About...
ADR Technology™*

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EURESYS™
Excellence in vision

ADR Technology™*
Advanced Downweb Resampling

ADR* (Advanced Downweb Resampling) is the ultimate method for digital acquisition from line-scan cameras at a variable web speed. Unique advantages of ADR are:

- ***Acquisition from shutterless cameras***
- ***Improved Image quality***
  - Permanent camera exposure and complete use of the resulting information
  - Fixed Pattern Noise due to electronic shutter is avoided
- ***System reliability compatible with industrial needs***

ADR is a radically new paradigm for acquiring images from line-scan cameras. Compared to traditional methods, ADR achieves ultimate quality images from a simpler and more reliable line-scan acquisition system.

In ADR, the line-scan camera operates at a constant cycling rate, without involving electronic shutter. Still, the speed of motion is allowed to fluctuate. High accuracy real-time digital computation delivers acquired images reproducing exactly the observed objects. By design, ADR faithfully preserves the original shape and color scale features.

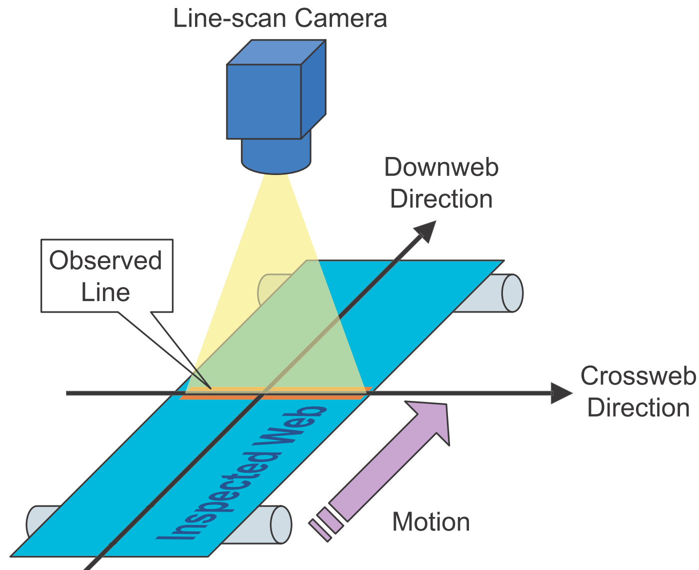
*Patent pending

Line-scan acquisition

Despite the single dimension recorded by the camera, two-dimensional images are provided. The second dimension is obtained from the motion of the observed scene relative to the camera. In the figured example, the camera is fixed, and the scene moves, but the reciprocal situation may be found as well.

Note that in the industrial imaging community, the word “web” designates a continuous stream of material, such as glass or paper. However, line-scan acquisition as discussed in this document may equally involve inspecting a series of distinct objects, for example conveyed on a moving band.

Whatever variant in the acquisition system, “web” will be used for the imaged items, “downweb” for the direction of motion, “web speed” for the speed of motion, and “crossweb” for the direction parallel to the linear sensor.

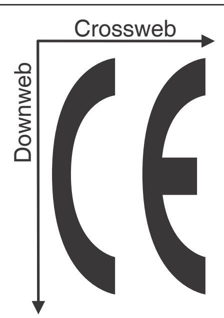
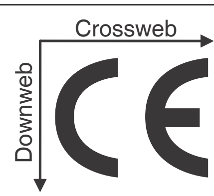
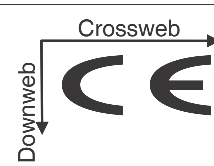


Typical line-scan acquisition system

Variable web speed

The traditional line-scan acquisition method delivers one crossweb line for each camera cycle. Consider for example a line-scan camera operating at 10 kHz and observing a web which movies at 100 inch/s. Each line corresponds to a web portion measuring 1/100 inch in the downweb direction. The analysis resolution in this direction is 100 dpi.

If the web speed changes, geometrical distortion occurs, as shown in this figure:

Slow web: 50 inch/s	100 inch/s	Fast web: 200 inch/s
 Incorrect downweb resolution. Too many lines.	 Correct downweb resolution. Correct number of lines.	 Incorrect downweb resolution. Too few lines.

This emphasizes the fact that the camera line rate and the web speed strictly determine the downweb resolution. If web speed variation is anticipated, the camera line rate should be made variable in proportion.

The traditional approach consists in sensing the web speed during acquisition, and acting on the camera line rate to maintain the proportion. An accepted way is to use of a motion encoder, a device issuing electrical pulses at a rate proportional to a rotation or translation speed. Euresys line-scan-capable frame grabbers feature a rate converter specially designed for controlling the camera line rate from the encoder pulse rate.

Having a constant web speed during the acquisition is a way of eluding the issue. However this may be impossible to achieve for mechanical reasons. At best, it will be difficult to maintain predictable speed accuracy. Industrial line-scan acquisition definitely needs a solution to support web speed variation.

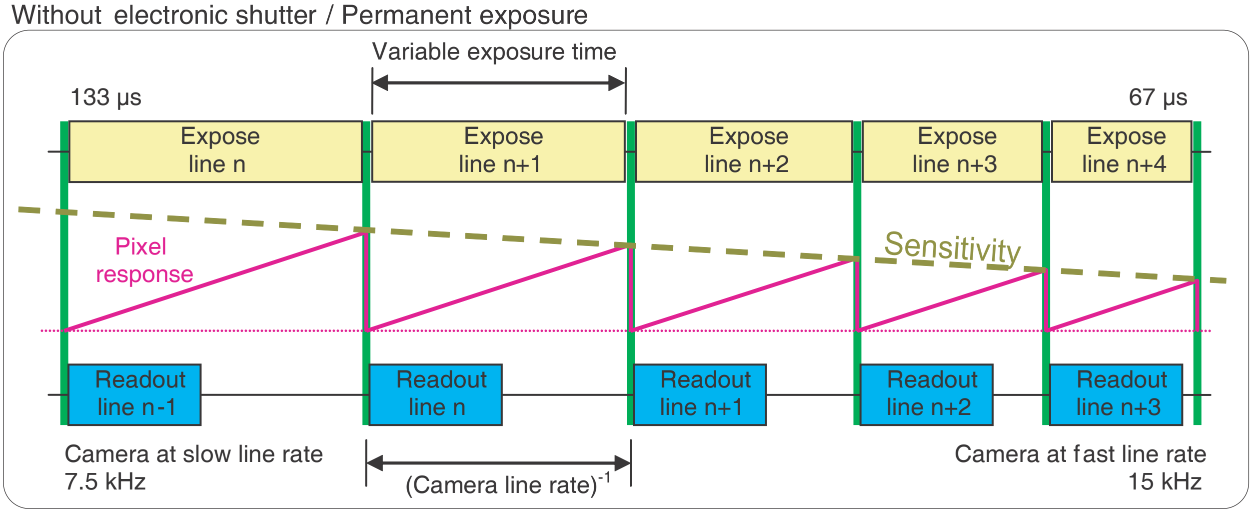
*Patent pending

Electronic shutter

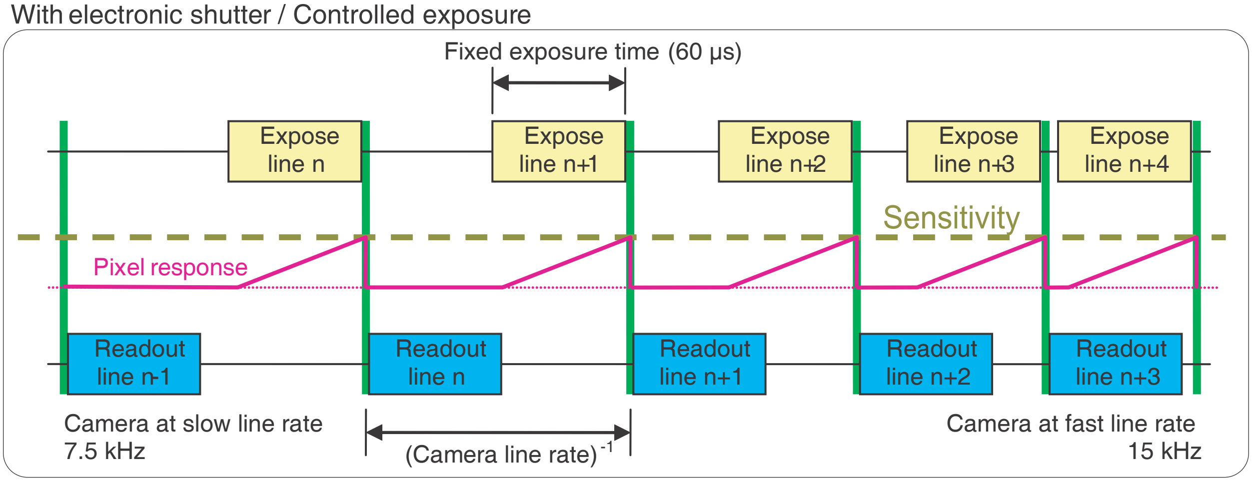
The traditional approach takes for granted that supporting web speed variation means adapting the camera line rate. Unfortunately, a variable camera line rate may have a direct effect on the camera sensitivity. Essentially, a line-scan camera develops the electrical response to illumination during the line cycle. A faster camera cycle shortens the exposure time, yielding dimmer response, and conversely. If nothing special is done, the brightness of the acquired image in the downweb direction is modulated by the web speed.

The solution is to control the exposure inside the line-scan camera with an electronic shutter. The following figure illustrates the principle of line-scan exposure, without and with an electronic shutter:

Without electronic shutter / Permanent exposure



With electronic shutter / Controlled exposure



The electronic shutter principle controls the exposure in making the linear sensor light-sensitive for a fixed amount of time at each line, regardless of the camera cycling time. Note that this exposure time should be set shorter than the fastest expected camera line.

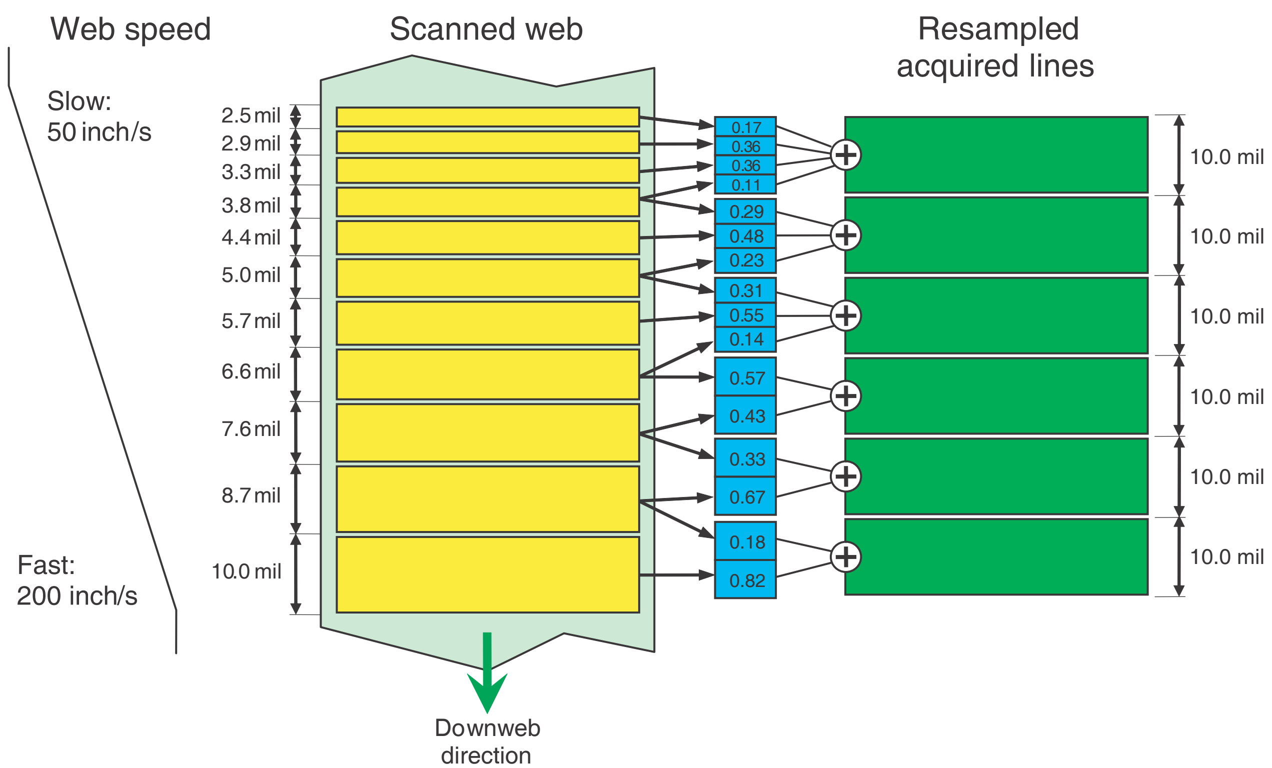
Without electronic shutter, the linear sensor is made permanently light-sensitive, although the response of each pixel is reset upon reading out the data.

*Patent pending

ADR acquisition

The ADR approach introduces an innovative solution to the web speed variation issue. The camera is operated at a fixed cycling rate, without electronic shutter. A motion encoder (or an equivalent sensor) is still used to accurately measure the speed of motion, but the measurement is not used to control the camera. The speed information controls a patented interpolating device, aimed at resampling the data provided by the camera.

The following figure illustrates this process:



In this example, the camera runs at 20 kHz. The web speed has changed from 50 inch/s to 200 inch/s, a 1-to-4 variation. The figure represents the web. The top part has been scanned at low speed, the bottom part at high speed. The information collected from the camera relates to successive sections in the web, with variable extensions in the downweb direction. Camera data are combined with appropriate weights to build resampled data corresponding to sections of equal size, yielding an accurate and uniform 100 dpi resolution in this example.

The computations are performed in real-time with a much better digital accuracy than the camera dynamics. The weighing coefficients are evaluated with a proprietary patented algorithm that constantly uses the speed information obtained from the motion encoder. In the figure, the coefficients are shown as illustrative values.

In ADR, the camera line rate will be chosen to satisfy the following requirements:

- The camera-scanned resolution is finer than the resampled resolution.
- The camera capability is not exceeded.
- The sensitivity is adequate.

*Patent pending

Shutterless cameras

Even with high resolution at high speed, some latest generation industrial cameras simply do not provide the electronic shutter feature. They use linear imaging sensors imported from the scanner and photocopy industry, where the web speed can be accurately controlled.

This missing feature precludes the use of these cameras in case of web speed variation. The ADR technology is an irreplaceable way of using them with the flexibility required by industrial machine vision.

Improved image quality

With the ADR technology, the camera is continuously exposed, and every part of the observed web is used to build the acquired image. This is not the case with the traditional approach, where the electronic shutter at low speed “wastes” a substantial fraction of time blocking the optical information.

The sensitivity of the camera is as good as it can be, and the signal-to-noise ratio of the resulting image is optimal. In fact, ADR is the best way to acquire images from a line-scan camera.

Beside the ideal sensitivity offered by ADR, a second-order improvement is worth considering. Controlling the exposure with an electronic shutter induces noise in the data delivered by the camera. This polluting noise comes from electrical pulses issued when the electronic shutter opens. Camera data sheets report this as an increased FPN (Fixed Pattern Noise) when electronic shuttering is in use.

The new technology smartly solves this issue. With ADR, disabling the shutter makes the most out of a shutter-equipped camera.

Reliability

From a system standpoint, the ADR approach is simpler than the traditional one. There are fewer controls connecting the camera, as neither the camera cycling rate nor the electronic shutter has to be exercised. This simplicity is an asset for the industrial robustness of the application.

Another acclaimed advantage of ADR is the operational safety resulting from an operative range wider than the camera line rate range.

Quite obviously, all line-scan cameras have speed performance limits. At the high end of the range, an absolute limitation comes from the time spent to read the data out of the camera. Traditional shuttered applications usually encounter an even lower speed limit caused by the selected exposure time.

The camera absolutely cannot operate above this limit. If by chance the mechanical drive speeds up excessively, this acceleration is notified by the motion encoder. In the traditional approach, this results in attempting to “overdrive” the camera. At best the camera loses information, at worst, if no special preventative measure is taken, the camera hangs up.

Using ADR offers a remarkable comfort in this respect, especially when troubleshooting the industrial application. The mechanical system may very well operate at twice the regular speed; this does not prevent the acquisition system from delivering valuable images.

The same is true for the low end of the speed range. For electronic reasons, the camera does not work below a certain limit. When the mechanical system moves slowly (starting condition, for instance), ADR will perform much better than the traditional approach. The maximum-to-minimum operating speed ratio for ADR is currently specified at 200.

WARNING

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