Basler Components

Optimizing a Basler Tri-linear Color Camera Setup

APPLICATION NOTES

Document Number: AW000724
Version: 01   Language: 000 (English)
Release Date: 18 August 2008

Contacting Basler Support Worldwide

Europe:

Basler AG
An der Strusbek 60 - 62
22926 Ahrensburg
Germany

Tel.: +49-4102-463-500
Fax.: +49-4102-463-599
bc.support.europe@baslerweb.com

Americas:

Basler, Inc.
855 Springdale Drive, Suite 160
Exton, PA 19341
U.S.A.

Tel.: +1-877-934-8472
Fax.: +1-610-280-7608
bc.support.usa@baslerweb.com

Asia:

Basler Asia Pte. Ltd
8 Boon Lay Way
03 - 03 Tradehub 21
Singapore 609964

Tel.: +65-6425-0472
Fax.: +65-6425-0473
bc.support.asia@baslerweb.com

www.baslerweb.com

1 Introduction

When it comes to capturing color images with a line scan camera, there are several common methods used to achieve color separation. The following table provides an overview of the most common methods as well as their advantages and disadvantages.

Color Separation Method	Pros	Cons
Tri-linear CCD	■ Cost effective ■ High resolution ■ Good color separation ■ Widely used	■ Demands linear movement and must be carefully adjusted ■ Edge artifacts possible
3 CCD with Prism	■ High resolution ■ Good color separation ■ Captures full color on a single exposure	■ Expensive ■ Needs special lenses ■ Sensors must be precisely aligned to achieve good image quality
Bayer Pattern	■ Very inexpensive ■ Useful for nonlinear movement	■ Interpolation artifacts possible ■ Color separation reduced by crosstalk ■ Lower "true" resolution

Table 1: Comparison Table

To achieve the best performance from a tri-linear camera, it is important that your camera setup be carefully adjusted. The objective of this application note is to describe a procedure that we use at Basler to test the setup of our tri-linear cameras. This description will provide you with some tips that will aid you when optimizing a tri-linear camera setup in your own system.

2 General Adjustments

Tri-linear color line scan cameras deliver the best performance with a specific optical setup. The camera should be exactly perpendicular to the inspected surface, and the line being inspected should be perpendicular to the direction of transport. The guidelines for setting up a color line scan camera are explained in great detail in the "Spatial Correction" section of the manuals for Basler color line scan cameras, e.g., the Basler ruL2098-9gc or the Basler L301kc.

Aside from these general rules and the rules described in the manuals, there are some less obvious causes for discolorations and other artifacts:

- Chromatic aberrations in the cylindrical lens of the line light and a small angle between the line light and the imaged line can cause a blue or red tint at the outer regions of the line.
- Jitter in the encoder signal. This is one of the main constraints on vertical resolution and color accuracy.
- Digital encoders such as the Sick DRS61 can be configured to any number of lines. They do this by dropping a line every so often, which causes steps in the image if the number of lines is not a binary number (2048, 4096, 8192, and so on).

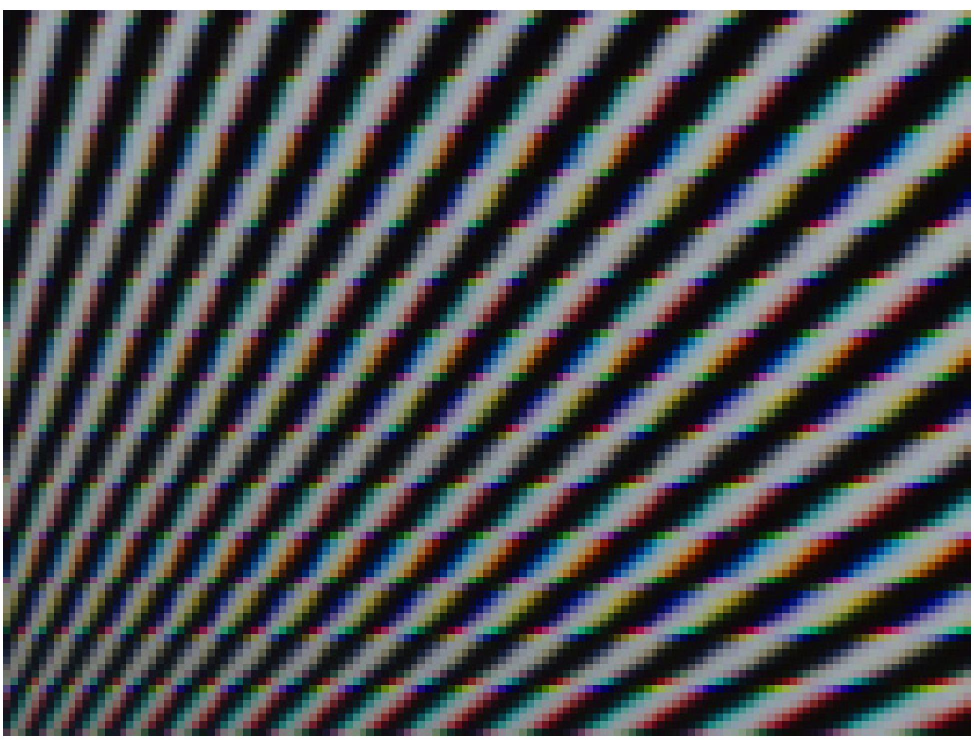

Fig. 1: Encoder Step Artifacts

- Even if you are using a shaft encoder, rapid acceleration in the transport direction can be another cause. The encoder will ensure that the point where exposure starts is the same for each of the three lines in the sensor. The end of exposure, however, is determined by the speed of the conveyor and the exposure time setting. If you accelerate an edge toward the blue line, the red line will image a shorter segment on the object than the blue line.

3 Fine Tuning the Setup

3.1 Test Setup

Basler employs a drum setup to test the functionality of line scan cameras in real world applications. The drum is rotated by an electric motor, has a circumference of 948 mm and is connected to a Sick Stegmann DRS61 programmable shaft encoder. The encoder can be configured to different numbers of lines per revolution. At the maximum resolution of 8192 lines, the quadrature signal of the encoder will produce a transitional edge every 0.011°, which equals 29 µm on the drum surface.

The camera for the tests described here is a Basler ruL2098-9gc with a Schneider-Kreuznach Apo Componon 4/60 macro lens. Lighting is provided by a cold light source with a fiber optic line light converter.

The inspected object is a star target from Edmund Optics (stock No. NT46-246). The minimum line width and spacing of the star chart is 70 µm at the center, which will stress our setup close to its resolution limit.

The captured images are evaluated with a freely available image processing software package called ImageJ from Wayne Rasband at the NIH (http://rsb.info.nih.gov/ij/). The three dimensional color space representations are created with the 3D Color Inspector plug-in for ImageJ (available at the same website) by Kai Uwe Barthel from the FHTW in Berlin.

The initial optical setup is designed to image pixels with an aspect ratio of 8:8 at the maximum resolution of the shaft encoder. The camera is moved to different distances from the drum to achieve different aspect ratios. At each new position, the lens is refocused and an image of the star chart is taken. The more the aspect ratio differs from an integer, the more edge artifacts become visible in the form of colored edges in the black and white image.

The captured images are analyzed with ImageJ. First the exact aspect ratio is calculated from a bounding ellipse fitted to the outline of the star. The aspect ratio is calculated by dividing the height of the ellipse by its width. The ImageJ screen shot below shows the target and the bounding ellipse. Dividing the "major" axis by the "minor" axis as provided by the ImageJ program would yield the aspect ratio.

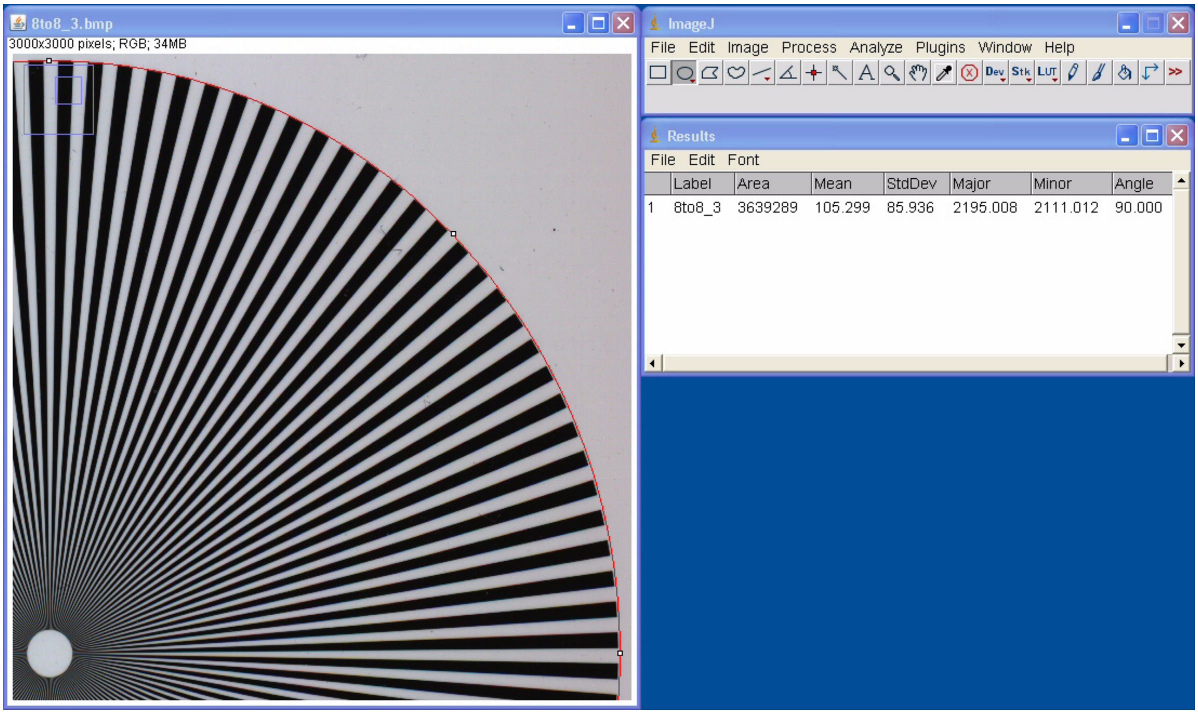

Fig. 2: Star Chart and Bounding Ellipse in ImageJ

Next, the color image is divided into its hue, saturation, and brightness contents. The standard deviation of the saturation image gives a good quantitative indication of the edge artifacts.

The effect of aspect ratio mismatch can be clearly seen in the three dimensional color space representations of the Color Inspector 3D plug-in for ImageJ.

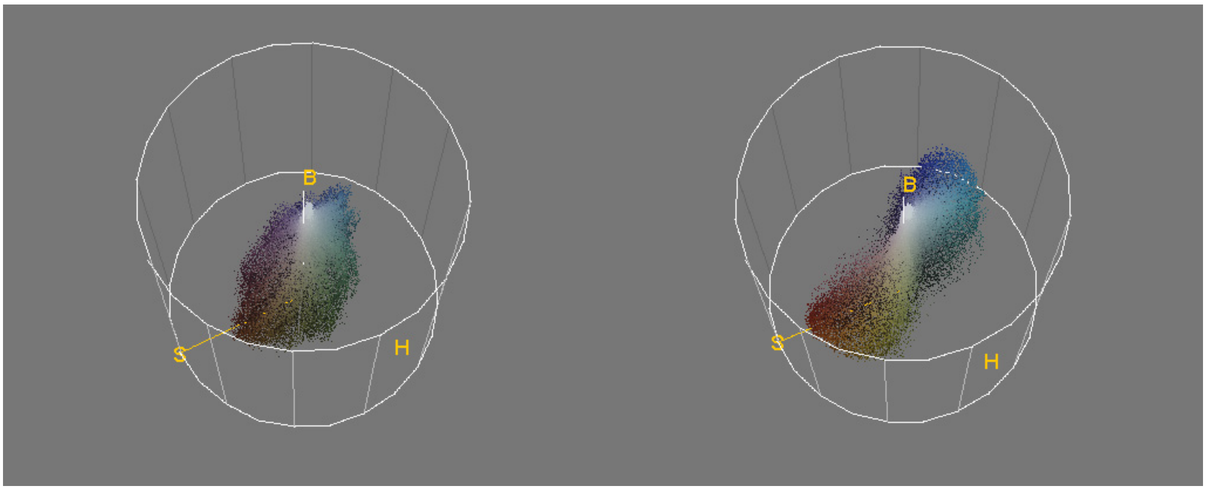

Fig. 3: Color Occurrence in Well Adjusted and Poorly Adjusted Images

Fig. 4: Edge Artifacts in an Image with an 8:8.318 Aspect Ratio (Colors Enhanced)

The ImageJ screen shot below shows two images with an 8 to 8 aspect ratio. The left image is from a poorly adjusted camera and the right image is from a well adjusted camera. The image from a poorly adjusted camera shows very distinct patterning in the star. The image from the well adjusted camera is much more uniform.

Note that when you are working with a test pattern that is near to the camera's resolution limit, there will be some minimal patterning even with a well adjusted setup. This is caused by the jitter that is inherent in all encoders.

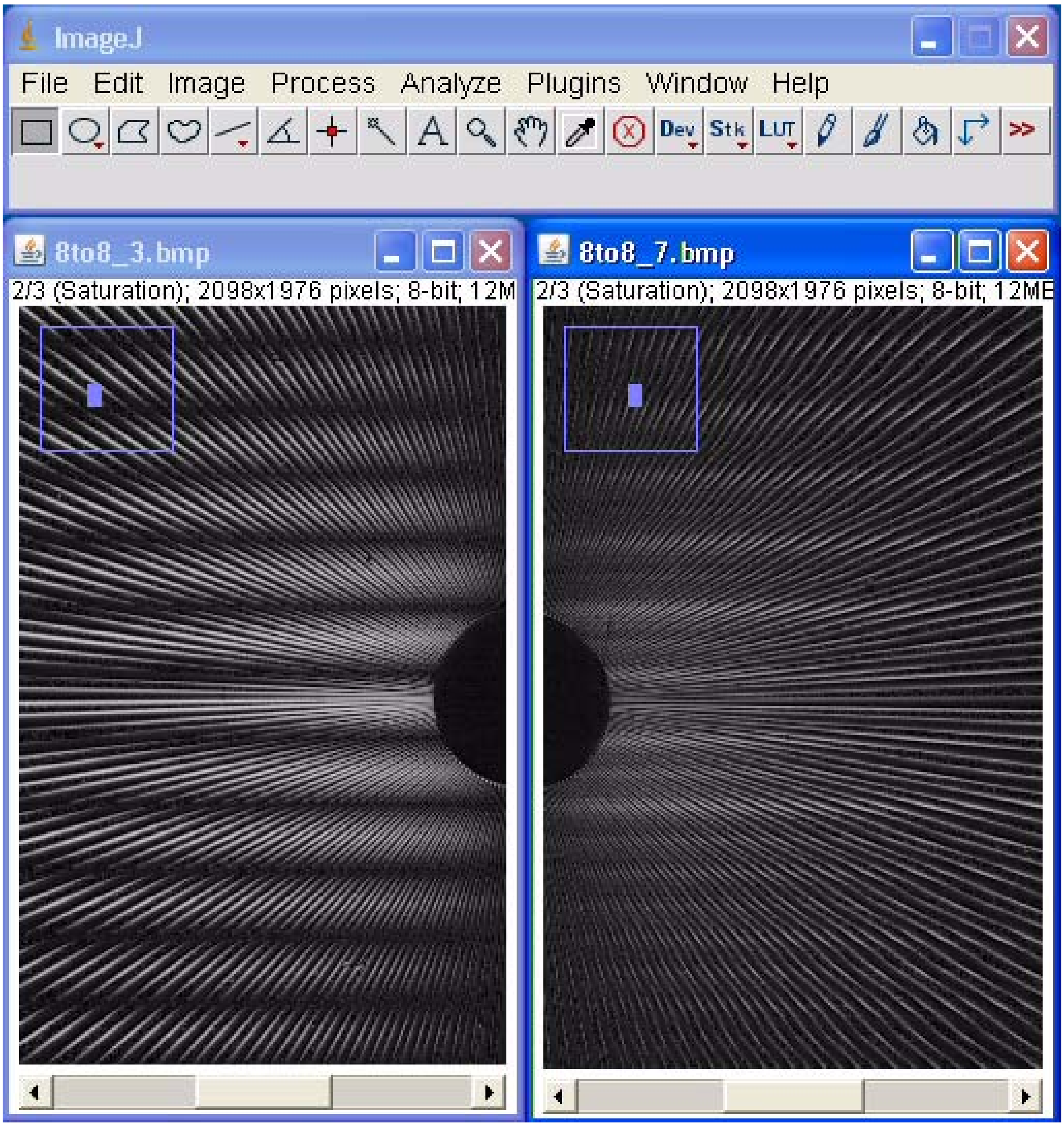

Fig. 5: Images from a Poorly Adjusted and a Well Adjusted Setup

3.2 Test Results

Image Number	Aspect Ratio	Standard Deviation of Saturation
1	8:7.758	24.85
2	8:8.103	25.24
3	8:8.318	30.09
4	8:8.247	27.77
5	8:8.145	24.53
6	8:8.100	23.75
7	8:7.982	21.96

Table 2: Standard Deviation of the Saturation at Various Aspect Ratios

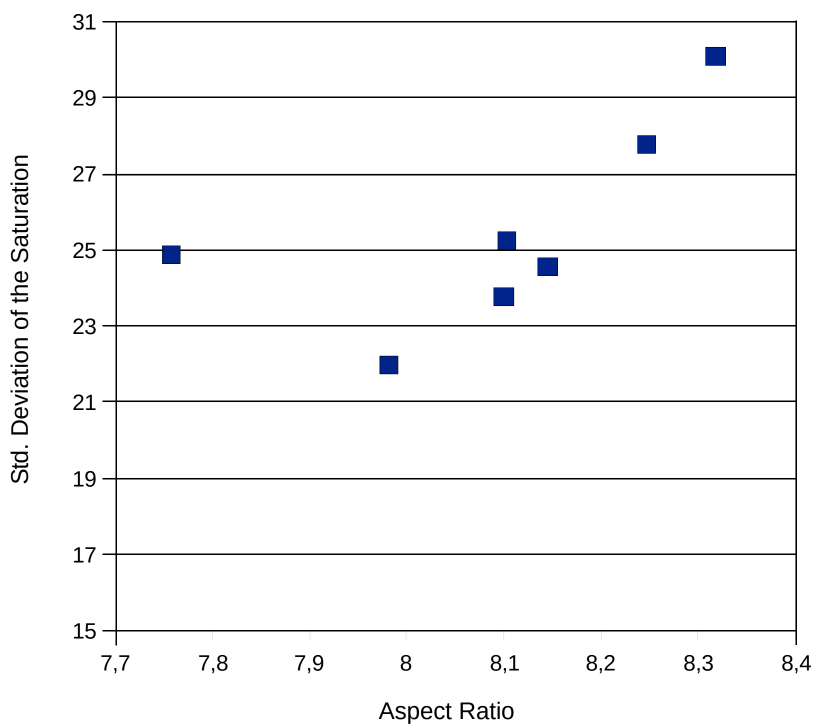

Fig. 6: Standard Deviation of the Saturation vs. Aspect Ratio

4 Conclusion

Tri-linear line scan cameras offer a cost effective way of scanning moving objects at high resolution. If special care is taken when adjusting these cameras, their color fidelity and accuracy can match even the much more expensive 3-CCD line scan cameras.

Revision History

Doc. ID Number	Date	Changes
AW00072401000	18 Aug 2008	Initial release of this document.