MURA & DEFECT DETECTION
WITH TrueTest™
OUTLINE

• The TrueTest™ system

• Quick introduction to TrueTest layout and structure

• TrueTest walk-through

• TrueTest gallery

• Summary
WHAT IS TrueTest™?

A library of FPD tests
- User defined test parameters
- User defined pass/fail criteria

A test sequencing and execution system

A test report generator

The TrueTest System consists of:
- A ProMetric imaging colorimeter
- The TrueTest Software
- Optional interfaces to:
  - Production Control System
  - Video Pattern Generator
  - Barcode reader (or similar)
  - Human operator
WHAT SOLUTIONS DO WE PROVIDE?

Core Technology

- Radiant Vision Systems provides optical testing systems that match human perception and judgment.
- We have 20 years of experience providing state-of-the-art light and color measurement, testing, analysis and optical system design.
- Thousands of our CCD-based display testing systems are deployed in production today, measuring millions of displays annually.

Testing Systems

- Dedicated testing systems:
  - Display optical performance, e.g., uniformity
  - Defect detection
  - Mura (unevenness, irregularity or inconsistency in appearance) detection with JND (Just Noticeable Difference) evaluation
- Fully configurable test suites.
- Fully automated, or partially automated test processes.
- System integration to Production Control Systems, video pattern generators, bar code readers, etc.
Family of scientific-grade CCD sensors
Simultaneously capturing millions of data points
Cooled to reduce thermal noise and improve accuracy

1. Precision filters, lenses, and shutter
2. Patented shutter for uniform exposure time across entire CCD
3. Proprietary calibrations to achieve optimal performance
   Every imaging colorimeter is individually calibrated to CIE luminance and color values
   NIST traceable calibrations

Extensive control and analysis software to simplify operation and testing applications
TrueTest™ SOFTWARE

Comprehensive Testing

- Pin-points and quantifies quality issues and defects
- Allows pass/fail determinations to be automated against a consistent standard – from DUT-to-DUT, line-to-line, and supplier-to-supplier

Uniformity testing  Defect detection  Mura detection and JND evaluation
TrueTest™ COMPONENTS

Test Library

Quality Tests  Defect Detection  Mura Tests

Measurement Sequence  Test Sequence  Pass/Fail  Report
TrueTest™ EXECUTION SEQUENCE

- Select test(s)
- Define test details
  - Measurement test pattern (e.g., 127 gray)
  - Test parameters (e.g., number, size, shape and positions of POIs)
  - Test pass/fail criteria
- Set test sequence
  - And set measurement sequence
- Define report format
- Execute, repeatedly
TURNKEY TEST SOLUTIONS

- Imaging colorimeter
- Test software
- Fixture (dark box)
  - may be on-line, or adjacent to line
  - may be full or partially automated
- Display
- VPG (optional)
- PRODUCTION LINE

Test chamber
Holder
Controls
## COMPARISON OF FPD TEST METHODS

<table>
<thead>
<tr>
<th>Test Method:</th>
<th>Human Inspectors</th>
<th>Spot meters</th>
<th>Machine Vision</th>
<th>Imaging Colorimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEST ATTRIBUTES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing Speed (avg.)</td>
<td>⊙</td>
<td>⊙</td>
<td>◀</td>
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<td>Test Complexity</td>
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<tr>
<td>Accuracy</td>
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<td>◀</td>
<td>◀</td>
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<tr>
<td>Repeatability</td>
<td>⊙</td>
<td>◀</td>
<td>◀</td>
<td>◀</td>
</tr>
<tr>
<td>Consistency (line-to-line)</td>
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<td>◀</td>
<td>◀</td>
<td>◀</td>
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<tr>
<td><strong>QUALITY ATTRIBUTES</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Detection of mechanical issues</td>
<td>⊙</td>
<td>◀</td>
<td>◀</td>
<td>◀</td>
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<tr>
<td>Detection of appearance issues</td>
<td>◀</td>
<td>◀</td>
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<td>◀</td>
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<tr>
<td>Spatial perception</td>
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<td>◀</td>
<td>◀</td>
<td>◀</td>
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<tr>
<td>Match to human perception</td>
<td>◀</td>
<td>◀</td>
<td>◀</td>
<td>◀</td>
</tr>
<tr>
<td>Adaptability (new tests, multiple models)</td>
<td>⊙</td>
<td>◀</td>
<td>◀</td>
<td>◀</td>
</tr>
</tbody>
</table>

**Key:**    Best ⊙     Average ⊙     Worst ⊙
QUICK INTRODUCTION TO TrueTest™ SOFTWARE
TrueTest™ SOFTWARE STRUCTURE

TrueTEST (main GUI)

- Report Generator
- Analyses
- Device Interface
- PMEngine

Device Under Test
ProMetric Camera

SEE THE DIFFERENCE
TrueTest™ SCREEN LAYOUT

- Test control
- Test sequence & results
- Measurement setup
- Test images
- Test results
TrueTest™ WALK-THROUGH
CREATE A TEST SEQUENCE

1. Test sequences created from scratch or by editing an existing sequence.

2. Each test in the sequence is specified by:
   1) The measurement it is based on, and
   2) The analysis that is run on the measurement image.

A single measurement image may be reused multiple analyses (TrueTest is smart enough to check for existing measurements before taking a new one.)

<table>
<thead>
<tr>
<th>Select</th>
<th>Measurement</th>
<th>Analysis</th>
<th>Edit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black</td>
<td>Gradient</td>
<td>Edit</td>
</tr>
<tr>
<td>2</td>
<td>Blue</td>
<td>TrueMURA</td>
<td>Edit</td>
</tr>
<tr>
<td>3</td>
<td>Blue</td>
<td>Edge Mura</td>
<td>Edit</td>
</tr>
<tr>
<td>4</td>
<td>White</td>
<td>Line Defects</td>
<td>Edit</td>
</tr>
<tr>
<td>5</td>
<td>White</td>
<td>Pixel Defects</td>
<td>Edit</td>
</tr>
<tr>
<td>6</td>
<td>White</td>
<td>ANSI Brightness</td>
<td>Edit</td>
</tr>
<tr>
<td>7</td>
<td>Gray</td>
<td>Line Mura</td>
<td>Edit</td>
</tr>
<tr>
<td>8</td>
<td>Red</td>
<td>Black Mura</td>
<td>Edit</td>
</tr>
</tbody>
</table>
### MEASUREMENT OPTIONS

For each Analysis, a Measurement is specified. A default test pattern can be selected, or a new pattern can be defined (see next slide).

(Aside: “None” is used when the Analysis is step is an operation, such as a pause.)

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</tr>
<tr>
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<td>Blob Analysis Center Mura</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Red</td>
<td>Edge Mura</td>
<td></td>
</tr>
<tr>
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</table>
Options exist to (A) select the pattern type, and ...

(B) to select the pattern color and other attributes.
ANALYSIS SELECTION

The Analysis can be selected from the TrueTest test library.
Each test has numerous options for test application, representation, ... and pass/fail criteria.
Global parameters can be set, as can be the device interface (e.g., Video Pattern Generator).
Sequences can be run beginning to end, or stepped through one test / analysis at a time.
Analysis test results are shown qualitatively in the sequence list, and numerically in an analysis window.

The Analysis Results window provides the input for the Test Report.
Analysis results can be summarized in an Excel format file for dissemination and future reference.
RUNNING IN OPERATOR MODE

Operator Mode supports running TrueTest without access to settings.

Run options are limited to test execution.
TrueTest™ ANALYSIS GALLERY
TrueTest™ 1.5

Compared with prior versions, TrueTest 1.5 now offers:

• **Windows 8** Compatibility
• Database performance improvements
  • 5x faster when reading a measurement from a database and rendering a bitmap view of the measurement data
  • 5x faster when writing a measurement to the database
• **Added Pixel Defects Analysis**
  • Similar to Particle Defects, but with fewer parameters
• **New Option: Automatically export analysis images**
  • **Exports image that includes analysis overlays**, such as what is shown to the user when a TrueTest sequence is run.
  • User can choose the format: BMP, JPG, PNG
  • User can choose export folder
• **New algorithms for Moire removal**
• Works with G, I and Y series cameras
TrueTest™ 1.5 STANDARD INSTALL:

Defect Testing
- Gradient
- Line Defects
- Particle Defects
- Pixel Defects

Display Testing
- ANSI Brightness
- ANSI Color Uniformity
- Checkerboard Contrast
- Chromaticity
- Compare Points Of Interest
- Distortion
- Focus Uniformity
- Points Of Interest
- Uniformity

Mura Testing
- Runs with the TrueTest license code
- Color Edge Mura
- Color Mura
- Diagonal Pattern Mura
- Polarizer Deformation
- Spot Pattern Mura

Display Testing
- Requires additional TrueMURA license code
- Black Mura
- Blob Analysis
- Butterfly Mura
- Corner Light
- Diagonal Line Mura
- Edge Mura
- LED Mura
- Line Mura
- Random Mura
- Spot Mura
- TrueMURATest
• Register Active Display Area (RADA) automatically rotates and crops display measurements so only the device under test (DUT) is considered and any background in the field of view of the colorimeter is eliminated.
LINE DEFECTS

- Line Defects are sharp, extended blemishes that usually span the entire width or height of the display and only exist in the vertical or horizontal directions.
LINE DEFECTS ANALYSIS
PARTICLE DEFECTS

- Particle Defects are very small blemishes on the display. These can be the result of dust or defective pixels present in the display.
PARTICLE DEFECTS ANALYSIS
For tests like Pixel Defects, the camera must be well focused to find tiny problems with the display. This generally results in a strong moiré pattern which could interfere with the analysis, therefore Radiant has developed a proprietary method to filter moiré.
• From the same image shown in the Moiré Removal slide, we are now able to identify the exact location of the dead pixel.
COLOR EDGE MURA

- Color Edge Mura is a deviation in color at one or more of the edges.
• The Color Edge Mura is shown in deviation from overall color
COLOR MURA

• Color Mura is a blemish that deviates in color. Intensity can be the same and therefore is not possible to detect on a luminance only image
COLOR MURA ANALYSIS

- Threshold can be set depending on customer preference in variance in Cx, Cy or other types of color systems like e.g. u’, v’.
POLARIZER DEFORMATION

- Polarizer Deformation consists of large, gradual blemishes across the screen. This can be the result of stress on or non-uniform thickness in an LCD layer.
POLARIZER DEFORMATION ANALYSIS
• Black Mura consists of large blemishes grouped together.
BLACK MURA ANALYSIS

- TrueTest finds the mura, highlights it and quantifies it.
- Quantification can be in local contract ration, JND or a customer specific manner
• Butterfly Mura consists of blemishes in the corners that are bright (or dark) when compared to the edges.
BUTTERFLY MURA ANALYSIS

Here the Butterfly Mura is shown on a “local contrast” image.
Corner light is a bright blemish in the corner that is more easily detectable with the human eye when the display is dim. This may occur when the LCD is pressed upon by the display casing, but could have other root causes.
• The Corner light test will only look is a bright blemish in the corner that is more easily detectable with the human eye when the display is dim. This may occur when the LCD is pressed upon by the display casing, but could have other root causes.
• Diagonal Line Mura (or diagonal band mura) is an extended blemish that can be oriented in any direction.
The Diagonal Line Mura can also be used for “rubbing mura” and could potentially be set to only look for lines in a specific angular span.
EDGE MURA

- Edge Mura are bright blemishes on the edges of the display that is easily seen when the display is dim.
EDGE MURA ANALYSIS
LED Mura consists of bright, evenly spaced blemishes at one edge of the display. They often vary in shape.
LED MURA ANALYSIS
LINE MURA

- Line Mura consists of extended blemishes oriented in the horizontal or vertical directions.
LINE MURA ANALYSIS
Spot Mura are circular or non-circular blemishes. One criteria for the test is the circularity of the blemish. In this example only circular blemishes are considered mura.
• Light Leakage consists of different size bright areas near the edge of the display. They typically appear when the display is set to black or a very dark pattern. This is typically the result of mechanical stress in the LCD layer.
LIGHT LEAKAGE ANALYSIS
BUILT-IN EXCEL® REPORT GENERATION

SEE THE DIFFERENCE
A LITTLE MORE ABOUT TrueTest™

• TrueTest can be fully turn-key
  • Radiant engineers can install, calibrate, train, and hand-over
  • Radiant can generate customer specific tests for addition to TrueTest test library

• TrueTest can be fully personalized
  • Customer can define test sequences, parameters, pass/fail criteria, etc.
  • Customer can add proprietary tests to TrueTest test library

• TrueTest is flexible
  • Test sequences and criteria can be changed on the fly
  • Test sequences and criteria can be updated globally by issuing new sequence files
THANK YOU

For more information, email us at:
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