Visual Inspection Solution and Technologies of Radiant Vision Systems

Toru KOBAYASHI*, Doug KREYSAR**

Abstract

Radiant Vision Systems has been a part of Konica Minolta's Sensing Business Unit since August 2015. The company has provided total test and measurement solutions for display inspection in production of mobile devices. The solutions utilize a combination of advanced measurement hardware, application software and integration/engineering services. Advantages of our major products, ProMetric I-Series imaging colorimeters and Y-series imaging photometers, are high speed, high resolution and high sensitivity. High speed is obviously important for production use. High resolution and high sensitivity enable the detection of various defects of displays and the transition from manual inspection by human eye to automated inspection. TrueTest software provides a wide variety of analysis for display defects and the capability of system integration. Automated display inspection systems are built of this hardware and software, adopting customer requirements by application engineers. We are planning to merge Radiant and Konica Minolta's technologies to improve and create new products.

1 Introduction

Millions of mobile devices such as smartphones, tablets and laptop computers are manufactured every day in the world. Almost all of these devices are equipped with a flat panel display (FPD) and its quality is critical. Brand owners and contract manufacturers have strived to ensure the quality, reduce the production costs and improve efficiencies. Since FPDs could have various type of visual defects, they should be eliminated by adjustments and/or inspections in the production process (Fig. 1). A need for automated quality inspection in consumer electronics is also increasing due to customer demand for product quality, improved supply chain management and labor cost.

Radiant Vision Systems provides the automated test and measurement solutions for display production and has proven experience in the industry.

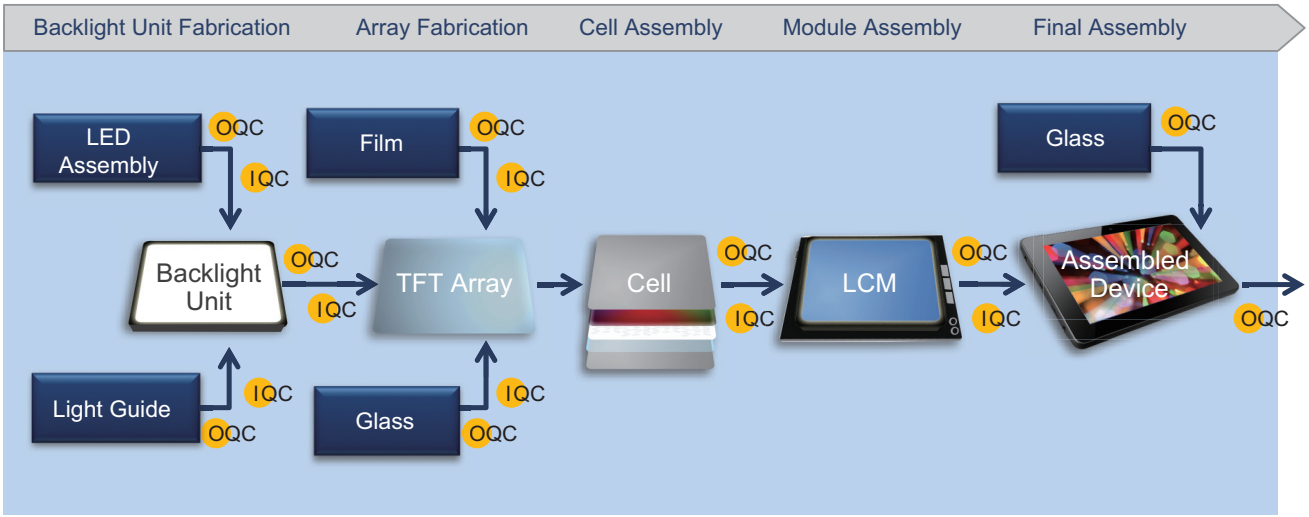

Fig. 1 Production flow of LCD.

* MA Technical Expert Department, Sales Division, Sensing Business Unit
** Chief Solutions Officer, Radiant Vision Systems

2 Solution overview

Radiant Vision Systems' colorimetry-based solutions are optimized for high-volume manufacturing environments, combining R&D level accuracy with the speed and flexibility required of the factory floor. The solution is a combination of 2D imaging colorimeter, software and application engineering (Fig. 2).

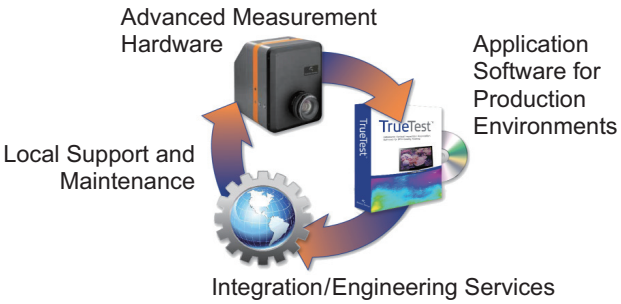

Fig. 2 Radiant solution - combination of software, hardware and application engineering.

We offer two product lines of hardware, ProMetric I-Series Imaging Colorimeters and Y-Series Imaging Photometers. I-Series are capable of 2D color measurement, and Y-Series are specialized in 2D photometric measurement (Fig. 3). Each series have variations of camera resolution, from 2M pixels to 29M pixels. These colorimeters and photometers mirror human response to brightness and color, combining the benefits of human vision with the benefits of an automated process.

ProMetric® I Colorimeters	
	• 2, 8, 16 and 29 MP • Interline, 12-bit dynamic range • High Dynamic Range mode • Ideal for production - when speed matters…
ProMetric® Y Photometers	
	• 2, 16 and 29 MP • Interline, 12-bit dynamic range • Small form factor, highest resolution • Optimized for displays, keyboards and visual surface testing

Fig. 3 Radiant ProMetric portfolio.

In most cases, TrueTest software (Fig. 4) is used to build automated inspection solutions along with ProMetric cameras. TrueTest controls ProMetric cameras, acquires image data, performs analysis of images, controls other external hardware such as video pattern generators, and generates test reports.

As well as the test sequence, measurement settings, patterns to be shown on device under test (DUT), type of analysis, pass/fail criteria and report format are configurable. Since every solution is unique, these settings should be tailored based on each of customer requirements.

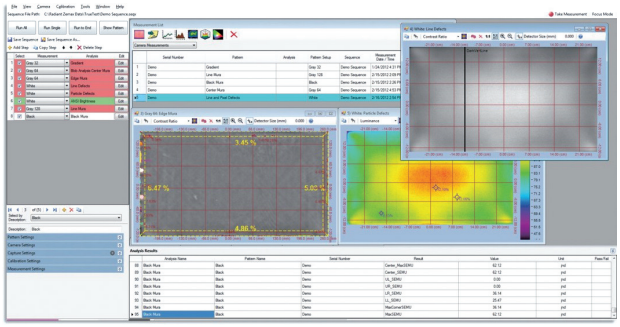

Fig. 4 Screen capture of TrueTest software.

We have a large China team to service Chinese production facilities for global manufacturing customers. Engineers at customer sites are working directly with the customer in real time to adapt software to customer specific needs.

3 Product and technologies

3. 1 Advanced hardware

Fig. 5 is an exploded view of a ProMetric I-Series colorimeter. The colorimeter is built around scientific-grade charge coupled device (CCD) sensors, ranging in resolution from 2M pixels (1600x1200) in Model I2 to 29M pixels (6576x4384) in Model I29. These CCD sensors simultaneously capture millions of data points and enable pixel-level measurements of FPDs. I-Series colorimeters also have a color filter wheel. Spectral transmittance of these color filters is designed so that the spectral response of the system conforms to CIE (Commission Internationale de l'Éclairage) color-matching functions. Multiple images which correspond to each tristimulous values X, Y and Z are taken by changing the color filters.

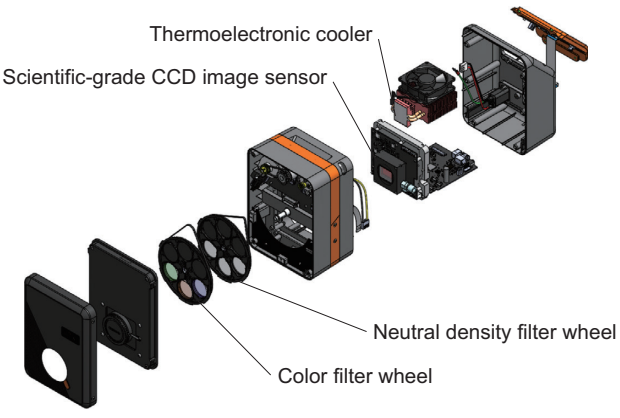

Fig. 5 ProMetric I-Series Colorimeter.

In production use, measurement speed is always critical as it significantly influences the takt time, which is directly connected to a customer's productivity and production cost. In the past two years we have dramatically improved the measurement speed. By utilizing the multi-tap readout of CCD at the full clock frequency and gigabit Ethernet interface with the host computer, the ProMetric imaging colorimeter is capable of high speed measurement, keeping low noise and high sensitivity. Table 1 shows the measurement speed achieved as of July 2016 for each model.

Table 1 Resolution and speed of imaging colorimeters. Speed is represented by minimum measurement time for 100 cd/m^2.

Model	Resolution (pixels)	Speed (seconds)
I2	1.9M (1600x1200)	0.8
I8	8.1M (3296x2472)	0.9
I16	16.0M (4896x3264)	1.3
I29	28.8M (6576x4384)	2.4
Competitor A	1.3M (1280x1000)	6.0
Competitor B	1.0M (1000x1000)	5.0
Competitor C	1.4M (1360x1024)	1.0
Competitor D	8.1M (3296x2472)	3.5

High speed data acquisition allows high-dynamic-range imaging (HDRI) technique by capturing multiple images, without sacrificing the total measurement speed. The CCD thermal noise is reduced by thermoelectronic cooling. With HDRI and cooled CCD, ProMetric I-Series can have a wide dynamic range.

There are multiple lens choices for a wide range of working distances and aperture settings. Advanced automated calibration using an electronic controlled lens enables flat field calibration at all working distances with compressed calibration data file.

ProMetric Y-Series imaging photometers have only a Y filter. Y-Series has no moving parts and a smaller form factor than I-Series.

3.2 Application software

TrueTest software has advanced library of test functions to find display defects and mura (unevenness, irregularity or inconsistency in appearance) defects. Fig. 6 shows some examples of display analysis TrueTest can perform. There are some supporting functionalities for these analyses such as register active display area (RADA), moiré removal, etc.

RADA automatically rotates and crops display measurement areas, so only the DUT is considered. Any background in the field of view of the colorimeter is eliminated.

For the pixel defect test, 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, we have developed a proprietary method to filter moiré.

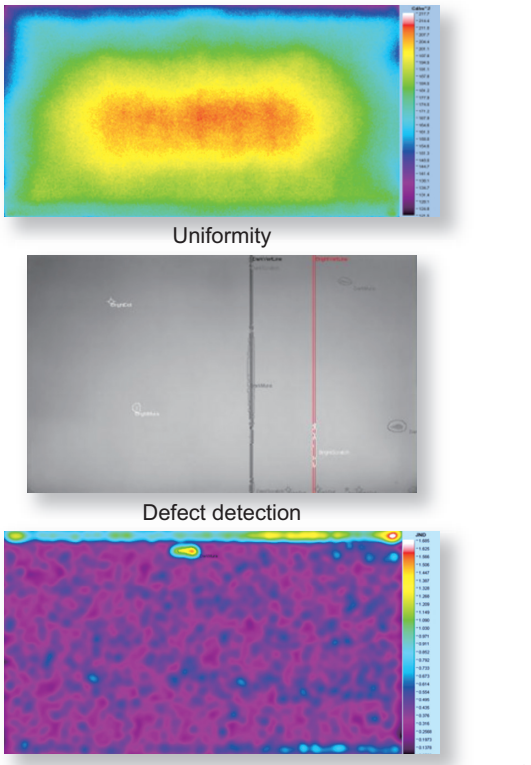

Fig. 6 Examples of display analysis.

Since the in-line production measurement requires high-speed processing, multiple analyses for captured image data are executed in parallel while the other image data are being acquired. TrueTest manages these schedules by multi-threading software processes.

In addition to standard tests, customized analysis is needed to meet a specific customer requirement. In many cases, external hardware interface (video pattern generators, bar code readers, production control systems, etc.) is also needed for fixture integration or

production line integration. TrueTest can dynamically load these analysis and hardware interface modules without rebuilding TrueTest application software. This makes it easy to adopt customer specific requirements for application engineers.

4 Other applications

We will introduce two other applications in addition to the display test application described so far.

4. 1 Instrument cluster for automobile

Testing of an instrument cluster is complicated. Many locations need to be measured at one time (Fig. 7).

High resolution 2D measurement system makes this testing easier. You can test every location by one measurement. Our powerful software, which has functionality to find the locations to be tested, can automate the testing.

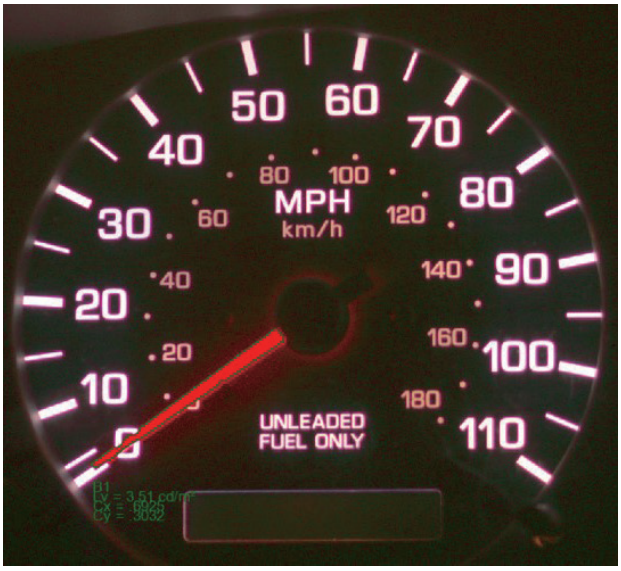

Fig. 7 Example of automotive application - inspection of instrument cluster.

4. 2 Visual surface testing

As well as displays, mobile devices need inspection of surface defects such as scratches, dents, dings, logo defects, surface particles and foreign materials (Fig. 8). Besides these cosmetic defects, the inspections of each part inside a device is necessary to check the existence and positioning of connectors, cameras, buttons, etc.

ProMetric Y-Series imaging photometers can meet these requirements. Wide dynamic range and high resolution of Y-Series camera enable detection of subtle defects on surfaces, which is hard for human eyes to find.

Since ProMetric Y-Series imaging photometers can detect unknown cosmetic flaw at unknown locations, we provide more comprehensive surface testing solution than other machine vision system companies.

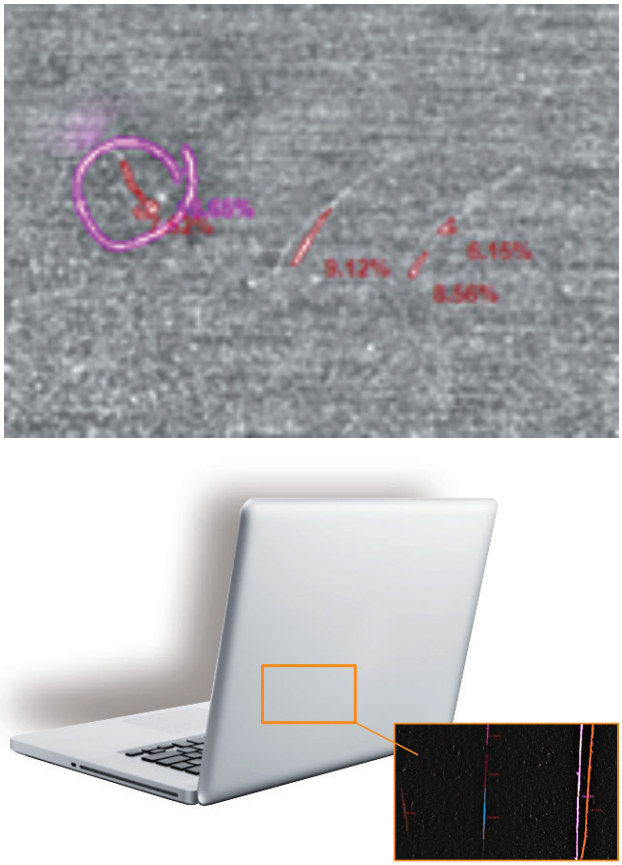

Fig. 8 Visual surface inspection.

5 Future development

5. 1 Further speed improvement

Thanks to the advancement of camera technologies, the bottleneck of total throughput is shifting from the camera to the application software. Analyses are taking longer time than image acquisition. We will have to optimize image processing routine of TrueTest. Distributed computing such as computing with graphics processing unit is an option.

5. 2 Synergies from Konica Minolta technologies

Radiant Vision Systems has been a part of Konica Minolta's Sensing Business Unit since August 2015. As Radiant Vision Systems and Konica Minolta have a product lineup which is complementary to each other, it is expected that we can create synergies in technology. Radiant has focused on fast and high resolution 2D measurement for display inspection in production lines. On the other hand, accurate and traceable color measurement is a specialty of Konica Minolta.

For some applications, a spectrophotometer or colorimeter can be combined with a ProMetric camera when very high color accuracy is required. The Konica Minolta spectroradiometer CS-2000 and display color analyzer CA-310 are to be integrated into the Radiant solution. As CA-310 is widely used for gamma adjustment and/or flicker measurement in display industry, integration of these instruments makes Radiant solution more comprehensive.

Besides display inspection, cosmetic surface inspection technology is also an interesting area for synergy. Konica Minolta has customers in automotive industry and offers color management solutions using spectrophotometers and software for exterior and interior parts of automobiles. Customers' interests are not only in colors, but also in "total appearance", including gloss, texture and defects on surfaces. With Radiant's surface inspection technology applicable to automotive parts, Konica Minolta could provide a much broader range of solutions for automotive customers. A challenge in the automotive application is an efficient measurement of more complicated and/or larger objects than displays. Robotics, image processing and machine learning technologies should be introduced to address these issues.

6 Conclusion

Radiant Vision Systems has been providing visual inspection solutions which can take over a manual inspection by human eyes in production. World leaders in consumer electronics and display technologies rely on Radiant Vision Systems for the solutions. The synergy with Konica Minolta technologies leverages the expansion of application areas. We will keep contributing to the digital manufacturing world such as Industrie 4.0.

References

[1] http://www.radiantvisionsystems.com/