Digital Image Processing with LogiCOREs

New Color Space Converter LogiCOREs and a Combined Forward/Inverse DCT LogiCORE give you pre-designed blocks that solve difficult design problems.

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The real-time manipulation of high-resolution images (either moving-picture video or still-frame image streams) usually demands custom digital video processing in hardware. But why use a bunch of different ASSPs for common video/image processing tasks-such as Color Space Conversion (RGB to YCrCb or vice versa), or Discrete Cosine Transform, when you can do it all in a Virtex, Virtex-E, or Spartan device? And the performance of these FPGA-optimized "Application-Specific Virtual Components" is very attractive.

There are several standard video processing functions that are common to many vision systems; these systems include video broadcast, machine vision, and image filtering applications. Now, thanks to Integrated Silicon Systems' ASVC technology, the IP cores powering these applications can be implemented in FPGAs, and Xilinx can supply all of the vital links in your customized video compression/decompression chain (as shown in Figure 1).

Color Space Conversion

Color Space Conversion (CSC) is one of the standard image processing techniques; it's a trick that allows you to more-efficiently use the digital image data, associated with a color pixel, by switching color domains. Processing an image in the Red-Green-Blue color space with a set of (R, G, B) values for each and every pixel really isn't very efficient. The RGB representation has a significant downside: although its the natural paradigm for rendering full-color pictures using display technologies that emit mixtures of the three primary colors (such as CRTs, LCDs, LEDs, etc), it is not as efficient as special alternative schemes.

The standard alternative representations use de-correlated components–luminance and chrominance. Thus CSC only comes into play whenever it's time to present a picture to the human visual cortex, or after a real-world image is captured using a scanner or camera followed by processing in the digital domain.

Color Space Converter LogiCOREs

Xilinx presently offers a family of four different Color Space Converter LogiCOREs, as shown in Table 1.

Other useful pre-processing functions such as Gamma Correction are also incorporated in these particular ISS-designed LogiCOREs, so you spend less time developing your CSC design using these solutions.

Here's just a few application areas for the Color Space Conversion family of LogiCOREs:

- Video output conversion to digital RGB.
- Image filtering.
- Machine vision.
- Video and still-image processing.

DCT Engine LogiCORE

Figure 1 shows where one of the RGB2YUV or RGB2YCrCb Color Space Converter LogiCOREs fits into a typical video/image processing flow. This example

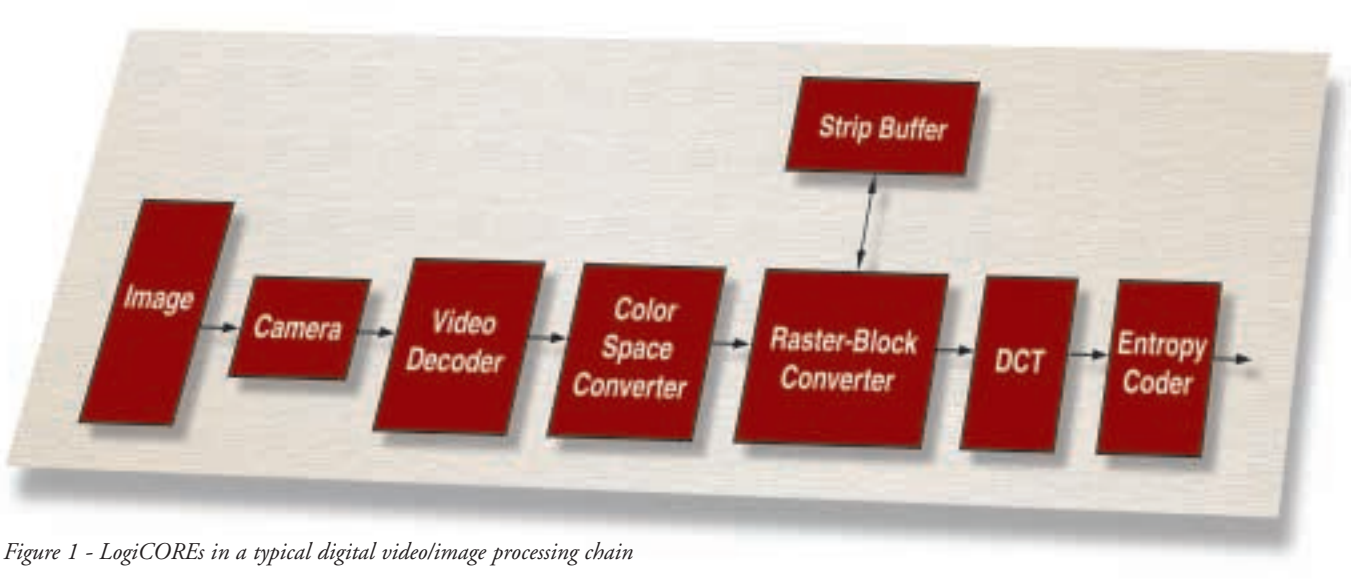

Figure 1 - LogiCOREs in a typical digital video/image processing chain

data path incorporates a Discrete Cosine Transform block–a necessary element in image compression algorithms.

Now, there's a new LogiCORE which combines both Forward DCT and Inverse DCT functions in one, and it's ISO/IEC 10918-1 JPEG compliant. This high-performance DCT/iDCT engine offers 1-symbol/cycle processing power thanks to its fully pipelined architecture. The design is highly-tuned for optimal performance across the various Xilinx FPGA technologies. It requires only 1756 slices in Virtex, 1759 in Virtex-E, or 1728 in Spartan devices; and only 48 IOBs are needed for interfacing.

This design is very efficient in the Xilinx architecture because the 2-D architecture uses row-column decomposition to separate the transform into two distinct 1-D operations. Each operation generates a set of intermediate results that are written into transpose memory. Data is "burst" into the DCT/iDCT core as blocks of 64 values, and the results of the transform are presented in the same format.

When in Forward DCT mode, this LogiCORE takes 8-bit input data words and produces an 11-bit output. In the Inverse mode, the converse is true. You've got 14-bit cosine coefficients, and a 15-bit representation in transpose memory, so there's no need to worry about precision.

LogiCORE	RGB to YUV	YUV to RGB	RGB to YCrCb	YCrCb to RGB
Slices used	230	147	211	186
IOBs used	50	50	49	49
System clock				
Virtex	>75 MHz	>75 MHz	>60 MHz	>75 MHz
Spartan-II	>80 MHz	>65 MHz	>65 MHz	>70 MHz
Virtex-E	>100 MHz	>100 MHz	>90 MHz	>90 MHz
Features used	Carry logic	Carry logic	Carry logic	Carry logic
Precision	10-bit	10-bit	10-bit	10-bit
Datasheet	Yes	Yes	Yes	Yes
Availability	Now	Now	Now	Now

Table 1 - LogiCORE specifications

Using the Combined Forward/Inverse DCT LogiCORE makes it very easy to create your own design, even if you don't have the engineering bandwidth or DCT expertise. And, the Xilinx software tools make it easy.

Designing with LogiCOREs

If you're familiar with HDL-based design and simulation, component instantiation, script-based logic synthesis, and the use of testbenches, then you're all set to design using LogiCOREs. All the LogiCORE modules described here are available under a standard license agreement from Xilinx. You get the code and test vectors, together with installation and instantiation instructions as part of the LogiCORE deliverables.

Conclusion

Digital video/image processing applications can be very difficult to develop. However, the new Xilinx LogiCOREs offer feature-enhanced Color Space Conversion and Forward/Inverse Discrete Cosine Transforms that give you a time-to-market advantage.

There are more LogiCOREs in development for digital video applications, including standalone M-JPEG Codec solutions for Virtex and Virtex-E. Talk to an ISS representative or your local Xilinx FAE about your particular application.

To find out more, or to access the datasheets, visit the Xilinx dedicated IP Center at: www.xilinx.com/ipcenter.