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Progressive-Scan Cameras:

Reducing Tradeoffs Between Speed and Resolution

No single image sensor will ever satisfy the diverse requirements of all industrial camera applications. The characteristics of higher resolution, faster speed, and a wide dynamic range are, however, increasingly important for a variety of imaging applications ranging from traditional machine vision systems to intelligent transportation systems (ITS). Hence, progressive-scan cameras based on charge-coupled device (CCD) image sensors are becoming particularly important across this application range.

The Problem With Interlacing

With a progressive-scan format sensor, also known as non-interlaced format, an entire image frame is acquired at a single instant in time (see Figure 1). With the traditional interlaced format only the odd lines of a sensor's pixels (field 1) are captured and read-out first, followed by the even lines (field 2). The two fields are then combined to create one frame (see Figure 2). This interlacing technique necessitates a tradeoff in speed versus accuracy, and becomes problematic when applied to leading-edge imaging applications that require both of these characteristics.

An image capture system using the interlaced format can be set up to capture only one of the fields, but this reduces resolution by half and undermines the ability, for example, to detect defects in an automated inspection system. Moreover, interlaced operation creates major problems when the objects to be scanned are in motion, for example, when they are passing under a camera on a moving conveyor belt or when a high-speed process such as die bonding is being monitored. In the former case, the conveyor may have to be stopped to capture a reliable image — a major detriment to throughput. Since the two fields are captured at different points in time the images will be slightly different and will cause distortion when combined.

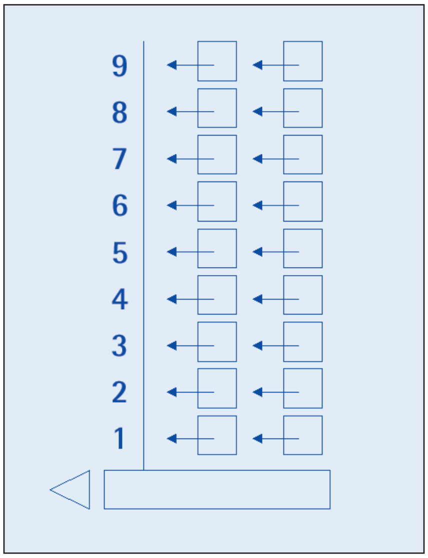

Figure 1. In progressive scan, or non-interlaced, format all rows are integrated simultaneously and read-out in the same frame. This provides a full-resolution snap shot.

Similar issues exist when using a digital camera. Electronic shuttering, essentially commanding the camera to capture an image by means of an external electronic signal, is highly desirable because it not only provides a non-mechanical means for automatically triggering image capture, but it also eliminates the blurring that can occur with dynamic image capture. Using an electronic shutter with an interlaced camera only captures one of the image fields, reducing resolution by half as it also does for non-digital cameras. When both fields are sequentially captured, the resulting images are out of sync. Thus, it has required progressive-scan sensors to bring high-resolution capabilities to digital cameras with electronic shutters.

Speed AND Resolution

While it is true that certain key characteristics of leading-edge image sensors and cameras have appeal across a broad range of applications, one characteristic typically offers more perceived value than the others. In the past, there was always a tradeoff between characteristics. Now progressive scan imaging has eliminated the tradeoff between speed and resolution by providing both, which is essential for very high-speed assembly machines such as wire bonders.

Compared to the conventional 15-frame/second video graphics array (VGA) cameras of yesteryear and today's baseline 30-frame/second devices, cameras with a very high readout rate of up to 120-frames/second offer substantial throughput improvements. In semiconductor manufacturing, speed improvement is essential to enhancing productivity. Improving the throughput in assembling individual chips is also a critical requirement.

A heightened demand for greater throughput is also increasing for assembly equipment such as pick and place machines for electronic products, as well as for automated inspection equipment in operations where the highest possible throughput is desired. The applications lie, for example, in the pharmaceutical industry and food processing industry, and

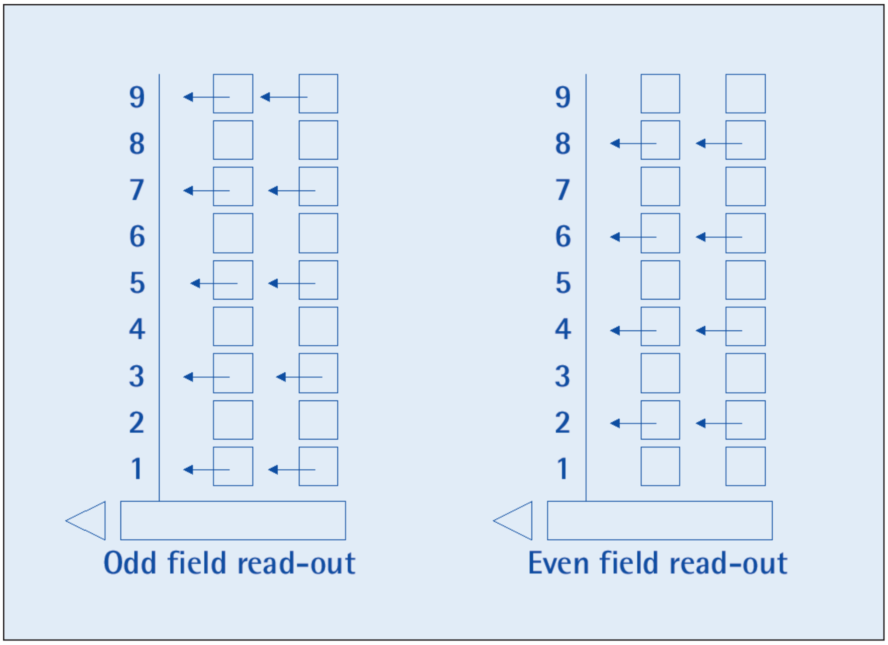

Figure 2. With the traditional interlaced format the odd lines of a sensor's pixels are captured and read-out first. The even lines subsequently follow. The two fields are then combined to create one frame, necessitating a tradeoff in speed versus accuracy.

in some agricultural sorting applications where very quick go/no-go decisions are required to make the most out of in-line inspection. Packaging applications across a range of industries are also pushing the envelope on inspection speed. With many of these processes taking place on moving conveyor belts, progressive-scan cameras are increasingly getting the nod.

Perceived Value

For some applications, high resolution may have more perceived value than high speed. A CCD with a relatively large size and very high pixel count provides an unusually wide field of view, as well as the precise definition required for inspecting leading-edge integrated circuits and other electronic components (see Figure 3).

As electronic components such as capacitors and resistors become ever smaller, increased camera resolution is becoming essential to detect very small defects, alignment deficiencies, and other quality deterrents. When small defects in a capacitor escape the inspection system, for example, an entire loaded printed circuit board (PCB) could wind up being defective. The cost of the capacitor defect becomes enormous when it is not detected before assembly. This, plus the adverse affect of increased rejects on final yields, places more and more pressure on component suppliers to effectively screen out flawed parts before they are shipped. Component users also have more pressure to find component defects at a very early stage before assembly.

A large field of view also makes cameras with large formats and high resolution attractive for other applications, including the automated inspection of larger items such as entire PCBs. The combination of large field of view and high resolution are also important features for inspecting X-ray film and liquid-crystal displays (LCDs). Here, the appeal lies in the ability to capture more image area with less camera movement, and to use a single camera rather than multiple cameras to gain the required coverage. Both have a positive impact on ultimate throughput.

While very wide dynamic range has broad applicability in ITS and other applications such as surveillance, it is not required in many traditional applications such as machine vision for automated inspection systems where the operational lighting environment is tightly controlled. It ranks, thus, among special characteristics that suit a particular class of applications, similar to the UV sensing that's required in some semiconductor inspection settings and the night-vision sensing that suits military applications.

On the other hand, certain characteristics valued in Intelligent Transportation Systems (ITS), such as high speed and high resolution, enjoy near universal demand in the broad array of today's cutting-edge imaging applications. As time goes on and the sophistication of applications increases, these characteristics will become even more important. Progressive-scan cameras based on CCD image sensors will continue to address those needs today and in the future.

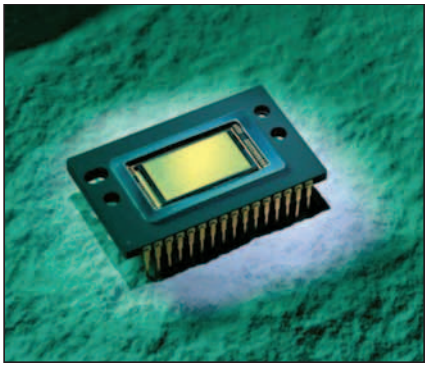

Figure 3. Image sensors providing, high resolution, faster speed, and a wide dynamic range, such as the Kodak KAI-2093 shown here, are increasingly important for inspection of electronic components.

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