MURA Measurement in VideoWin
Introduction

Mura: *any local non-uniformity due to the unevenness of light emission*

Conceptually, Mura algorithms attempt to correlate visual non-uniformities in digital terms. There are many descriptions of MURA, but in Photo Research's VideoWin software application, there are six fundamental Mura measures[1] :

1.   Luminance Edge Area
   Defined in terms of a rapidly changing gradient at the edge of the display with respect to the average luminance value of the display

2.   Luminance Mura Area
   The area of varying lightness and darkness with respect to the average value of the display luminance

3.   Luminance Lightness Area
   Defined by the maximum lightness difference in the display area

4.   Color Edge Area
   Defined in terms of a rapidly changing gradient at the edge of the display with respect to the average Chroma value of the display

5.   Color Mura Area
   The area of varying Chroma with respect to the average value of the display Chroma

6.   Color Lightness Area
   The peak Chroma difference in the display

Each of these fundamental measurements are quantitative evaluation indices that are combined in a weighted fashion to arrive at a weighted sum that correlates to the magnitude of the visual error. The weighting of these indices is derived from physiological experiments. A typical weighting is given as:

$$Y_{Lum} = 1.901X_a + 0.186X_b + 19.922X_c - 1.794 \qquad (2)$$

Y_{Lum}: Predicted ME value for luminance uniformity
X_a: Value of the "high and low luminance area"
X_b: Value of the "maximum luminance difference"
X_c: Value of the "luminance edge area"

As stated above, the weights are typically based upon subjective testing. These weights can be altered to individual customer requirements. The weights used in this example are from IEC/TR 62977-3-2-ED1.

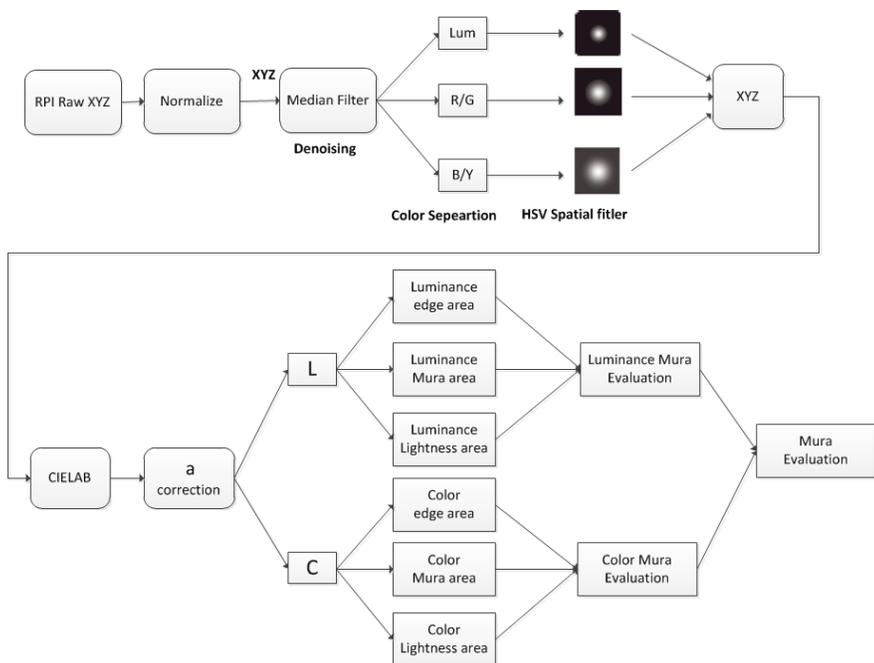Mura evaluation index computational diagram.

Figure 1 computational flow diagram

Photo Research's Mura algorithm utilizes a variant of the S-CIELAB algorithm to convert the initial CIEXYZ data to an opponent color representation. The opponent color data is then spatially filtered and converted back to XYZ and later to CIELAB. A correction is applied to the CIELab "a" term and the image data is converted to a Luminance/ Chroma representation.

The Mura application requires that the user enter the working distance from the camera. This data is used to modify the Spatial Filter used in the S-CIELAB algorithm.

The weighting calculations are applied to the data[1,2], and the compounded data is summed.
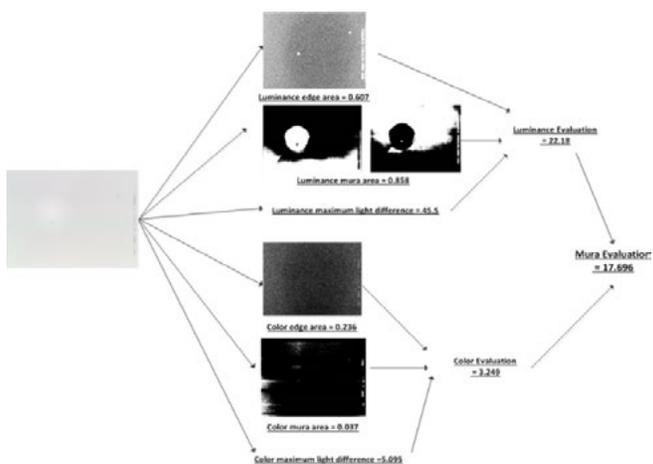

Figure 2 Separated image calculation

Application of the numbers

It is important to note that the compounded data is the result of subjective tests and weights, and it can be adjusted for particular customer assessment. It is also important to understand that the data is always based upon an absolute difference metric. A very good result is a low number. Figure 3 shows a plot that illustrates one potential use of the data. In this case, subjective quality ratings of 0 to 5 are correlated with the output of the Mura algorithm. Large Mura values are indicative of lower quality displays. This sort of test is typically performed by the corporation running the MURA testing.

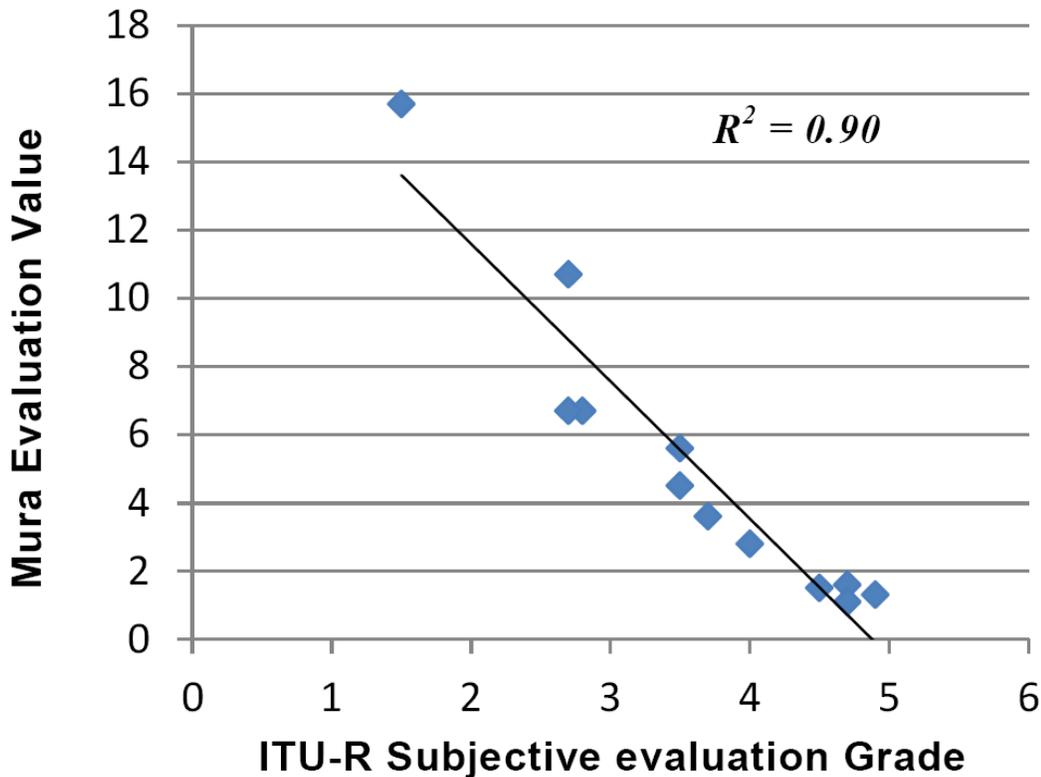The illustration below is taken from IEC 62977-3-2-ED.1

$$R^2 = 0.90$$

Figure 3 Mura Evaluation Value compared to Subjective Quality

As displayed in Figure three, a lower Mura Evaluation Value indicates better subjective grades of the Device Under Test (DUT).

VideoWin Mura Functionality

VideoWin now comes equipped with Photo Research's Mura Measurement algorithms. VideoWin's Mura Measurement capability can detect defects in displays and maintain the quality standards for your product. These directions are provided on how to use VideoWin's Mura Measurement capability:

1. **Take a Measurement**
In a VideoWin process, first open an existing measurement or take a new measurement using the PRI TRU-8 Imager. Please consult the VideoWin quick start guide for more information.

2. Open the Mura Dialog

VideoWin has two locations from which you can access the Mura Measurement functionality. Look for the Mura Measurement icon [M] in either the Quick Tools bar, or from within the **Tools** menu item.
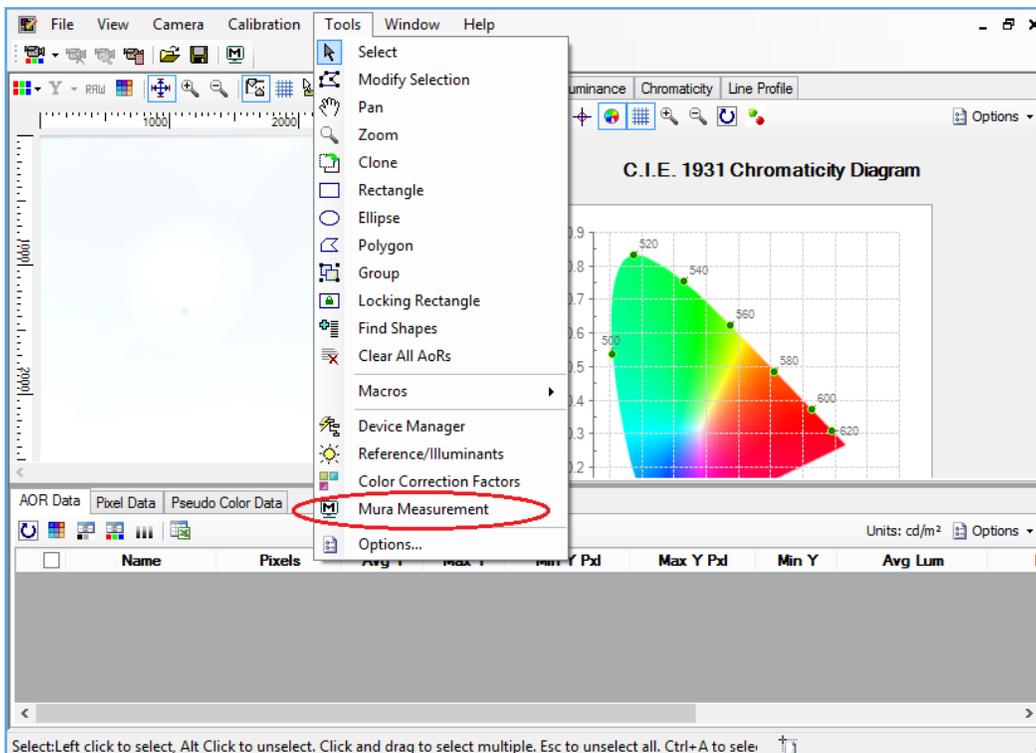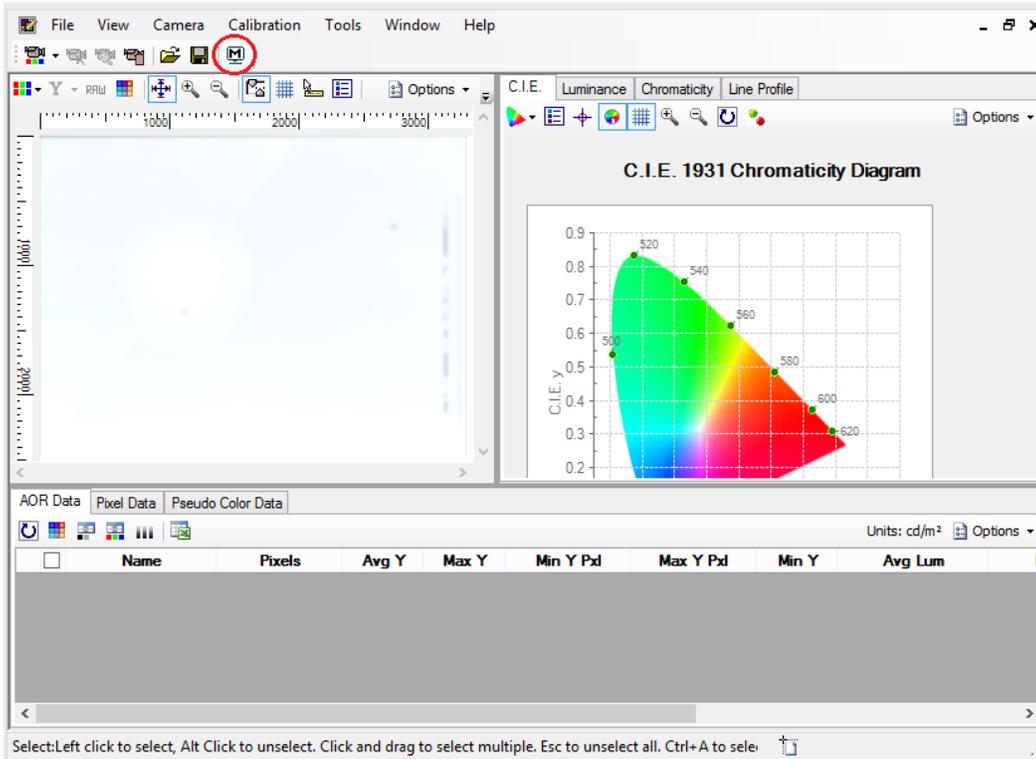
3. Start Mura Measurement

Once the dialog appears, you will see the most recent measurement taken in the **Captured Image** area. This is the measurement you will be using to perform a Mura Measurement. The **Open File** menu item under **File** on the menu bar can load a new measurement.

For a proper Mura Measurement the user must enter inputs into the **Mura Inputs** field to describe the environment.

4. White Reference

In order to obtain an accurate Mura measurement, you must describe a true white value in terms of luminance for the camera. Measuring a true white target in the same environment and taking the luminance value is an example of providing this value. Often times this is not easily achievable or may not be needed. By setting the **White Reference** input to its default value of "-1", the Mura Measurement algorithm will use the max luminance value in the measurement as the target white.

5. Pixels per Degree

Mura's intent is to measure pixel-to-pixel variations across a display. The **Pixel per Degree** input tells the Mura algorithm the estimated distances between pixels on the actual display being measured. This input represents the number of pixels on the display for 1 degree of the image at the distance measured. If this value is set higher than the actual pixels on the display per 1 degree of the image, then it is more likely the algorithm will be sensitive to changes magnifying a small defect as a variation that occurs over many pixels. The reverse is true in that if the value is low, drastic changes in the image must occur to be qualified as a defect. The calculation of pixels per degree is as follows:

- Let N = number of horizontal pixels of the display
- Let W = the physical width of the display
- Let D = the physical distance between the display and viewer

$$\text{Pixels per Degree} = N/(2 * \text{atan}\left(\frac{W}{2*D}\right))$$

Note that when computing the arc tangent it is important to ensure that the calculation returns degrees and not radians. This measurement is used set the conditions for the spatial filter used in the calculation (See Figure 1.)

6. Measure Mura Button

When you click this button, VideoWin will perform a Mura Measurement on the current measurement loaded and return the results of the measurement on the screen. The results will include the values listed in section.

7. Pass/Fail Criteria

The Mura Measurement returns a series of results that can be evaluated against a known value for a passing or failing result. In the Mura Measurement dialog menu, select **Pass/Fail Criteria** to bring up a new dialog allowing the setting of criteria values.   Each returned Mura Measurement value is independently enabled/disabled and configured for a passing score.

8. Click **Enable Criteria** for the pass fail reporting, and set the value to use as the threshold.

9. When you run the next **Mura Measurement,** the table will show the results. If the measured score is below the criteria score, the table displays the result with a green passing score. If the measured score is above the criteria, the table displays the failing score in a red box.
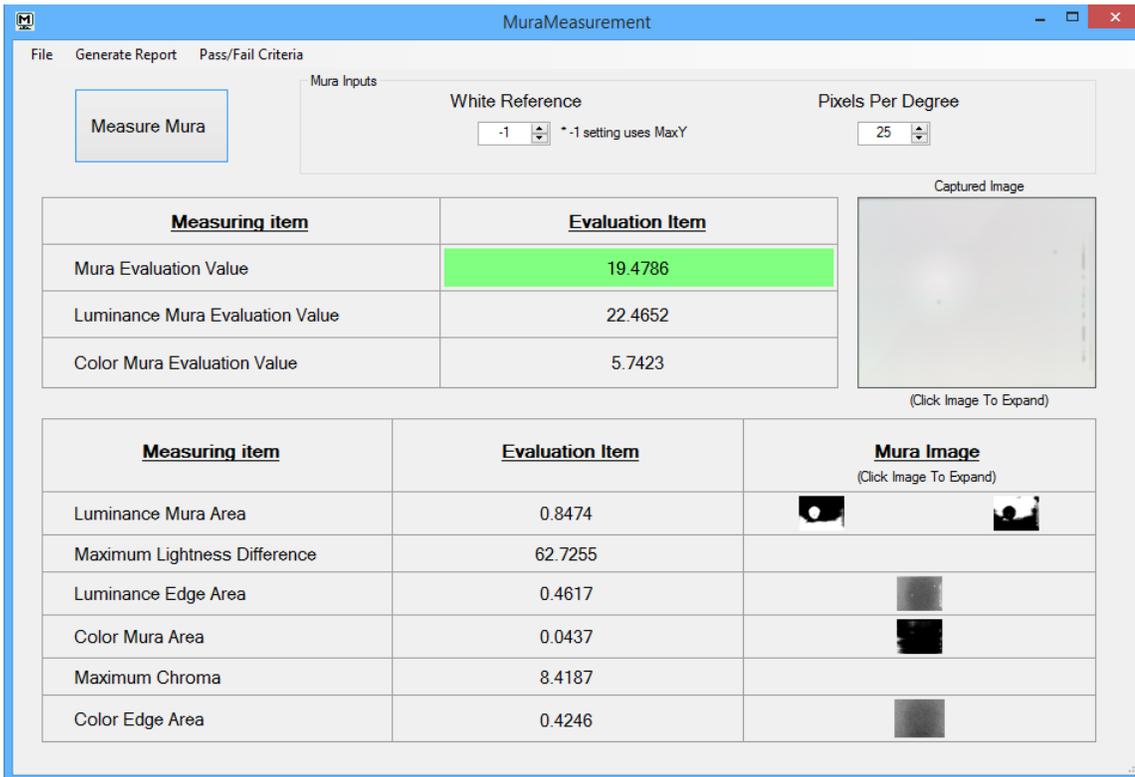
10. Generate PDF Report

Once the Mura Measurement has taken place, using menu item **Generate Report** will save a PDF version of the current results table and the passing and failing result from the user defined **Pass/Failed Criteria**. Selecting this item will bring up a file dialog allowing you to select where to place the PDF report.
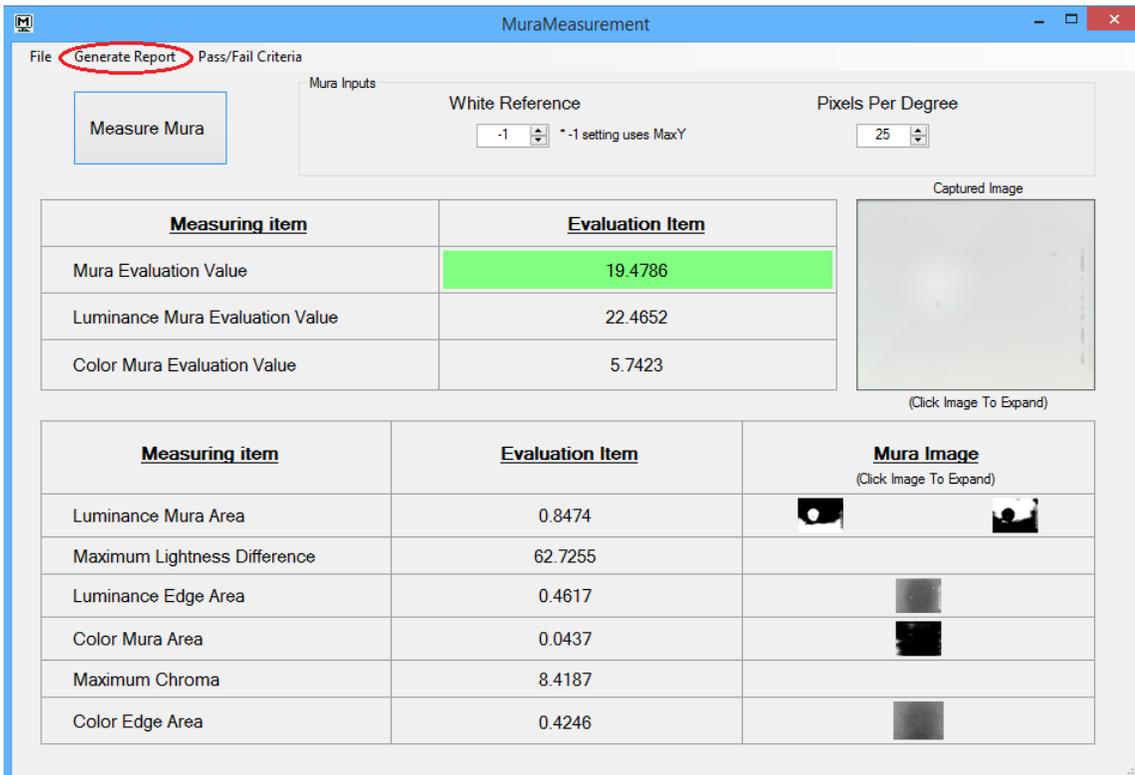
Sources:

[1]IEC/TR 62977-3-2-ED1

[2]K. Nagamine, S. Tomioka, T. Tamura, and Y. Shimpuku, *A Quantitative Evaluation Method for Luminance and Color Uniformity of a Display Screen Based on Human Perceptions.* IEICE TRANS. ELECTRON., Vol.E95-C, No.11 Nov.2012: p1699-1706

[3]Xuemei Zhang and Brian A. Wandell, A Spatial Extension of CIELAB for Digital Color Image Reproduction. Department of Psychology, Stanford University. Stanford, CA 94305.