

COGNEX®

In-Sight 3800L

Introduction to Line Scan



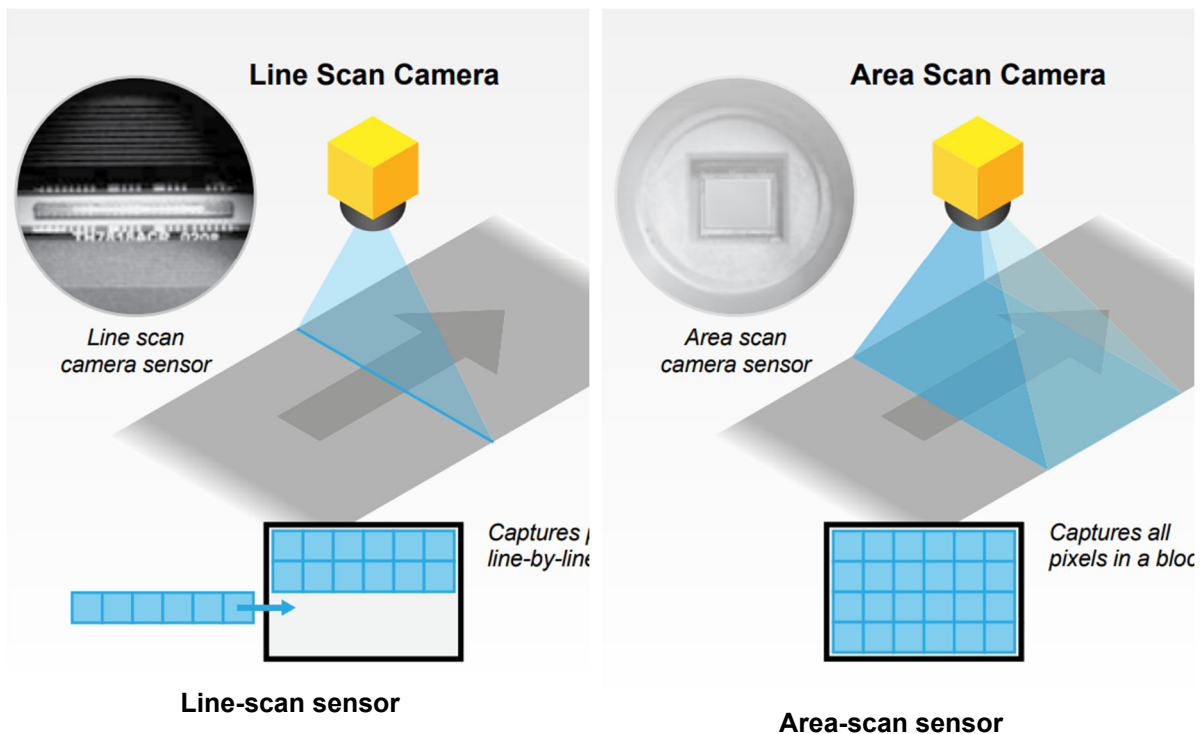
3/18/2025
v1.0

Introduction to Line-Scan Vision Systems

1 Introduction to Line-Scan Vision Systems

There are two types of acquisition methods to acquire an image of an object – area scan and line scan. The most common 2D machine vision systems use area-scan cameras, which require a complete matrix of pixels to be exposed at the moment of acquisition. By contrast, line-scan cameras contain a single row of pixels, building the final 2D image pixel line by pixel line. Building a line-scan image requires movement between the camera and object, usually along a conveyor belt or rotating shaft. As the objects pass in front of the camera, a new pixel line is acquired.

Software on a vision processor or frame grabber stores each line, then reconstructs pixel data into the final 2D image. This unique image acquisition process excels at capturing fast-moving discrete parts on a conveyor, inspecting all sides of cylindrical objects and building images of very large objects. Commercial devices like document scanners and photocopiers which scan documents into memory use line-scan technology, as do production and distribution lines in manufacturing and logistics, which rely on this special technology to acquire high-resolution images quickly for detailed part inspections.



With line-scan imagers available from 500 to 16,000 pixels per line—and some even able to match high-speed line acquisition rates of 169,000 lines per second—the latest generation of line-scan cameras generate all the power necessary for applications that formerly required a cluster of high-resolution vision imagers.

These attributes make line-scan cameras an ideal choice for capturing target objects in continuous or discrete “web” surface inspections, such as for plastic, textiles, metal, or paper. Line-scan cameras can also “unwrap” cylindrical objects to capture their entire surface area making them more easily inspectable.

Large objects that require high-resolution imaging for precise measurement and defect detection, such as flat panel displays, solar cells, and electrode material, are also well-suited to this technology. And because line-scan systems only need to view a small portion of the target object for each line acquisition, they did not require a large, unobstructed view of the target object. Because of this, they work well in installations with restricted fields of view or mounting space.

The Main Components

2 The Main Components

Line-scan vision systems can be configured with a line-scan camera and PC or vision controller running machine vision software, or as an embedded system with the camera and software contained in one package like the Cognex In-Sight 3800L. Nevertheless, the components of these two set-ups share many elements in common. Like with all machine vision systems, selecting the correct lens, lighting, and trigger mechanism is crucial to the success of any line-scan application.

Encoder

An encoder conveys the belt's linear motion to the line-scan camera, indicating when to acquire the next line for the image. In many applications, it is difficult to guarantee constant and stable movement of the moving object, especially during ramp up or ramp down of the line speed. Changes in speed affect the aspect ratio of the resulting image. For example, the line-scan camera could acquire lines too quickly, resulting in repeated lines and a stretched image. If the camera acquires lines too slowly, it will skip some lines, making the image shrink.

To keep a constant aspect ratio while allowing the speed to fluctuate, an encoder instructs the camera to acquire a line each time the distance traveled equals a defined value – usually the length of a projected pixel. An encoder is usually mounted on an axle and provides signals to indicate motion. Some encoders produce two separate signals (A and B), from which it is possible to detect the direction of the line and more granular information about the motion. Line-scan systems can work with either hardware (motion-based) encoders or software (time-based and calculated by movement) encoders.

Lighting

Line-scan cameras require only a single line of light to acquire a row of pixels. This means that unlike with an area-scan camera, a part does not need to be illuminated uniformly. A strong, non-fluctuating, tightly focused “line” type illumination is the most suitable in line-scan applications. These lights are higher in intensity due to the fast acquisition speed (typically in the microseconds per line), which require more light than most area-scan systems. The line-scan light aligns with the camera to maximize the intensity of the light and is typically always on, not strobed.

Lenses

Lenses vary in optical quality and ultimately determine the resolution of a captured image. It is important to choose a high-quality lens to take full advantage of a line-scan camera's pixel size. Using the right lens will help the system acquire the best possible image for finely detailed inspections.

Trigger

The trigger mechanism commands to the camera when to begin acquiring pixels. Line-scan systems can use either a hardware trigger connected directly to the camera or a software trigger issued via factory floor industrial protocol or PC.

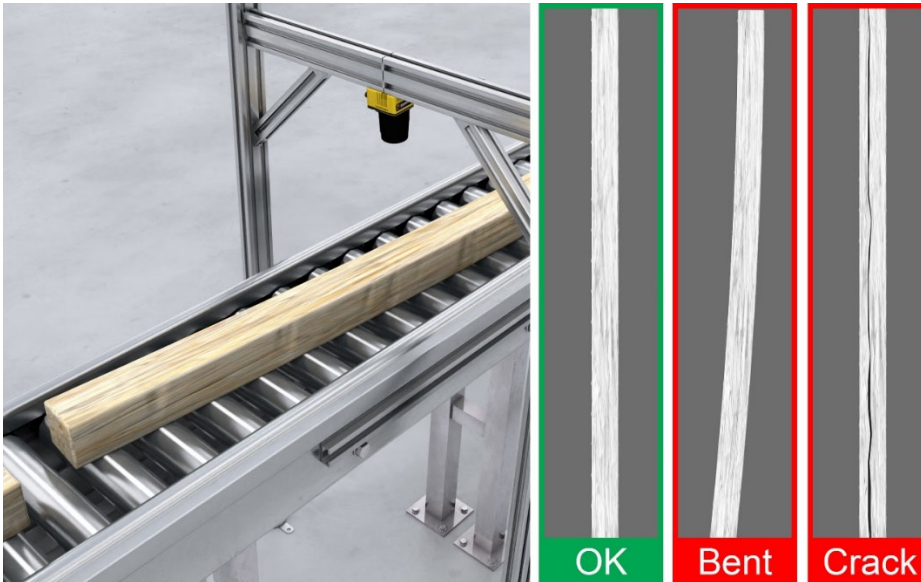
Application for Line-Scan Systems

3 Application for Line-Scan Systems

Since line-scan acquisition builds an image line by line, only a sliver of the object you want to inspect needs to be visible at any given time to the line-scan camera. As the product moves past the camera, new lines are acquired until the full image (total number of lines) is built to reveal the full product view. This presents a number of advantages over area-scan camera, as illustrated in the following application descriptions.

3.1 Large Parts

Parts that are several times longer than they are wide can be good candidates for line-scan systems as the image length is variable. Parts such as poles, lumber, flooring, make for good applications.



Cylindrical Parts

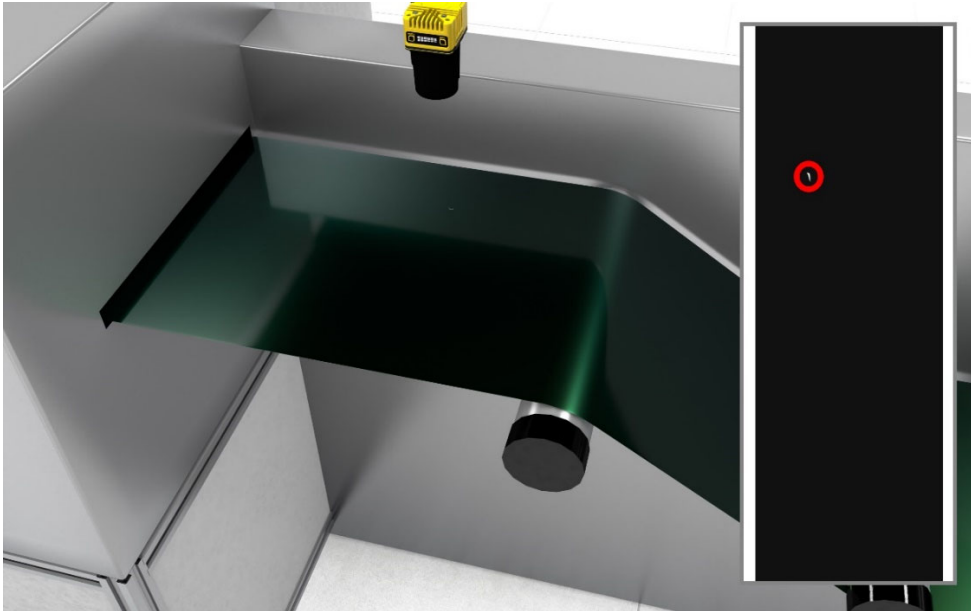
Because line scans take only a sliver of an image at a time, cylindrical parts can appear flat and easier to inspect without appearing distorted due to the shape of the object. Inspections for round labels, bottles, gears, tires, and other round objects can make for good candidates.



Application for Line-Scan Systems

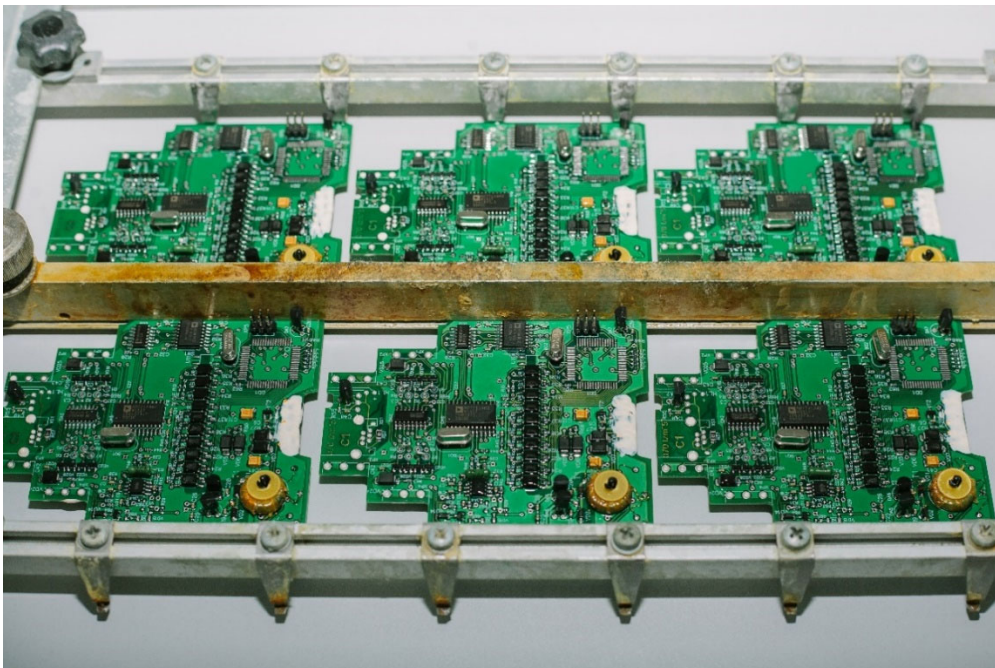
Continuous Material / Web Surfaces

Continuous material applications like electrode sheets, carpet, linen, and other web-based applications are good candidates for line-scan systems. With the overlapping ability within the In-Sight 3800L, you can ensure that defects are always able to fully present when they might be in-between image slices.



High Resolution with Movement

Line-scan systems can also generally provide much higher resolution than traditional area-scan cameras. High resolution inspection is critical in most tech-oriented industries. A line-scan camera with the appropriate imager can produce very large images at significantly lower cost than an area-scan camera. For this reason, a line-scan camera in motion is a practical replacement for a high-resolution area-scan camera.



Application for Line-Scan Systems

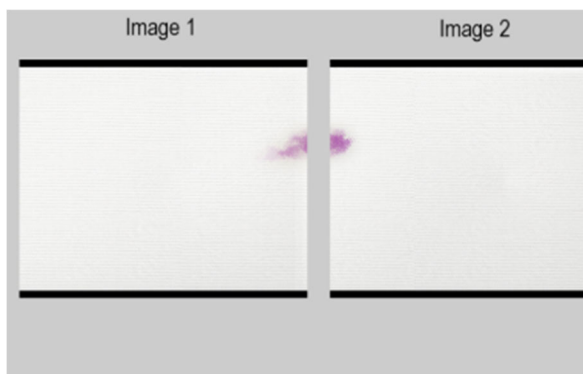
3.2 The In-Sight 3800L from Cognex

The Cognex In-Sight 3800L is the latest line-scan offering from Cognex's In-Sight Vision Product line. Incorporating a 1 in. CMOS imager with multiple resolution modes (1K for low light applications) 2K, and 4K the In-Sight 3800L can build images with lengths up to 16,384 lines. Keeping up with your demands, the In-Sight 3800L's high-speed acquisition allows line acquisition rates up to 168 kHz.

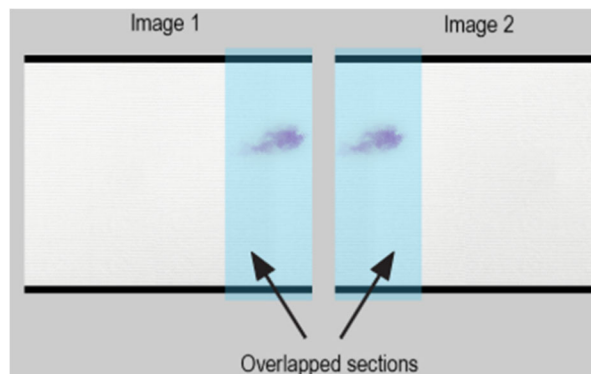
I/O to the camera includes 1 Opto-isolated, acquisition trigger input, 2 dedicated encoder line inputs for quadrature support, and 1 additional general-purpose input. Support for 12-30 VDC encoders with up to 500 kHz pulse cycles. Includes 2 High-Speed Opto-isolated outputs.

The In-Sight 3800L has two networking ports to enable Industrial communications for the most popular protocols such as EthernetIP, Profinet, SLMP, ModbusTCP and more. Multiple ports offer flexible connection options. And RS-232C is available with the use of a breakout cable.

The In-Sight 3800L works with the In-Sight Vision Suit (ISVS) ecosystem which allows you to program, monitor and maintain your vision systems. With the use of spread sheet programming, you can finely develop your application to your exact needs with powerful built-in tools such Edge Learning Classify and Edge Learning Segment all within the ISVS platform. The In-Sight 3800L also offers overlap mode to ensure defects don't get missed between triggers.



Without Overlap: Defects or features can be split between two images with gaps between them.



With Overlap: Defects or features are never split between two images with no gaps in coverage.