Vision HDL Toolbox™

Reference

MATLAB®

R2015a

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Vision HDL Toolbox™ Reference

Revision History

March 2015	Online only	New for Version 1.0 (Release R2015a)

Contents

Blocks — Alphabetical List

Chroma Resampler

Downsample or upsample chrominance component

Library

visionhdlconversions

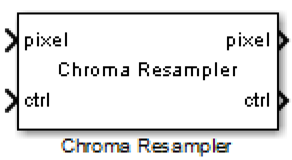
Description

The Chroma Resampler block downsamples or upsamples a pixel stream.

- Downsampling reduces bandwidth and storage requirements in a video system by combining pixel chrominance components over multiple pixels. You can specify a filter to prevent aliasing, by selecting the default filter or by entering coefficients.
- Upsampling restores a signal to its original rate. You can use interpolation or replication to calculate the extra sample.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox™ blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see "Streaming Pixel Interface".

The block accepts luma and chrominance components. The block does not modify the luma component, and applies delay to align it with the resampled chrominance outputs. The rate of the output luma component is the same as the input.

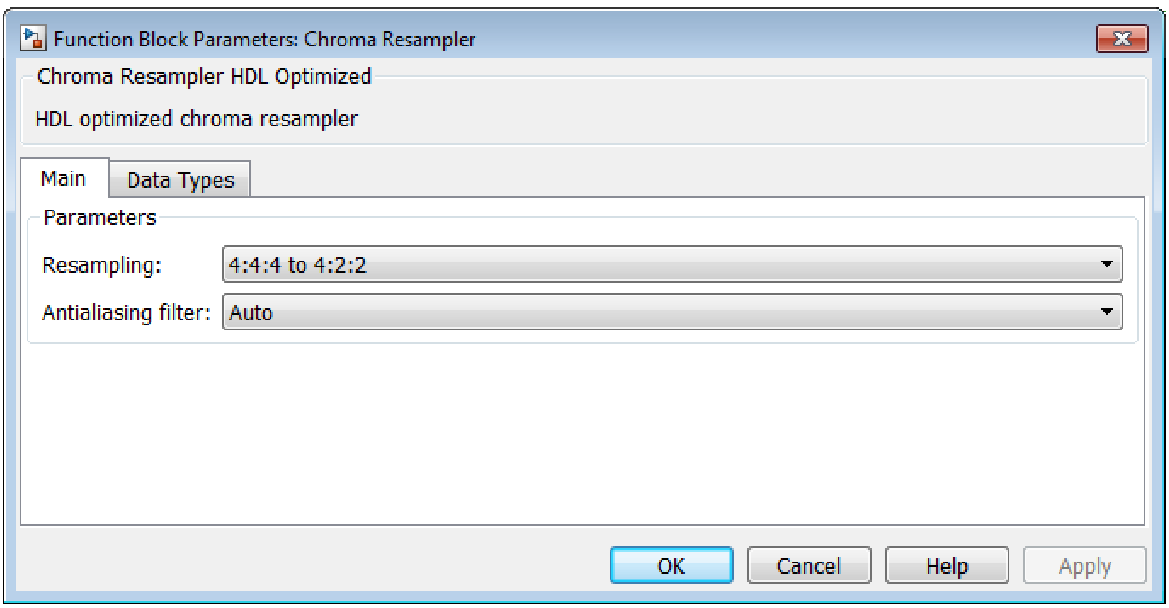


Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input/ Output	Single pixel in Y'CbCr color space, specified as a vector of three values. The data type of the output is the same as the data type of the input.	• `uint8` or `uint16` • `fixdt(0,N,0)`, N = 8,9,...,16 `double` and `single` data types are supported for simulation but not for HDL code generation.
`ctrl`	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	`pixelcontrol`

Dialog Box and Parameters

Main



Resampling

Resampling operation.

- `4:4:4 to 4:2:2` (default)
- `4:2:2 to 4:4:4`

If you select `4:4:4 to 4:2:2`, the block performs a downsampling operation. If you select `4:2:2 to 4:4:4`, the block performs an upsampling operation.

Antialiasing filter

Lowpass filter to follow a downsample operation.

- `Auto` (default)
- `Property`
- `None`

If you select `Auto`, the block uses a built-in lowpass filter. If you select `Property`, the **Horizontal filter coefficients** parameter appears on the dialog box. If you select `None`, the block does not filter the input signal. This parameter is visible when you set **Resampling** to `4:4:4 to 4:2:2`.

Horizontal filter coefficients

Coefficients for the antialiasing filter.

Enter the coefficients as a vector. The default is `[0.2,0.6,0.2]`. This parameter is visible if you set **Resampling** to `4:4:4 to 4:2:2` and **Antialiasing filter** to `Property`.

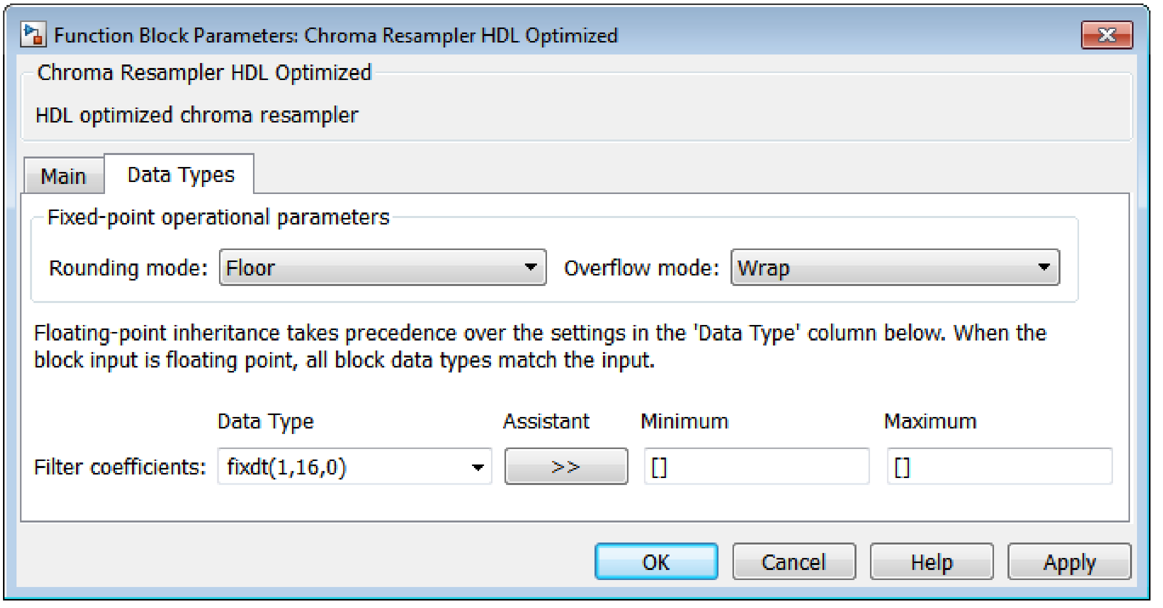
Interpolation

Interpolation method for an upsample operation.

- `Linear` (default)
- `Pixel replication`

If you select `Linear`, the block uses linear interpolation to calculate the missing values. If you select `Pixel replication`, the block repeats the chrominance values of the preceding pixel to create the missing pixel. This parameter is visible if you set **Resampling** to `4:2:2 to 4:4:4`.

Data Types



The parameters on this tab appear only when they are relevant. If your selections on the **Main** tab configure the block so that no filter coefficients are needed, or no rounding or overflow is possible, the irrelevant parameter is hidden.

Rounding Method

Rounding method for internal fixed-point calculations. **Rounding Method** appears when you select linear interpolation, or include an antialiasing filter. The default is `Floor`.

Overflow Action

Overflow action for internal fixed-point calculations. Overflow can occur when you include an antialiasing filter. The default is `Wrap`.

Filter coefficients

Data type for the antialiasing filter coefficients.

The default is `fixdt(1,16,0)`. This parameter is visible when you set **Antialiasing filter** to `Auto` or `Property`.

Algorithm

The default antialiasing filter is a lowpass filter. The passband occupies half of the total bandwidth, which is sufficient to suppress any aliasing after `4:4:4 to 4:2:2` downsampling.

Whether you use the default filter or specify your own coefficients, the filter is implemented in HDL using a fully parallel architecture.

The block uses symmetric padding to apply the filter to the pixels at the beginning and end of lines. Also, if the frame is an odd number of pixels wide, the block symmetrically pads the line. This accommodation makes the block more resilient to video timing variation.

Latency

The latency is the number of cycles between the first valid input pixel and the first valid output pixel. When you use an antialiasing filter, the latency depends on the size and value of the filter coefficients.

Block Configuration	Latency
Downsample (4:4:4 to 4:2:2), no filter	3
Downsample (4:4:4 to 4:2:2), with filter	4+N/2+FIR delay, N = number of filter coefficients
Upsample (4:2:2 to 4:4:4), replication	3
Upsample (4:2:2 to 4:4:4), interpolation	5

For example, the latency for a downsample using the default filter is 30 cycles.

See Also

`visionhdl.ChromaResampler` | Chroma Resampling | Frame To Pixels

Introduced in R2015a

Closing

Morphological close

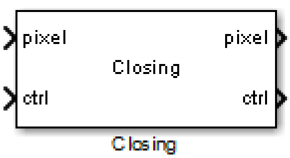
Library

visionhdlmorph

Description

Closing is a morphological dilation operation, followed by a morphological erosion operation, using the same neighborhood for both calculations. The block operates on a stream of binary intensity values.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see "Streaming Pixel Interface".

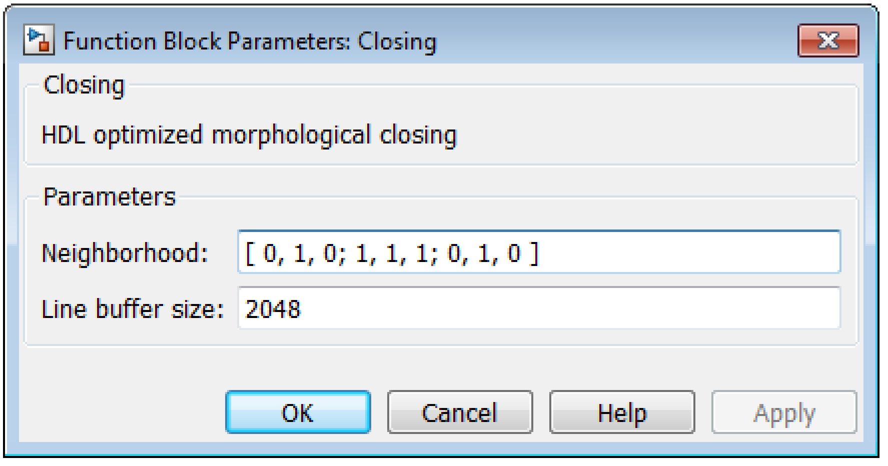


Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input/ Output	Single image pixel, specified as a scalar binary value.	`boolean`

Port	Direction	Description	Data Type
`ctrl`	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	`pixelcontrol`

Dialog Box and Parameters



Neighborhood

Neighborhood, specified as a matrix or vector of ones and zeros.

The block supports neighborhoods up to 32×32 pixels. To use a structuring element, specify the **Neighborhood** as `getnhood(strel(`*`shape`*`))`. The default is `[0,1,0;1,1,1;0,1,0]`.

Line buffer size

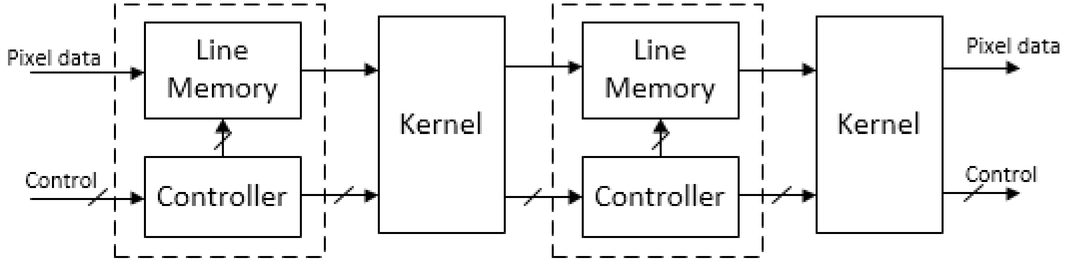
Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the block uses the next largest power of two. The block allocates *neighborhood lines - 1*-by-**Line buffer size** memory locations to store the pixels. The default value is 2048.

Algorithm

Latency

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Closing is a compound operation. Therefore, this block contains a second line buffer between the dilation kernel and the erosion kernel. Use the output control signals to determine when the output pixels are valid.



See Also

`visionhdl.Closing` | Closing | Dilation | Erosion | Frame To Pixels | `getnhood` | `strel`

Introduced in R2015a

Color Space Converter

Convert color information between color spaces

Library

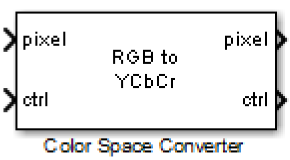
visionhdlconversions

Description

The Color Space Converter block converts between R'G'B' and Y'CbCr color spaces, and also converts R'G'B' to intensity.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.

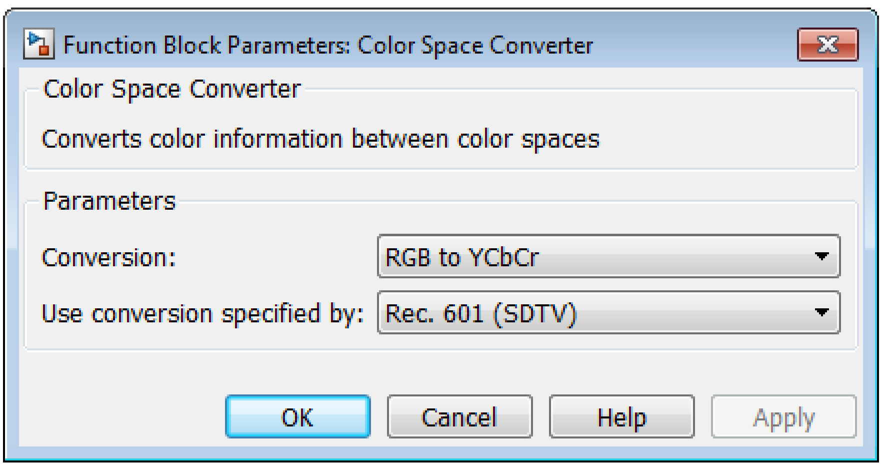
Note: The Color Space Converter block operates on gamma-corrected color spaces. However, to simplify use of the block, the block and mask labels do not include the prime notation.



Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input/ Output	Single image pixel, specified by a vector of three values representing R'G'B' or Y'CbCr, or a scalar value representing intensity. The data type of the output is the same as the data type of the input.	• `uint8` or `uint16` • `fixdt(0,N,0)`, $N = 8,9,\ldots,16$ `double` and `single` data types are supported for simulation but not for HDL code generation.
`ctrl`	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	`pixelcontrol`

Dialog Box and Parameters



Conversion

Conversion that the block performs on the input video stream.

- `RGB to YCbCr` (default)

- `YCbCr to RGB`
- `RGB to intensity`

The block accepts input as a vector of three values representing a single pixel. If you choose `RGB to intensity`, the output is a scalar value. Otherwise, the output is a vector of three values.

Use conversion specified by

Conversion equation to use on the input video stream. This parameter does not apply when you set **Conversion** to `RGB to intensity`.

- `Rec. 601 (SDTV)` (default)
- `Rec. 709 (HDTV)`

Scanning standard

Scanning standard to use for HDTV conversion. This parameter applies when you set **Use conversion specified by** to `Rec. 709 (HDTV)`.

- `1250/50/2:1` (default)
- `1125/60/2:1`

Algorithm

Conversion Between R'G'B' and Y'CbCr Color Spaces

The following equations define R'G'B' to Y'CbCr conversion and Y'CbCr to R'G'B' conversion:

$$\begin{bmatrix} Y' \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \mathrm{A} \times \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix}$$

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \mathrm{B} \times \left(\begin{bmatrix} Y' \\ Cb \\ Cr \end{bmatrix} - \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} \right)$$

The values in matrices A and B are based on your choices for the **Use conversion specified by** and **Scanning standard** parameters.

Matrix	Use conversion specified by = Rec. 601 (SDTV)	Use conversion specified by = Rec. 709 (HDTV)	
		Scanning standard = 1125/60/2:1	Scanning standard = 1250/50/2:1
A	$\begin{bmatrix} 0.25678824 & 0.50412941 & 0.09790588 \\ -0.1482229 & -0.29099279 & 0.43921569 \\ 0.43921569 & -0.36778831 & -0.07142737 \end{bmatrix}$	$\begin{bmatrix} 0.18258588 & 0.61423059 & 0.06200706 \\ -0.10064373 & -0.33857195 & 0.43921569 \\ 0.43921569 & -0.39894216 & -0.04027352 \end{bmatrix}$	$\begin{bmatrix} 0.25678824 & 0.50412941 & 0.09790588 \\ -0.1482229 & -0.29099279 & 0.43921569 \\ 0.43921569 & -0.36778831 & -0.07142737 \end{bmatrix}$
B	$\begin{bmatrix} 1.1643836 & 0 & 1.5960268 \\ 1.1643836 & -0.39176229 & -0.81296765 \\ 1.1643836 & 2.0172321 & 0 \end{bmatrix}$	$\begin{bmatrix} 1.16438356 & 0 & 1.79274107 \\ 1.16438356 & -0.21324861 & -0.53290933 \\ 1.16438356 & 2.11240179 & 0 \end{bmatrix}$	$\begin{bmatrix} 1.1643836 & 0 & 1.5960268 \\ 1.1643836 & -0.39176229 & -0.81296765 \\ 1.1643836 & 2.0172321 & 0 \end{bmatrix}$

Conversion from R'G'B' to Intensity

The following equation defines conversion from R'G'B' color space to intensity:

$$\text{intensity} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix}$$

Data Types

For fixed-point and integer input, the block converts matrix *A* to `fixdt(1,17,16)`, and matrix *B* to `fixdt(1,17,14)`.

For double or single input, the block applies the conversion matrices in double type, and scales the Y'CbCr offset vector (`[16,128,128]`) by 1/255. The block saturates double or single R'G'B' and intensity outputs to the range `[0,1]`.

The Y'CbCr standard includes headroom and footroom. For 8-bit data, luminance values 16–235, and chrominance values 16–240, are valid. The Color Space Converter block pins out-of-range input to these limits before calculating the conversion. The block scales the offset vector and the allowed headroom and footroom depending on the word length of the input signals. For example, when you convert a Y'CbCr input of type `fixdt(0,10,0)` to R'G'B', the block multiplies the offset vector by $2^{(10-8)} = 4$. As a result, the valid luminance range becomes 64–940 and the valid chrominance range becomes 64–960.

Latency

Blocks with R'G'B' input have a latency of 9 cycles. Blocks with Y'CbCr input have a latency of 10 cycles because one cycle is required to check for and correct headroom and footroom violations.

See Also

`visionhdl.ColorspaceConverter` | Color Space Conversion | Frame To Pixels

Introduced in R2015a

Demosaic Interpolator

Construct RGB pixel data from Bayer pattern pixels

Library

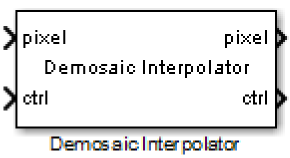
visionhdlconversions

Description

The Demosaic Interpolator block provides a Bayer pattern interpolation filter for streaming video data. The block implements the calculations using hardware-efficient, multiplier-free algorithms for HDL code generation. You can select a low complexity bilinear interpolation, or a moderate complexity gradient-corrected bilinear interpolation.

- When you choose bilinear interpolation, the block operates on a 3×3 pixel window using only additions and bit shifts.
- When you choose gradient correction, the block operates on a 5×5 pixel window. The calculation is performed using bit shift, addition, and low order Canonical Signed Digit (CSD) multiplication.

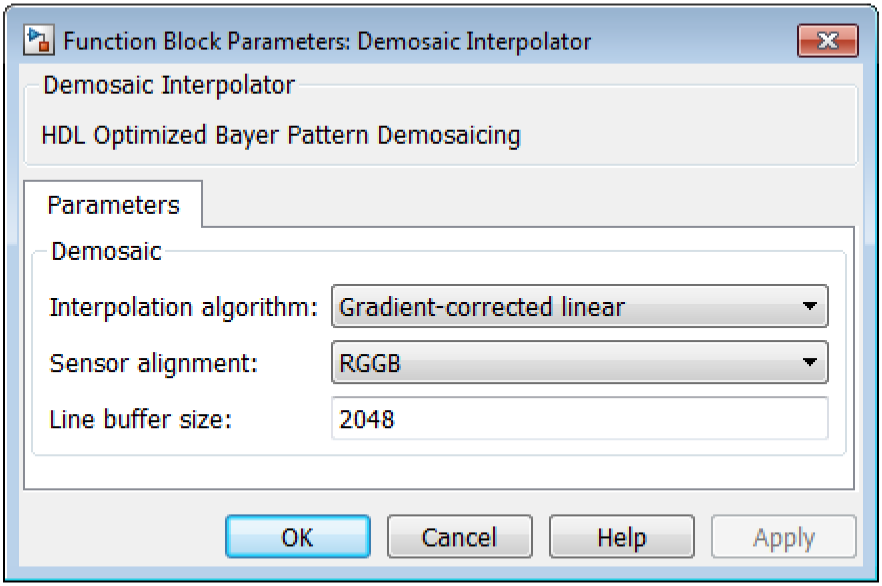
This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.



Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input	Single pixel, specified as a scalar value.	• `uint` or `int` • `fixdt(0,N,0)` `double` and `single` data types are supported for simulation but not for HDL code generation.
`ctrl`	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	`pixelcontrol`
`pixel`	Output	Single pixel in RGB color space, returned as a vector of three values.	Same as the input`pixel`

Dialog Box and Parameters



Interpolation algorithm

Algorithm the block uses to calculate the missing pixel values.

- `Bilinear` — Average of the pixel values in the surrounding 3×3 neighborhood.
- `Gradient-corrected linear` (default) — Bilinear average, corrected for intensity gradient.

Sensor alignment

Color sequence of the pixels in the input stream.

Select the sequence of R, G and B pixels that correspond to the 2-by-2 block of pixels in the top-left corner of the input image. Specify the sequence in left-to-right, top-to-bottom order. For instance, the default `RGGB` represents an image with this pattern.

R	G
G	B

Line buffer size

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. When you select `Bilinear` interpolation, the block allocates 2-by-**Line buffer size** memory locations. When you select `Gradient-corrected linear` interpolation, the block allocates 4-by-**Line buffer size** memory locations. The default value is 2048.

Algorithm

Interpolation

Bilinear Interpolation

The block interpolates the missing color values using a 3×3 neighborhood. The average is calculated over the adjacent two pixels or four pixels, depending on the sensor color pattern. The block implements this algorithm using only add and shift operations.

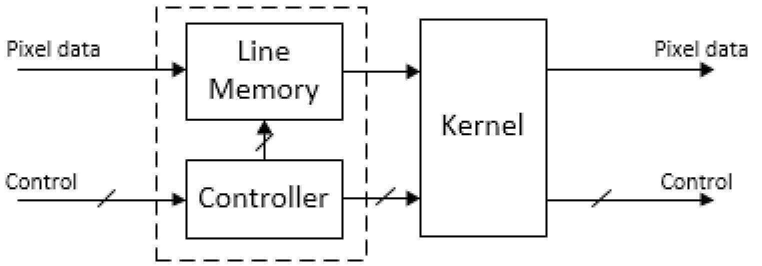
Gradient-Corrected Linear Interpolation

Gradient correction improves interpolation performance across edges by taking advantage of the correlation between the color channels. The block calculates the missing color values using bilinear interpolation, and then modifies the value corresponding to the intensity gradient calculated over a 5×5 neighborhood. The block applies the gradient correction using a fixed set of filter kernels. The filter coefficients were designed empirically to perform well over a wide range of image data. The coefficients are multiples of powers of two to enable an efficient hardware implementation. See [1].

Latency

The block buffers one line of input pixels before starting bilinear interpolation calculations. The gradient correction calculation starts after the block buffers 2 lines.

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Use the output control signals to determine when the output pixels are valid.



References

[1] Malvar, Henrique S., Li-wei He, and Ross Cutler. "High-Quality Linear Interpolation for Demosaicing of Bayer-Patterned Color Images." *Microsoft Research*, May 2004. http://research.microsoft.com/pubs/102068/Demosaicing_ICASSP04.pdf.

See Also

`visionhdl.DemosaicInterpolator` | Demosaic | Frame To Pixels

Introduced in R2015a

Dilation

Morphological dilate

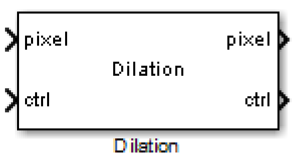
Library

visionhdlmorph

Description

Dilation replaces each pixel with the local minimum of the neighborhood around the pixel. The block operates on a stream of binary intensity values.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.

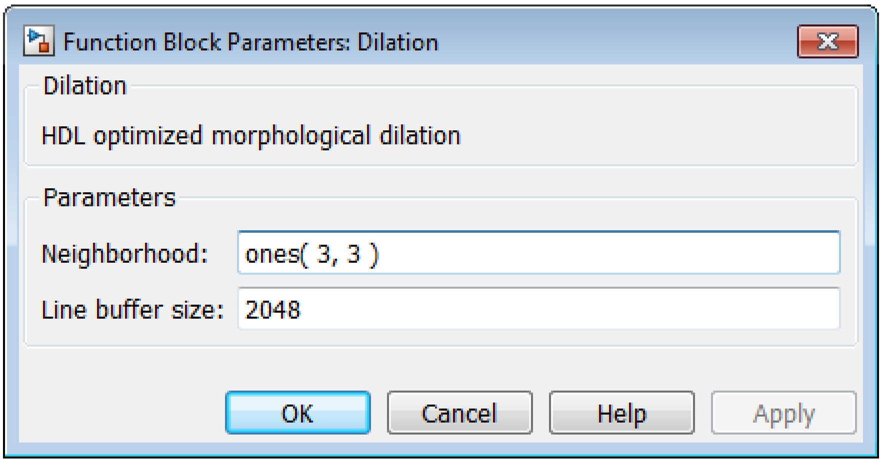


Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input/ Output	Single image pixel, specified as a scalar binary value.	`boolean`

Port	Direction	Description	Data Type
`ctrl`	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	`pixelcontrol`

Dialog Box and Parameters



Neighborhood

Neighborhood, specified as a matrix or vector of ones and zeros.

The block supports neighborhoods up to 32×32 pixels. To use a structuring element, specify the **Neighborhood** as `getnhood(strel(`*`shape`*`))`. The default is `ones(3,3)`.

Line buffer size

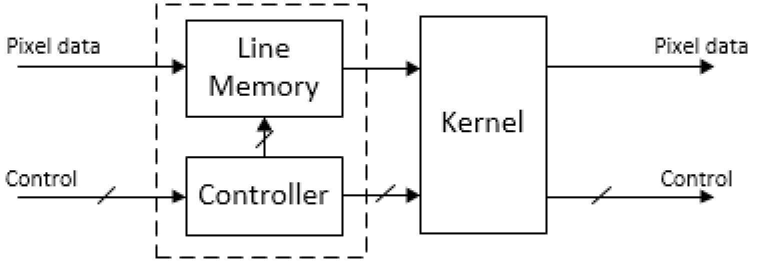
Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the block uses the next largest power of two. The block allocates *neighborhood lines - 1*-by-**Line buffer size** memory locations to store the pixels. The default value is 2048.

Algorithm

Latency

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Use the output control signals to determine when the output pixels are valid.



See Also

visionhdl.Dilation | Dilation | Frame To Pixels | getnhood | strel

Introduced in R2015a

Edge Detector

Find edges of objects in image

Library

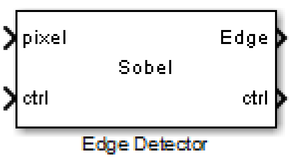
visionhdlanalysis

Description

Edge Detector finds the edges in a grayscale pixel stream using Sobel, Prewitt or Roberts methods. The block convolves the input pixels with derivative approximation matrices to find the gradient of pixel magnitude along two orthogonal directions. It then compares the sum of the squares of the gradients to the square of a configurable threshold to determine if the gradients represent an edge. The Sobel and Prewitt methods calculate the gradient in horizontal and vertical directions. The Roberts method calculates the gradients at 45 and 135 degrees.

By default, the block returns a binary image, as a stream of pixel values. If a pixel value is 1, it is an edge. You can disable the edge output. You can optionally enable output of the gradient values in the two orthogonal directions at each pixel.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.

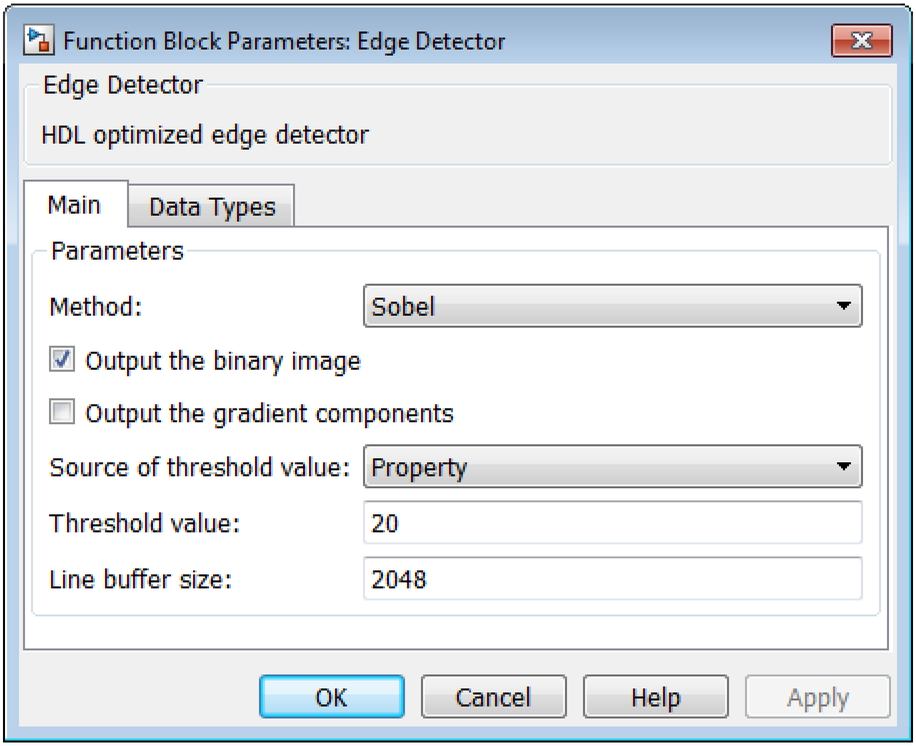


Signal Attributes

Port	Direction	Description	Data Type
pixel	Input	Single image pixel, specified as a scalar value.	• uint or int • fixdt() double and single data types are supported for simulation but not for HDL code generation.
ctrl	Input	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See “Pixel Control Bus”.	pixelcontrol
Th	Input (optional)	Threshold value that defines an edge, specified as a scalar. The block compares this value squared to the sum of the squares of the gradients.	• uint or int • fixdt() double and single data types are supported for simulation but not for HDL code generation.
Edge	Output (optional)	Pixel value indicating an edge at this pixel, returned as a scalar binary value.	boolean
Gv, Gh	Output (optional)	Vertical and horizontal gradient values. These ports are visible when you choose Sobel or Prewitt method.	• uint or int • fixdt() double and single data types are supported for simulation but not for HDL code generation.
G45, G135	Output (optional)	Orthogonal gradient values. These ports are visible when you choose Roberts method.	Same as Gv, Gh
ctrl	Output	Control signals describing the validity of the pixel and the location of the pixel within	pixelcontrol

Port	Direction	Description	Data Type
		the frame, specified as a bus containing five signals. See “Pixel Control Bus”.	

Dialog Box and Parameters



Method

Edge detection algorithm

Select `Sobel`, `Prewitt`, or `Roberts` method.

Output the binary image

Enable the `Edge` output port when selected

When selected, the block returns a stream of binary pixels representing the edges detected in the input frame. The default is selected. You must select at least one of **Output the binary image** and **Output the gradient components**.

Output the gradient components

Enable the gradient output ports when selected

When selected, two output ports return values representing the gradients calculated in the two orthogonal directions. The default is not selected. If you choose `Sobel` or `Prewitt` algorithm, the output ports `Gv` and `Gh` appear on the block. If you choose `Roberts` algorithm, the output ports `G45` and `G135` appear on the block.

You must select at least one of **Output the binary image** and **Output the gradient components**.

Source of threshold value

Source for the gradient threshold value that indicates an edge

You can set the threshold from an input port or from the dialog box. The default value is Property. If you select Input port, the `Th` port appears on the block icon.

Threshold value

Gradient threshold value that indicates an edge.

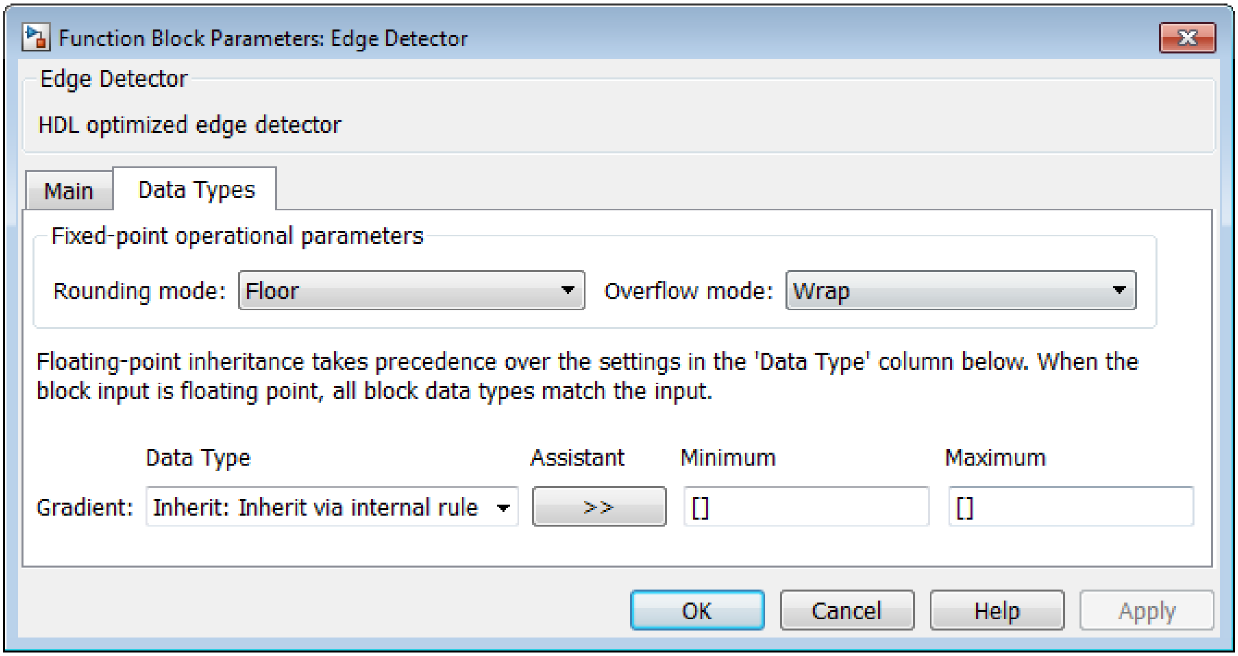
The block compares this value squared to the sum of the squares of the gradients. The block casts this value to the data type of the gradients. The default value is 20. This option is visible when you set **Source of threshold value** to `Property`.

Line buffer size

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the block uses the next largest power of two. The block allocates (N - 1)-by-**Line buffer size** memory locations to store the pixels, where N is the number of lines in the differential approximation matrix. If you choose `Sobel` or `Prewitt` algorithm, N is 3. If you choose `Roberts` algorithm, N is 2. The default value is 2048.

Data Types



Rounding Method

Rounding method for internal fixed-point calculations. The default is `Floor`.

Overflow Action

Overflow action for internal fixed-point calculations. The default is `Wrap`.

Gradient Data Type

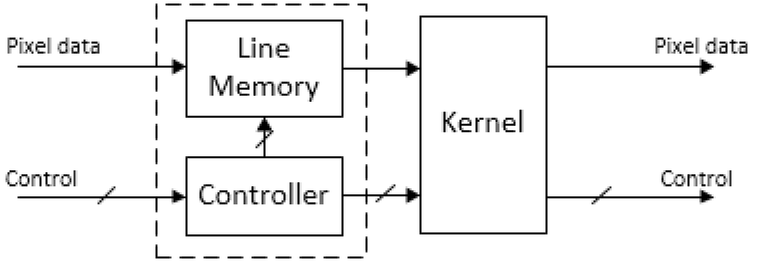
Data type for the two gradient output ports.

If you enable gradient output ports on the **Main** tab, the **Gradient Data Type** appears on this tab. The default is full-precision.

Algorithm

Latency

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Use the output control signals to determine when the output pixels are valid.



See Also

`visionhdl.EdgeDetector` | Edge Detection | Frame To Pixels

Related Examples

- "Edge Detection and Image Overlay"

Introduced in R2015a

Erosion

Morphological erode

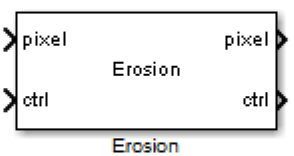
Library

visionhdlmorph

Description

Erosion replaces each pixel with the local maximum of the neighborhood around the pixel. The block operates on a stream of binary intensity values.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.

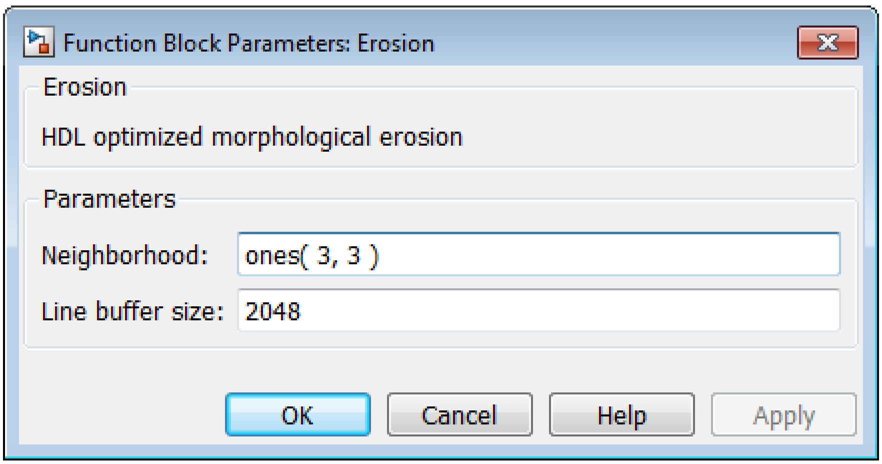


Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input/ Output	Single image pixel, specified as a scalar binary value.	`boolean`

Port	Direction	Description	Data Type
`ctrl`	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See “Pixel Control Bus”.	`pixelcontrol`

Dialog Box and Parameters



Neighborhood

Neighborhood, specified as a matrix or vector of ones and zeros.

The block supports neighborhoods up to 32×32 pixels.

To use a structuring element, specify the **Neighborhood** as `getnhood(strel(`*`shape`*`))`. The default is `ones(3,3)`.

Line buffer size

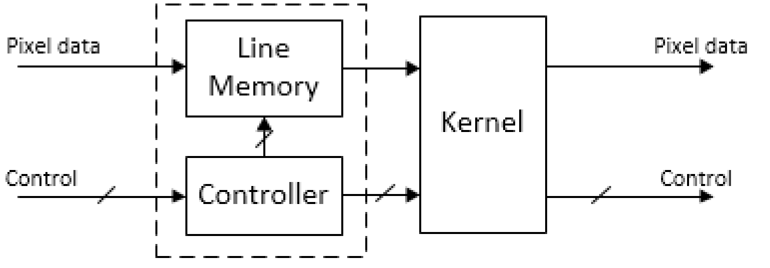
Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the block uses the next largest power of two. The block allocates *neighborhood lines - 1*-by-**Line buffer size** memory locations to store the pixels. The default value is 2048.

Algorithm

Latency

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Use the output control signals to determine when the output pixels are valid.



See Also

`visionhdl.Erosion` | Erosion | Frame To Pixels | `getnhood` | `strel`

Introduced in R2015a

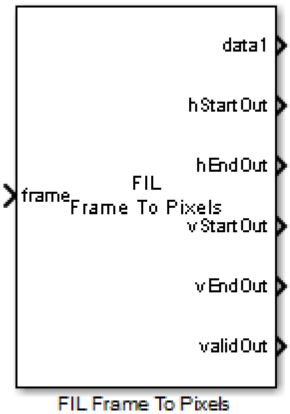
FIL Frame To Pixels

Convert full-frame video to pixel stream for FPGA-in-the-loop

Library

visionhdlio

Description



The FIL Frame To Pixels block performs the same frame-to-pixel conversion as the Frame To Pixels block. In addition, you can configure the width of the output vector to be a single pixel, a line, or an entire frame. The block returns control signals in vectors of the same width as the pixel data. This optimization makes more efficient use of the communication link between the FPGA board and your Simulink® simulation when using FPGA-in-the-loop (FIL). To run FPGA-in-the-loop, you must have an HDL Verifier™ license.

When you generate a programming file for a FIL target in Simulink, the tool creates a model to compare the FIL simulation with your Simulink design. For Vision HDL Toolbox designs, the FIL block in that model replicates the pixel-streaming interface to send one pixel at a time to the FPGA. You can modify the autogenerated model to use the

FIL Frame To Pixels and FIL Pixels To Frame blocks to improve the bandwidth of the communication with the FPGA board by sending one frame at a time. For how to modify the auto-generated model, see “FPGA-in-the-Loop”.

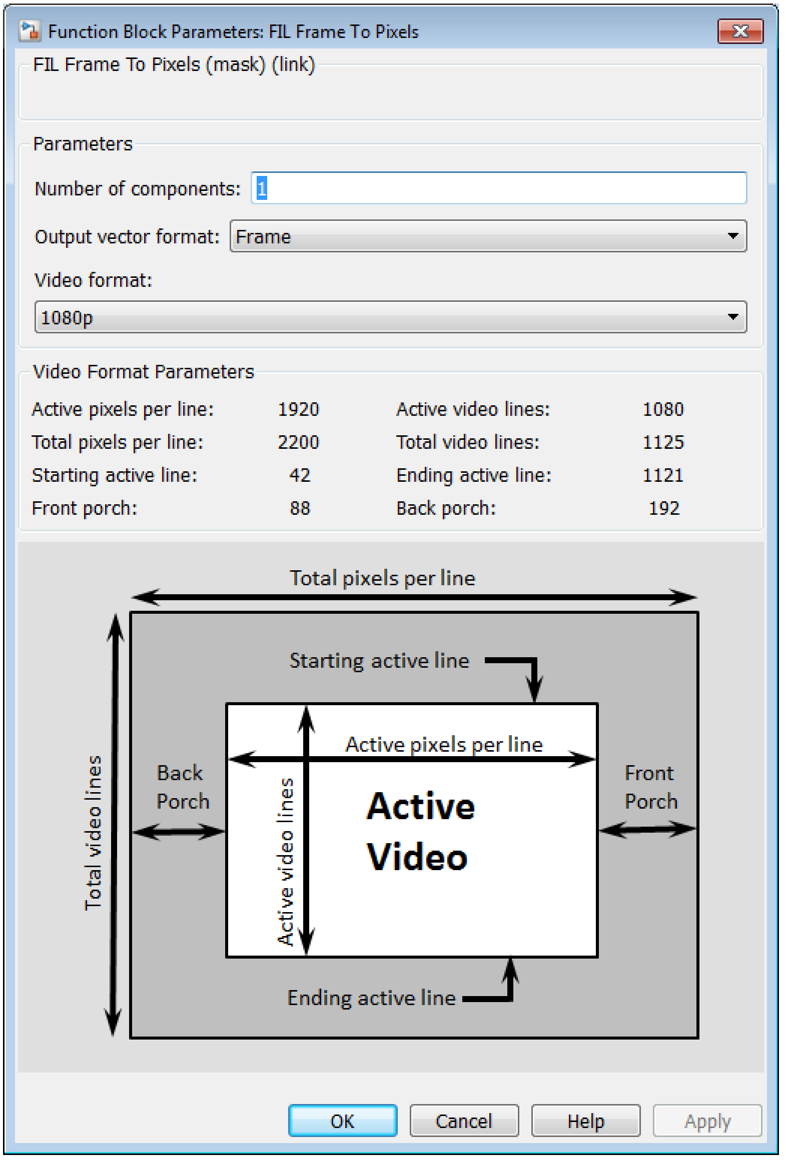
Specify the same video format and vector size for the FIL Frames To Pixels block and the FIL Pixels To Frame block.

Signal Attributes

Port	Direction	Description	Data Type
`matrix`	Input	Full image, specified as an **Active pixels per line**-by-**Active video lines**-by-*N* matrix. The height and width are the dimensions of the active image specified in **Video format**. *N* is the **Number of components** used to express a single pixel.	• `uint` or `int` • `fixdt()` • `boolean` • `double` or `single`
`data1,...,da`	Output	Image pixels, returned as a vector of *M* values, where *M* is the width of the **Output vector format**. There are *N* data ports, where *N* is the **Number of components**.	Specified by **Data type**
`hStartOut`	Output	Control signal indicating whether each pixel is the first pixel in a horizontal line of a frame, returned as a vector of *M* values.	`boolean`
`hEndOut`	Output	Control signal indicating whether each pixel is the last pixel in a horizontal line of a frame, returned as a vector of *M* values.	`boolean`
`vStartOut`	Output	Control signal indicating whether each pixel is the first pixel in the first (top) line of a frame, returned as a vector of *M* values.	`boolean`
`vEndOut`	Output	Control signal indicating whether each pixel is the last pixel in the last (bottom) line of a frame, returned as a vector of *M* values.	`boolean`

Port	Direction	Description	Data Type
validOut	Output	Control signal indicating the validity of the output pixel, returned as a vector of M values.	boolean

Dialog Box and Parameters



Number of components

Component values of each pixel. The pixel can be represented by 1, 3, or 4 components. Set to 1 for grayscale video. Set to 3 for color video, for example, {R,G,B} or {Y,Cb,Cr}. Set to 4 to use color with an alpha channel for transparency. The output is an **Active pixels per line**-by-**Active video lines**-by-**Number of components** image matrix.

Data type

Output pixel data type. The default is `uint8`.

Output vector format

Size of the vector used to communicate with the FPGA subsystem. The block outputs pixels and control signals in vectors of the same length. The block calculates the length of the vectors based on the **Video format** parameter.

- `Pixel` — Output scalar values for pixel and control signals.
- `Line` — Output vectors contain **Total pixels per line** values.
- `Frame` — Output vectors contain **Total pixels per line** × **Total video lines** values.

A larger value results in faster communication between the FPGA board and Simulink. Choose the largest option that is supported by the I/O and memory resources on your board.

Video format

Dimensions of active and inactive regions of a video frame. To select a predefined format, use the **Video format** list. For a custom format, select `Custom`, and then specify the dimensions as integers.

Video Format	Active Pixels Per Line	Active Video Lines	Total Pixels Per Line	Total Video Lines	Starting Active Line	Front Porch
240p	320	240	402	324	1	44
480p	640	480	800	525	36	16
480pH	720	480	858	525	33	16
576p	720	576	864	625	47	12
720p	1280	720	1650	750	25	110
768p	1024	768	1344	806	10	24
1024p	1280	1024	1688	1066	42	48

Video Format	Active Pixels Per Line	Active Video Lines	Total Pixels Per Line	Total Video Lines	Starting Active Line	Front Porch
1080p (default)	1920	1080	2200	1125	42	88
1200p	1600	1200	2160	1250	50	64
2KCinema	2048	1080	2750	1125	42	639
4KUHDTV	3840	2160	4400	2250	42	88
8KUHDTV	7680	4320	8800	4500	42	88
Custom	User-defined	User-defined	User-defined	User-defined	User-defined	User-defined

Note: When using a custom format, the values you enter for the active and inactive dimensions of the image must add up to the total frame dimensions.

For the horizontal direction, **Total pixels per line** must be greater than or equal to **Front porch** + **Active pixels per line**. The block calculates **Back porch** = **Total pixels per line** − **Front porch** − **Active pixels per line**.

For the vertical direction, **Total video lines** must be greater than or equal to **Starting active line** + **Active video lines** − 1. The block calculates **Ending active line** = **Starting active line** + **Active video lines** − 1.

If you specify a format that does not conform to these rules, the block reports an error.

See Also

FIL Pixels To Frame | Frame To Pixels

More About

- "Streaming Pixel Interface"
- "FPGA Verification"

Introduced in R2015a

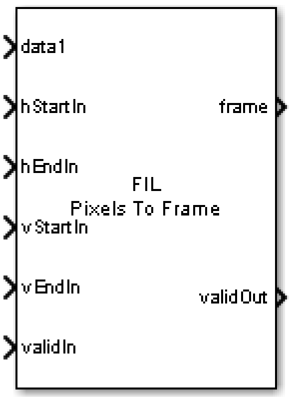
FIL Pixels To Frame

Convert pixel stream from FPGA-in-the-loop to full-frame video

Library

visionhdlio

Description



FIL Pixels To Frame

The FIL Pixels To Frame block performs the same pixel-to-frame conversion as the Pixels To Frame block. In addition, you can configure the width of the input to be a single pixel, a line, or an entire frame per step. The block expects control signal input vectors of the same width as the pixel data. This optimization can speed up the communication link between the FPGA board and your Simulink simulation when using FPGA-in-the-loop. To run FPGA-in-the-loop, you must have an HDL Verifier license.

When you generate a programming file for a FIL target in Simulink, the tool creates a model to compare the FIL simulation with your Simulink design. For Vision HDL Toolbox designs, the FIL block in that model replicates the pixel-streaming interface to send one pixel at a time to the FPGA. You can modify the autogenerated model to use the

FIL Frame To Pixels and FIL Pixels To Frame blocks to improve the bandwidth of the communication with the FPGA board by sending one frame at a time. For how to modify the auto-generated model, see “FPGA-in-the-Loop”.

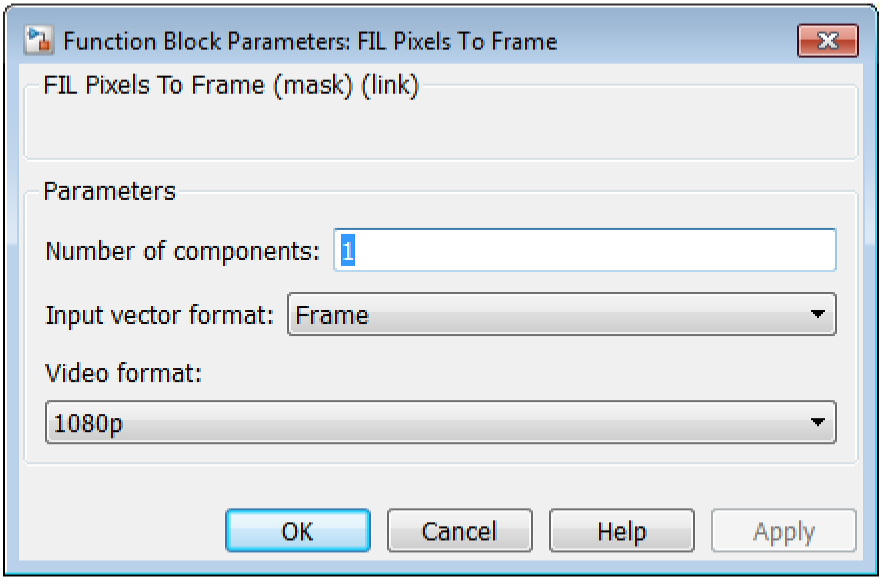
Specify the same video format for the FIL Frames To Pixels block and the FIL Pixels To Frame block.

Signal Attributes

Port	Direction	Description	Data Type
data1,...,da	Input	Image pixels, specified as a vector of *M* values, where *M* is the width of the **Output vector format**. There are *N* data ports, where *N* is the **Number of components**.	• uint or int • fixdt() • boolean • double or single
hStartIn	Input	Control signal indicating whether each pixel is the first pixel in a horizontal line of an input frame, returned as a vector of *M* values.	boolean
hEndIn	Input	Control signal indicating whether each pixel is the last pixel in a horizontal line of a frame, returned as a vector of *M* values.	boolean
vStartIn	Input	Control signal indicating whether each pixel is the first pixel in the first (top) line of a frame, returned as a vector of *M* values.	boolean
vEndIn	Input	Control signal indicating whether each pixel is the last pixel in the last (bottom) line of a frame, returned as a vector of *M* values.	boolean
validIn	Input	Control signal indicating the validity of the input pixel, returned as a vector of *M* values.	boolean
matrix	Output	Full image, returned as an **Active pixels per line**-by-**Active video lines**-by-*N* matrix. The height and	Same as data1,...,dataN

Port	Direction	Description	Data Type
		width are the dimensions of the active image specified in **Video format**. *N* is the **Number of components** used to express a single pixel.	
`validOut`	Output	True when the output frame is successfully recompiled from the input stream.	`boolean`

Dialog Box and Parameters



Number of components

Component values of each pixel. The pixel can be represented by 1, 3, or 4 components. Set to 1 for grayscale video. Set to 3 for color video, for example, {R,G,B} or {Y,Cb,Cr}. Set to 4 to use color with an alpha channel for transparency. The output is an **Active pixels per line**-by-**Active video lines**-by-**Number of components** image matrix.

Input vector format

Size of the vector used to communicate with the FPGA subsystem. The block accepts input pixels and control signals in vectors of the same length. The block calculates the length of the vectors based on the **Video format** parameter.

- `Pixel` — Accept scalar values for pixel and control signals.
- `Line` — Accept input vectors containing **Total pixels per line** values.
- `Frame` — Accept input vectors containing **Total pixels per line** × **Total video lines** values.

A larger value results in faster communication between the FPGA board and Simulink. Choose the largest option that is supported by the I/O and memory resources on your board.

Video format

Dimensions of active and inactive regions of a video frame. To select a predefined format, use the **Video format** list. For a custom format, select `Custom`, and then specify the dimensions as integers.

Video Format	Active Pixels Per Line	Active Video Lines
240p	320	240
480p	640	480
480pH	720	480
576p	720	576
720p	1280	720
768p	1024	768
1024p	1280	1024
1080p (default)	1920	1080
1200p	1600	1200
2KCinema	2048	1080
4KUHDTV	3840	2160
8KUHDTV	7680	4320
Custom	User-defined	User-defined

See Also

FIL Frame To Pixels | Pixels To Frame

More About

- “Streaming Pixel Interface”
- “FPGA Verification”

Introduced in R2015a

Frame To Pixels

Convert full-frame video to pixel stream

Library

visionhdlio

Description

The Frame To Pixels block converts color or grayscale full-frame video to a pixel stream and control signals. The control signals indicate the validity of each pixel and its location in the frame. The pixel stream format can include padding pixels around the active frame. You can configure the frame and padding dimensions by selecting a common video format or specifying custom dimensions. See "Streaming Pixel Interface" for details of the pixel stream format.

Use this block to generate input for a subsystem targeted for HDL code generation. This block does not support HDL code generation.

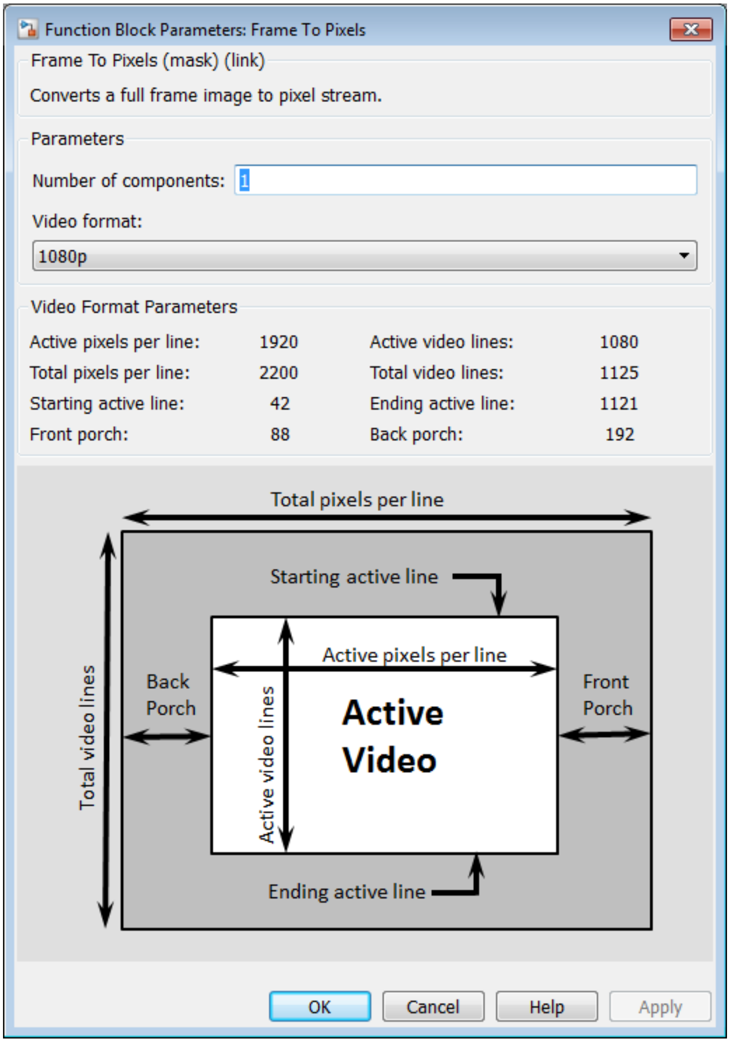
If your model converts frames to a pixel stream and later converts the stream back to frames, specify the same video format for the Frame To Pixels block and the Pixels To Frame block.

Signal Attributes

Port	Direction	Description	Data Type
`frame`	Input	Full image specified as a **Active pixels per line**-by-**Active video lines**-by-*N* matrix. Height and width	• `uint` or `int` • `fixdt()`

Port	Direction	Description	Data Type
		are the dimensions of the active image specified in **Video format**. *N* is the **Number of components** used to express a single pixel.	• `boolean` • `double` or `single`
`pixel`	Output	Single image pixel returned as a vector of 1-by-**Number of components** values.	Specified by **Data type**
`ctrl`	Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See “Pixel Control Bus”.	`pixelcontrol`

Dialog Box and Parameters



Number of components

Component values of each pixel. The pixel can be represented by 1, 3, or 4 components. Set to 1 for grayscale video. Set to 3 for color video, for example, {R,G,B} or {Y,Cb,Cr}. Set to 4 to use color with an alpha channel for transparency. The output is an **Active pixels per line**-by-**Active video lines**-by-**Number of components** image matrix.

Data type

Output pixel data type. The default is `uint8`.

Video format

Dimensions of active and inactive regions of a video frame. To select a predefined format, use the **Video format** list. For a custom format, select `Custom`, and then specify the dimensions as integers.

Video Format	Active Pixels Per Line	Active Video Lines	Total Pixels Per Line	Total Video Lines	Starting Active Line	Front Porch
`240p`	320	240	402	324	1	44
`480p`	640	480	800	525	36	16
`480pH`	720	480	858	525	33	16
`576p`	720	576	864	625	47	12
`720p`	1280	720	1650	750	25	110
`768p`	1024	768	1344	806	10	24
`1024p`	1280	1024	1688	1066	42	48
`1080p` (default)	1920	1080	2200	1125	42	88
`1200p`	1600	1200	2160	1250	50	64
`2KCinema`	2048	1080	2750	1125	42	639
`4KUHDTV`	3840	2160	4400	2250	42	88
`8KUHDTV`	7680	4320	8800	4500	42	88
`Custom`	User-defined	User-defined	User-defined	User-defined	User-defined	User-defined

Note: When using a custom format, the values you enter for the active and inactive dimensions of the image must add up to the total frame dimensions.

For the horizontal direction, **Total pixels per line** must be greater than or equal to **Front porch** + **Active pixels per line**. The block calculates **Back porch** = **Total pixels per line** − **Front porch** − **Active pixels per line**.

For the vertical direction, **Total video lines** must be greater than or equal to **Starting active line** + **Active video lines** − 1. The block calculates **Ending active line** = **Starting active line** + **Active video lines** − 1.

If you specify a format that does not conform to these rules, the block reports an error.

See Also

`visionhdl.FrameToPixels` | Pixels To Frame

More About

- "Streaming Pixel Interface"

Introduced in R2015a

Gamma Corrector

Apply or remove gamma correction

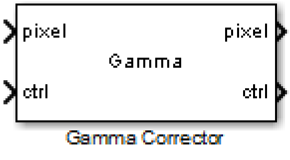
Library

visionhdlconversions

Description

Gamma Corrector applies or removes gamma correction on a stream of pixels. Gamma correction adjusts linear pixel values so that the modified values fit a curve. The de-gamma operation performs the opposite operation to obtain linear pixel values.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.

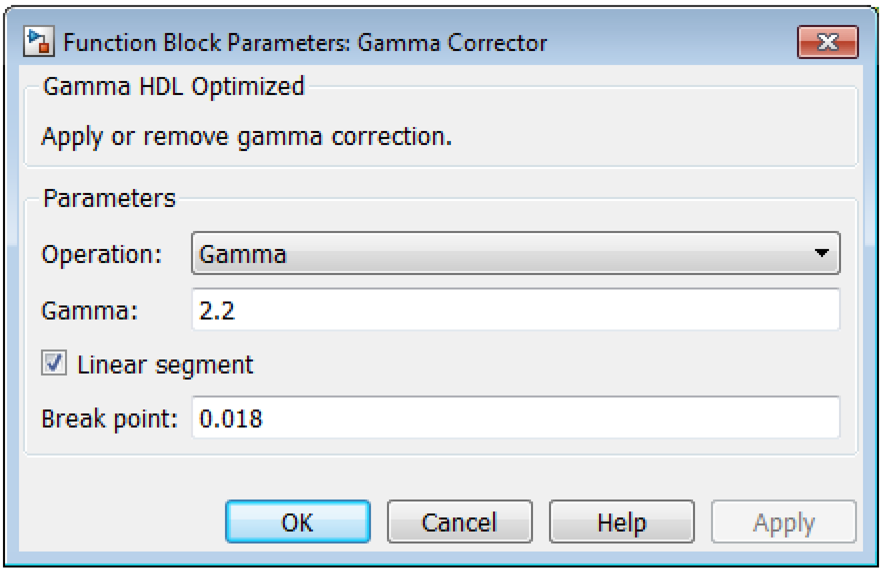


Signal Attributes

Port	Direction	Description	Data Type
pixel	Input/ Output	Single image pixel, specified as a scalar value. The data type of the output is the same as the data type of the input.	• uint8 or uint16 • int8 or int16

Port	Direction	Description	Data Type
			• `fixdt(0,N,M)`, $N + M \leq 16$ `double` and `single` data types are supported for simulation but not for HDL code generation.
`ctrl`	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See “Pixel Control Bus”.	`pixelcontrol`

Dialog Box and Parameters



Operation

Direction of pixel value adjustment.

- `Gamma` (default) — Apply gamma correction.

- `De-gamma` — Remove gamma correction.

Gamma

Target gamma value, specified as a scalar greater than or equal to 1.

- When you set **Operation** to `Gamma`, specify **Gamma** as the target gamma value of the output video stream.
- When you set **Operation** to `De-gamma`, specify **Gamma** as the gamma value of the input video stream.

The default value is `2.2`.

Linear segment

Option to include a linear segment in the gamma curve. When you select this check box, the gamma curve has a linear portion near the origin. By default, this check box is selected.

Break point

Pixel value that corresponds to the point where the gamma curve and linear segment meet. Specify **Break point** as a scalar value between 0 and 1, exclusive. This parameter applies only when you select the **Linear segment** check box.

The default value is `0.018`.

Algorithm

For the equations used for gamma correction, see Gamma Correction in the Computer Vision System Toolbox™ documentation.

To save hardware resources, the block implements the gamma correction equation as a lookup table. The lookup table maps each input pixel value to a corrected output value.

Latency

The latency of the Gamma Corrector block is 2 cycles.

See Also

`visionhdl.GammaCorrector` | Frame To Pixels | Gamma Correction

Related Examples

- "Gamma Correction"

Introduced in R2015a

Histogram

Frequency distribution

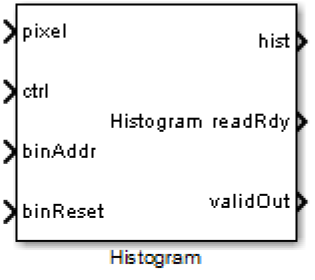
Library

visionhdlstatistics

Description

The Histogram block computes the frequency distribution of pixel values in a video stream. You can configure the number and size of the bins. The block provides a read interface for accessing each bin. The block keeps a running histogram until you reset the bin values.

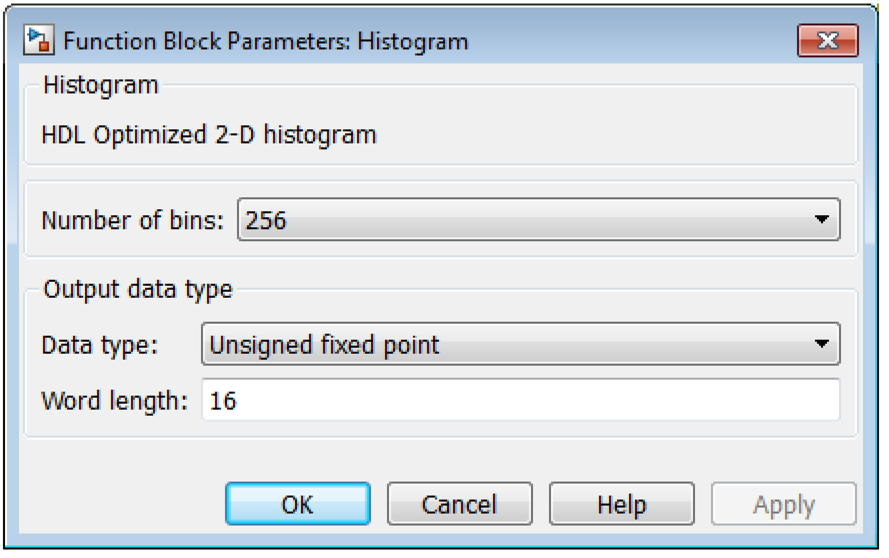
This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.



Signal Attributes

Port	Direction	Description	Data Type
pixel	Input	Single image pixel, specified as an unsigned integer scalar.	• uint • fixdt(0,N,0) double and single data types are supported for simulation but not for HDL code generation.
ctrl	Input	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	pixelcontrol
binAddr	Input	Bin number for reading histogram values. The block captures this value each cycle that readRdy is true.	fixdt(0,N,0), N = 5,6,...,10. Word length must be $\log_2$(**Number of bins**).
binReset	Input	Triggers RAM initialization sequence when true.	boolean
readRdy	Output	Indicates true when histogram is ready for read.	boolean
hist	Output	Histogram value corresponding to a binAddr request, returned as a scalar.	fixdt(0,N,0) double and single data types are supported for simulation but not for HDL code generation.
validOut	Output	Indicates true when dataOut is available.	boolean

Dialog Box and Parameters



Number of bins

Number of bins for the histogram.

Choose the number of bins depending on the input word length (WL). If the number of bins is less than 2^{WL}, the block truncates the least-significant bits of each pixel. If the number of bins is greater than 2^{WL}, the block warns about an inefficient use of hardware resources. The default is 256.

Data type

Data type of the histogram bin values.

- `double`
- `single`
- `Unsigned fixed point` (default)

`double` and `single` data types are supported for simulation but not for HDL code generation.

Word length

Word length of the histogram bins when **Data type** is `Unsigned fixed point`. If a bin overflows, the count saturates and the block shows a warning. The default is 16.

Algorithm

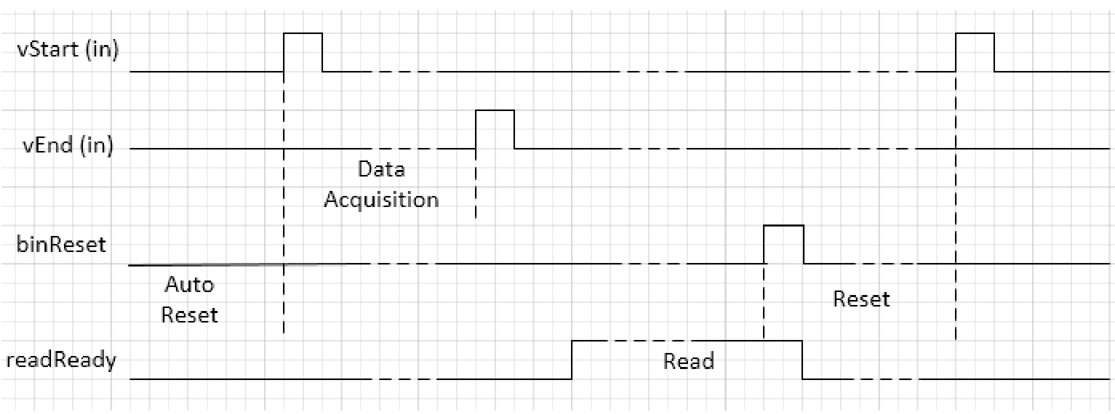
RAM Reset and Ready Sequence

At startup, you must wait **Number of bins** cycles for the block to reset the RAM, before sending input data. This initial reset happens without asserting `binReset`.

You cannot read histogram bins and apply pixel data at the same time. When you want to read the bin values, wait for `readRdy` and then apply each bin address of interest. The block provides the corresponding histogram values on the `dataOut` port, with accompanying `validOut` signal.

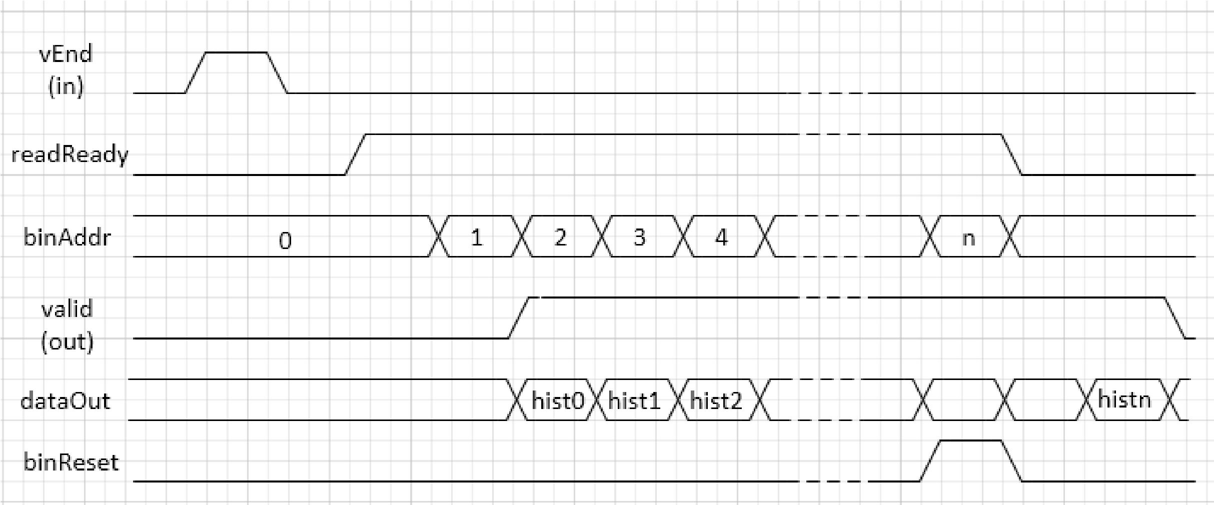
The histogram values persist and accumulate across frames until you assert `binReset`. When you assert `binReset`, the block takes **Number of bins** cycles to clear the RAM and be ready for new input. Other input signals are ignored during reset.

The diagram shows an overview of the reset sequence. `vStart` and `vEnd` are control signals in the `pixelcontrol` input bus.



The diagram shows the automatic startup reset, followed by a frame of video input. The read window starts when `readReady` is asserted. The `binReset` signal initiates a bin reset. The next input frame is not applied until after the reset is complete.

The diagram illustrates a bin read sequence. vEnd is a control signal in the pixelcontrol input bus. valid is a control signal in the pixelcontrol output bus.



After the last pixel of a video frame, indicated by vEnd = true, the block asserts readRdy to show that the histogram is ready for reading. Two cycles after applying a bin address, the block provides the value of that bin on dataOut, with a corresponding valid signal. You can request the last bin address and assert binReset at the same time.

Latency

The block sets readRdy to true 2 cycles after receiving the last pixel of a frame. The input pixelcontrol bus indicates the last pixel of a frame by vEnd = true. While readRdy is true, the block captures binAddr requests on each cycle. The block provides the corresponding histogram bin values on dataOut two cycles later.

See Also

visionhdl.Histogram | 2-D Histogram | Frame To Pixels | imhist

Related Examples

- “Histogram Equalization”

Introduced in R2015a

Image Filter

2-D FIR filtering

Library

visionhdlfilters

Description

The Image Filter block performs two-dimensional FIR filtering on a pixel stream.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.

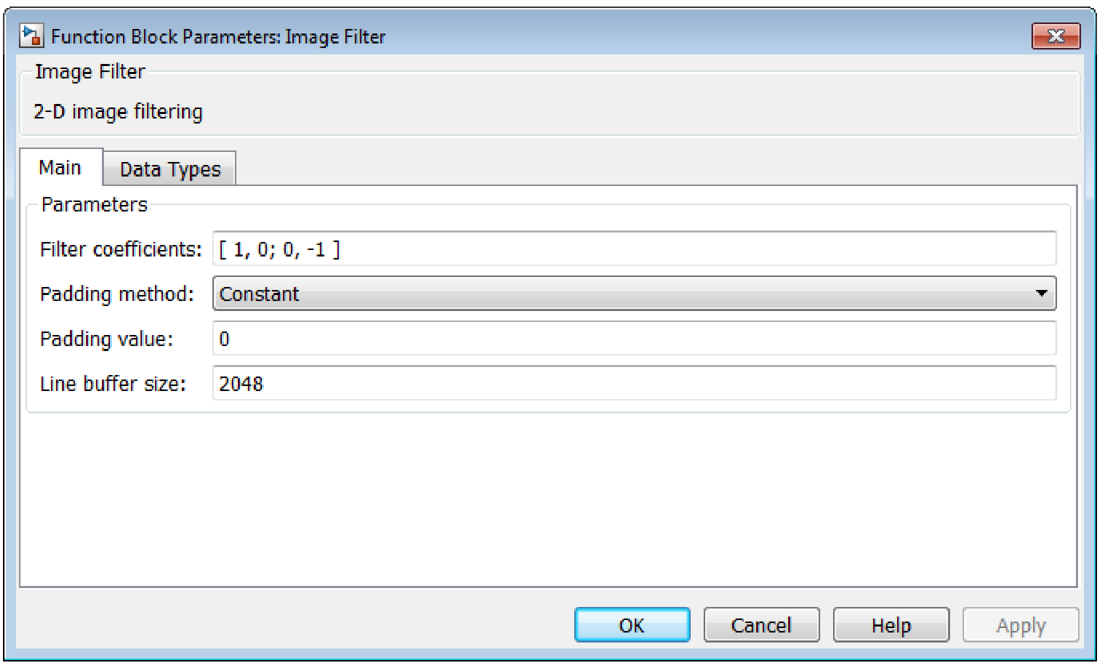
Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input	Single pixel, specified by a scalar value.	• `uint` or `int` • `fixdt()` `double` and `single` data types are supported for simulation but not for HDL code generation.

Port	Direction	Description	Data Type
ctrl	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See “Pixel Control Bus”.	pixelcontrol
pixel	Output	Single pixel, returned as a scalar value. You can specify the output data type in the block mask.	• uint or int • fixdt() double and single data types are supported for simulation but not for HDL code generation.

Dialog Box and Parameters

Main



Filter coefficients

Coefficients of the desired filter, specified as a vector or matrix of any numeric type.

The maximum size along any dimension of a matrix or vector is 16.

Padding method

Method for padding the boundary of the input image.

- `Constant` (default) — Interpret pixels outside the image frame as having a constant value.
- `Replicate` — Repeat the value of pixels at the edge of the image.
- `Symmetric` — Pad input matrix with its mirror image.

Padding value

Constant value used to pad the boundary of the input image.

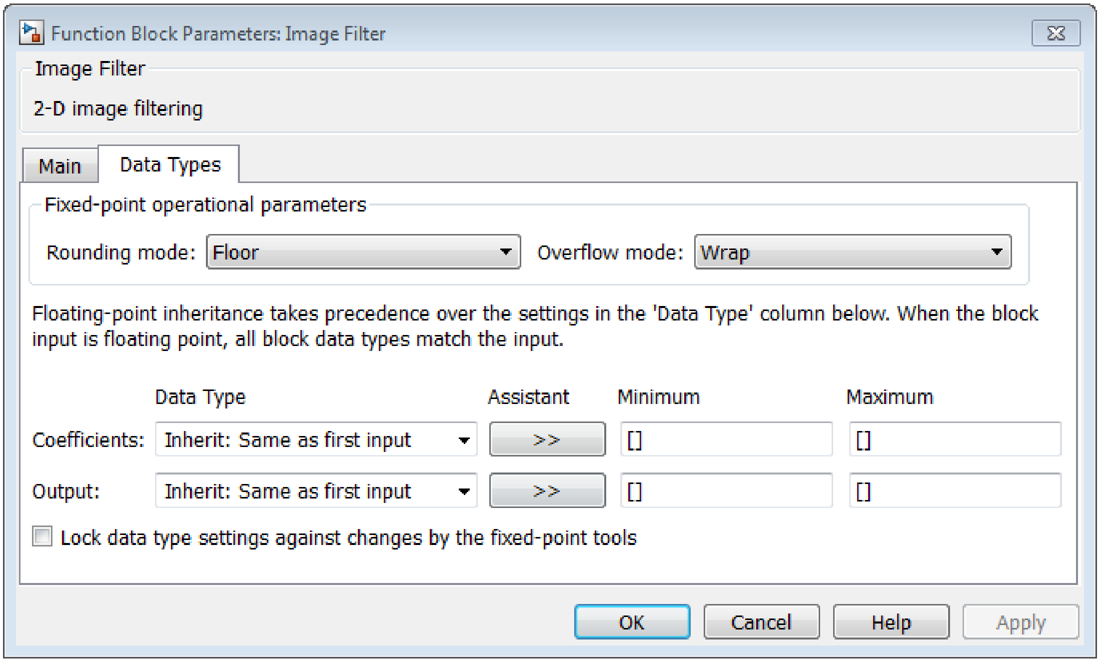
This parameter is visible when you set **Padding method** to `Constant`. The block casts this value to the same data type as the input pixel. The default value is 0.

Line buffer size

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the block uses the next largest power of two. The block allocates *coefficient rows - 1*-by-**Line buffer size** memory locations to store the pixels. The default value is 2048.

Data Types



Rounding mode

Rounding mode for fixed-point operations.

Overflow mode

Overflow mode for fixed-point operations.

Coefficients Data Type

Method for determining the data type of the filter coefficients.

The default is `Inherit: Same as first input`.

The filter coefficients do not obey the **Rounding mode** and the **Overflow mode** parameters; instead, they are always saturated and rounded to Nearest.

Output Data Type

Method for determining the data type of the output pixels.

The default is `Inherit: Same as first input`.

Lock output data type setting against changes by the fixed-point tools

The Fixed-Point Tool automatically changes the scaling for model objects that specify fixed-point data types. However, if this option is selected, the tool refrains from scaling that object. See “Fixed-Point Tool”.

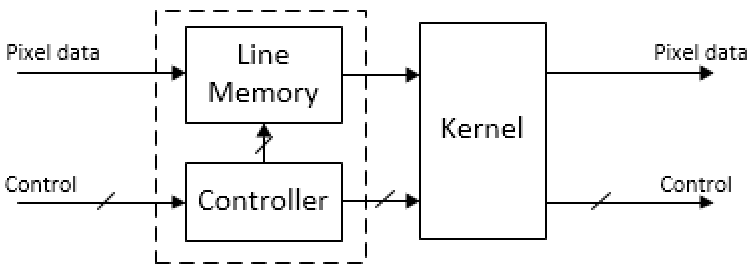
Algorithm

The block implements the filter with a fully-pipelined architecture. Each multiplier has two pipeline stages on each input and two pipeline stages on the output. The adder is a pipelined tree structure. HDL code generation takes advantage of symmetric, unity, or zero-value coefficients to reduce the number of multipliers.

You can optimize the multipliers for HDL code generation using canonical signed digit (CSD) or factored CSD. Right-click on the block and select **HDL Code** > **HDL Properties** and set the **ConstMultiplierOptimization** parameter.

Latency

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Use the output control signals to determine when the output pixels are valid.



The latency of the kernel varies depending on the coefficients you choose.

See Also

`visionhdl.ImageFilter` | 2-D FIR Filter | Frame To Pixels

Introduced in R2015a

Image Statistics

Mean, variance, and standard deviation

Library

visionhdlstatistics

Description

The Image Statistics block calculates the mean, variance, and standard deviation of streaming video data. Each calculation is performed over all pixels in the input region of interest (ROI). The block implements the calculations using hardware-efficient algorithms.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see "Streaming Pixel Interface".

- To change the size and dimensions of the ROI, you can manipulate the input video stream control signals. See "Regions of Interest" on page 1-69.
- The number of valid pixels in the input image affect the accuracy of the mean approximation. To avoid approximation error, use an image that contains fewer than 64 pixels, or a multiple of 64 pixels. For details of the mean approximation, see "Algorithm" on page 1-66.

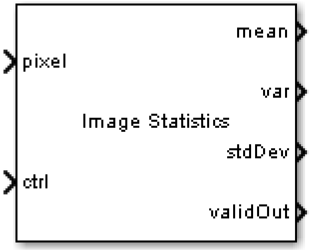


Image Statistics

Signal Attributes

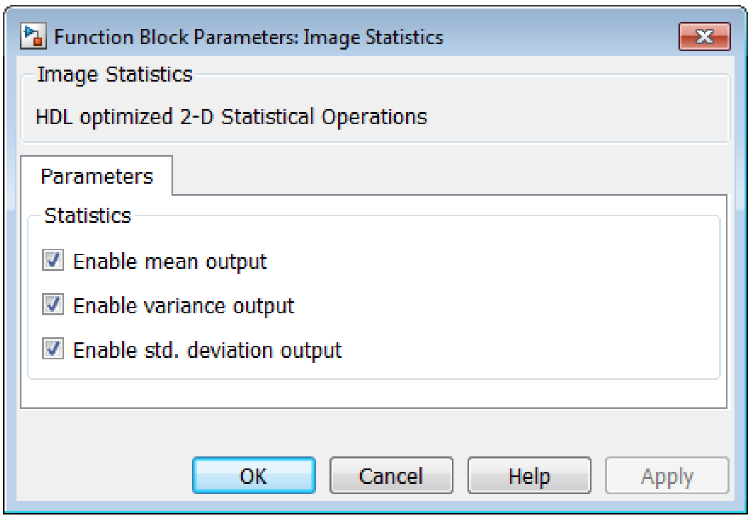
Port	Direction	Description	Data Type
pixel	Input	Single image pixel specified as a scalar value.	• uint8/uint16 • fixdt(0,N,0), N = 8,9,...,16 double and single data types are supported for simulation but not for HDL code generation.
ctrl	Input	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	pixelcontrol
mean	Output	Mean of the most recent input frame completed.	Same as pixel
var	Output	Variance of the most recent input frame completed.	Same as pixel
stdDev	Output	Standard deviation of the most recent input frame completed.	Same as pixel
validOut	Output	Computations completed. The block sets this output to true when the statistic outputs for a frame are ready.	boolean

Note: The block uses full-precision arithmetic for internal calculation. At the output, intermediate data is cast back to the input type using the following fixed-point settings: `RoundingMethod` = `Nearest`, and `OverflowAction` = `Saturate`. The table shows the output word length for each calculation, relative to the input word length (IWL).

Mean	Variance	Std. Deviation
IWL	2×IWL	2×IWL

Dialog Box and Parameters

Main



Enable mean output

Select this check box to calculate the mean of each input frame. If you clear this check box, the `mean` output does not show on the block.

Enable variance output

Select this check box to calculate the variance of each input frame. If you clear this check box, the `var` output does not show on the block.

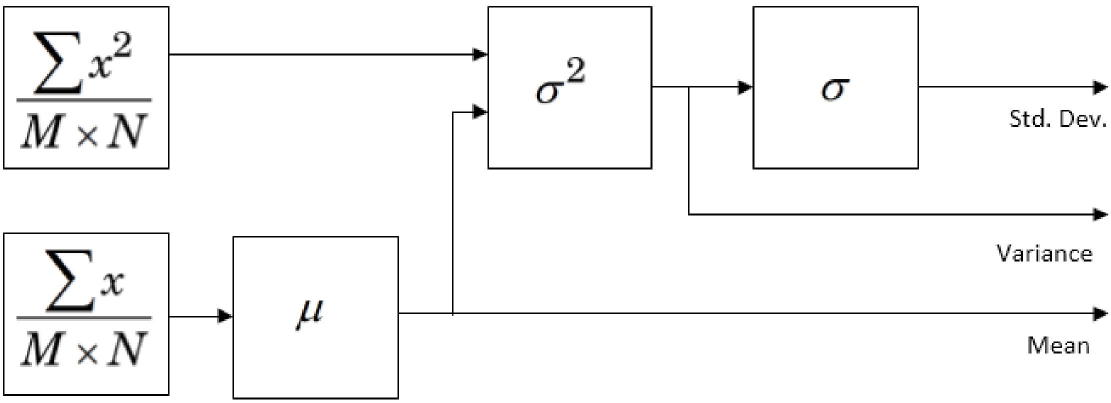
Enable std. deviation

Select this check box to calculate the standard deviation of each input frame. If you clear this check box, the `stdDev` output does not show on the block.

Algorithm

Architecture

The calculations of mean, variance, and standard deviation build off each other. For hardware efficiency, the calculation logic is shared as shown.



Mean

The equation to calculate the precise mean pixel value requires large internal word lengths and expensive division logic.

$$\mu = \frac{1}{M * N} \sum_{i=1}^{M} \sum_{j=1}^{N} x_{ij}$$

Instead of using this equation, the block calculates the mean by a series of three accumulators that compute the mean of a segment of pixels. First, find the sum of a window of 64 pixels, and normalize.

$$\mu_{L_1} = \frac{1}{64} \sum_{n=1}^{64} x_n$$

Then accumulate 64 of the previous windows, and normalize.

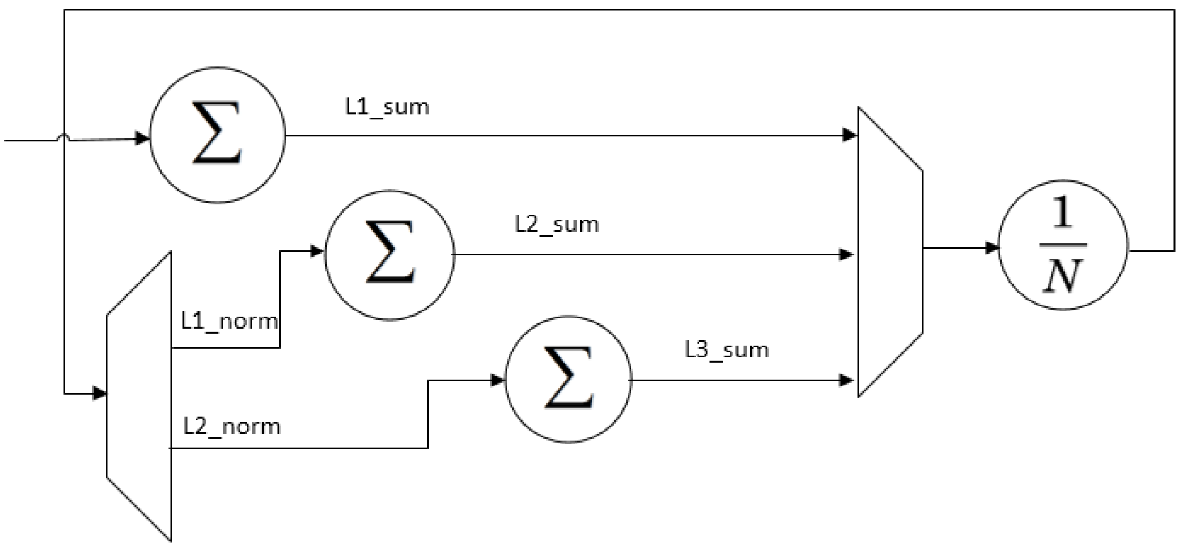
$$\mu_{L_2} = \frac{1}{64}\sum_{n=1}^{64} \mu_{nL_1}$$

A third accumulator sums 64 of the 64×64 windows, and normalizes the same way.

$$\mu_{L_3} = \frac{1}{64}\sum_{n=1}^{64} \mu_{nL_2}$$

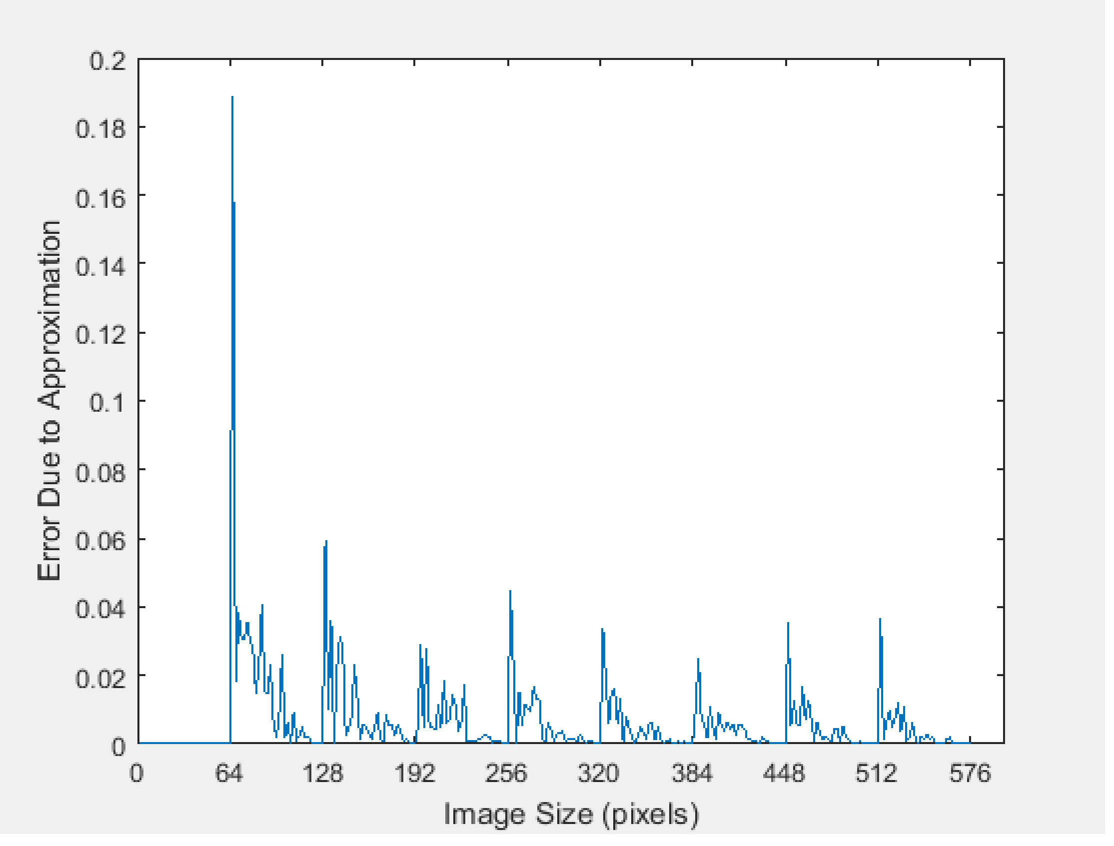
Each valid pixel is accumulated as it arrives. Its location within a line or frame does not affect the accumulation logic.

When vEnd is received, the block promotes any remaining data in the three levels of mean calculation to calculate the final output. If an accumulator counter is not at 64 when vEnd arrives, that level normalizes by the actual value of the counter. The constants for this multiplication are in a lookup table (LUT). The three accumulators share a single LUT and multiplier.



This method of mean calculation is accurate when the frame includes a multiple of 64 pixels, because vEnd aligns with the accumulator rollovers. This method is also accurate when the frame has fewer than 64 pixels, because only the first accumulator is needed.

However, when the number of pixels in the frame is not a multiple of 64, the block must promote the final accumulation to the next level before the counter reaches 64. This promotion introduces an error in the normalization calculation at subsequent levels. The figure shows the normalization error introduced in the mean calculation by various image sizes. The spikes occur where an image size is just over a multiple of 64 pixels.



Variance

The block calculates variance of the input pixels using the following equation.

$$\sigma^2 = \left(\frac{1}{M*N}\sum_{i=1}^{M}\sum_{j=1}^{N} x_{ij}^2\right) - \mu^2$$

The mean and the mean of the squared input are calculated in parallel. The block calculates the mean of squares using the same approximation method used to calculate the mean, as described in the previous section.

Standard Deviation

The block calculates the square root of the variance using a pipelined bit-set-and-check algorithm. This algorithm computes the square root using addition and shifts rather than multipliers. For an N-bit input, the result has N bits of accuracy.

This method is hardware efficient for general inputs. If your data has known characteristics that allow for a more efficient square root implementation, you can disable the calculation in this block and construct your own logic from HDL-supported blocks.

Regions of Interest

Statistics are often calculated on small regions of interest (ROI) rather than an entire video frame. This block performs calculations on all pixels between `vStart` and `vEnd` signals in the `ctrl` bus, and does not track pixel location within the frame. You can manipulate the streaming control signals to reduce the size of a frame and delineate the boundaries of a region of interest before passing the video stream to this block. For an example that selects multiple small ROIs from a larger image, see (example link).

The block supports images containing up to 64×64×64 (262,144) pixels. This size represents the number of valid pixels, not the dimensions of the image. If you provide an image with more than 64×64×64 pixels, the block calculates the requested statistics on only the first 262,144 pixels and then asserts `validOut`. The block ignores extra pixels until it receives a `vEnd` signal.

Latency

The latency from `vEnd` to `validOut` depends on the calculations you select.

When the block receives a `vEnd` signal that is `true`, it combines the remaining data in the three levels of mean calculation to calculate the final output. This final step takes 4 cycles per level, resulting in a maximum of 12 cycles of latency between the input `vEnd` signal and the `validOut` signal. Once the mean is available, the variance calculation takes 4 cycles. The square root logic requires input word length (IWL) cycles of latency.

If a calculation is not selected, and is not needed for other selected calculations, that logic is excluded from the generated HDL code.

The table shows the calculation logic and latency for various block configurations.

Mean	Variance	Std. Deviation	Logic Excluded From HDL	Latency (cycles)
✓	✓	✓		[4,8, or 12]+4+IWL
✓			variance and square root	[4,8, or 12] (depending on input size relative to the 64-bit accumulators)
	✓		square root	[4,8, or 12]+4
		✓		[4,8, or 12]+4+IWL
✓	✓		square root	[4,8, or 12]+4
✓		✓		[4,8, or 12]+4+IWL
	✓	✓		[4,8, or 12]+4+IWL

Note: There must be at least 12 cycles between the `vEnd` signals on the input. This timing restriction enables the block to finish processing the current frame before the new one arrives.

See Also

`visionhdl.ImageStatistics` | 2-D Standard Deviation | 2-D Mean | 2-D Variance | Frame To Pixels

Related Examples

- "Multi-Zone Metering"

Introduced in R2015a

Lookup Table

Map input pixel to output pixel using custom rule

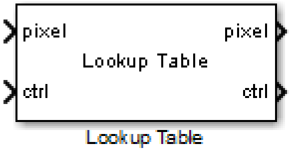
Library

visionhdlconversions

Description

The Lookup Table block provides a custom one-to-one map between input pixel values and output pixel values.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.



Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input	Single image pixel, specified as a scalar value.	• `boolean` • `uint8` or `uint16` • `fixdt(0,N,M)`, $N+M \leq 16$

Port	Direction	Description	Data Type
`ctrl`	Input/Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	`pixelcontrol`
`pixel`	Output	Single image pixel, returned as a scalar value.	Specified by **Table data**. `double` and `single` data types are supported for simulation but not for HDL code generation.

Dialog Box and Parameters

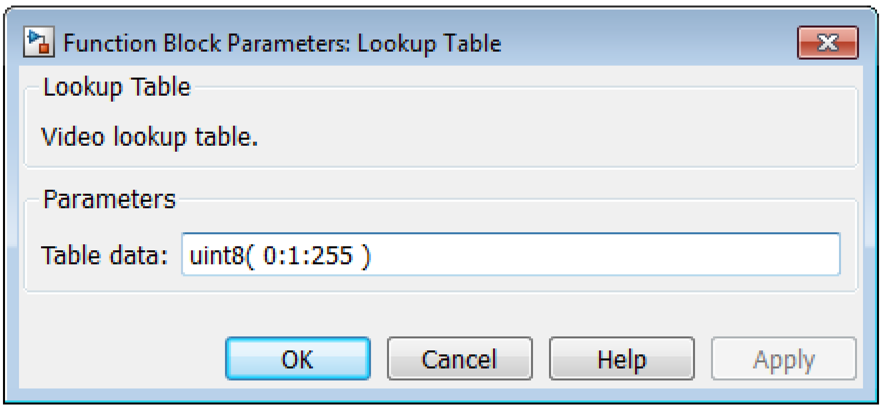


Table data

Determines the one-to-one correspondence between an input `pixel` value and an output `pixel` value.

- The table data is a row or column vector of any data type. The data type of the table data determines that of the output `pixel`.
- The length of the vector must be $2^{WordLength}$, where *WordLength* is the size, in bits, of the input `pixel`.
- The smallest representable value of the input data type maps to the first element of the table, the second smallest value maps to the second element, and so on. For

example, if the input `pixel` has a data type of `fixdt(0,3,1)`, the input value 0 maps to the first element of the table, 0.5 maps to the second element, 1 maps to the third, and so on.

The default value is `uint8(0:1:255)`.

Algorithm

Latency

The latency of the Lookup Table block is 2 cycles.

See Also

`visionhdl.LookupTable` | Frame To Pixels

Introduced in R2015a

Median Filter

2-D median filtering

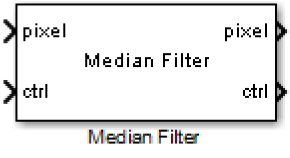
Library

visionhdlfilter

Description

Median Filter replaces each pixel with the median value of the surrounding *N*-by-*N* neighborhood. The median is less sensitive to extreme values than the mean. Use this block to remove salt-and-pepper noise from an image without significantly reducing the sharpness of the image. You can specify the neighborhood size and the padding values for the edges of the input image.

This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see "Streaming Pixel Interface".

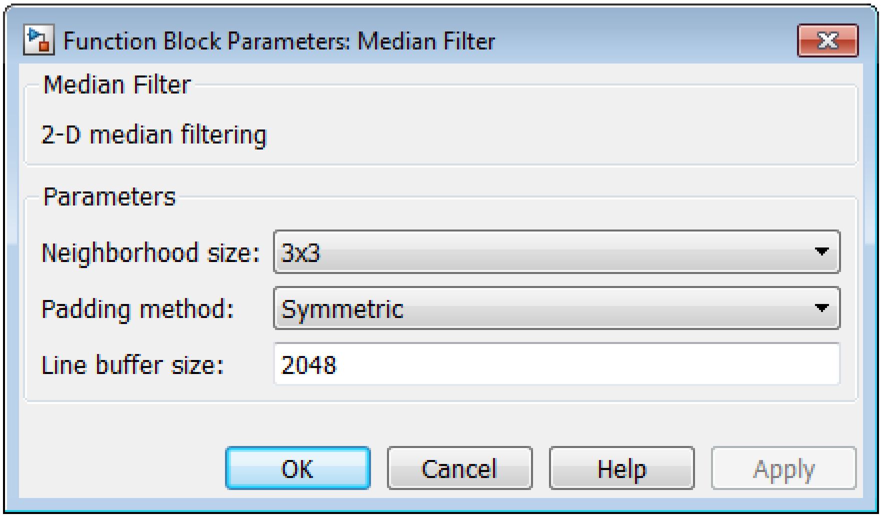


Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input/Output	Single image pixel, specified as a scalar integer value. The data	• `uint` or `int` • `fixdt(~,N,0)`

Port	Direction	Description	Data Type
		type of the output is the same as the data type of the input.	• boolean double and single data types are supported for simulation but not for HDL code generation.
ctrl	Input/Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See “Pixel Control Bus”.	pixelcontrol

Dialog Box and Parameters



Neighborhood size

Size in pixels of the image region used to compute the median.

- 3×3 (default)
- 5×5
- 7×7

Padding method

Method for padding the boundary of the input image.

- `Constant` — Pad input matrix with a constant value.
- `Replicate` — Repeat the value of pixels at the edge of the image.
- `Symmetric` (default) — Pad image edge with its mirror image.

Padding value

Constant value used to pad the boundary of the input image.

This parameter is visible when you set **Padding method** to `Constant`. The block casts this value to the same data type as the input pixel. The default value is 0.

Line buffer size

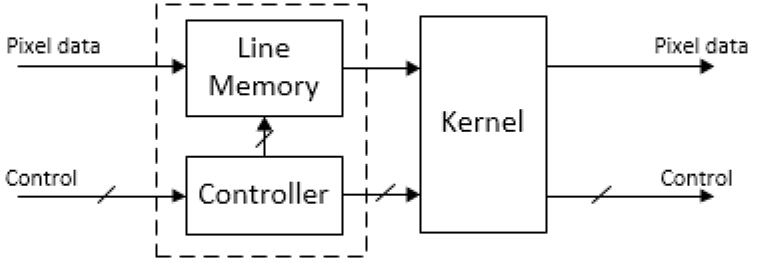
Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The block allocates *N - 1*-by-**Line buffer size** memory locations to store the pixels used to compute the median value. *N* is the dimension of the square region specified in **Neighborhood size**. The default value is 2048.

Algorithm

Latency

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Use the output control signals to determine when the output pixels are valid.



The latency of the filter kernel depends on the neighborhood size as shown in the table.

Neighborhood size	# of Comparisons to Find Median
3×3	11
5×5	75
7×7	230

See Also

`visionhdl.MedianFilter` | Frame To Pixels | Median Filter

Introduced in R2015a

Opening

Morphological open

Library

visionhdlmorph

Description

Opening is a morphological erosion operation, followed by a morphological dilation operation, using the same neighborhood for both calculations. The block operates on a stream of intensity values. The block implements the calculations using hardware-efficient approximations for use with HDL code generation.

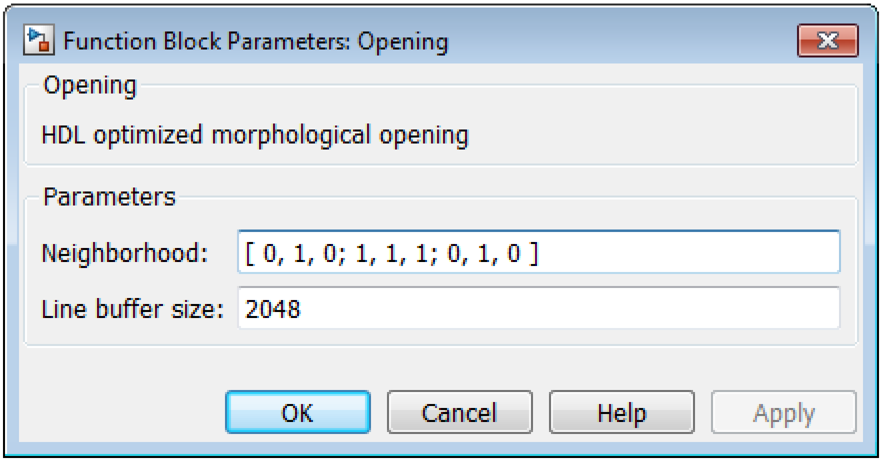
This block uses a streaming pixel interface with a bus for synchronization control signals. This interface enables the block to operate independent of image size and format, and to connect easily with other Vision HDL Toolbox blocks. The block accepts and returns a scalar pixel value and a bus containing five control signals. These signals indicate the validity of each pixel and the location of each pixel in the frame. Use the Frame to Pixels block to convert a pixel matrix into a pixel stream and these control signals. For a full description of the interface, see “Streaming Pixel Interface”.

Signal Attributes

Port	Direction	Description	Data Type
`pixel`	Input/ Output	Single image pixel, specified as a scalar binary value.	`boolean`

Port	Direction	Description	Data Type
ctrl	Input/ Output	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	pixelcontrol

Dialog Box and Parameters



Neighborhood

Neighborhood, specified as a matrix or vector of 1s and 0s.

The block supports neighborhoods up to 32×32 pixels. To use a structuring element, specify the **Neighborhood** as `getnhood(strel(`*`shape`*`))`. The default is `[0,1,0;1,1,1;0,1,0]`.

Line buffer size

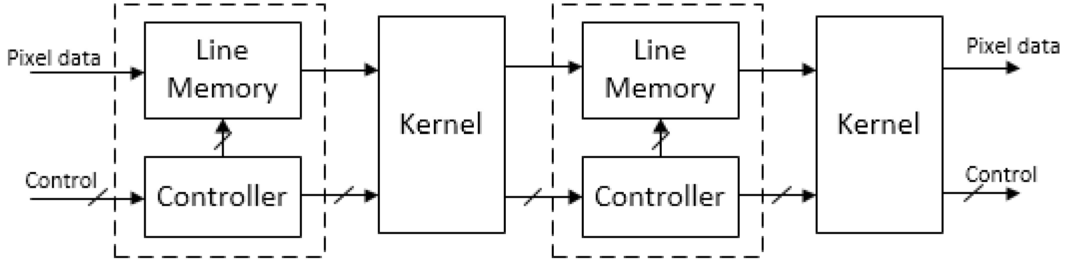
Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the block uses the next largest power of two. The block allocates *neighborhood lines - 1*-by-**Line buffer size** memory locations to store the pixels. The default value is 2048.

Algorithm

Latency

The total latency of the block is the line buffer latency plus the latency of the kernel calculation. Opening is a compound operation. Therefore, this block contains a second line buffer between the erosion kernel and the dilation kernel. Use the output control signals to determine when the output pixels are valid.



See Also

`visionhdl.Opening` | Dilation | Erosion | Frame To Pixels | `getnhood` | Opening | `strel`

Introduced in R2015a

Pixel Control Bus Creator

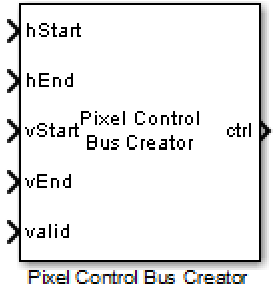
Create control signal bus for use with Vision HDL Toolbox blocks

Library

visionhdlutilities

Description

The Pixel Control Bus Creator block creates a `pixelcontrol` bus. See “Pixel Control Bus”.



The block is an implementation of the Simulink Bus Creator block. See Bus Creator for more information.

See Also

“Streaming Pixel Interface” | Frame To Pixels | Pixels To Frame

Introduced in R2015a

Pixel Control Bus Selector

Select signals from control signal bus used by Vision HDL Toolbox blocks

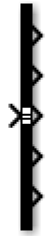
Library

visionhdlutilities

Description

The Pixel Control Bus Selector block selects signals from the `pixelcontrol` bus. See "Pixel Control Bus".

The block is an implementation of the Simulink Bus Selector block. See Bus Selector for more information.



Pixel Control Bus Selector

See Also

"Streaming Pixel Interface" | Frame To Pixels | Pixels To Frame

Introduced in R2015a

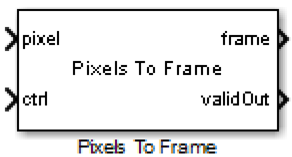
Pixels To Frame

Convert pixel stream to full-frame video

Library

visionhdlio

Description



The Pixels To Frame block converts a color or grayscale pixel stream and control signals to full-frame video. The control signal bus indicates the validity of each pixel and its location within the frame. The pixel stream format can include padding pixels around the active frame. You can configure the frame and padding dimensions by selecting a common video format or specifying custom dimensions. See "Streaming Pixel Interface" for details of the pixel stream format.

Use this block to convert the output of a subsystem targeted for HDL code generation back to frames. This block does not support HDL code generation.

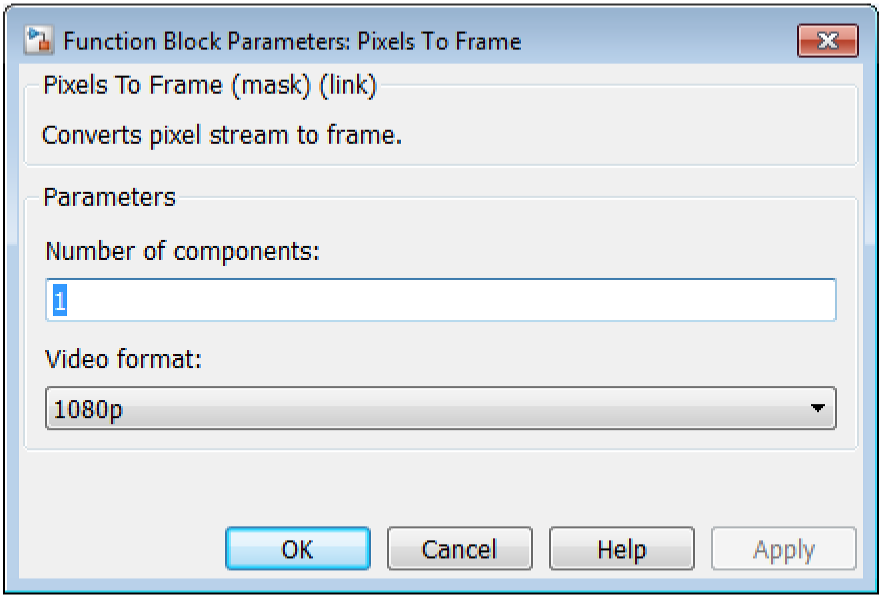
If your model converts frames to a pixel stream and later converts the stream back to frames, specify the same video format for the Frame To Pixels block and the Pixels To Frame block.

Signal Attributes

The Pixels To Frame block has the following input and output ports.

Port	Direction	Description	Data Type
pixel	Input	Single image pixel specified by a vector of 1-by-**Number of components** values.	• uint or int • fixdt() • boolean • double or single
ctrl	Input	Control signals describing the validity of the pixel and the location of the pixel within the frame, specified as a bus containing five signals. See "Pixel Control Bus".	pixelcontrol
frame	Output	Full image returned as a **Active pixels per line**-by-**Active video lines**-by-*N* matrix. Height and width are the dimensions of the active image specified in **Video format**. *N* is the **Number of components** used to express a single pixel.	Same as pixel
validOut	Output	True when the output frame is successfully recompiled from the input stream.	boolean

Dialog Box and Parameters



Number of components

Component values of each pixel. The pixel can be represented by 1, 3, or 4 components. Set to 1 for grayscale video. Set to 3 for color video, for example, {R,G,B} or {Y,Cb,Cr}. Set to 4 to use color with an alpha channel for transparency. The output is an **Active pixels per line**-by-**Active video lines**-by-**Number of components** image matrix.

Video format

Dimensions of active and inactive regions of a video frame. To select a predefined format, use the **Video format** pull-down menu. For a custom format, select `Custom`, then specify the dimensions as integers.

Video Format	Active Pixels Per Line	Active Video Lines
240p	320	240
480p	640	480
480pH	720	480

Video Format	Active Pixels Per Line	Active Video Lines
576p	720	576
720p	1280	720
768p	1024	768
1024p	1280	1024
1080p (default)	1920	1080
1200p	1600	1200
2KCinema	2048	1080
4KUHDTV	3840	2160
8KUHDTV	7680	4320
Custom	User-defined	User-defined

See Also

visionhdl.PixelsToFrame | Frame To Pixels

More About

- "Streaming Pixel Interface"

Introduced in R2015a

2

System Objects — Alphabetical List

visionhdl.ChromaResampler System object

Package: visionhdl

Downsample or upsample chrominance component

Description

`visionhdl.ChromaResampler` downsamples or upsamples a pixel stream.

- Downsampling reduces bandwidth and storage requirements in a video system by combining pixel chrominance components over multiple pixels. You can specify a filter to prevent aliasing, by selecting the default filter or by entering coefficients.
- Upsampling restores a signal to its original rate. You can use interpolation or replication to calculate the extra sample.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

The object accepts luma and the chrominance components. The object does not modify the luma component and applies delay to align with the resampled chrominance outputs. The rate of the output luma component is the same as the input.

Construction

`CR = visionhdl.ChromaResampler` returns a System object™, CR, that downsamples from 4:4:4 to 4:2:2 and applies the default antialiasing filter.

`CR = visionhdl.ChromaResampler(Name,Value)` returns a chroma resampler System object, CR, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

Resampling

Resampling format.

- `4:4:4 to 4:2:2` (default) — Perform a downsampling operation.
- `4:2:2 to 4:4:4` — Perform an upsampling operation.

AntialiasingFilterSource

Lowpass filter to accompany a downsample operation.

- `Auto` (default) — Built-in lowpass filter.
- `Property` — Filter using the coefficients in `HorizontalFilterCoefficients` property.
- `None` — No filtering of the input signal.

This property applies when you set `Resampling` to `4:4:4 to 4:2:2`.

HorizontalFilterCoefficients

Coefficients for the antialiasing filter.

Enter the coefficients as a vector. This property applies when you set `Resampling` to `4:4:4 to 4:2:2` and `Antialiasing filter` to `Property`.

Default: `[0.2,0.6,0.2]`

InterpolationFilter

Interpolation method for an upsample operation.

- `Linear` (default) — Linear interpolation to calculate the missing values.
- `Pixel replication` — Repeat the chrominance value of the preceding pixel to create the missing pixel.

This property applies when you set `Resampling` to `4:2:2 to 4:4:4`.

RoundingMethod

Rounding mode used for fixed-point operations.

The object uses fixed-point arithmetic for internal calculations when the input is any integer or fixed-point data type. This option does not apply when the input is single or double type.

Default: `Floor`

`OverflowAction`

Overflow action used for fixed-point operations.

The object uses fixed-point arithmetic for internal calculations when the input is any integer or fixed-point data type. This option does not apply when the input is single or double type.

Default: `Wrap`

`CustomCoefficientsDataType`

Data type for the antialiasing filter coefficients.

Specify a custom data type as a string. This parameter applies when you set `Antialiasing filter` to `Property` or `Auto`.

Default: `fixdt(1,16,0)`

Methods

clone	Create object with the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Compute next pixel in upsampled or downsampled pixel stream

Algorithm

This object implements the algorithms described on the Chroma Resampler block reference page.

Latency

The `ChromaResampler` object has a latency of 2 cycles.

See Also

`vision.ChromaResampler` | Chroma Resampler | `visionhdl.FrameToPixels`

Introduced in R2015a

clone

System object: visionhdl.ChromaResampler
Package: visionhdl

Create object with the same property values

Syntax

```
newCR = clone(CR)
```

Description

`newCR = clone(CR)` creates another instance of the `ChromaResampler` System object, `CR`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

`CR`

`visionhdl.ChromaResampler` System object

Output Arguments

`newCR`

New `ChromaResampler` System object that has the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.ChromaResampler
Package: visionhdl

Locked status (logical)

Syntax

`TF = isLocked(CR)`

Description

`TF = isLocked(CR)` returns the locked status, `TF`, of the `ChromaResampler` System object, `CR`.

Introduced in R2015a

release

System object: visionhdl.ChromaResampler
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(CR)`

Description

`release(CR)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

`CR`

`visionhdl.ChromaResampler` System object

Introduced in R2015a

step

System object: visionhdl.ChromaResampler
Package: visionhdl

Compute next pixel in upsampled or downsampled pixel stream

Syntax

```
[pixelOut,ctrlOut] = step(CR,pixelIn,ctrlIn)
```

Description

`[pixelOut,ctrlOut] = step(CR,pixelIn,ctrlIn)` computes the next output pixel, pixelOut, in the resampled video stream. The pixel data arguments, pixelIn and pixelOut, are vectors of three values representing a pixel in Y'CbCr color space. The luma component and control signals, ctrlIn, are passed through and aligned with the output pixel stream.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

CR

`visionhdl.ChromaResampler` System object.

pixelIn

Single pixel in gamma-corrected Y'CbCr color space, specified as a vector of three values.

Supported data types:

- `uint8` or `uint16`
- `fixdt(0,N,0)`, N = 8,9,...,16
- `double` and `single` data types are supported for simulation but not for HDL code generation.

ctrlIn

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

pixelOut

Single pixel in gamma-corrected Y'CbCr color space, returned as a vector of three values.

Supported data types:

- `uint8` or `uint16`
- `fixdt(0,N,0)`, N = 8,9,...,16
- `double` and `single` data types are supported for simulation but not for HDL code generation.

ctrlOut

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.ColorSpaceConverter System object

Package: visionhdl

Convert signals between color spaces

Description

`visionhdl.ColorSpaceConverter` converts between R'G'B' and Y'CbCr color spaces, and also converts R'G'B' to intensity.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The `ColorSpaceConverter` System object operates on gamma-corrected color spaces. However, to simplify use of the System object, the property arguments do not include the prime notation.

Construction

`CSC = visionhdl.ColorSpaceConverter` returns a System object, CSC, that converts R'G'B' to Y'CbCr using the Rec. 601 (SDTV) standard.

`CSC = visionhdl.ColorSpaceConverter(Name,Value)` returns a System object, CSC, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`Conversion`

Conversion that the object performs on the input video stream.

- `RGB to YCbCr` (default)
- `YCbCr to RGB`
- `RGB to intensity`

The `step` method accepts input as a vector of three values representing a single pixel. If you choose `RGB to intensity`, the output is a scalar value. Otherwise, the output is a vector of three values.

`ConversionStandard`

Conversion equation to use on the input video stream.

- `Rec. 601 (SDTV)` (default)
- `Rec. 709 (HDTV)`

This property does not apply when you set `Conversion` to `RGB to intensity`.

`ScanningStandard`

Scanning standard to use for HDTV conversion.

- `1250/50/2:1` (default)
- `1125/60/2:1`

This property applies when you set `ConversionStandard` to `Rec. 709 (HDTV)`.

Methods

clone	Create object having the same property values

isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Convert one pixel between color spaces

Examples

Convert a RGB image to grayscale.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('fabric.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels,:);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',3,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

csc = visionhdl.ColorSpaceConverter(...
    'Conversion','RGB to intensity');

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
```

```
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);
pixOut = zeros(numPixelsPerFrame,1,'uint8');

for p = 1:numPixelsPerFrame
    [pixOut(p),ctrlOut(p)] = step(csc,pixIn(p,:),ctrlIn(p));
end

% Create deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);

[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Color Space Converter block reference page.

Latency

Objects with R'G'B' input have a latency of 9 cycles. Objects with Y'CbCr input have a latency of 10 cycles because one cycle is required to check for and correct headroom and footroom violations.

See Also

Colorspace Converter | `vision.ColorSpaceConverter` | `rgb2ycbcr` | `visionhdl.FrameToPixels` | `ycbcr2rgb` | `rgb2gray`

Introduced in R2015a

clone

System object: visionhdl.ColorSpaceConverter
Package: visionhdl

Create object having the same property values

Syntax

```
newCSC = clone(CSC)
```

Description

`newCSC = clone(CSC)` creates another instance of the `ColorSpaceConverter` System object, `CSC`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

`CSC`

`visionhdl.ColorSpaceConverter` System object

Output Arguments

`newCSC`

New `ColorSpaceConverter` System object that has the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.ColorSpaceConverter
Package: visionhdl

Locked status (logical)

Syntax

`TF = isLocked(CSC)`

Description

`TF = isLocked(CSC)` returns the locked status, `TF`, of the `ColorSpaceConverter` System object, `CSC`.

Introduced in R2015a

release

System object: visionhdl.ColorSpaceConverter
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(CSC)`

Description

`release(CSC)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

`CSC`

`visionhdl.ColorSpaceConverter` System object

Introduced in R2015a

step

System object: visionhdl.ColorSpaceConverter
Package: visionhdl

Convert one pixel between color spaces

Syntax

`[pixelOut,ctrlOut] = step(CSC,pixelIn,ctrlIn)`

Description

`[pixelOut,ctrlOut] = step(CSC,pixelIn,ctrlIn)` converts a single pixel from one color space to another. The input, pixelIn is a vector of three values representing one pixel in R'G'B' or Y'CbCr color space. If the `Conversion` property is set to `RGB to YCbCr` or `YCbCr to RGB`, then pixelOut is a vector of three values representing one pixel. If the `Conversion` property is set to `RGB to intensity`, then pixelOut is a scalar value representing one pixel.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The `ColorSpaceConverter` System object operates on gamma-corrected color spaces. However, to simplify use of the System object, the property arguments do not include the prime notation.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

csc

`visionhdl.ColorSpaceConverter` System object.

pixelIn

Input pixel in gamma-corrected R'G'B' or Y'CbCr color space, specified as a vector of unsigned integer values.

Supported data types:

- `uint8` or `uint16`
- `fixdt(0,N,0)`, N = 8,9,...,16
- `double` and `single` data types are supported for simulation but not for HDL code generation.

ctrlIn

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

pixelOut

Output pixel specified as a vector of three unsigned integer values, or a scalar unsigned integer value.

- If you set the `Conversion` property to `RGB to YCbCr` or `YCbCr to RGB`, then `pixelOut` is a vector representing the pixel in gamma-corrected color space.
- If you set the `Conversion` property to `RGB to intensity`, then `pixelOut` is a scalar representing pixel intensity.

Supported data types:

- `uint8` or `uint16`

- `fixdt(0,N,0)`, N = 8,9,....,16
- `double` and `single` data types are supported for simulation but not for HDL code generation.

ctrlOut

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.Closing System object

Package: visionhdl

Morphological close

Description

`visionhdl.Closing` performs a morphological dilation operation, followed by a morphological erosion operation, using the same neighborhood for both calculations. The object operates on a stream of binary intensity values.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Construction

`C = visionhdl.Closing` returns a System object, C, that performs morphological close on a binary video stream.

`C = visionhdl.Closing(Name,Value)` returns a System object, C, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`Neighborhood`

Neighborhood for computing local maxima and minima, specified as a matrix or vector of ones and zeros.

The object supports neighborhoods up to 32×32 pixels. To use a structuring element, specify the `Neighborhood` as `getnhood(strel(`*`shape`*`))`.

Default: [0,1,0;1,1,1;0,1,0]

`LineBufferSize`

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The object allocates *neighborhood lines - 1*-by-`LineBufferSize` memory locations to store the pixels.

Default: 2048

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Report closed pixel value based on neighborhood

Examples

Perform morphological close on a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');
```

```
% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
% Convert to binary image
frmInput = frmInput>128;
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

% Create filter
 mclose = visionhdl.Closing( ...
          'Neighborhood',getnhood(strel('disk',5)));

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = false(numPixelsPerFrame,1);
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(mclose,pixIn(p),ctrlIn(p));
    if (ctrlOut(p).valid && foundValOut==0)
```

```
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Closing block reference page.

See Also

visionhdl.FrameToPixels | vision.MorphologicalClose | imclose | strel | getnhood | Closing

Introduced in R2015a

clone

System object: visionhdl.Closing
Package: visionhdl

Create object having the same property values

Syntax

`newC = clone(C)`

Description

`newC = clone(C)` creates another instance of the `Closing` System object, `C`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

`C`

`visionhdl.Closing` System object

Output Arguments

`newC`

New `Closing` System object that has the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.Closing
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(C)
```

Description

`TF = isLocked(C)` returns the locked status, `TF`, of the `Closing` System object, `C`.

Introduced in R2015a

release

System object: visionhdl.Closing
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(C)`

Description

`release(C)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

`C`

`visionhdl.Closing` System object

Introduced in R2015a

step

System object: visionhdl.Closing
Package: visionhdl

Report closed pixel value based on neighborhood

Syntax

`[pixelOut,ctrlOut] = step(C,pixelIn,ctrlIn)`

Description

`[pixelOut,ctrlOut] = step(C,pixelIn,ctrlIn)` returns the next pixel value, pixelOut, in the pixel stream resulting from a morphological close operation on the neighborhood around each input pixel, pixelIn.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

C

`visionhdl.Closing` System object

`pixelIn`

Single pixel, specified as a scalar `logical` value.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

`pixelOut`

Single pixel value, representing the closed value based on the pixel neighborhood, returned as a scalar `logical`.

`ctrlOut`

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.DemosaicInterpolator System object

Package: visionhdl

Construct full RGB pixel data from Bayer pattern pixels

Description

`visionhdl.DemosaicInterpolator` provides a Bayer pattern interpolation filter for streaming video data. You can select a low complexity bilinear interpolation, or a moderate complexity gradient-corrected bilinear interpolation. The object implements the calculations using hardware-efficient algorithms for HDL code generation.

- The object performs bilinear interpolation on a 3×3 pixel window using only additions and bit shifts.
- The object performs gradient correction on a 5×5 pixel window. The object implements the calculation using bit shift, addition, and low order Canonical Signed Digit (CSD) multiply.

Construction

`D = visionhdl.DemosaicInterpolator` returns a System object, D, that interpolates R'G'B' data from a Bayer pattern pixel stream.

`D = visionhdl.DemosaicInterpolator(Name,Value)` returns a System object, D, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`InterpolationAlgorithm`

Algorithm the object uses to calculate the missing pixel values.

- `Bilinear` — Average of the pixel values in the surrounding 3×3 neighborhood.
- `Gradient-corrected linear` (default) — Bilinear average, corrected for intensity gradient.

SensorAlignment

Color sequence of the pixels in the input stream.

Specify the sequence of R, G, and B pixels that correspond to the 2-by-2 block of pixels in the top-left corner of the input image. Specify the sequence in left-to-right, top-to-bottom order. For instance, the default value, `RGGB`, represents an image with this pattern.

R	G
G	B

LineBufferSize

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. When you set `InterpolationAlgorithm` to `Bilinear`, the object allocates 2-by-`LineBufferSize` memory locations. When you set `InterpolationAlgorithm` to `Gradient-corrected linear`, the object allocates 4-by-`LineBufferSize` memory locations.

Default: 2048

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)

release	Allow changes to property values and input characteristics
step	Demosaic a Bayer pattern video stream

Algorithm

This object implements the algorithms described on the Demosaic Interpolator block reference page.

See Also

`vision.DemosaicInterpolator` | `demosaic` | Demosaic Interpolator | `visionhdl.FrameToPixels`

Introduced in R2015a

clone

System object: visionhdl.DemosaicInterpolator
Package: visionhdl

Create object having the same property values

Syntax

`newD = clone(D)`

Description

`newD = clone(D)` creates another instance of the `DemosaicInterpolator` System object, `D`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

`D`

`visionhdl.DemosaicInterpolator` System object

Output Arguments

`newD`

New `DemosaicInterpolator` System object that has the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.DemosaicInterpolator
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(D)
```

Description

`TF = isLocked(D)` returns the locked status, `TF`, of the `DemosiacInterpolator` System object, `D`.

Introduced in R2015a

release

System object: visionhdl.DemosaicInterpolator
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(D)`

Description

`release(D)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

D

`visionhdl.DemosaicInterpolator` System object

Introduced in R2015a

step

System object: visionhdl.DemosaicInterpolator
Package: visionhdl

Demosaic a Bayer pattern video stream

Syntax

`[pixelOut,ctrlOut] = step(D,pixelIn,ctrlIn)`

Description

`[pixelOut,ctrlOut] = step(D,pixelIn,ctrlIn)` interpolates the missing color values of a Bayer pattern input pixel stream, and returns the next pixel value, pixelOut, as a vector of R'G'B' values. pixelIn represents one pixel in a Bayer pattern image.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

D

`visionhdl.DemosaicInterpolator` System object.

pixelIn

Single pixel, specified as a scalar value.

Supported data types:

- `uint` or `int`
- `fixdt(0,N,0)`
- `double` and `single` data types are supported for simulation but not for HDL code generation.

ctrlIn

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

pixelOut

Single pixel, returned as a vector of three values in R'G'B' color space.

The data type of `pixelOut` is the same as the data type of `pixelIn`.

ctrlOut

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.Dilation System object

Package: visionhdl

Find local maxima

Description

`visionhdl.Dilation` replaces each pixel with the local minimum of the neighborhood around the pixel. The object operates on a stream of binary intensity values.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Construction

`D = visionhdl.Dilation` returns a System object, D, that performs morphological dilation on a binary video stream.

`D = visionhdl.Dilation(Name,Value)` returns a System object, D, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`Neighborhood`

Neighborhood for computing local minima, specified as a matrix or vector of ones and zeros.

The object supports neighborhoods up to 32×32 pixels. To use a structuring element, specify the `Neighborhood` as `getnhood(strel(`*`shape`*`))`.

Default: [0,1,0;1,1,1;0,1,0]

`LineBufferSize`

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The object allocates *neighborhood lines - 1*-by-`LineBufferSize` memory locations to store the pixels.

Default: 2048

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Report dilated pixel value based on neighborhood

Examples

Perform morphological dilation on a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');
```

```
% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
% Convert to binary image
frmInput = frmInput>128;
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

% Create filter
 mdilate = visionhdl.Dilation( ...
          'Neighborhood',getnhood(strel('disk',5)));

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = false(numPixelsPerFrame,1);
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(mdilate,pixIn(p),ctrlIn(p));
    if (ctrlOut(p).valid && foundValOut==0)
```

```
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Dilation block reference page.

See Also

Dilation | `visionhdl.FrameToPixels` | `vision.MorphologicalDilate` | `imdilate` | `strel` | `getnhood`

Introduced in R2015a

clone

System object: visionhdl.Dilation
Package: visionhdl

Create object having the same property values

Syntax

`newD = clone(D)`

Description

`newD = clone(D)` creates another instance of the `Dilation` System object, `D`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

`D`

`visionhdl.Dilation` System object

Output Arguments

`newD`

New `Dilation` System object that has the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.Dilation
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(D)
```

Description

`TF = isLocked(D)` returns the locked status, `TF`, of the `Dilation` System object, `D`.

Introduced in R2015a

release

System object: visionhdl.Dilation
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(D)`

Description

`release(D)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

D

`visionhdl.Dilation` System object

Introduced in R2015a

step

System object: visionhdl.Dilation
Package: visionhdl

Report dilated pixel value based on neighborhood

Syntax

```
[pixelOut,ctrlOut] = step(D,pixelIn,ctrlIn)
```

Description

`[pixelOut,ctrlOut] = step(D,pixelIn,ctrlIn)` returns the next pixel value, pixelOut, in the pixel stream resulting from a morphological dilate operation on the neighborhood around each input pixel, pixelIn.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

D

`visionhdl.Dilation` System object

`pixelIn`

Single pixel, specified as a scalar `logical` value.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

`pixelOut`

Single pixel value, representing the closed value based on the pixel neighborhood, returned as a scalar `logical`.

`ctrlOut`

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.EdgeDetector System object

Package: visionhdl

Find edges of objects in image

Description

`visionhdl.EdgeDetector` finds the edges in a grayscale pixel stream using Sobel, Prewitt or Roberts methods. The object convolves the input pixels with derivative approximation matrices to find the gradient of pixel magnitude along two orthogonal directions. It then compares the sum of the squares of the gradients to a configurable threshold to determine if the gradients represent an edge. The Sobel and Prewitt methods calculate the gradient in horizontal and vertical directions. The Roberts method calculates the gradients at 45 and 135 degrees.

The object returns a binary image, as a stream of pixel values. If a pixel value is 1, it is an edge. You can optionally enable output of the gradient values in the two orthogonal directions at each pixel.

Construction

`ED = visionhdl.EdgeDetector` returns a System object, ED, that detects edges using the Sobel method.

`ED = visionhdl.EdgeDetector(Name,Value)` returns a System object, ED, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`Method`

Edge detection algorithm

Specify 'Sobel', 'Prewitt', or 'Roberts' method.

Default: 'Sobel'

BinaryImageOutputPort

Enable the Edge output of the step method when true

When this property is true, the step method returns a binary pixel value representing whether the object detected an edge at each location in the frame.

Default: true

GradientComponentOutputPorts

Enable the G1 and G2 outputs of the step method when true

When this property is true, the step method returns two values representing the gradients calculated in two orthogonal directions at each pixel. Set the data type for this argument in GradientDataType property.

Default: false

ThresholdSource

Source for the gradient threshold value that indicates an edge

You can set the threshold as an input to the step method, or from a property. Set this property to 'Input port' to set the threshold as an input argument to the step method. When this property is set to 'Property', set the threshold in the Threshold property.

Default: 'Property'

Threshold

Gradient threshold value that indicates an edge, specified as a scalar numeric value.

The object compares this value squared to the sum of the squares of the gradients. The object casts this value to the data type of the gradients. This property applies when you set ThresholdSource to 'Property'.

Default: 20

LineBufferSize

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The object allocates (*N - 1*)-by-`LineBufferSize` memory locations to store the pixels, where *N* is the number of lines in the differential approximation matrix. If you set the `Method` property to `'Sobel'` or `'Prewitt'`, *N* is 3. If you set the `Method` property to `'Roberts'`, *N* is 2.

Default: 2048

RoundingMethod

Rounding mode used for fixed-point operations.

The object uses fixed-point arithmetic for internal calculations when the input is any integer or fixed-point data type. This option does not apply when the input is single or double type.

Default: `Floor`

OverflowAction

Overflow action used for fixed-point operations.

The object uses fixed-point arithmetic for internal calculations when the input is any integer or fixed-point data type. This option does not apply when the input is single or double type.

Default: `Wrap`

GradientDataType

Data type for the gradient output values, specified as `numerictype(signed,WL,FL)`, where *WL* is word length and *FL* is fraction length in bits.

- `'Full precision'` (default) — Full-precision based on the data type of the `pixelIn` argument of the `step` method, and the coefficients of the derivative approximation matrices.
- `'custom'` — Use the data type defined in the`CustomGradientDataType` property.

CustomGradientDataType

Data type for the gradient output values, specified as `numerictype(signed,WL,FL)`, where *WL* is word length and *FL* is fraction length in bits.

Default: `numerictype(1,8,0)`

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Detect edges at an image pixel

Examples

Detect edges of a thumbnail image using Sobel method.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
```

```
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

 edgeDetect = visionhdl.EdgeDetector();

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
ctrlOut = repmat(pixelcontrolstruct,numPixelsPerFrame,1);
edgeOut  = false(numPixelsPerFrame,1);

% Input pixel data
for p = 1:numPixelsPerFrame
   [edgeOut(p),ctrlOut(p)] = step(edgeDetect,pixIn(p),ctrlIn(p));
end

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,edgeOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Edge Detector block reference page.

See Also

Edge Detector | `visionhdl.FrameToPixels` | `vision.EdgeDetector` | `edge`

Introduced in R2015a

clone

System object: visionhdl.EdgeDetector
Package: visionhdl

Create object having the same property values

Syntax

```
newED = clone(ED)
```

Description

`newED = clone(ED)` creates another instance of the `EdgeDetector` System object, `ED`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

ED

`visionhdl.EdgeDetector` System object

Output Arguments

newED

New `EdgeDetector` System object that has the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.EdgeDetector
Package: visionhdl

Locked status (logical)

Syntax

`TF = isLocked(ED)`

Description

`TF = isLocked(ED)` returns the locked status, `TF`, of the `EdgeDetector` System object, `ED`.

Introduced in R2015a

release

System object: visionhdl.EdgeDetector
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(ED)`

Description

`release(ED)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

`ED`

`visionhdl.EdgeDetector` System object

Introduced in R2015a

step

System object: visionhdl.EdgeDetector
Package: visionhdl

Detect edges at an image pixel

Syntax

```
[edge,ctrlOut] = step(ED,pixelIn,ctrlIn)
[G1,G2,ctrlOut] = step(ED,pixelIn,ctrlIn)
[edge,ctrlOut] = step(ED,pixelIn,ctrlIn,thresh)
```

Description

`[edge,ctrlOut] = step(ED,pixelIn,ctrlIn)` detects edges in the neighborhood of pixelIn by computing the gradient in two orthogonal directions. The edge output argument is a binary value indicating whether the sum of the squares of the gradients for the input pixel is above the threshold indicating an edge.

`[G1,G2,ctrlOut] = step(ED,pixelIn,ctrlIn)` detects edges in the neighborhood of pixelIn by computing the gradient in two orthogonal directions. Use this syntax when you set `GradientComponentOutputPorts` property to `true`. The G1 and G2 output arguments are the gradients calculated in the two orthogonal directions. When you set the `Method` property to '`Sobel`' or '`Prewitt`', the first argument is the vertical gradient, and the second argument is the horizontal gradient. When you set the `Method` property to '`Roberts`', the first argument is the 45 degree gradient, and the second argument is the 135 degree gradient.

`[edge,ctrlOut] = step(ED,pixelIn,ctrlIn,thresh)` detects edges in the neighborhood of pixelIn by computing the gradient in two orthogonal directions. Use this syntax when you set `ThresholdSource` property to '`InputPort`'. The edge output argument is a binary value indicating whether the sum of the squares of the gradients was above the threshold, thresh, squared.

You can use any combination of the optional port syntaxes.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

`ED`

`visionhdl.EdgeDetector` System object.

`pixelIn`

Intensity of a single pixel, specified as a scalar value.

Supported data types:

- `uint` or `int`
- `fixdt()`
- `double` and `single` data types are supported for simulation but not for HDL code generation.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

`thresh`

Gradient threshold value that indicates an edge, specified as a scalar numeric value.

The object compares this value squared to the sum of the squares of the gradients. This argument is accepted when you set `ThresholdSource` property to `'InputPort'`.

Output Arguments

edge

Pixel value indicating an edge at this pixel, returned as a scalar binary value.

G1

Gradient calculated in the first direction, returned as a scalar value.

This argument is returned when you set GradientComponentOutputPorts property to true. If you set the Method property to 'Sobel' or 'Prewitt', this argument is the vertical gradient. When you set the Method property to 'Roberts', this argument is the 45 degree gradient.

Configure the data type of the gradients by using the GradientComponentDataType and CustomGradientComponent properties.

G2

Gradient calculated in the second direction, returned as a scalar value.

This argument is returned when you set GradientComponentOutputPorts property to true. If you set the Method property to 'Sobel' or 'Prewitt', this argument is the horizontal gradient. When you set the Method property to 'Roberts', this argument is the 135 degree gradient.

Configure the data type of the gradients by using the GradientComponentDataType and CustomGradientComponent properties.

ctrlOut

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five logical signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.Erosion System object

Package: visionhdl

Morphological erode

Description

`visionhdl.Erosion` replaces each pixel with the local maximum of the neighborhood around the pixel. The object operates on a stream of binary intensity values.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Construction

`E = visionhdl.Erosion` returns a System object, E, that performs morphological erosion on a binary video stream.

`E = visionhdl.Erosion(Name,Value)` returns a System object, E, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`Neighborhood`

Neighborhood for computing local maxima, specified as a matrix or vector of ones and zeros.

The object supports neighborhoods up to 32×32 pixels. To use a structuring element, specify the `Neighborhood` as `getnhood(strel(shape))`.

Default: ones(3,3)

`LineBufferSize`

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The object allocates *neighborhood lines - 1*-by-`LineBufferSize` memory locations to store the pixels.

Default: 2048

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Report eroded pixel value based on neighborhood

Examples

Perform morphological erosion on a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');
```

```
% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
% Convert to binary image
frmInput = frmInput>128;
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

% Create filter
 merode = visionhdl.Erosion( ...
          'Neighborhood',ones(5,5));

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = false(numPixelsPerFrame,1);
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(merode,pixIn(p),ctrlIn(p));
    if (ctrlOut(p).valid && foundValOut==0)
```

```
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Erosion block reference page.

See Also

Erosion | `visionhdl.FrameToPixels` | `vision.MorphologicalErode` | `imerode` | `strel` | `getnhood`

Introduced in R2015a

clone

System object: visionhdl.Erosion
Package: visionhdl

Create object having the same property values

Syntax

`newE = clone(E)`

Description

`newE = clone(E)` creates another instance of the `Erosion` System object, E, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

E

`visionhdl.Erosion` System object

Output Arguments

newE

New `Erosion` System object that has the same property values as the original System object. The new unlocked object contains uninitialized states.

Introduced in R2015a

isLocked

System object: visionhdl.Erosion
Package: visionhdl

Locked status (logical)

Syntax

`TF = isLocked(E)`

Description

`TF = isLocked(E)` returns the locked status, `TF`, of the `DemosiacInterpolator` System object, `E`.

Introduced in R2015a

release

System object: visionhdl.Erosion
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(E)`

Description

`release(E)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

E

`visionhdl.Erosion` System object

Introduced in R2015a

step

System object: visionhdl.Erosion
Package: visionhdl

Report eroded pixel value based on neighborhood

Syntax

`[pixelOut,ctrlOut] = step(E,pixelIn,ctrlIn)`

Description

`[pixelOut,ctrlOut] = step(E,pixelIn,ctrlIn)` returns the next pixel value, pixelOut, in the pixel stream resulting from a morphological erode operation on the neighborhood around each input pixel, pixelIn.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

E

`visionhdl.Erosion` System object

`pixelIn`

Single pixel, specified as a scalar `logical` value.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

`pixelOut`

Single pixel value, representing the closed value based on the pixel neighborhood, returned as a scalar `logical`.

`ctrlOut`

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.FrameToPixels System object

Package: visionhdl

Convert full-frame video to pixel stream

Description

`visionhdl.visionhdl.FrameToPixels` converts color or grayscale full-frame video to a pixel stream and control structure. The control structure indicates the validity of each pixel and its location in the frame. The pixel stream format can include padding pixels around the active frame. You can configure the frame and padding dimensions by selecting a common video format or specifying custom dimensions. See "Streaming Pixel Interface" for details of the pixel stream format.

Use this object to generate input for a function targeted for HDL code generation. This block does not support HDL code generation.

If your design converts frames to a pixel stream and later converts the stream back to frames, specify the same video format for the `FrameToPixels` object and the `PixelsToFrame` object.

Construction

`F2P = visionhdl.FrameToPixels` returns a System object, F2P, that serializes a grayscale 1080×1920 frame into a 1080p pixel stream with standard padding around the active data.

`F2P = visionhdl.FrameToPixels(Name,Value)` returns a System object, F2P, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`NumComponents`

Components of each pixel, specified as 1, 3, or 4. Set to 1 for grayscale video. Set to 3 for color video, for example, {R,G,B} or {Y,Cb,Cr}. Set to 4 to use color with an alpha channel for transparency. The `step` method returns a *P*-by-`NumComponents` matrix, where *P* is the total number of pixels. The default is 1.

`VideoFormat`

Dimensions of active and inactive regions of a video frame. To select a predefined format, specify the `VideoFormat` property as a string from the options in the first column of the table. For a custom format, set `VideoFormat` to `Custom`, and specify the dimension properties as integers.

Video Format	Active Pixels Per Line	Active Video Lines	Total Pixels Per Line	Total Video Lines	Starting Active Line	Front Porch
`240p`	320	240	402	324	1	44
`480p`	640	480	800	525	36	16
`480pH`	720	480	858	525	33	16
`576p`	720	576	864	625	47	12
`720p`	1280	720	1650	750	25	110
`768p`	1024	768	1344	806	10	24
`1024p`	1280	1024	1688	1066	42	48
`1080p` (default)	1920	1080	2200	1125	42	88
`1200p`	1600	1200	2160	1250	50	64
`2KCinema`	2048	1080	2750	1125	42	639
`4KUHDTV`	3840	2160	4400	2250	42	88
`8KUHDTV`	7680	4320	8800	4500	42	88
`Custom`	User-defined	User-defined	User-defined	User-defined	User-defined	User-defined

Note: When using a custom format, the properties you enter for the active and inactive dimensions of the image must add up to the total frame dimensions.

For the horizontal direction, `TotalPixelsPerLine` must be greater than or equal to `FrontPorch` + `ActivePixelsPerLine`. The block calculates *BackPorch* = `TotalPixelsPerLine` − `FrontPorch` − `ActivePixelsPerLine`.

For the vertical direction, `TotalVideoLines` must be greater than or equal to `StartingActiveLine` + `ActiveVideoLines` − 1. The block calculates *EndingActiveLine* = `StartingActiveLine` + `ActiveVideoLines` − 1.

If you specify a format that does not conform to these rules, the object reports an error.

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Convert image frame to pixel stream

Examples

Convert custom-size grayscale image to pixel stream. Use the `visionhdl.LookupTable` object to convert it to a negative image, then convert the pixel-stream back to full-frame.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
```

```
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

% Create LUT to output the negative of the input image
 tabledata = linspace(255,0,256);
 lut = visionhdl.LookupTable(tabledata);

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = zeros(numPixelsPerFrame,1,'uint8');
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(lut,pixIn(p),ctrlIn(p));
    if (ctrlOut(p).valid && foundValOut==0)
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
```

```
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

See Also

`visionhdl.PixelsToFrame` | Frame To Pixels

Related Examples

- Pixel-Streaming Design in MATLAB

More About

- "Streaming Pixel Interface"

Introduced in R2015a

clone

System object: visionhdl.FrameToPixels
Package: visionhdl

Create object having the same property values

Syntax

`newF2P = clone(F2P)`

Description

`newF2P = clone(F2P)` creates another instance of the `FrameToPixels` System object, `F2P`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

`F2P`

`visionhdl.FrameToPixels` System object

Output Arguments

`newF2P`

New `FrameToPixels` System object that has the same property values as the original object.

Introduced in R2015a

isLocked

System object: visionhdl.FrameToPixels
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(F2P)
```

Description

`TF = isLocked(F2P)` returns the locked status, `TF`, of the `FrameToPixels` System object, `F2P`.

Introduced in R2015a

release

System object: visionhdl.FrameToPixels
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

```
release(F2P)
```

Description

`release(F2P)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

`F2P`

`visionhdl.FrameToPixels` System object

Introduced in R2015a

step

System object: visionhdl.FrameToPixels
Package: visionhdl

Convert image frame to pixel stream

Syntax

`[pixels,ctrlOut] = step(F2P,frm)`

Description

`[pixels,ctrlOut] = step(F2P,frm)`

Converts the input image matrix, frm, to a vector of pixel values, pixels, and an associated vector of control structures, ctrlOut. The control structure indicates the validity of each pixel and its location in the frame. The output pixels include padding around the active image, specified by the `VideoFormat` property.

See “Streaming Pixel Interface” for details of the pixel stream format.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

`F2P`

`visionhdl.FrameToPixels` System object

`frm`

Input image, specified as an `ActiveVideoLines`-by-`ActivePixelsPerLine`-by-`NumComponents` matrix, where:

- `ActiveVideoLines` is the height of the active image
- `ActivePixelsPerLine` is the width of the active image
- `NumComponents` is the number of components used to express a single pixel

Set the size of the active image using the `VideoFormat` property. If the dimensions of im do not match that specified by `VideoFormat`, the object returns a warning.

Supported data types:

- `uint` or `int`
- `fixdt()`
- `logical`
- `double` or `single`

Output Arguments

`pixels`

Pixel values, returned as a *P*-by-`NumComponents` matrix, where:

- *P* is the total number of pixels in the padded image, calculated as `TotalPixelsPerLine` × `TotalVideoLines`
- `NumComponents` is the number of components used to express a single pixel

Set the size of the padded image using the `VideoFormat` property. The data type of the pixel values is the same as `im`.

`ctrlOut`

Control structures associated with the output pixels, returned as a *P*-by-1 vector. *P* is the total number of pixels in the padded image, calculated as `TotalPixelsPerLine` × `TotalVideoLines`. Each structure contains five control signals indicating the validity of the pixel and its location in the frame. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.GammaCorrector System object

Package: visionhdl

Apply or remove gamma correction

Description

`visionhdl.GammaCorrector` applies or removes gamma correction on a stream of pixels. Gamma correction adjusts linear pixel values so that the modified values fit a curve. The de-gamma operation performs the opposite operation to obtain linear pixel values.

Construction

`G = visionhdl.GammaCorrector` returns a System object that applies or removes gamma correction on a stream of pixels.

`G = visionhdl.GammaCorrector(Name,Value)` returns a System object, G, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

`G = visionhdl.GammaCorrector(operation,gammaValue,Name,Value)` returns a System object with the `Correction` property set to operation, the `Gamma` property set to gammaValue, and additional options specified by one or more Name,Value pair arguments.

Input Arguments

`operation`

Type of correction, specified as either `Gamma` or `De-gamma`. This argument sets the `Correction` property value.

`gammaValue`

Target or current gamma value, specified as a scalar value greater than or equal to 1. This argument sets the Gamma property value.

Output Arguments

`G`

`visionhdl.GammaCorrector` System object

Properties

`Correction`

Direction of intensity curve adjustment

- `Gamma` (default) — Apply gamma correction.
- `De-gamma` — Remove gamma correction.

`Gamma`

Target or current gamma value, specified as a scalar greater than or equal to 1.

- When you set `Correction` to `Gamma`, set this property to the target gamma value of the output video stream.
- When you set `Correction` to `De-gamma`, set this property to the gamma value of the input video stream.

Default: 2.2

`LinearSegment`

Option to include a linear segment in the gamma curve, specified as a `logical` value. When you set this property to `true`, the gamma curve has a linear portion near the origin.

Default: `true`

BreakPoint

Pixel value that corresponds to the point where the gamma curve and linear segment meet. Specify `Breakpoint` as a scalar value between 0 and 1, exclusive. This property applies only when the `LinearSegment` property is set to `true`.

Default: 0.018

Methods

clone	Create object with same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Apply or remove gamma correction on one pixel

Examples

Use gamma correction to brighten thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
```

```
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

 gammacorr = visionhdl.GammaCorrector(...
      'Gamma', 1.75);

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = zeros(numPixelsPerFrame,1,'uint8');
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

for p = 1:numPixelsPerFrame
    [pixOut(p),ctrlOut(p)] = step(gammacorr,pixIn(p),ctrlIn(p));
end

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Gamma Corrector block reference page.

Latency

The `GammaCorrector` object has a latency of 2 cycles.

See Also

Gamma Corrector | `visionhdl.FrameToPixels` | `vision.GammaCorrector` | `imadjust`

Introduced in R2015a

clone

System object: visionhdl.GammaCorrector
Package: visionhdl

Create object with same property values

Syntax

`newG = clone(G)`

Description

`newG = clone(G)` creates another instance of the `GammaCorrector` System object, `newG`, with the same property values as input argument G. The new object is unlocked and contains uninitialized states.

Input Arguments

`G`

`visionhdl.GammaCorrector` System object

Output Arguments

`newG`

New `GammaCorrector` System object with the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.GammaCorrector
Package: visionhdl

Locked status (logical)

Syntax

`TF = isLocked(G)`

Description

`TF = isLocked(G)` returns the locked status, TF, of the `GammaCorrector` System object, G.

Introduced in R2015a

release

System object: visionhdl.GammaCorrector
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(G)`

Description

`release(G)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

G

`visionhdl.GammaCorrector` System object

Introduced in R2015a

step

System object: visionhdl.GammaCorrector
Package: visionhdl

Apply or remove gamma correction on one pixel

Syntax

```
[pixelOut,ctrlOut] = step(G,pixelIn,ctrlIn)
```

Description

`[pixelOut,ctrlOut] = step(G,pixelIn,ctrlIn)` returns the intensity value of a pixel after gamma correction, and the control signals associated with the pixel. The input, `pixelIn`, and output, `pixelOut`, are scalar values representing a single pixel.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time the `step` method is executed. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, you must first call the `release` method to unlock the object.

Input Arguments

G

`visionhdl.GammaCorrector` System object.

pixelIn

Intensity of a single pixel, specified as a scalar value. For fixed-point data types, the input word length must be less than or equal to 16.

Supported data types:

- `int8` and `int16`
- `uint8` and `uint16`
- `fixdt()`

`double` and `single` data types are supported for simulation but not for HDL code generation.

ctrlIn

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See "Pixel Control Structure".

Output Arguments

pixelOut

Gamma-corrected intensity of a single pixel, specified as a scalar value. The data type of the output pixel is the same as the data type of pixelIn.

ctrlOut

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See "Pixel Control Structure".

Introduced in R2015a

visionhdl.Histogram System object

Package: visionhdl

Frequency distribution

Description

`visionhdl.Histogram` computes the frequency distribution of pixel values in a video stream. You can configure the number and size of the bins. The object provides a read interface for accessing each bin. The object keeps a running histogram until you clear the bin values.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface allows object operation independent of image size and format, and easy connection with other Vision HDL Toolbox objects. The `step` method accepts pixel data as integer, fixed-point, or floating-point data types. The `step` method accepts control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Construction

`H = visionhdl.Histogram` returns a System object, H, that computes image histograms over 256 bins, with a bin size of 16 bits.

`H = visionhdl.Histogram(Name,Value)` returns a System object, H, with additional options specified by one or more `Name,Value` pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`NumBins`

Number of bins for the histogram.

Choose the number of bins depending on the input word length (WL). If the number of bins is less than 2^{WL}, the object truncates the least-significant bits of each pixel. If the number of bins is greater than 2^{WL}, the object warns about an inefficient use of hardware resources.

Default: `256`

`OutputDataType`

Data type of the histogram values.

- `double`
- `single`
- `Unsigned fixed point` (default)

`double` and `single` data types are supported for simulation but not for HDL code generation.

`OutputWordLength`

Histogram bin value word length when `OutputDataType` is `Unsigned fixed point`. If a bin overflows, the count saturates and the object shows a warning.

Default: `16`

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Sort input pixel into histogram bin, or read histogram bin

Examples

Accumulate histogram for a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

 histo = visionhdl.Histogram();

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
bins = str2double(histo.NumBins);
readRdy = false(numPixelsPerFrame,1);
dataOut = zeros(bins-1,1,'uint8');
validOut  = false(bins-1,1);
dummyCtrl = pixelcontrolstruct(0,0,0,0,0);

% Initialization
```

```
for p = 1:bins
    step(histo,uint8(0),dummyCtrl,uint8(0),false);
end

% Input pixel data
for p = 1:numPixelsPerFrame
   [~,readRdy(p),~] = step(histo,pixIn(p),ctrlIn(p),uint8(0),false);
end

% Read bin values
if readRdy(numPixelsPerFrame)
  for p = 1:bins-1
     [dataOut(p),~,validOut(p)] = step(histo,uint8(0),dummyCtrl,uint8(p-1),false);
  end
end

% Read final bin value and initiate binReset.
step(histo,uint8(0),dummyCtrl,uint8(bins-1),true);
% Final bin value is ready after 2 calls to step.
step(histo,uint8(0),dummyCtrl,uint8(0),false);
[finalBin,~,finalValidOut] = step(histo,uint8(0),dummyCtrl,uint8(0),false);

% graph bin values
dataOut = dataOut(validOut==1);
dataOut(bins) = finalBin;
figure
bar(dataOut)
title('Histogram of Input Image')

% binReset
for p = 1:bins
    step(histo,uint8(0),dummyCtrl,uint8(0),false);
end
```

Algorithm

This object implements the algorithms described on the Histogram block reference page.

Latency

The object returns `readRdy` = `true` 2 calls to the `step` method after receiving the last pixel of a frame. The object indicates the last pixel of a frame by `vEnd` = `true`. While readRdy is true, the object captures binAddr requests on each subsequent call to the step method. The object returns the corresponding histogram bin value in dataOut two calls to the step method later.

See Also

Histogram | visionhdl.FrameToPixels | vision.Histogram | imhist

Introduced in R2015a

clone

System object: visionhdl.Histogram
Package: visionhdl

Create object having the same property values

Syntax

`newH = clone(H)`

Description

`newH = clone(H)` creates another instance of the `Histogram` System object, `H`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

`H`

`visionhdl.Histogram` System object

Output Arguments

`newH`

New `Histogram` System object that has the same property values as the original System object. The new unlocked object contains uninitialized states.

Introduced in R2015a

isLocked

System object: visionhdl.Histogram
Package: visionhdl

Locked status (logical)

Syntax

`TF = isLocked(H)`

Description

`TF = isLocked(H)` returns the locked status, `TF`, of the `Histogram` System object, `H`.

Introduced in R2015a

release

System object: visionhdl.Histogram
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(H)`

Description

`release(H)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

H

`visionhdl.Histogram` System object

Introduced in R2015a

step

System object: visionhdl.Histogram
Package: visionhdl

Sort input pixel into histogram bin, or read histogram bin

Syntax

```
step(H,~,~,~,~)
[dataOut,readRdy,validOut] = step(H,pixelIn,ctrlIn,~,0)
[dataOut,readRdy,validOut] = step(H,~,~,binAddr,0)
[dataOut,readRdy,validOut] = step(H,~,~,binAddr,binReset)
```

Description

`step(H,~,~,~,~)` performs an initial reset phase before processing input data. After object creation or reset, call `step` with dummy arguments for `NumberOfBins` cycles before applying data. You do not have to assert binReset during this phase.

`[dataOut,readRdy,validOut] = step(H,pixelIn,ctrlIn,~,0)` adds the input pixel, pixelIn, to the internal histogram. Call `step` with this syntax for each pixel in a frame. The object returns readRdy `true` when the histogram for the frame is complete.

`[dataOut,readRdy,validOut] = step(H,~,~,binAddr,0)` reads the histogram bin specified by binAddr. Use this syntax when readRdy is returned `true`. Call `step` with this syntax for each histogram bin. The bin value at binAddr is returned in dataOut, with validOut set to `true`, after two further calls to `step`.

`[dataOut,readRdy,validOut] = step(H,~,~,binAddr,binReset)` resets the histogram values when binReset is `true`. You can initiate the reset while simultaneously giving the final binAddr. Before applying more video data, complete the reset sequence by calling `step` with dummy arguments for `NumBins` cycles.

To visualize the sequence of operations, see the timing diagrams in the “Algorithm” section of the Histogram block page.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

`H`

`visionhdl.Histogram` System object.

`pixelIn`

Single pixel, specified by a scalar value.

Supported data types:

- `uint`
- `fixdt(0,N,0)`
- `double` and `single` data types are supported for simulation but not for HDL code generation.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See "Pixel Control Structure".

`binAddr`

Bin number request for reading histogram values. This input is captured after readRdy is returned `true`. The data type is `fixdt(0,N,0)`, `N` = 5,6,...,10. The word length must be $\log_2$`(NumBins)`.

`binReset`

Triggers histogram RAM reset when true. Reset takes `NumBins` cycles to clear all locations. Input signals are ignored during this interval. Data type is `logical`.

Output Arguments

`readRdy`

Flag indicating when the histogram bins are ready for read, returned as a `logical` value. The object returns `readRdy` set to `true` two cycles after the final pixel of a frame.

`dataOut`

Histogram value for the bin requested in binAddr. The `OutputDataType` property specifies the data type for this output.

`validOut`

Flag indicating the validity of dataOut, returned as a `logical` value.

Introduced in R2015a

visionhdl.ImageFilter System object

Package: visionhdl

2-D FIR filtering

Description

`visionhdl.visionhdl.ImageFilter` performs two-dimensional FIR filtering of a pixel stream.

Construction

`F = visionhdl.ImageFilter` returns a System object, F, that performs two-dimensional FIR filtering of an input pixel stream.

`F = visionhdl.ImageFilter(Name,Value)` returns a 2-D FIR filter System object, F, with additional options specified by one or more `Name,Value` pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

`F = visionhdl.ImageFilter(coeff, lineSize,Name,Value)` returns a 2-D FIR filter System object, F, with the `Coefficients` property set to coeff, `LineBufferSize` property to lineSize, and additional options specified by one or more `Name,Value` pair arguments.

Input Arguments

`coeff`

Filter coefficients specified as a vector or matrix. The maximum size along any dimension of a matrix or vector is 16. This argument sets the `Coefficients` property value.

`lineSize`

Size of the line memory buffer, as a power of 2 that accommodates the number of active pixels in a horizontal line. This argument sets the `LineBufferSize` property value.

Output Arguments

F

`visionhdl.ImageFilter` System object.

Properties

Coefficients

Coefficients of the desired filter, specified as a vector or matrix of any numeric type. The maximum size along any dimension of a matrix or vector is 16.

`double` and `single` data types are supported for simulation but not for HDL code generation.

Default: `[1,0;0,-1]`

CoefficientsDataType

Method for determining the data type of the filter coefficients.

- `'Same as first input'` (default) — Data type used to represent the coefficients is the same as the data type of the `pixelIn` argument of the `step` method.
- `'custom'` — Use the data type defined in the`CustomCoefficientsDataType` property.

CustomCoefficientsDataType

Data type for the filter coefficients, specified as `numerictype(signed,WL,FL)`, where *WL* is word length and *FL* is fraction length in bits. This property applies when you set `CoefficientsDataType` to `custom`.

Default: `numerictype(true,16,15)`

CustomOutputDataType

Data type for the output pixels, specified as `numerictype(signed,WL,FL)`, where *WL* is word length and *FL* is fraction length in bits. This property applies only when you set `OutputDataType` to `custom`.

Default: `numerictype(true,8,0)`

LineBufferSize

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The object allocates *coefficient rows - 1*-by-`LineBufferSize` memory locations to store the pixels.

Default: 2048

OutputDataType

Method for determining the data type of the output pixels

- '`Same as first input`' (default) — Data type used to represent the output pixels is the same as the data type of the `pixelIn` argument of the `step` method.
- '`full precision`' — Use full precision rules. The System object computes internal arithmetic and output data types using full precision rules. These rules provide the most accurate fixed-point numerics. These rules guarantee that no quantization occurs within the object. Bits are added, as needed, to ensure that no rounding or overflow occurs.
- `custom` — Use the data type you define in the`CustomOutputDataType` property.

OverflowAction

Overflow action used for fixed-point operations.

The object uses fixed-point arithmetic for internal calculations when the input is any integer or fixed-point data type. This option does not apply when the input is single or double type.

Default: `Wrap`

PaddingMethod

Method for padding the boundary of the input image

- '`Constant`' (default) — Pad input matrix with a constant value.
- '`Replicate`' — Repeat the value of pixels at the edge of the image.
- '`Symmetric`' — Pad input matrix with its mirror image.

PaddingValue

Constant value used to pad the boundary of the input image. This property applies when you set PaddingMethod to 'Constant'. The object casts this value to the same data type as the input pixel.

Default: 0

RoundingMethod

Rounding mode used for fixed-point operations.

The object uses fixed-point arithmetic for internal calculations when the input is any integer or fixed-point data type. This option does not apply when the input is single or double type.

Default: Floor

Methods

clone	Create object with same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	2-D FIR filtering

Examples

Implement a 2-D blur filter on a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');
```

```
% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

% Create filter
 filt2d = visionhdl.ImageFilter(...
          'Coefficients',ones(2,2)/4,...
          'CoefficientsDataType','Custom',...
          'CustomCoefficientsDataType',numerictype(0,1,2),...
          'PaddingMethod','Symmetric');

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = zeros(numPixelsPerFrame,1,'uint8');
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(filt2d,pixIn(p),ctrlIn(p));
```

```
    if (ctrlOut(p).valid && foundValOut==0)
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Image Filter block reference page.

See Also

Image Filter | `visionhdl.FrameToPixels` | `vision.ImageFilter` | `imfilter`

Introduced in R2015a

clone

System object: visionhdl.ImageFilter
Package: visionhdl

Create object with same property values

Syntax

```
newF = clone(F)
```

Description

`newF = clone(F)` creates another instance of the `ImageFilter` System object, `F`, with the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

F

`visionhdl.ImageFilter` System object.

Output Arguments

newF

New `ImageFilter` System object with the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.ImageFilter
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(F)
```

Description

`TF = isLocked(F)` returns the locked status, `TF`, of the `ImageFilter` System object, `F`.

Introduced in R2015a

release

System object: visionhdl.ImageFilter
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(F)`

Description

`release(F)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Note: You can use the release method on a System object in code generated from MATLAB®, but once you release its resources, you cannot use that System object again.

Input Arguments

F

`visionhdl.ImageFilter` System object

Introduced in R2015a

step

System object: visionhdl.ImageFilter
Package: visionhdl

2-D FIR filtering

Syntax

`[pixelOut,ctrlOut] = step(F,pixelIn,ctrlIn)`

Description

`[pixelOut,ctrlOut] = step(F,pixelIn,ctrlIn)` returns the next pixel, pixelOut, of the filtered image resulting from applying the coefficients in the `Coefficients` property to the image described by the input pixel stream, pixelIn.

Note: The object performs an initialization the first time the `step` method is executed. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, you must first call the `release` method to unlock the object.

Input Arguments

`F`

`visionhdl.ImageFilter` System object.

`pixelIn`

Single pixel, specified as a scalar value.

Supported data types:

- `uint` or `int`
- `fixdt()`
- `double` and `single` data types are supported for simulation but not for HDL code generation.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

`pixelOut`

Single filtered pixel, returned as a scalar value.

Configure the data type of the output pixel by using the `OutputDataType` and `CustomOutputDataType` properties.

`ctrlOut`

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.ImageStatistics System object

Package: visionhdl

Mean, variance, and standard deviation

Description

`visionhdl.ImageStatistics` calculates the mean, variance, and standard deviation of streaming video data. Each calculation is performed over all pixels in the input region of interest (ROI). The object implements the calculations using hardware-efficient algorithms.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface allows object operation independent of image size and format, and easy connection with other Vision HDL Toolbox objects. The `step` method accepts pixel data as integer, fixed-point, or floating-point data types. The `step` method accepts control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

- To change the size and dimensions of the ROI, you can manipulate the input video stream control signals. See "Regions of Interest" on page 1-69.
- The number of valid pixels in the input image affect the accuracy of the mean approximation. To avoid approximation error, use an image that contains fewer than 64 pixels, or a multiple of 64 pixels. For details of the mean approximation, see "Algorithm" on page 1-66.

Construction

`S = visionhdl.ImageStatistics` returns a System object, S, that calculates the mean, variance, and standard deviation of each frame of a video stream.

`S = visionhdl.ImageStatistics(Name,Value)` returns a System object, S, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`mean`

Calculate the mean of each input frame. If you set this property to `false`, the `step` method does not return this output.

Default: `true`

`variance`

Calculate the variance of each input frame. If you set this property to `false`, the `step` method does not return this output.

Default: `true`

`stdDev`

Calculate the standard deviation of each input frame. If you set this property to `false`, the `step` method does not return this output.

Default: `true`

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Calculate the contribution of one pixel to the mean, variance, and standard deviation of a video stream

Examples

Compute the mean, variance, and standard deviation of a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

 stats = visionhdl.ImageStatistics();

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
validOut  = false(numPixelsPerFrame,1);
mean  = zeros(numPixelsPerFrame,1,'uint8');
variance  = zeros(numPixelsPerFrame,1,'uint8');
stddev  = zeros(numPixelsPerFrame,1,'uint8');

% Input pixel data
for p = 1:numPixelsPerFrame
```

```
   [mean(p),variance(p),stddev(p),validOut(p)] = step(stats,pixIn(p),ctrlIn(p));
end
mean = mean(validOut==1)
variance = variance(validOut==1)
stddev = stddev(validOut==1)
```

Algorithm

This object implements the algorithms described on the Image Statistics block reference page.

Latency

The latency from `vEnd` to `validOut` depends on what calculations you select.

When the object receives a `true` `vEnd` signal, it combines the remaining data in the three levels of mean calculation to calculate the final output. This final step takes 4 cycles per level, resulting in a maximum of 12 cycles of latency between the input `vEnd` signal and the `validOut` signal. Once the mean is available, the variance calculation takes 4 cycles. The square root logic requires input word length (IWL) cycles of latency.

If a calculation is not selected, and is not needed for other selected calculations, that logic is excluded from the generated HDL code.

The table shows the calculation logic and latency for various object configurations.

Mear	Variar	Std. Devic	Logic Excluded From HDL	Latency (cycles)
✓	✓	✓		[4,8, or 12]+4+IWL
✓			variance and square root	[4,8, or 12] (depending on input size relative to the 64-bit accumulators)
	✓		square root	[4,8, or 12]+4
		✓		[4,8, or 12]+4+IWL
✓	✓		square root	[4,8, or 12]+4
✓		✓		[4,8, or 12]+4+IWL
	✓	✓		[4,8, or 12]+4+IWL

See Also

Image Statistics | `vision.Variance` | `visionhdl.FrameToPixels` | `vision.Mean` | `vision.StandardDeviation` | `mean2` | `std2`

Introduced in R2015a

clone

System object: visionhdl.ImageStatistics
Package: visionhdl

Create object having the same property values

Syntax

`newS = clone(S)`

Description

`newS = clone(S)` creates another instance of the `ImageStatistics` System object, `S`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

S

`visionhdl.ImageStatistics` System object

Output Arguments

newS

New `ImageStatistics` System object that has the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.ImageStatistics
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(S)
```

Description

`TF = isLocked(S)` returns the locked status, `TF`, of the `ImageStatistics` System object, `S`.

Introduced in R2015a

release

System object: visionhdl.ImageStatistics
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(S)`

Description

`release(S)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

S

`visionhdl.ImageStatistics`System object

Introduced in R2015a

step

System object: visionhdl.ImageStatistics
Package: visionhdl

Calculate the contribution of one pixel to the mean, variance, and standard deviation of a video stream

Syntax

`[mean,variance,stdDeviation,validOut] = step(S,pixelIn,ctrlIn)`

Description

`[mean,variance,stdDeviation,validOut] = step(S,pixelIn,ctrlIn)` incorporates the new pixel value, pixelIn, into calculations of video frame statistics. The control signals associated with each pixel, ctrlIn, indicate the frame boundaries. When validOut is `true`, the output values of mean, variance, and stdDeviation represent the statistics for the most recent input frame completed. The number of statistics returned depends on the object property settings.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface allows object operation independent of image size and format, and easy connection with other Vision HDL Toolbox objects. The `step` method accepts pixel data as integer, fixed-point, or floating-point data types. The `step` method accepts control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

`S`

`visionhdl.ImageStatistics` System object.

`pixelIn`

Single pixel, specified as a scalar value.

Supported data types:

- `uint8` or `uint16`
- `fixdt(0,N,0)`, N = 8,9,...,16
- `double` and `single` data types are supported for simulation but not for HDL code generation.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

`mean`

Mean of the most recent frame of video input, returned as a scalar value.

The data type is the same as `pixelIn`.

`variance`

Variance of the most recent frame of video input, returned as a scalar value.

The data type is the same as `pixelIn`. The fixed-point output word length is double the input word length.

`stdDeviation`

Standard deviation of the most recent frame of video input, returned as a scalar value.

The data type is the same as `pixelIn`. Fixed-point output word length is double the input word length.

`validOut`

Validity of output statistics. When the object completes the calculations, it returns `true`. When this output is `true`, the other output arguments are valid. Data type is `logical`.

Introduced in R2015a

visionhdl.LookupTable System object

Package: visionhdl

Map input pixel to output pixel using custom rule

Description

The `visionhdl.LookupTable` System object uses a custom one-to-one map to convert between an input pixel value and an output pixel value.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Construction

`LUT = visionhdl.LookupTable` returns a System object, LUT, that performs a one-to-one mapping between the input pixel and output pixel, according to the lookup table contents.

`LUT = visionhdl.LookupTable(tabledata)` returns a lookup table System object, LUT, with the table contents set to TABLEDATA.

Input Arguments

`tabledata`

One-to-one correspondence between input pixels and output pixels, specified as a vector. This argument sets the `Table` property value.

Output Arguments

`LUT`

`visionhdl.visionhdl.LookupTable` System object

Properties

`Table`

Map between input pixel values and output pixel values.

- The table data is a vector, row or column, of any data type. The data type of the table data determines that of `pixelOut`. See step (visionhdl.LookupTable) method.
- The length of the table data must equal $2^{WordLength}$, where *WordLength* is the size, in bits, of `pixelIn`. See step (visionhdl.LookupTable) method.
- The smallest representable value of the input data type maps to the first element of the table, the second smallest value maps to the second element, and so on. For example, if `pixelIn` has a data type of `fixdt(0,3,1)`, the input value 0 maps to the first element of the table, input value 0.5 maps to the second element, 1 maps to the third, and so on.

Default: `uint8(0:1:255)`

Methods

clone	Create object with same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Map input pixel to output pixel based on table contents

Examples

Create negative image by flipping pixel values with a lookup table.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;
```

```
frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

 tabledata = linspace(255,0,256);
 lut = visionhdl.LookupTable(tabledata);

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = zeros(numPixelsPerFrame,1,'uint8');
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

for p = 1:numPixelsPerFrame
    [pixOut(p),ctrlOut(p)] = step(lut,pixIn(p),ctrlIn(p));
end

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
```

```
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Lookup Table block reference page.

Latency

The `LookupTable` object has a latency of 2 cycles.

See Also

Lookup Table | `visionhdl.FrameToPixels`

Introduced in R2015a

clone

System object: visionhdl.LookupTable
Package: visionhdl

Create object with same property values

Syntax

```
newLUT = clone(LUT)
```

Description

`newLUT = clone(LUT)` creates another instance of the `LookupTable` System object, `newLUT`, with the same property values as input argument LUT. The new object is unlocked and contains uninitialized states.

Input Arguments

`LUT`

`visionhdl.LookupTable` System object

Output Arguments

`newLUT`

New `LookupTable` System object with the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.LookupTable
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(LUT)
```

Description

`TF = isLocked(LUT)` returns the locked status, TF, of the `LookupTable` System object, LUT.

Introduced in R2015a

release

System object: visionhdl.LookupTable
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(LUT)`

Description

`release(LUT)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

`LUT`

`visionhdl.LookupTable` System object

Introduced in R2015a

step

System object: visionhdl.LookupTable
Package: visionhdl

Map input pixel to output pixel based on table contents

Syntax

```
[pixelOut,ctrlOut] = step(LUT,pixelIn,ctrlIn)
```

Description

`[pixelOut,ctrlOut] = step(LUT,pixelIn,ctrlIn)` returns the pixel value, pixelOut, located in the table at the address specified by the input pixel value, pixelIn. The object passes the control signals, ctrlIn, through and aligns the output control signals, ctrlOut, with the output data.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time the `step` method is executed. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, you must first call the `release` method to unlock the object.

Input Arguments

LUT

`visionhdl.LookupTable` System object

pixelIn

Input pixel, specified as a scalar value. For unsigned fixed-point data types, the input word length must be less than or equal to 16.

Supported data types:

- `logical`
- `uint8` or `uint16`
- `fixdt()`

ctrlIn

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

pixelOut

Output pixel, returned as a scalar value. The data type of the output is the same as the data type of the entries you specify in the `Table` property.

ctrlOut

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.MedianFilter System object

Package: visionhdl

2-D median filtering

Description

`visionhdl.MedianFilter` performs 2-D median filtering on a pixel stream. The object replaces each pixel value with the median value of the adjacent pixels.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Construction

`MF = visionhdl.MedianFilter` returns a System object, MF, that performs two-dimensional median filtering of serial pixel data.

`MF = visionhdl.MedianFilter(Name,Value)` returns a median filter System object, MF, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

`MF = visionhdl.MedianFilter(size,Name,Value)` returns a median filter System object, MF, with the `NeighborhoodSize` property set to size and additional options specified by one or more Name,Value pair arguments.

Input Arguments

`size`

Size in pixels of the image region used to compute the median. This argument sets the `NeighborhoodSize` property value.

Output Arguments

`MF`

`visionhdl.MedianFilter` System object.

Properties

`NeighborhoodSize`

Neighborhood size, in pixels.

- `'3×3'` (default)
- `'5×5'`
- `'7×7'`

`LineBufferSize`

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The object allocates *N - 1*-by-`LineBufferSize` memory locations to store the pixels used to compute the median value. *N* is the number of lines in the square region specified in **Neighborhood size**.

Default: 2048

`PaddingMethod`

Method for padding the boundary of the input image

- `'Constant'` — Pad input matrix with a constant value.
- `'Replicate'` — Repeat the value of pixels at the edge of the image.

- `'Symmetric'` (default) — Pad image edge with its mirror image.

PaddingValue

Constant value used to pad the boundary of the input image. This property applies when you set `PaddingMethod` to `'Constant'`. The object casts this value to the same data type as the input pixel.

Default: 0

Methods

clone	Create object with same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Median pixel value of neighborhood

Examples

Implement a 5×5 median filter on a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
```

```
'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

% Create filter
 mfilt = visionhdl.MedianFilter(...
          'NeighborhoodSize','5x5');

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = zeros(numPixelsPerFrame,1,'uint8');
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(mfilt,pixIn(p),ctrlIn(p));
    if (ctrlOut(p).valid && foundValOut==0)
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
```

```
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Median Filter block reference page.

See Also

Median Filter | `visionhdl.FrameToPixels` | `vision.MedianFilter` | `medfilt2`

Introduced in R2015a

clone

System object: visionhdl.MedianFilter
Package: visionhdl

Create object with same property values

Syntax

`newF = clone(F)`

Description

`newF = clone(F)` creates another instance of the `MedianFilter` System object, `F`, with the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

F

`visionhdl.MedianFilter` System object

Output Arguments

newF

New `MedianFilter` System object with the same property values as the original System object.

Introduced in R2015a

isLocked

System object: visionhdl.MedianFilter
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(F)
```

Description

`TF = isLocked(F)` returns the locked status, `TF`, of the `MedianFilter` System object, `F`.

Introduced in R2015a

release

System object: visionhdl.MedianFilter
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(F)`

Description

`release(F)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

F

`visionhdl.MedianFilter` System object

Introduced in R2015a

step

System object: visionhdl.MedianFilter
Package: visionhdl

Median pixel value of neighborhood

Syntax

`[pixelOut,ctrlOut] = step(F,pixelIn,ctrlIn)`

Description

`[pixelOut,ctrlOut] = step(F,pixelIn,ctrlIn)` returns the next pixel value, pixelOut, in the filtered pixel stream resulting from calculating the median of the neighborhood around each input pixel, pixelIn. Before filtering, the object pads image edges according to the `PaddingMethod` property.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time the `step` method is executed. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, you must first call the `release` method to unlock the object.

Input Arguments

F

`visionhdl.MedianFilter` System object.

`pixelIn`

Single pixel, specified as a scalar value.

Supported data types:

- `uint` or `int`
- `fixdt(~,N,0)`
- `logical`
- `double` and `single` data types are supported for simulation but not for HDL code generation.

`ctrlIn`

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See “Pixel Control Structure”.

Output Arguments

`pixelOut`

Single pixel value representing the median of its neighborhood, returned as a scalar value.

The data type is the same as the data type of `pixelIn`.

`ctrlOut`

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See “Pixel Control Structure”.

Introduced in R2015a

visionhdl.Opening System object

Package: visionhdl

Morphological open

Description

`visionhdl.Opening` performs a morphological erosion operation, followed by a morphological dilation operation, using the same neighborhood for both calculations. The object operates on a stream of binary intensity values.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Construction

`O = visionhdl.Opening` returns a System object, O, that performs morphological open on a binary video stream.

`O = visionhdl.Opening(Name,Value)` returns a System object, O, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

`Neighborhood`

Neighborhood for computing local maxima and minima, specified as a matrix or vector of ones and zeros.

The object supports neighborhoods up to 32×32 pixels. To use a structuring element, specify the `Neighborhood` as `getnhood(strel(`*`shape`*`))`.

Default: ones(3,3)

`LineBufferSize`

Size of the line memory buffer, specified as a scalar integer.

Choose a power of 2 that accommodates the number of active pixels in a horizontal line. If you specify a value that is not a power of two, the object uses the next largest power of two. The object allocates *neighborhood lines - 1*-by-`LineBufferSize` memory locations to store the pixels.

Default: 2048

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Report opened pixel value based on neighborhood

Examples

Perform morphological open on a thumbnail image.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');
```

```
% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
% Convert to binary image
frmInput = frmInput>128;
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);

% Create filter
 mopen = visionhdl.Opening(...
          'Neighborhood',ones(5,5));

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = false(numPixelsPerFrame,1);
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(mopen,pixIn(p),ctrlIn(p));
    if (ctrlOut(p).valid && foundValOut==0)
```

```
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

Algorithm

This object implements the algorithms described on the Opening block reference page.

See Also

Opening | `visionhdl.FrameToPixels` | `vision.MorphologicalOpen` | `imopen` | `strel` | `getnhood`

Introduced in R2015a

clone

System object: visionhdl.Opening
Package: visionhdl

Create object having the same property values

Syntax

```
newH = clone(O)
```

Description

`newH = clone(O)` creates another instance of the `Opening` System object, O, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

O

`visionhdl.Opening` System object

Output Arguments

newO

New `Opening` System object that has the same property values as the original System object. The new unlocked object contains uninitialized states.

Introduced in R2015a

isLocked

System object: visionhdl.Opening
Package: visionhdl

Locked status (logical)

Syntax

`TF = isLocked(O)`

Description

`TF = isLocked(O)` returns the locked status, `TF`, of the `DemosiacInterpolator` System object, `O`.

Introduced in R2015a

release

System object: visionhdl.Opening
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(O)`

Description

`release(O)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

O

`visionhdl.Opening` System object

Introduced in R2015a

step

System object: visionhdl.Opening
Package: visionhdl

Report opened pixel value based on neighborhood

Syntax

`[pixelOut,ctrlOut] = step(O,pixelIn,ctrlIn)`

Description

`[pixelOut,ctrlOut] = step(O,pixelIn,ctrlIn)` returns the next pixel value, pixelOut, in the pixel stream resulting from a morphological open operation on the neighborhood around each input pixel, pixelIn.

This object uses a streaming pixel interface with a structure for synchronization control signals. This interface enables the object to operate independently of image size and format, and to connect easily with other Vision HDL Toolbox objects. The `step` method accepts and returns a scalar pixel value. The `step` method accepts and returns control signals as a structure containing five signals. These signals indicate the validity of each pixel and the location of each pixel in the frame.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

O

`visionhdl.Opening` System object

pixelIn

Single pixel, specified as a scalar `logical` value.

ctrlIn

Control signals indicating the validity of the input pixel and the location of the pixel within the frame, specified as a structure containing five `logical` signals. See "Pixel Control Structure".

Output Arguments

pixelOut

Single pixel value, representing the closed value based on the pixel neighborhood, returned as a scalar `logical`.

ctrlOut

Control signals indicating the validity of the output pixel and the location of the pixel within the frame, returned as a structure containing five `logical` signals. See "Pixel Control Structure".

Introduced in R2015a

visionhdl.PixelsToFrame System object

Package: visionhdl

Convert pixel stream to full-frame video

Description

`visionhdl.visionhdl.PixelsToFrame` converts a color or grayscale pixel stream and control structures into full-frame video. The control structure indicates the validity of each pixel and its location in the frame. The pixel stream format can include padding pixels around the active frame. You can configure the frame and padding dimensions by selecting a common video format or specifying custom dimensions. See “Streaming Pixel Interface” for details of the pixel stream format.

Use this object to convert the output of a function targeted for HDL code generation back to frames. This object does not support HDL code generation.

If your design converts frames to a pixel stream and later converts the stream back to frames, specify the same video format for the `FrameToPixels` object and the `PixelsToFrame` object.

Construction

`P2F = visionhdl.PixelsToFrame` returns a System object, P2F, that converts a 1080p pixel stream, with standard padding, to a grayscale 1080×1920 frame.

`P2F = visionhdl.PixelsToFrame(Name,Value)` returns a System object, P2F, with additional options specified by one or more Name,Value pair arguments. `Name` is a property name and `Value` is the corresponding value. `Name` must appear inside single quotes (`''`). You can specify several name-value pair arguments in any order as `Name1,Value1,...,NameN,ValueN`. Properties not specified retain their default values.

Properties

NumComponents

Components of each pixel, specified as 1, 3, or 4. Set to 1 for grayscale video. Set to 3 for color video, for example, {R,G,B} or {Y,Cb,Cr}. Set to 4 to use color with an alpha channel for transparency. The `step` method expects a matrix of *P*-by-`NumComponents` values, where *P* is the total number of pixels. The default is 1.

VideoFormat

Dimensions of the active region of a video frame. To select a predefined format, specify the `VideoFormat` property as a string from the options in the first column of the table. For a custom format, set `VideoFormat` to '`Custom`', and specify the dimensional properties as integers.

Video Format	Active Pixels Per Line	Active Video Lines
`240p`	320	240
`480p`	640	480
`480pH`	720	480
`576p`	720	576
`720p`	1280	720
`768p`	1024	768
`1024p`	1280	1024
`1080p` (default)	1920	1080
`1200p`	1600	1200
`2KCinema`	2048	1080
`4KUHDTV`	3840	2160
`8KUHDTV`	7680	4320
`Custom`	User-defined	User-defined

Methods

clone	Create object having the same property values
isLocked	Locked status (logical)
release	Allow changes to property values and input characteristics
step	Convert pixel stream to image frame

Examples

Convert custom-size grayscale image to pixel stream. Use the `visionhdl.LookupTable` object to convert it to a negative image, then convert the pixel-stream back to full-frame.

```
% Set dimensions of test image
frmActivePixels = 64;
frmActiveLines = 48;

frmOrig = imread('rice.png');

% Select portion of image matching the desired test size
frmInput = frmOrig(1:frmActiveLines,1:frmActivePixels);
figure
imshow(frmInput,'InitialMagnification',300)
title 'Input Image'

% Create serializer
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines,...
      'TotalPixelsPerLine',frmActivePixels+10,...
      'TotalVideoLines',frmActiveLines+10,...
      'StartingActiveLine',6,...
      'FrontPorch',5);
```

```
% Create LUT to output the negative of the input image
 tabledata = linspace(255,0,256);
 lut = visionhdl.LookupTable(tabledata);

% Serialize the test image
% pixel is a vector of intensity values
% ctrl is a vector of control signals accompanying each pixel
[pixIn,ctrlIn] = step(frm2pix,frmInput);

% Prepare to process pixels
%[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[numPixelsPerFrame,~] = size(pixIn);
pixOut = zeros(numPixelsPerFrame,1,'uint8');
ctrlOut  = repmat(pixelcontrolstruct,numPixelsPerFrame,1);

% Monitor control signals to determine latency of the object
foundValIn = false;
foundValOut = false;
for p = 1:numPixelsPerFrame
    if (ctrlIn(p).valid && foundValIn==0)
        sprintf('valid in at index %d',p)
        foundValIn = p;
    end
    [pixOut(p),ctrlOut(p)] = step(lut,pixIn(p),ctrlIn(p));
    if (ctrlOut(p).valid && foundValOut==0)
        sprintf('valid out at index %d',p)
        foundValOut = p;
    end
end
sprintf('object latency is %d cycles',foundValOut-foundValIn)

% deserializer
pix2frm = visionhdl.PixelsToFrame(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',frmActivePixels,...
      'ActiveVideoLines',frmActiveLines);
[frmOutput,frmValid] = step(pix2frm,pixOut,ctrlOut);
if frmValid
    figure
    imshow(frmOutput, 'InitialMagnification',300)
    title 'Output Image'
end
```

See Also

`visionhdl.FrameToPixels` | Pixels To Frame

Related Examples

- Pixel-Streaming Design in MATLAB

More About

- “Streaming Pixel Interface”

Introduced in R2015a

clone

System object: visionhdl.PixelsToFrame
Package: visionhdl

Create object having the same property values

Syntax

`newP2F = clone(P2F)`

Description

`newP2F = clone(P2F)` creates another instance of the `PixelsToFrame` System object, `P2F`, that has the same property values. The new object is unlocked and contains uninitialized states.

Input Arguments

P2F

`visionhdl.PixelsToFrame` System object

Output Arguments

newP2F

New `PixelsToFrame` System object that has the same property values as the original object.

Introduced in R2015a

isLocked

System object: visionhdl.PixelsToFrame
Package: visionhdl

Locked status (logical)

Syntax

```
TF = isLocked(P2F)
```

Description

`TF = isLocked(P2F)` returns the locked status, `TF`, of the `PixelsToFrame` System object, `P2F`.

Introduced in R2015a

release

System object: visionhdl.PixelsToFrame
Package: visionhdl

Allow changes to property values and input characteristics

Syntax

`release(P2F)`

Description

`release(P2F)` releases system resources (such as memory, file handles, or hardware connections), allowing you to change System object properties and input characteristics.

Input Arguments

P2F

`visionhdl.PixelsToFrame` System object

Introduced in R2015a

step

System object: visionhdl.PixelsToFrame
Package: visionhdl

Convert pixel stream to image frame

Syntax

`[frm,validOut] = step(P2F,pixels,ctrlIn)`

Description

`[frm,validOut] = step(P2F,pixels,ctrlIn)`

Converts a vector of pixel values representing a padded image, pixels, and an associated vector of control structures, ctrlIn, to an image matrix, frm. The control structure indicates the validity of each pixel and its location in the frame. The output image, frm is valid if validOut is `true`.

See “Streaming Pixel Interface” for details of the pixel stream format.

Note: The object performs an initialization the first time you call the `step` method. This initialization locks nontunable properties and input specifications, such as dimensions, complexity, and data type of the input data. If you change a nontunable property or an input specification, the System object issues an error. To change nontunable properties or inputs, first call the `release` method to unlock the object.

Input Arguments

`P2F`

`visionhdl.PixelsToFrame` System object

`pixels`

Pixel values, specified as a *P*-by-`NumComponents` matrix, where:

- P is the total number of pixels in the padded image, calculated as `TotalPixelsPerLine` × `TotalVideoLines`
- `NumComponents` is the number of components used to express a single pixel

Set the size of the padded image using the `VideoFormat` property. If the number of elements in pixels does not match that specified by `VideoFormat`, The object returns a warning.

Supported data types:

- `uint` or `int`
- `fixdt()`
- `logical`
- `double` or `single`

`ctrlIn`

Control structures associated with the input pixels, specified as a P-by-1 vector. P is the total number of pixels in the padded image, calculated as `TotalPixelsPerLine` × `TotalVideoLines`. Each structure contains five control signals indicating the validity of the pixel and its location in the frame. See “Pixel Control Structure”. If the dimensions indicated by ctrlIn do not match that specified by `VideoFormat`, the object returns a warning.

Output Arguments

`frm`

Full-frame image, returned as an `ActiveVideoLines`-by-`ActivePixelsPerLine`-by-`NumComponents` matrix, where:

- `ActiveVideoLines` is the height of the active image
- `ActivePixelsPerLine` is the width of the active image
- `NumComponents` is the number of components used to express a single pixel

Set the size of the active image using the `VideoFormat` property. The data type of the pixel values is the same as `pixels`.

validOut

Frame status, returned as a logical value. When validOut is `true`, the frame is reassembled and ready for use.

Introduced in R2015a

Functions — Alphabetical List

getparamfromfrm2pix

Get frame format parameters from `visionhdl.FrameToPixels` System object

Syntax

```
[activePixelsPerLine,activeLines,numPixelsPerFrame] =
getparamfromfrm2pix(frm2pix)
```

Description

`[activePixelsPerLine,activeLines,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix)` returns video format parameters of a `visionhdl.FrameToPixels` System object, frm2pix. The parameters returned are as follows.

- activePixelsPerLine — pixels in one horizontal line of the active video frame. For custom video formats, this corresponds to the `ActivePixelsPerLine` property.
- activeLines — number of horizontal lines in the active video frame. For custom video formats, this corresponds to the `ActiveVideoLines` property.
- numPixelsPerFrame — number of pixels in the active video frame. For custom video formats, this corresponds to `ActiveVideoLines`×`ActivePixelsPerLine`.

Examples

```
frm2pix = visionhdl.FrameToPixels(...
      'NumComponents',1,...
      'VideoFormat','custom',...
      'ActivePixelsPerLine',64,...
      'ActiveVideoLines',48,...
      'TotalPixelsPerLine',84,...
      'TotalVideoLines',58,...
      'StartingActiveLine',5,...
      'FrontPorch',10);

[activePixels,activeLines,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix)
```

```
activePixels =

  64
activeLines =

    48
numPixelsPerFrame =

   4096
```

More About

- "Streaming Pixel Interface"

See Also

Frame To Pixels | Pixels To Frame

pixelcontrolbus

Create control signal bus for use with Vision HDL Toolbox blocks

Syntax

```
pixelcontrolbus
```

Description

`pixelcontrolbus` is a script that declares a bus instance in the workspace. This instance is necessary for HDL code generation from Vision HDL Toolbox blocks.

Examples

In the `InitFcn` callback function of your Simulink model, include this line to declare a bus instance in the base workspace.

```
evalin('base','pixelcontrolbus');
```

More About

- "Streaming Pixel Interface"

See Also

"Pixel Control Bus" | Frame To Pixels | Pixels To Frame

pixelcontrolsignals

Extract signals from control signal structure used by Vision HDL Toolbox objects

Syntax

`[hStart,hEnd,vStart,vEnd,valid] = pixelcontrolsignals(ctrl)`

Description

`[hStart,hEnd,vStart,vEnd,valid] = pixelcontrolsignals(ctrl)` extracts five scalar `logical` control signals from a structure. See “Pixel Control Structure”.

Examples

```
inputIm = imread('rice.png');
[imActiveLines, imActivePixels] = size(inputIm)
frm2pix = visionhdl.FrameToPixels(...
         'NumComponents',1,...
         'VideoFormat','custom',...
         'ActivePixelsPerLine',imActivePixels,...
         'ActiveVideoLines',imActiveLines,...
         'TotalPixelsPerLine',imActivePixels+20,...
         'TotalVideoLines',imActiveLines+10,...
         'StartingActiveLine',6,...
         'FrontPorch',10);
[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[pixel,ctrl] = step(frm2pix,inputIm);
for p = 1:numPixelsPerFrame
   [hStart,hEnd,vStart,vEnd,valid] = pixelcontrolsignals(ctrl(p));
   % Call HDL-targeted function here.
   % Structures must be flattened to signals to support HDL code generation.
   ctrlOut(p) = pixelcontrolstruct(hStart,hEnd,vStart,vEnd,valid);
end
```

More About

- “Streaming Pixel Interface”

See Also

visionhdl.FrameToPixels | visionhdl.PixelsToFrame | pixelcontrolstruct

pixelcontrolstruct

Create control signal structure for use with Vision HDL Toolbox objects

Syntax

```
ctrl = pixelcontrolstruct(hStart,hEnd,vStart,vEnd,valid)
```

Description

`ctrl = pixelcontrolstruct(hStart,hEnd,vStart,vEnd,valid)` creates a structure containing the five control signals used by Vision HDL Toolbox objects. The input arguments must be five scalars of `logical` type. See "Pixel Control Structure".

Examples

```
inputIm = imread('rice.png');
[imActiveLines, imActivePixels] = size(inputIm)
frm2pix = visionhdl.FrameToPixels(...
         'NumComponents',1,...
         'VideoFormat','custom',...
         'ActivePixelsPerLine',imActivePixels,...
         'ActiveVideoLines',imActiveLines,...
         'TotalPixelsPerLine',imActivePixels+20,...
         'TotalVideoLines',imActiveLines+10,...
         'StartingActiveLine',6,...
         'FrontPorch',10);
[~,~,numPixelsPerFrame] = getparamfromfrm2pix(frm2pix);
[pixel,ctrl] = step(frm2pix,inputIm);
for p = 1:numPixelsPerFrame
   [hStart,hEnd,vStart,vEnd,valid] = pixelcontrolsignals(ctrl(p));
   % Call HDL-targeted function here.
   % Structures must be flattened to signals to support HDL code generation.
   ctrlOut(p) = pixelcontrolstruct(hStart,hEnd,vStart,vEnd,valid);
end
```

More About

- "Streaming Pixel Interface"

See Also

`visionhdl.FrameToPixels` | `visionhdl.PixelsToFrame` | `pixelcontrolsignals`