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Understanding Line Scan Cameras

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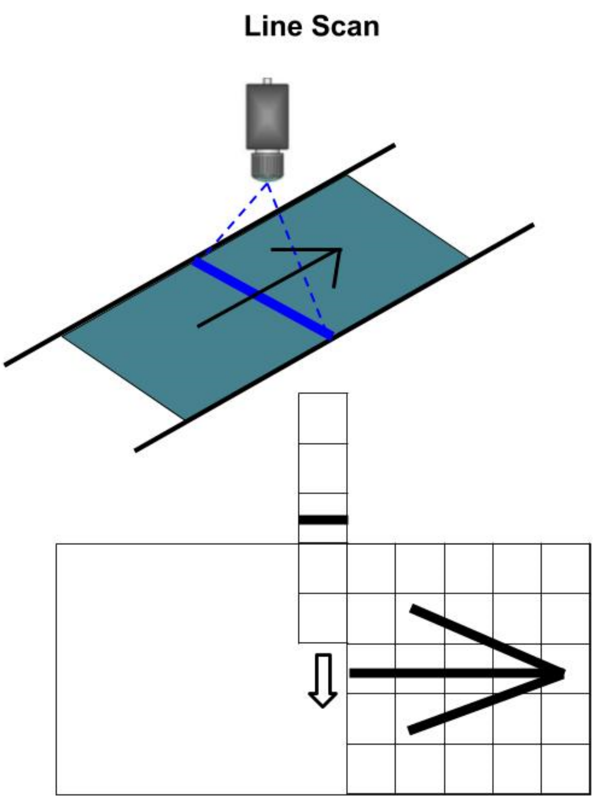
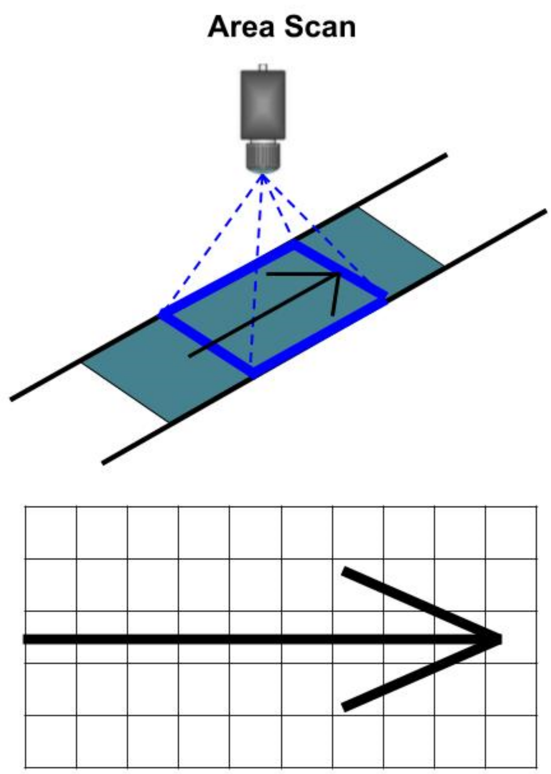
Many options exist when selecting the appropriate hardware for machine vision applications. There are two methods of image acquisition; line scan and area scan.

Line scan cameras acquire a single row of pixels during each acquisition. Pixel rows are collected and stitched together to create a composite image. Area Scan cameras utilize a pixel grid to collect an image during a single acquisition. Due to the increasing availability of larger, faster, and lower cost area sensors in addition to the increased complexity when dealing with line scan hardware, Area Scan implementation far exceeds Line Scan. With Area Scan cameras being used most often for vision inspections, let's further the discussion with line scan, how line scan differs from area scan, and discuss niche areas were line scan might have advantages over the area scan.



Pixel grid filled line by line.



Pixel grid filled with a single image acquisition.

Line Scan Hardware Requirements

The hardware requirements of line scan systems are similar to most machine vision applications. A light, a lens, and an imager should be selected specifically to meet/exceed application requirements. Two specific hardware requirements unique to line scan applications are the encoder and the line scan light.

Encoders
When using a line scan imager, either the object being imaged, or the camera requires linear movement perpendicular to the imaging axis to form an image. If variation exists in the speed of the linear movements, an encoder would be required to track the conveyor speed. The encoder tracks position to ensure slices can be pieced together correctly when forming the image.

Line Light
Since line scan systems only image the target one line at a time, uniform illumination over the entire part will not be required. Instead a line light provides linear illumination across the field of view where only the line is being imaged during each acquisition. At the high imaging frequency required for line scan systems, they only have microseconds to acquire a single sliver of the image. At such a low exposure the line light's high intensity and focused light output will provide illumination uniformly for each image sliver as it is acquired.

Line Scan Advantages

Continuous Web Inspection
When looking for applications that may be well suited for line scan imagers, continuous web applications are a niche when performing surface inspections on textiles or other web-line materials. This is especially true when the area you want to inspect is extremely long.

Inspecting 360° of a Cylindrical Object
Line scan systems are well suited for imaging cylindrical objects. Think about a soup can label wrapped around the cylindrical can. If we used an area scan imager the information as the label wraps around the can we begin to lose information toward the outer edges of the label. A line scan system would unwrap the label line by line. The final 2D image would look like the label was removed from the can and laid flat for inspection.

Limited Space Requirements (when the part is moving)
Another advantage of line scan results from the ability to collect an image wider than the thin narrow slot it can be imaged through. Since we are building the final image from a culmination of individual lines being collected during each acquisition, the entire object can be inspected through very narrow channels or in somewhat confined spaces. Since we are using a specialized light that illuminates only a row of pixels being imaged, line scan hardware can normally fit into more compact spaces than area scan options. An example of this type of application would consist of imaging the underside of a box through a narrow viewing area on a conveyor. This would be impossible with an area scan camera as the rollers would oculate the target being imaged.

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Determining Line Scan Camera Requirements: Resolution & Line Rate

In determining if a line scan camera's resolution will work for an application, the size of the minimal defect/feature and the field of view requirements for the application must be identified. For this example, estimate 5 pixels will be required to identify the smallest defect/feature. Assume, the required field of view is 20" and the minimum defect/feature size is 0.05". Therefore, the minimal pixel requirements for the application are as follows:

*Resolution Required = (Field of View/Minimal Feature Size) * (Pixels Per Feature)*

*= (15"/0.05") * (5 pixels) = 1500 pixels*

A 2K line scan imager, like the Cognex In-Sight 9902L, with 2048 sensor pixels, would meet the example application requirements.

Now that the resolution requirements for the application are known, the line rate should be calculated to ensure the selected line scan camera can acquire lines at a pace to keep up on this application. To calculate the line rate required, the Field of View requirements, object speed, and object pixel size need to be identified. For this example, the required field of view is 15", the part is moving at 240"/s, and a 2K (2048 pixels) line scan camera is being used.

Object Pixel Size = (Field of View/Camera Size in Sensor Pixels)

= (15"/2048) = 0.00732"

Line Rate Needed = (Part Speed/Object Pixel Size)

= (240"/s) / (0.00732") = 32.789 kHz

The Cognex In-Sight 9902L can acquire at up to 66kHz so would be an adequate camera selection for this application.