input contrast) is called Modulation Transfer Function (MTF), which is similar to the Spatial Frequency Response (SFR), and is a key to measuring sharpness. Imatest modules measure MTF using the slanted-edge technique. Spatial frequency is measured in cycles (or line pairs) per distance instead of time. As with temporal (e.g., audio) frequency response, the more extended the response, the more detail can be conveyed.

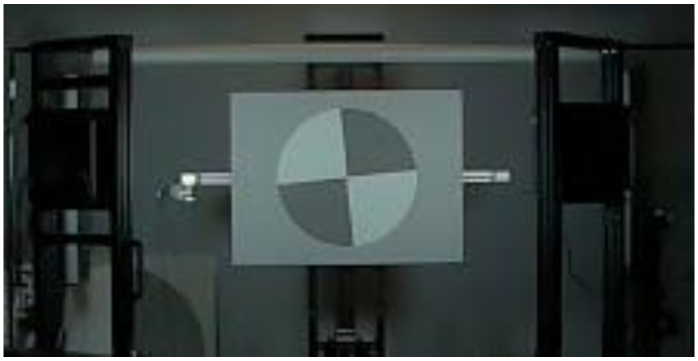

Figure 1: SFR Reg Chart Device 1

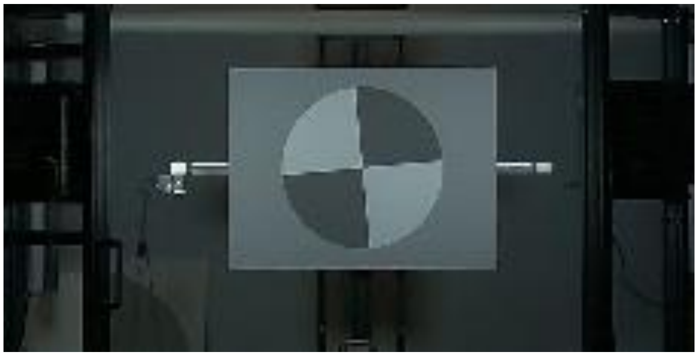

Figure 2: SFR Reg Chart Device 2

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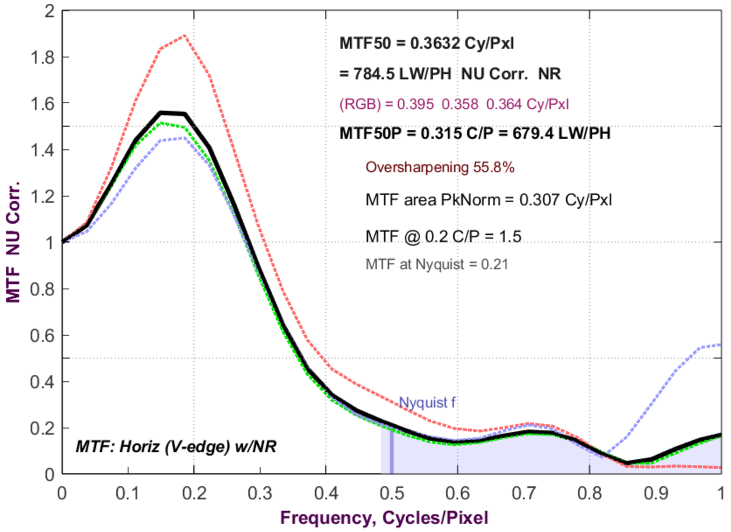


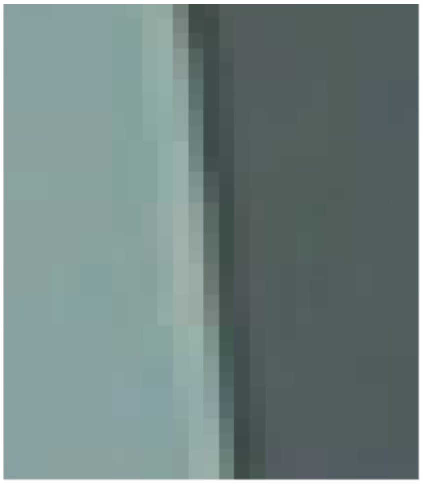
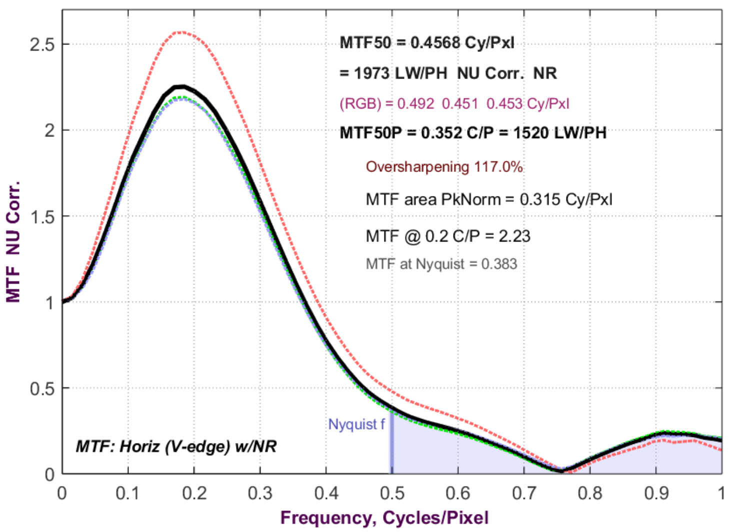


Figure 3: Device 1 Horizontal MTF



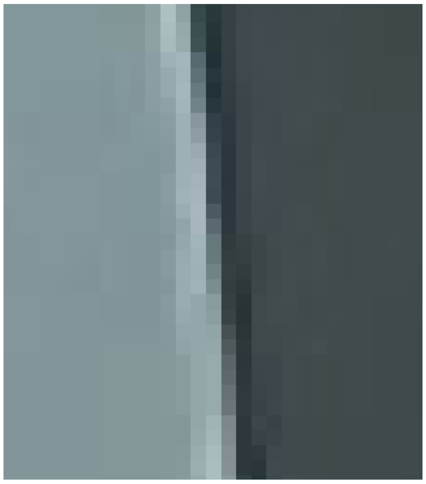


Figure 4: Device 2 Horizontal MTF

Table 3: ROI 1 (Vertical)

MTF Metric Cy/Pxl	Device 1	Device 2
mtfPeak	1.5577	2.2518
mtf50	0.3632	0.4568
mtf50p	0.3146	0.3519
mtf30	0.4317	0.5513
mtf30p	0.3696	0.4172

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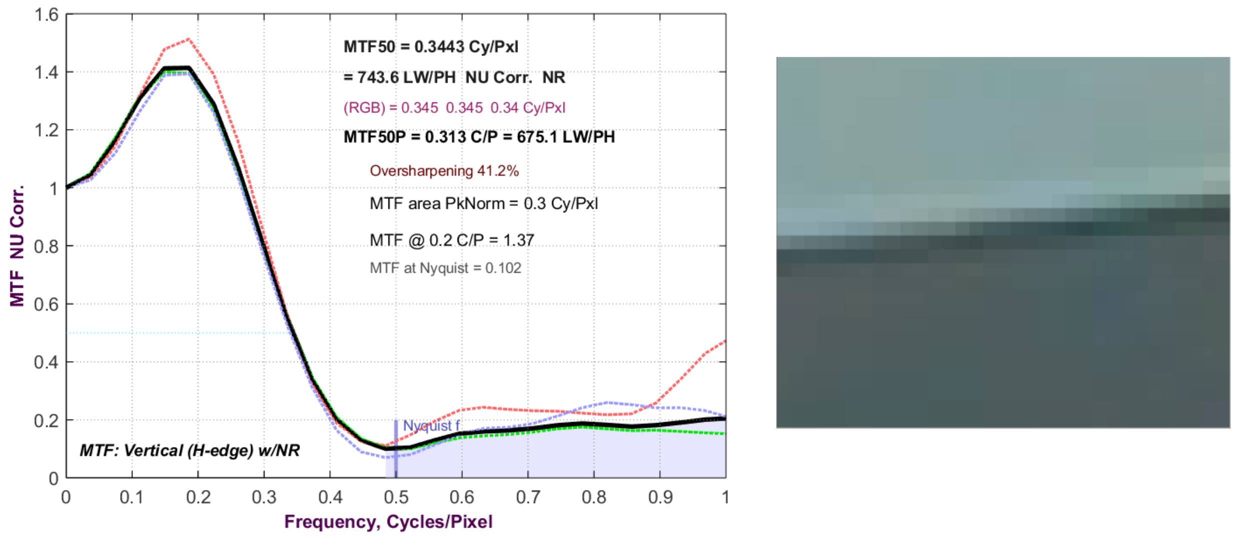

Figure 5: Device 1 Vertical MTF

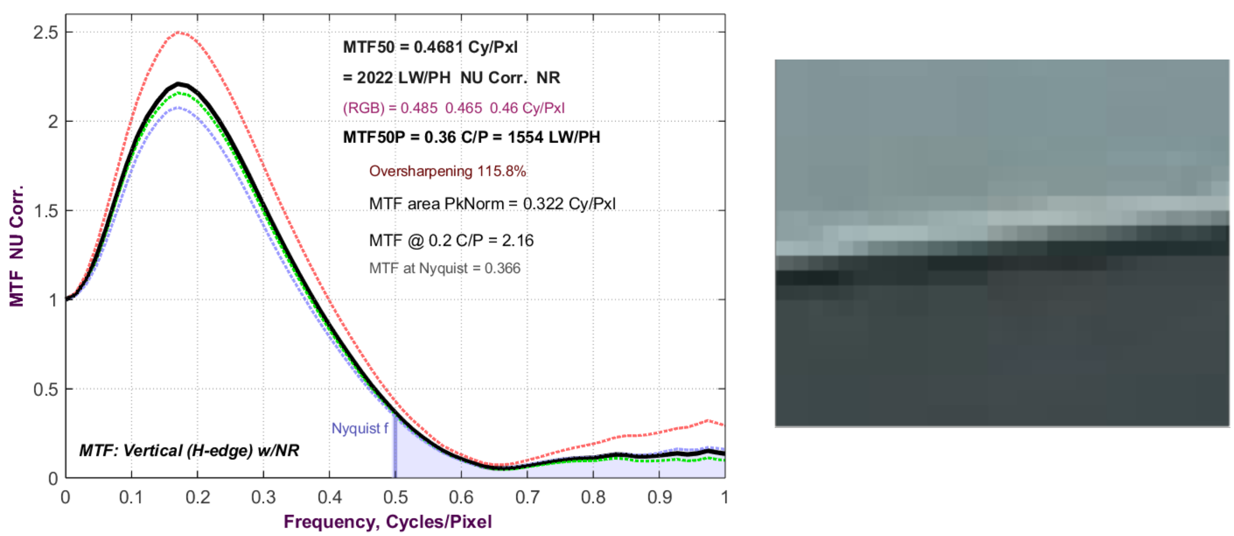

Figure 6: Device 2 Vertical MTF

Table 4: ROI 3 (Horizontal)

MTF Metric Cy/Pxl	Device 1	Device 2
mtfPeak	1.4134	2.2091
mtf50	0.3443	0.4681
mtf50p	0.3125	0.3598
mtf30	0.3836	0.5178
mtf30p	0.3578	0.4351

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Texture MTF Metrics and Observations

Dead leaves and spilled coins statistics resemble those of natural scenes; they are less affected by edge sharpening than other patterns, such as the slanted edge. These charts provide estimates of texture detail that correlate better with perceptual observations. The Spilled Coins (dead leaves) pattern in the central region is almost perfectly scale-invariant (unlike conventional dead leaves charts.

Spilled Coins (Texture MTF) is primarily of interest for processed images, such as JPEG and MP4. The measurement is very sensitive to noise and works best when multiple images are averaged. For the two devices, the texture acutance values were similar, with slight advantage to Device 1. This is probably due to the oversharpening in Device 2, which obliterates some texture with its significant oversharpening. See Tables 5 and 6 for the results.

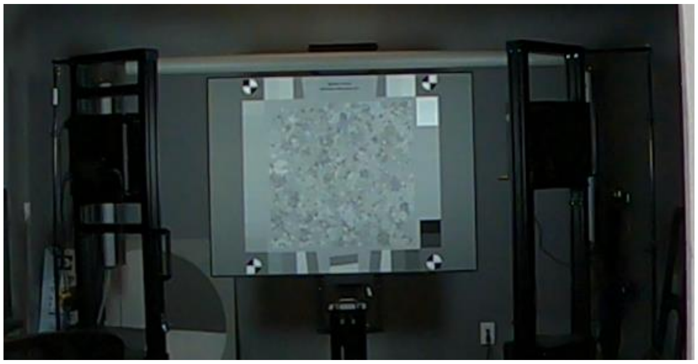

Figure 7: Spilled Coins Chart Device 1

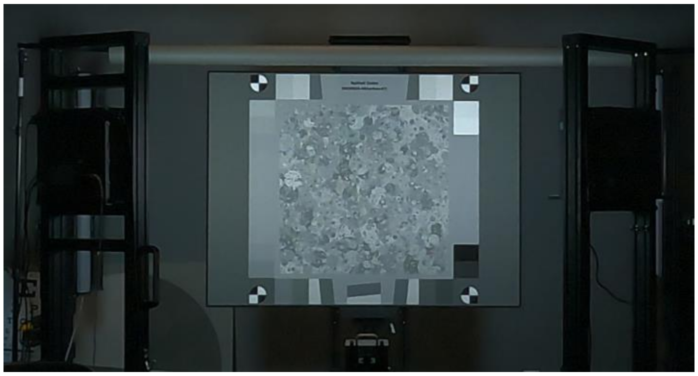

Figure 8: Spilled Coins Chart Device 2

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Table 5: MTF Results

MTF Metric	Device 1	Device 2
MTF70P_Cycles_per_Pixel	0.2479	0.2386
MTF50P_Cycles_per_Pixel	0.2944	0.2946
MTF30P_Cycles_per_Pixel	0.3024	_NaN_
MTF20P_Cycles_per_Pixel	0.3606	_NaN_
MTF10P_Cycles_per_Pixel	0.3649	_NaN_

Table 6. Texture Results

Texture IQ Factors	Device 1	Device 2
Peak MTF	**1.94**	**1.73**
Computer Monitor Acutance	**1.21**	**1.10**

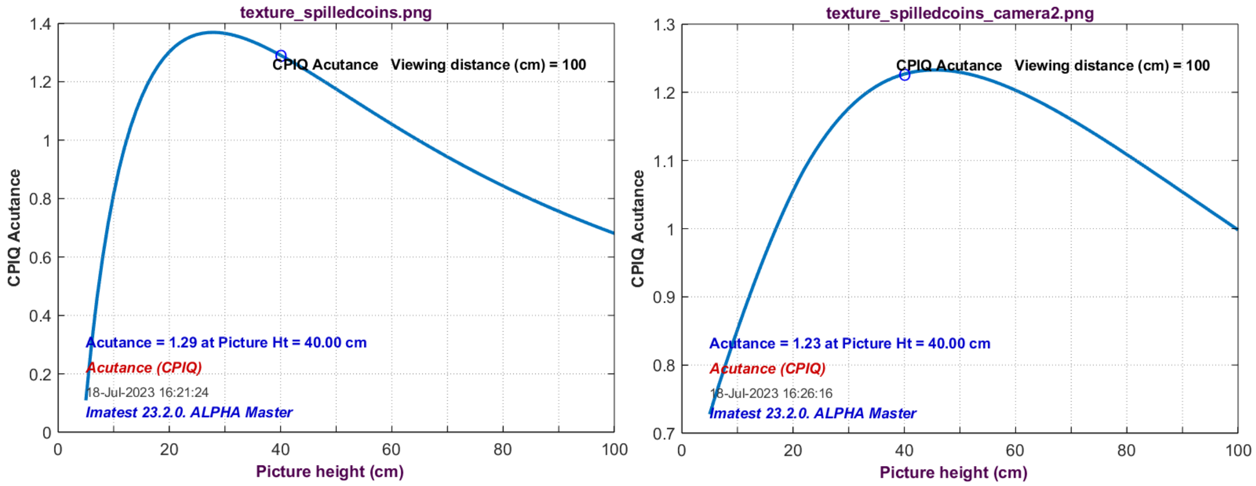

Figure 9: CPIQ Acutance for Device 1 (left) and Device 2 (right)

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Color Metrics and Observations

The CIELAB (L*a*b*) color space was designed to be relatively perceptually uniform. That means that perceptible color difference is approximately equal to the Euclidean distance between L*a*b* values. several additional color difference formulas have been established. In these formulas, just-noticeable differences (JNDs) are represented by ellipsoids rather than circles.

Both devices have strong levels of saturation applied, but are more accurate along hue directions. Though their mean chromas are over 30% above aim, their mean ΔE2000 values are significantly lower than that of other consumer devices. Note that the mean chroma of these cameras is typical of consumer photography preferences.

Figure 10: ColorChecker Device 1

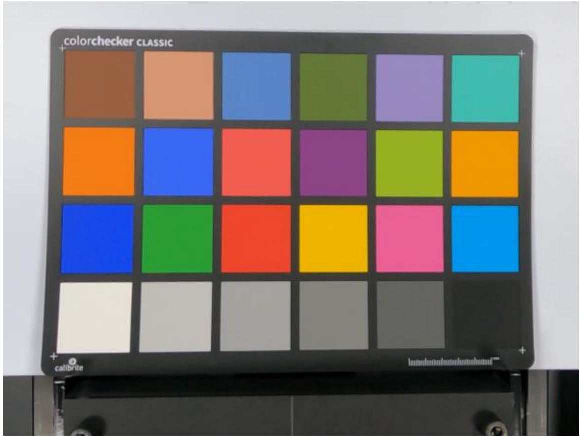

Figure 11: ColorChecker Device 2

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Table 7: Mean Color Metrics

Mean Color Metric	Device 1	Device 2
mean_Delta_E	16.4	16.1
mean_Delta_C	13.3	14.6
mean_Delta_E94	10.5	9.10
mean_Delta_C94	5.97	6.75
mean_Delta_E2000	9.32	7.81
mean_Delta_C2000	5.17	5.78
mean_Delta_L	7.75	3.45
mean_Delta_Chroma	10.9	11.6
mean_Delta_Hue_Distance	4.98	5.87
mean_Delta_Hue_Degrees	6.28	7.00
mean_Delta_C_sat_corr	7.93	9.07
mean_Delta_C94_sat_corr	3.92	4.53
mean_Delta_C2000_sat_corr	3.79	4.37

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Table 8: Max Color Metrics

Max Color Metric	Device 1	Device 2
max_Delta_E	43.4	44.4
max_Delta_C	41	43.3
max_Delta_E94	21.9	22.5
max_Delta_C94	18.8	21.1
max_Delta_E2000	18.5	17.5
max_Delta_C2000	13.7	15.2
max_Delta_L	16.1	14.4
max_Delta_Chroma	40.8	42.8
max_Delta_Hue_Distance	27.4	30.9
max_Delta_Hue_Degrees	37.3	41.6
max_Delta_C_sat_corr	24	26.9
max_Delta_C94_sat_corr	15.5	17.4
max_Delta_C2000_sat_corr	13	14.6

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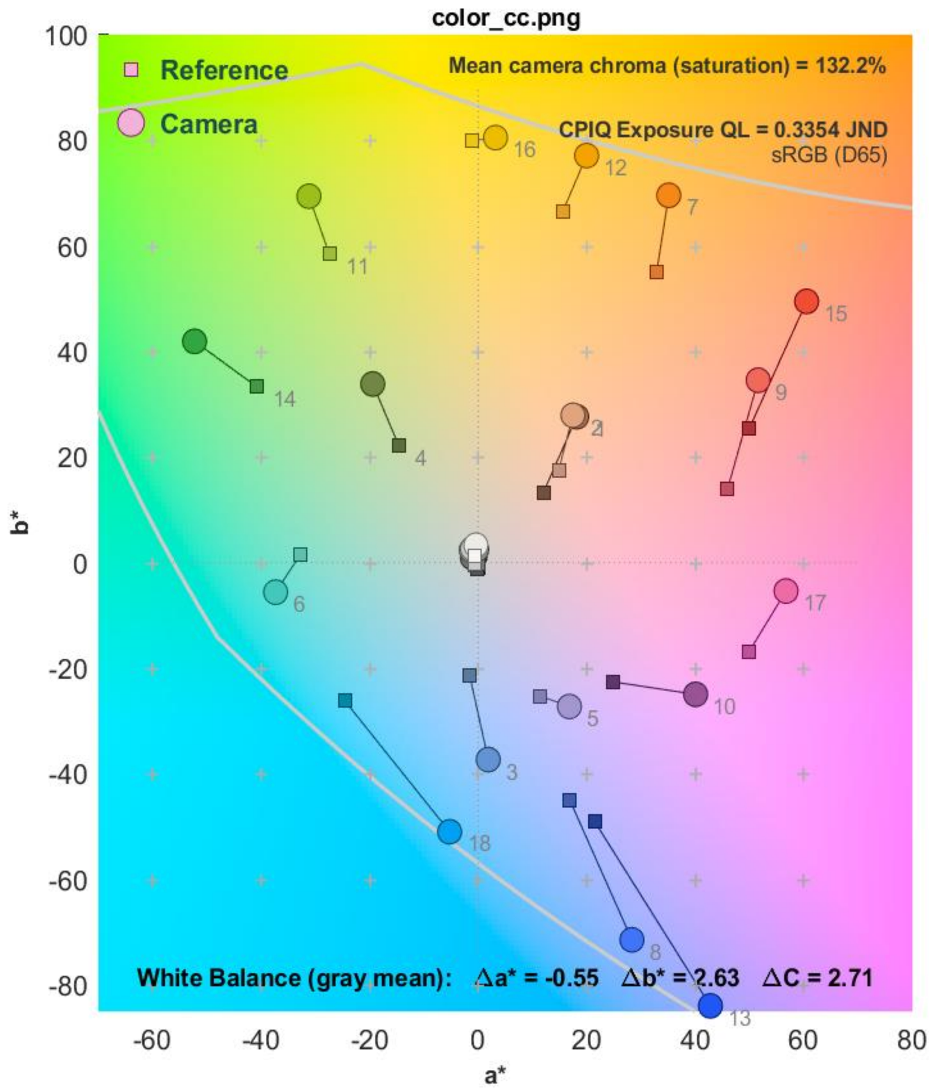
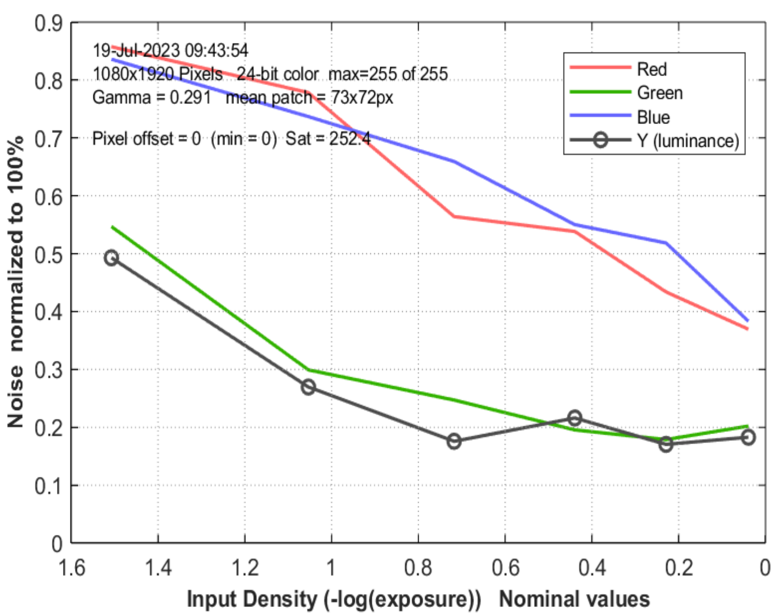
Device 1 Color Result Visualization

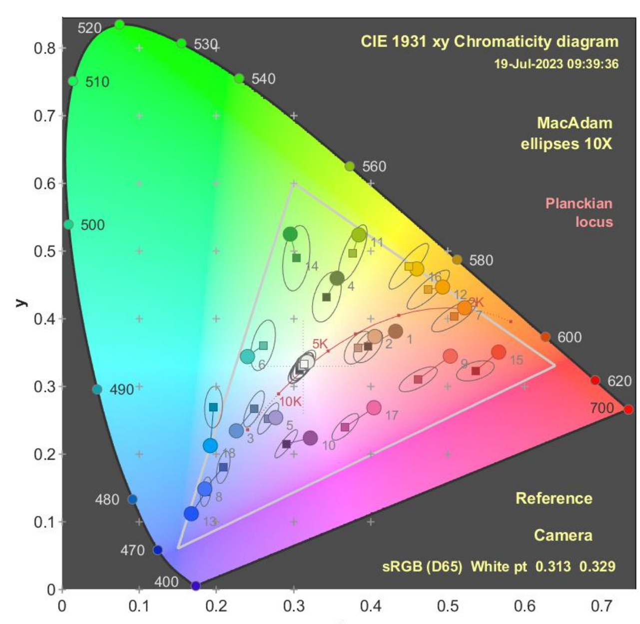
The 2D a*b* plot (right) displays the a*b* plane of L*a*b* color space. Chroma differences are approximately the distance between the reference and camera values.

The noise vs. input density (RGB) plot (bottom left) shows a simple noise derived from standard deviation (σ) of pixel levels.

The xy chromaticity plot (bottom right) is familiar, but less perceptually uniform than the a*b* plot, above. Green gets too much area in this plot.







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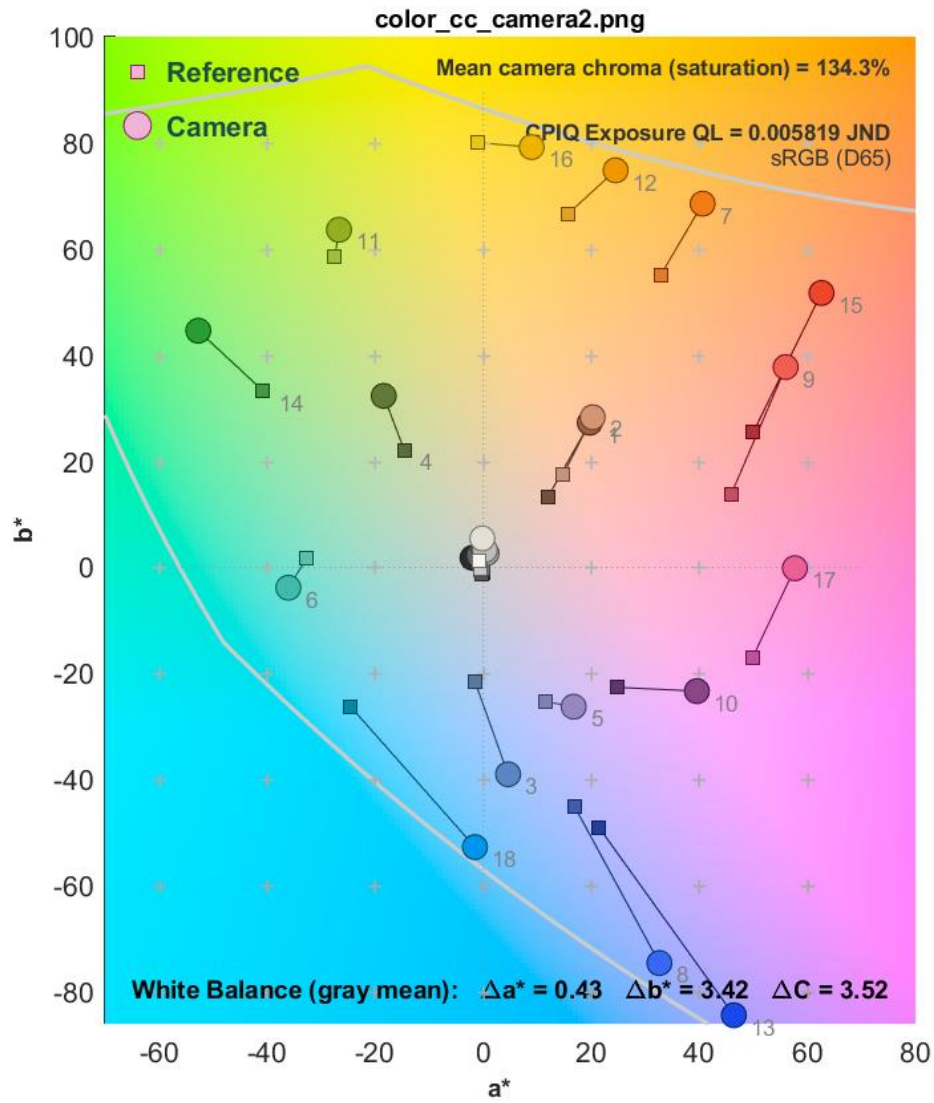
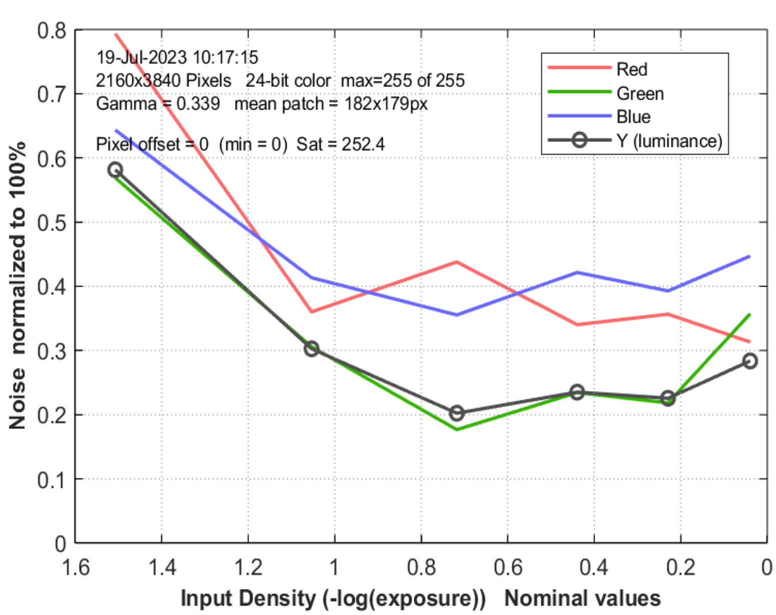
Device 2 Color Result Visualization

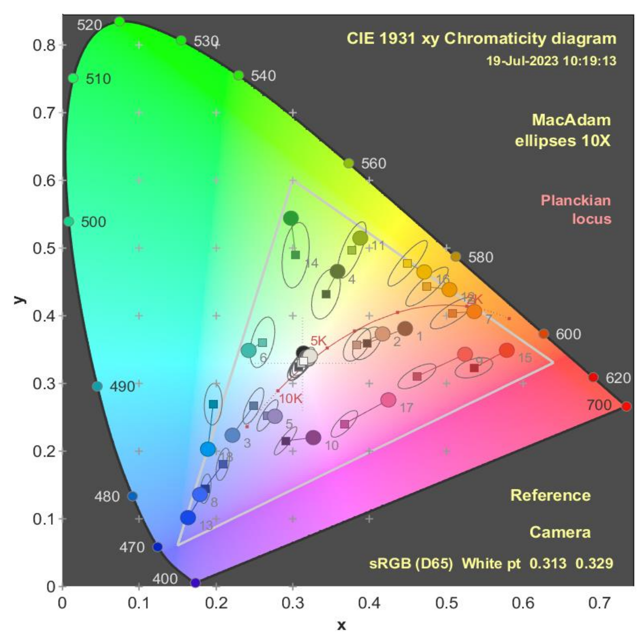
The 2D a*b* plot (right) displays the a*b* plane of L*a*b* color space. Chroma differences are approximately the distance between the reference and camera values.

The noise vs. input density (RGB) plot (bottom left) reveals considerably lower R/B noise than Device 1.

The xy chromaticity plot (bottom right) is familiar, but less perceptually uniform than the a*b* plot, above. Green gets too much area in this plot.







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Dynamic Range and SNR Observations

Dynamic Range (DR) is the range of exposure, i.e., scene brightness, over which a camera responds with good contrast and good Signal-to-Noise Ratio (SNR).The most straightforward way to measure a camera's dynamic range is with a transmissive step chart illuminated from behind by a lightbox. The Imatest 36-patch Wide Dynamic Range (HDR) test chart, with target density steps from 0.1 to 0.3, and a maximum density of at least base+5 (~17 f-stops), is recommended for traditional Dynamic Range measurements. A nearly circular patch arrangement ensures that vignetting has minimal effect on results.

The following SNR metric is taken from the SNR_BW metric calculated in Imatest software. SNR_BW is an average SNR based on White-Black patch levels (density difference = 1.5). It's designed to be relatively independent of the chart type and system contrast (gamma). We used "low quality" dynamic range for SNR=1 (0 dB). The dynamic range results indicate that Device 2 has the higher range.

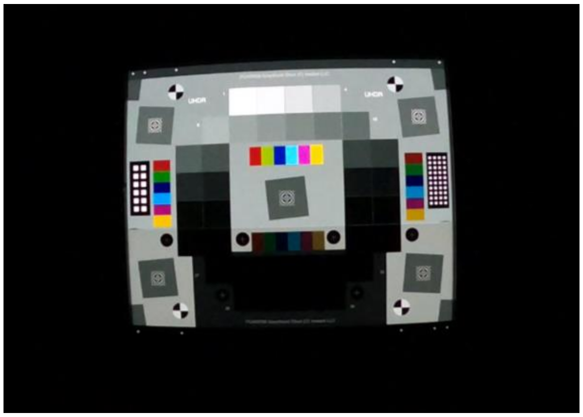

Figure 11: Device 1

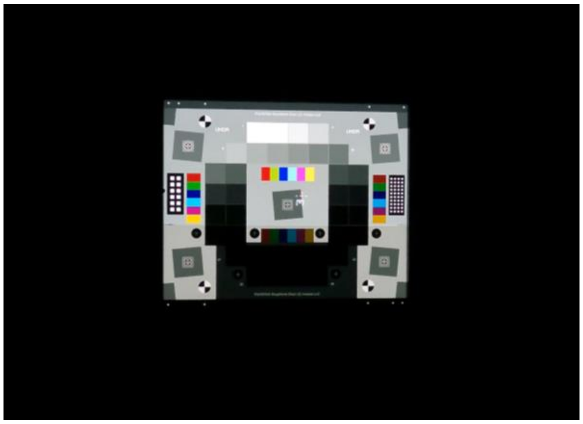

Figure 12: Device 2

Table 9. DR and SNR Results

Dynamic Range IQ Factors	Device 1	Device 2
Dynamic range at SNR=1	57 dB	69.6 dB
SNR_BW (luminance)	44.9 dB	43.8 dB

Table 10: Additional Dynamic Range Metrics

Dynamic Range Metric	Device 1	Device 2
noise_pct_ISO15739_at_13pct_Lref	0.2973	0.2629
snr_ISO15739_at_13pct_Lref	30.27	38.63
snr_dB_ISO15739_at_13pct_Lref	29.62	31.74
DynamicRange_at_density_2	337.6	365.6
DynamicRange_total	57.84	0.7807
DynamicRange_from_slope_OD	2.765	2.73
DynamicRange_from_slope_EV	9.18	9.064
DynamicRange_from_slope_dB	55.3	54.6

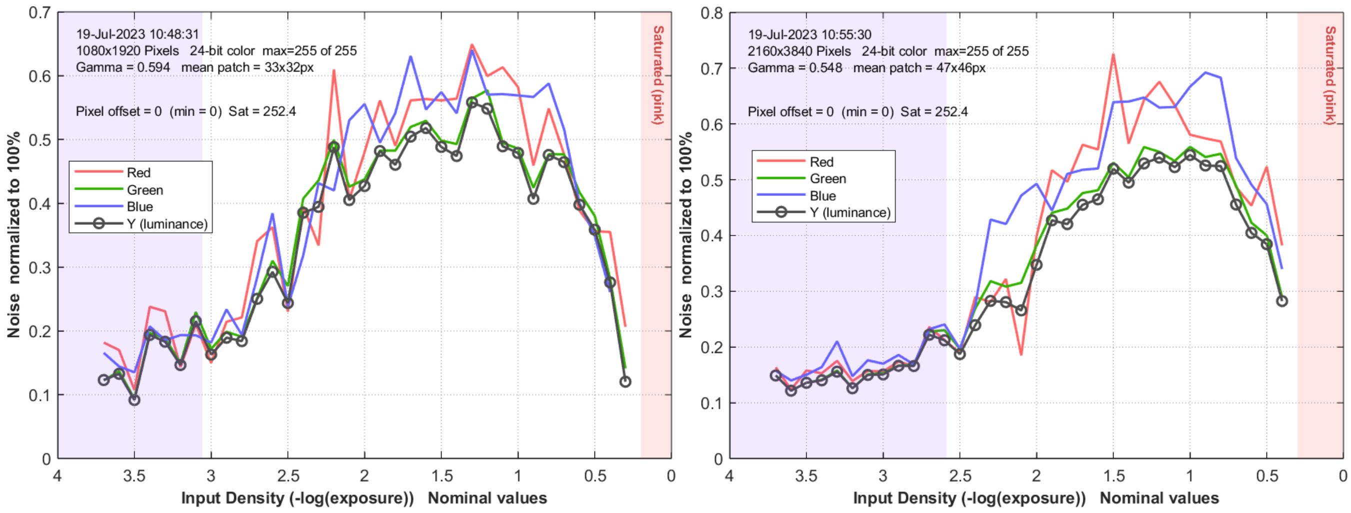

Figure 13: Noise vs Input Density for Device 1 (left) and Device 2 (right)

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Uniformity Metrics and Observations

Image nonuniformity can be caused by the lens, the sensor, and the lighting. Nonuniformities may include lens shading, light falloff, or vignetting. These appear in images as visible darkening the further you get from the center. This is due to the radial nature of the lens which collects more light in the center. It can be particularly strong with wide angle lenses. Nonuniformity is also caused by the chief ray angle of light incident to the sensor which has reduced quantum efficiency as the angle increases. Device 2 is measurably less uniform.

Figure 14: Device 1

Figure 15: Device 2

Table 11: Relative Uniformity

Uniformity Metric	Device 1	Device 2
side_levels_Pct_L_R	[92.8, 94.2]	[88.5, 91.2]

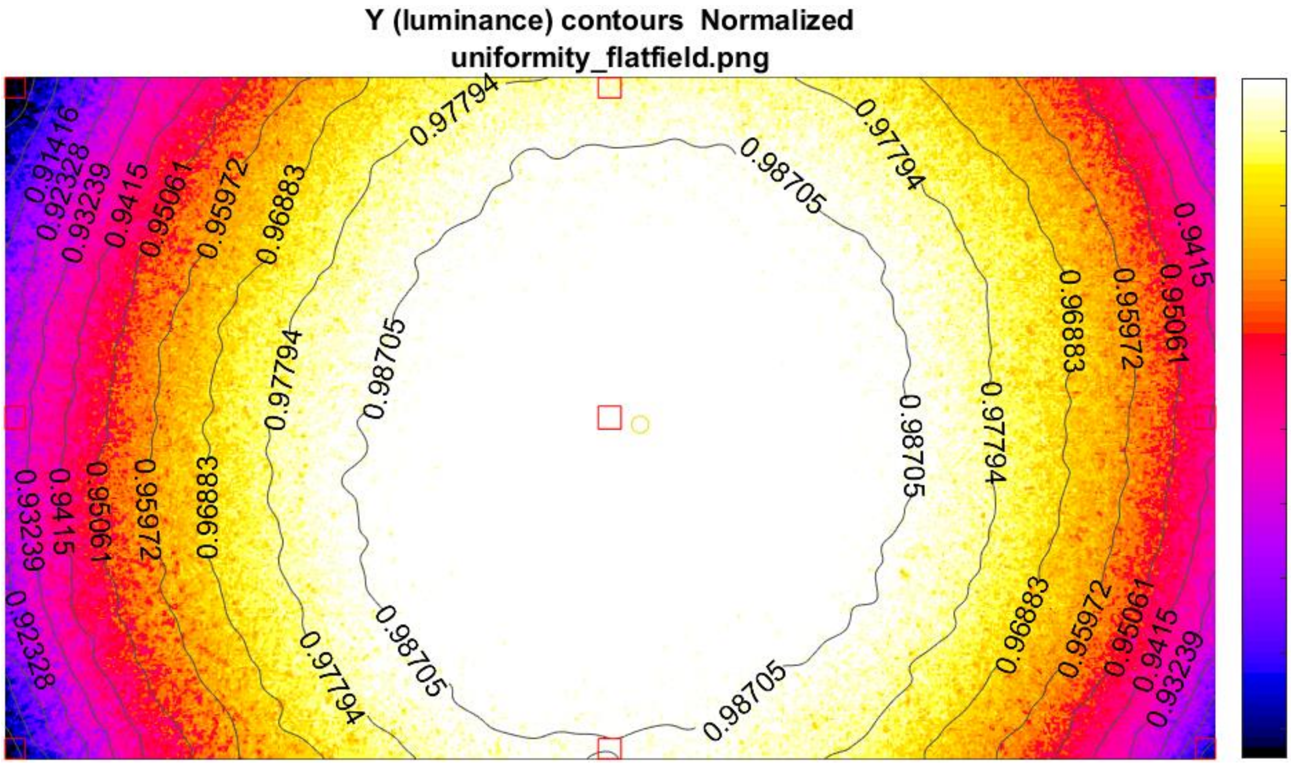

Figure 16: Device 1 Pseudo-color Pixel Contours

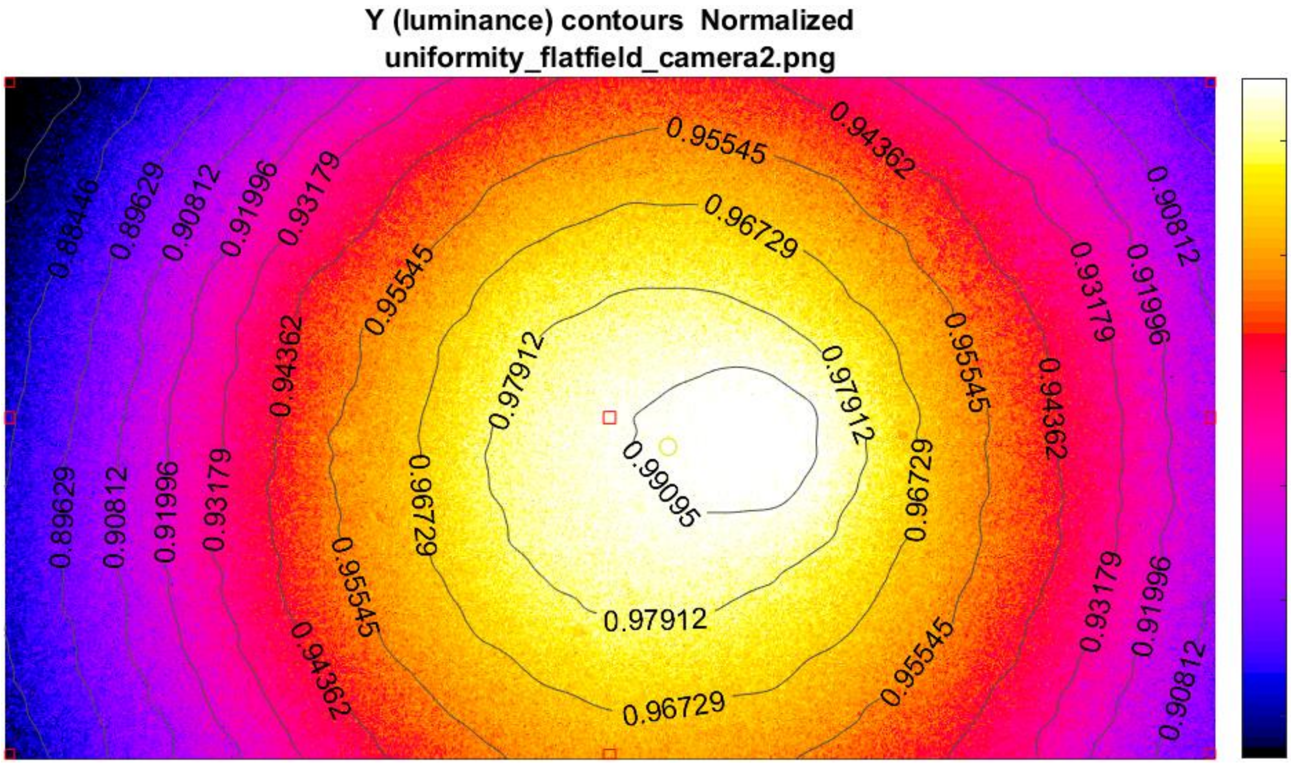

Figure 17: Device 2 Pseudo-color Pixel Contours

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