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Working With The R64-CL-IP2 in Bayer Decoder Configuration
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Introduction

The R64-CL-IP2 is a special version of the R64 board. This board is capable of decoding the raw output of color cameras based on Bayer sensors. This process is often referred to as "de-mosaicing". These sensors use a matrix of filters over the optical detectors to create a color image. Each pixel in a Bayer sensor detects only one color. Each pixel in a color image is made of up three values: red, green and blue. The missing two colors at each location are interpolated from surrounding pixels. This interpolation is computational expensive.

Traditionally, in a system with a Bayer camera connected to a frame grabber in a PC, the CPU had to decode each image as it was acquired. As of this writing, only the fastest dual CPU systems can keep up with the high speed Bayer cameras available today. If the CPU is spending all its time decoding images, no cycles are left over to process these images. While the speed of the PC is rapidly increasing, so are the frame rates and resolutions of machine vision Bayer cameras.

BitFlow's solution to this problem is to move the processing burden from the CPU to the frame grabber. This technique guarantees full resolution, full frame rate color images will be continuously acquired. Thus leaving 100% of the CPU available for image processing. BitFlow's FlowThru architecture also helps this situation as the R64 has been designed to minimize latency and CPU usage while continuously acquiring and DMA images to host memory.

Requirements

In order to take advantage of this Bayer decoding system, the following items are required.

> PC, preferably with at least on 64-bit/66 MHz slot (running Windows NT 4.0, 2000 or XP)
> BitFlow's R64-PCI-CL-IP2
> BitFlow's SDK 4.012 or later
> One or two Bayer cameras
> Camera Link cable(s)
> Camera specific Bayer configuration files

Installation

1. Install the SDK as described in Getting Started document. Make sure that the synthetic image can be acquired correctly before connecting your camera.

2. Configure your system to run your Bayer camera in raw mode. In this mode the board acquires and displays the raw (grey scale) pixels coming out of the camera. There should be a camera configuration file to acquire just the raw data (e.g. "Pulnix-TM4000CL-E2.r64"), contact BitFlow if it is not part of the release. Run CiView and make sure the board is acquiring the images correctly. If you look closely at the image (you can zoom using the display surface menu) you should see the artifacts of the color filter matrix on the grey scale images.

3. Configure your system to run your Bayer camera using the R64's Bayer decoder. Again, contact BitFlow if you do not have a camera configuration file for this mode (e.g. "Pulnix-TMC4000CL-Bay-E3-FreeRun.r64"). Run CiView, and you should get color images.

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Bayer Processing Parameters

There are few registers that control the Bayer Decoder. All of these bitfields are located in the register CON21. These registers are described in detail in the R64 Hardware Reference Manual. However the following list outlines their functionality.

> RED_GAIN - controls the gain on the red output channel.
> BLUE_GAIN - controls the gain on the blue output channel.
> GREEN_GAIN - controls the gain on the green output channel.
> DECODER_OUT- controls which color channels are output, mainly for diagnostic purposes.
> BAYER_10_BIT - tell the engine that the incoming data is 10 bits (v.s 8 bits).
> DECODER_PHASE - tells the engine which configuration color matrix the camera is using.

All of these registers are stored in the camera configuration file. Whenever any application is run, the board is restored with these parameters. Thus they normally need to be set only once. However, a change in the lighting may require a change in the color balance. There are a few ways that the gain parameters can be modified. This simplest way is to modify that camera configuration file using CamVert or CamEd (available starting with SDK 4.1). The second way, is interactively, using the application BayView (described below). Finally, customers can write their own applications and program these registers directly from their software.

BayView

BayView is a Bayer real time capture and display application. Its main purpose is to display live color video from Bayer cameras on the monitor, and allow the user to interactively modify the Bayer decoder parameters. This application can save color images to hard disk. It can also open a grey scale Bayer image file and convert to a color image. There are also some options to perform automatic color correction.

BayView works in one of two different modes, either using the R64 Bayer decode engine, or using the CPU to perform the decode. The software automatically detects which kind of camera configuration is selected, then runs in the appropriate mode. Not all of the interactive options or controls are available in both modes. BayView works with all of BitFlow's families of frame grabbers. Although only the R64 currently supports hardware decoding. Also note that the R64 can acquire from Bayer cameras both with decoding (output is 24-bit color) and without decoding (output is 8-bit raw data).

BayView only works with 8-bit raw data. This is true for both hardware and software decoding modes. If a 10 bit camera is attached, then the board must shift each pixel down to 8 bits before DMAing it to memory. The R64 with the Bayer Decoder has a register (BAYER_10_BIT) that must be set for 10 bit cameras. The main reason for only handling 8 bit data is that the main purpose of BayView is to display color images. Almost all computer displays can only handle 24 bits of color, which is the natural result of de-mosaicing 8-bit raw Bayer images. It does not make any sense, therefore, do decode 10-bit raw data. The result would be an undisplayable 30-bit color image, and the processing time would increase dramatically.

All parameters and settings are saved to the registry when the application is closed. Each time BayView is run, it will be restored exactly as it was previously.

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Using BayView

START UP

When BayView first starts, a live display window is opened up and the board is programmed to start grabbing immediately. After a few seconds, the top of the display window will indicate the frame rate (FPS) that the application is processing incoming frames. If the application is running with the R64 hardware decoder, this frame rate should always match the frame rate for your camera. If the CPU is being used, then the frame rate will vary considerably depending on the speed and resolution of your camera, and the capabilities of your computer.

THE FILE MENU

This menu works like most Window applications. Captured images can be save to disk (as 24-bit Window BMP format images). Raw grey scale Bayer images can be opened and converted to color images. When a grey scale image is opened, the conversion can be modified by the same color correction parameters as are available for live conversion. Opening of 24-bit color images is not supported.

THE PREVIEW MENU

The Preview menu is used to stop and start capture and processing of video. When the application first starts, capture is started automatically. It can be stopped and restarted at any time from this menu. Also this menu is used to capture an image for subsequent saving to disk. Capture is only possible when the system is not grabbing. When capture command is invoked, the last image acquired is capture. This image can then be further modified using the color correction tools. The image can be saved to disk using the File menu.

THE COLOR MENU

The color menu is used to modify the parameters of the Bayer Conversion. The Color Correction command opens the Color Correction dialog. This dialog allows the offsets and gains to be interactively modified (this is a non-modal dialog) for each color channel. Changes made in this dialog effect all conversions, both static images loaded from disk as well as live images being captured from a BitFlow board. Note that the Offset parameters are not available when using the hardware decoder on the R64. The Reset button sets all gains to one and all offsets to zero.

The Choose Bayer Matrix command opens the Choose Bayer Matrix dialog. This dialog lets you set the type of color filter matrix being used by your camera. There are four types, the decoding engine must use the type that correctly matches the camera, in order to decode the colors correctly.

The Auto Balance command attempts to set the color correction parameters automatically, based on the image contents. This operation will only work if the camera is pointing at a scene with a wide range of colors and/or a wide dynamic range of grey scales. Images that only contain one or few colors, will not correctly balance using this command.

The White Balance command requires that the camera field be filled with a white object (e.g. a piece of paper). The object used to fill the field of view should be illuminated by the same lighting as the target scene. The object does not have to be in focus, but should fill the entire field of view. The object should also not be 100% saturated (i.e. all pixels are at their maximum value).

The Hardware Decoder command allows access to the R64's DECODER_OUT register. This register can program the R64's decoder to output alternate data (e.g. only one color channel, or intensity data). This command is only available if BayView is running in hardware decoder mode.

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THE ALGORITHM MENU

The menu controls which Bayer de-mosaicing algorithm is used by BayView when it is in software decoding mode. The algorithm can be switched at any time. There are three options.

> Nearest Neighbor - this is very fast, but results in poor quality images. Most useful for focusing or using on older PCs or when focusing and quick feed back is needed.
> Bilinear - this algorithm is based on bilinear interpolation of a 3x3 neighborhood around each target pixel. This is the most standard algorithm, and is what the R64 hardware decoder uses.
> Smooth Hue - this algorithm tries to correct for some of the edge defects that result from the bilinear method. This algorithm is very computationally intensive, and usually results in only a few FPS, even on the fastest machines. However, the resulting images are of very high quality.

Using BayView to Determine Color Correction Values

BayView can be used to interactively set the color correction of the R64's bayer decoder. Once the optimal values are found, BayView will continue to use these values each time it is run. However, in the case of running a different application our your own software, the values stored in the camera configuration file will be used. The correction values can be modified easily using CamVert (or CamEd starting with SDK 4.1). However, CamVert does not have interactively view the effects of changes to these parameters. The easiest way to solve this problem is to transfer the desired color correction values determined using BayView into a camera configuration file, edited with CamVert. This section outlines the simple procedure required to accomplish this transfer.

When using BayView's Color Correction dialog, the gain values are display as number from 0.0 to 4.0. These values can be transferred into register setting using the following formula:

> REGISTER_GAIN = BayViewDialogGain x 64

For example, if the dialog setting had the Red Gain of 2.11. The register REG_GAIN should be set for 135. This is done in CamVert's registry editor (edit CON21). The binary code for 135 is entered using the buttons for each bit for the bitfield REG_GAIN. The green and blue gains are entered in a similar manner.

This step can be performed for all three gain registers. Keep in mind that the R64 hardware decoder does not support offset adjustments.

Getting Help

There are many resources, beyond this document, that are available to you if you have trouble getting started:

> The manuals: There is a wealth of information in both the SDK manual and the individual hardware manuals.
> Our web site: www.bitflow.com
> E-mail: support@bitflow.com
> Telephone: 781-932-2900 (9 AM to 6 PM EST)
> Facsimile: 781-933-9965

Please have the following available when seeking support:

> 1 Model and serial number of Raven, Road Runner, R3 or R64.
> 2 Make and model of camera and mode being used.
> 3 Manufacturer and model of camera cable.

4 Software revision, run VerCheck to find the installed version information.

5 Computer CPU type, PCI chipset, and bus speed.

6 Operating system, service pack.

7 Example code (if applicable).