CCD Versus CIS: Does The Type of Wide-Format Scanning Technology Matter?

The answer depends on the end user's needs.

If you are in the market for a new wide-format scanner, you may wonder if you should be concern about the type of underlying scanning technology your next scanner uses. After all, a scanner with the latest advances in technology should be able to scan your document without any degradation of quality, right?

The answer to that question is maybe. This paper addresses the issue of scanning technology in an unbiased way to guide buyers in making the right decision when selecting their next scanner. The paper also addresses and refutes most of the manufacturers' marketing hype regarding their technology, so scanner buyers will have a clear understanding of what is important and what matters less for their situation.

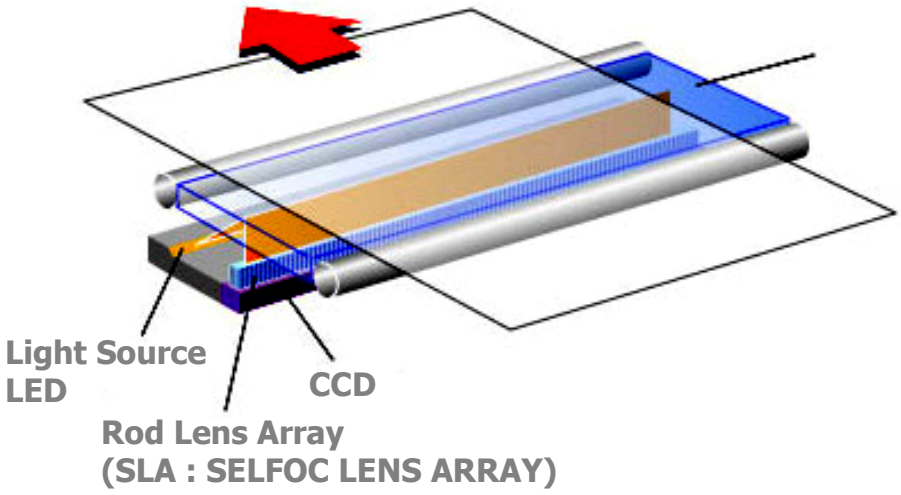
The Technology at a Glance

A wide-format scanner today uses either a Charge Coupled Device (CCD) or a Contact Image Sensor (CIS) to capture your data in the scanner through a lens system and a light source that is reflected from the document and captured by the photo sensors. Today the dominating light source for a CCD-based scanner is a fluorescent lamp, and for CIS-based technology it is LED lights. This subtle difference is the key issue in regards to the achievable color quality of a CIS-based versus a CCD-based scanning system.

Overview of CIS Technology

CIS technology has steadily improved since the 1960s. Today CIS is in widespread use for multifunctional desktop all-in-one printer/scanner/copiers, desktop scanners, and fax machines. In addition, CIS scanning technology has developed new uses in check readers, lottery readers, and ATM card readers. This makes it very likely that you see CIS technology at work in your daily life! CIS has been deployed in the wide-format scanner segment since the 1990s.

A CIS scanning system typically uses low-power light-emitting diodes (LED) to light up the document. The LED light is passed through a light pipe to ensure even distribution of light across the entire scan line. The light is then reflected by the document and captured by a glass rod lens, directing the light towards the image sensors which capture the pixel. The CIS image sensor(s) spans the entire scan line and has a 1:1 mapping between a pixel across the current scan line and the pixel in the image sensors.

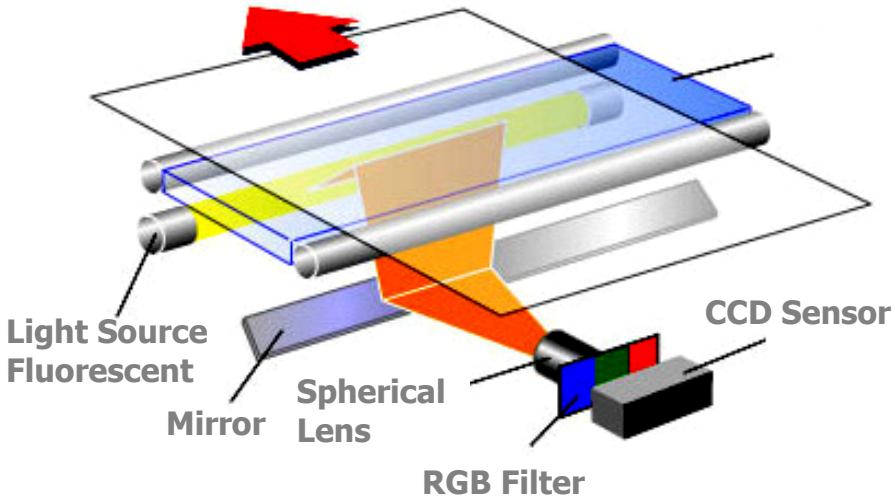


The LED lights are a series of red, green, and blue LEDs that are turned on in a round robin fashion to capture the red, blue, and green information in the scanned image.

Overview of CCD Technology

Focused-based technology using CCD image sensors has been the dominate player throughout the 1980s and 1990s for scanning technology. However, primarily due to the cost issue, it has lost market share to other technologies like CIS.

A CCD-based scanning system uses a broad daylight source for illumination of the image to be scanned. The lights are reflected by the images and pass through an aperture and a series of mirrors to create a focus length of approx 3.3 feet (1 meter) before they pass through a lens that focuses the lights onto one to four CCD sensors. The CCD sensors are 2-3 inches wide. The CCD consists of either three or four linear sensors with a color filter in front to filter out the red, green, and blue color information and an optional fourth line to capture monochromatic information only.



The three linear color CCD arrays are spatially displaced with respect to each other. During read operation, it will read the red information and location [x,y], the blue and [x,y+displacement], and the green [x,y+2*displacement] at the same time. A CCD-based system therefore requires complicated logic in firmware and hardware to reorder the information to compensate or interpolate for this displacement.

Who Are the Scanner Players?

There are four major scanner manufacturers in the world:

- contex WHEN IMAGING MATTERS www.contex.com
- Colortrac Our Business is Your Image www.colortrac.com
- GRAPHTEC www.graphtecusa.com
- Image Access www.imageaccess.de

Graphtec offers only CIS-based technology. Image Access manufactures only CCD-based technology. Contex and all its sub-brands — like GTCO Calcomp and Vidar — sell a mix of CCD- and CIS-based technology. Finally, Colortrac also offers both CIS and CCD technology.

Total availability of wide-format scanners per technology type as of November 2008 was:

	Contex	Colortrac	Graphtec	Image Access	Total
CCD-based	8	4	0	3	15
CIS-based	3	2	3	0	8
Total	11	6	3	3	23

The majority of the market is still CCD-based scanning technology. Colortrac and Contex are the only vendors that offer both technologies, and they position the CCD-based technology as higher color quality at a higher price and the CIS technology as acceptable color quality at a lower price.

What is the Issue?

The issue is that both technologies claim to be superior to the other in regards to color quality for monochromatic scanning. However both camps agreed that both technologies are sufficient for all applications. In other words, the discrepancy is in regards to color quality. Below are some quotes from the vendors.

> "The Graphtec scanner archives a wider color gamut using the CIS method instead of the older CCD method."
>
> (CIS) "Capture Superior Color, Grayscale & Monochrome Digital Images at High Speeds!"
>
> "CCD technology will give you an image with a relatively wide color gamut and a relatively high dynamic range."

Clearly we have conflicting story! Now what is the truth? What kinds of realistic expectations can you have in regards to both technologies? Does it really matter?

Myth and Reality

Despite all the marketing hype, scanning superiority is not based on the underlying scanning technology of CCD versus CIS alone. The real story is much

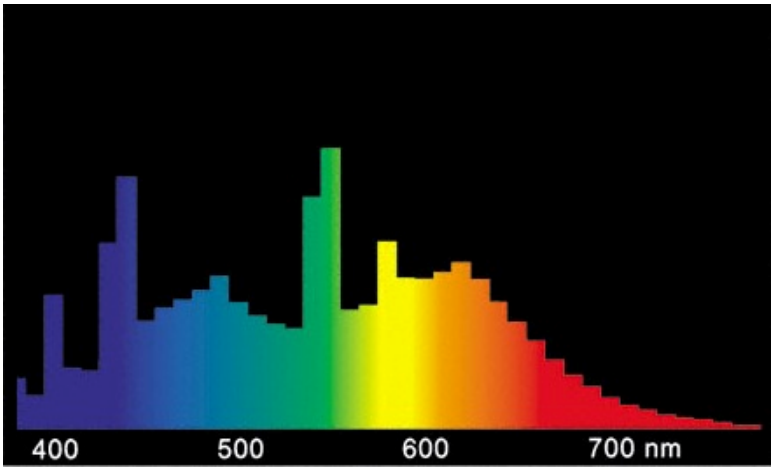
more complex. Scanning quality is based on a series of factors build into a scanner. This includes:

- The scanner's optical resolution.
- The internal bit depth of color capture.
- The quality of the light source.
- Image processing and calibrations.
- Color filters and lenses.

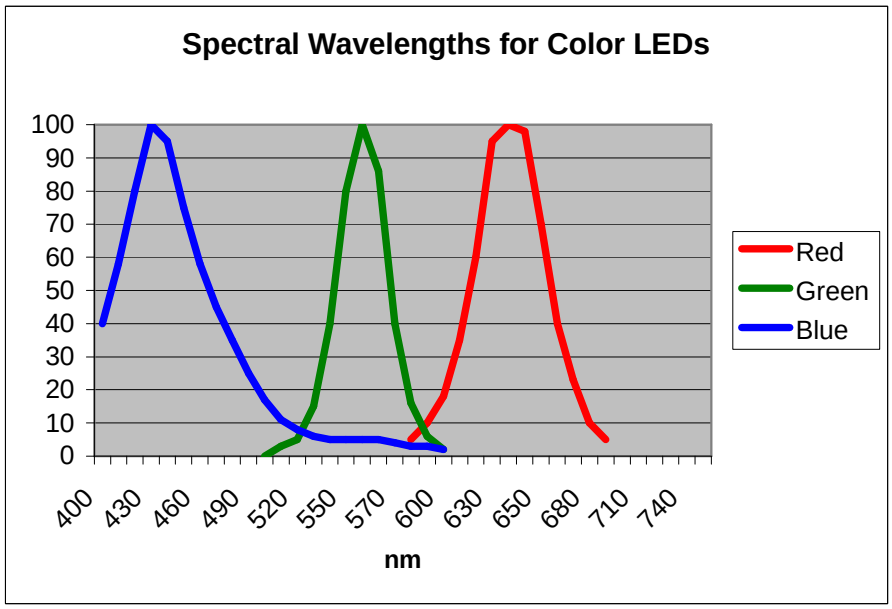
The Light Source

The light source is particularly interesting and can have a significant impact on the overall scanning quality. Surprisingly enough, this is the main reason why the CIS scanners in today's market do not provide the same color quality as the CCD-based scanners. The problem lays in the narrow bandwidth of wavelength that the LED light source illuminates in a CIS scanner.

Remember that a CCD-based scanner captures all the primary colors in one operation using color filter in front of the CCD, while a CIS-based scanner uses flashing LEDs in red, green, and blue where each color is capture in a round robin fashion. When a LED lights up, only the illuminated bandwidth of the wavelength can be return to the sensors. And a LED light wavelength bandwidth is considerably less than the wavelength spectrum from the blue color to the red color. Therefore CIS scanners capture a smaller color gamut than a CCD-based scanner, reducing the overall quality of CIS-based scanning.



Typically fluorescent lamps match the wavelength from natural sunlight relatively closely.

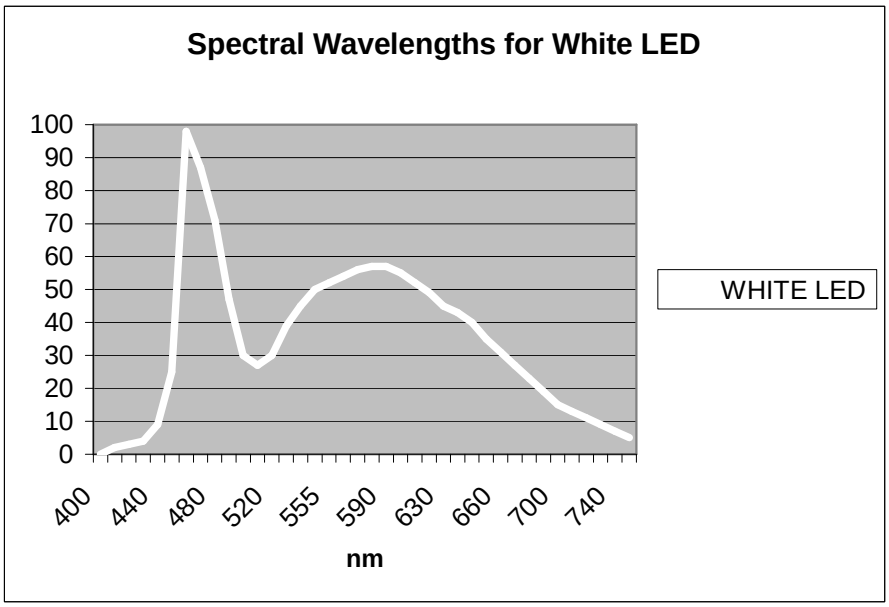


The typical wavelengths of colored LED lights.

The problem with CIS scanning illumination is the use of very narrow spectrum LED lights as depicted in the image above. In particular, the colors at the boundary between blue and green and between green and red are hard to catch for a CIS scanner due to the extremely low sensitivity for these wavelengths.

Colortrac and Contex, which offer both scanning technologies, are very careful in positioning each technology. They usually recommend CIS-based technology for the CAD/AEC and GIS marketplace due to these users' relative insensitivity to accurate color capturing. Fine Art, Graphic Art and Professional Photography users usually require a more accurate capturing of color and therefore require the higher color accuracy of CCD-based scanners.

Graphtec, which offers CIS scanners, naturally proclaims that CIS technology is suitable for all market segments. Finally, Image Access, which offers CCD technology using a broad white LED as the illumination source, claims that only CCD technology can delivered the highest scanning quality.



A white LED has weaknesses in the blue and red areas.

Image Access is using white LEDs as the illumination source for its CCD scanners. White LED typically has a weaker sensitivity in the blue and red area, as shown in the figure above. As an interesting side story, Contex offers the use of white LEDs as an optional light source for its HD CCD-based scanners series.

Conclusion

The war between CCD- and CIS-based scanning technology is not about whether or not one technology is superior over the other, but the different uses of the light source for these technologies — e.g., fluorescent lamps for most CCD-based scanners and LED lights for CIS-based scanners. It's the type of light source that mostly determines the achievable color accuracy for these technologies.

Despite the myths surrounding the applicability of scanning technology, we advise that CIS technology generates sufficient color quality for most applications in most cases. Particularly within the CAD/AEC and GIS market segment, we see no added value for CCD-based scanning technology over CIS technology.

For the Fine Art and high-end Graphic segment, we do see the need for the more accurate color capturing using CCD-based technology; however most often these segments also need to print scanned images, requiring high-end RIP software to accurately print these images. This extra layer reduces or blurs the boundary between CCD- and CIS-based scanning technologies further.

Lastly with the advances in image processing, we predict that CCD's advantage over CIS-based scanning will be further reduced due to image improvement logic that compensates for the inherit deficit of the CIS-based scanner light source. As a result of that, the premium pricing that CCD-based scanners have today will diminished as end users realized that both technologies deliver the same quality for their needs.

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About the Author
Henrik Vestermark is an independent consultant and professional who has worked in the wide-format scanner and printer industry since 1988. His expertise includes all aspects of the wide-format digital capture market, and particularly focuses on the wide-format scanner industry.