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JPEG2000 wave rises as ADI shows still-camera accelerator

By Junko Yoshida, EE Times
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SAN MATEO, Calif. — A brand-new, wavelet-based digital still-imaging compression format called JPEG2000 will get a shot in the arm over the next week when Analog Devices Inc. launches the first JPEG2000-compliant accelerator chip.

An international standard since December, JPEG2000 could soon become a must-have codec inside digital still cameras. The spec offers a host of features unavailable with conventional JPEG, and is particularly useful when transmitting scalable still images in multiple quality and resolution formats over the Internet.

One industry worry, however, is that adding a wavelet codec that's mathematically distinct from the discrete cosine transform (DCT)-based compression algorithm used in today's JPEG cameras could be costly for manufacturers, thus slowing the transition to the new standard.

Further, JPEG2000 could ignite fresh debate over the best codec for next-generation digital cameras. Vendors face an onslaught of choices, from JPEG, motion JPEG, Digital Video and JPEG-LS (for lossless and near-lossless compression) to MPEG-1, MPEG-2 and MPEG-4.

Some argue that JPEG2000 beats them all. "JPEG2000 is a single all-encompassing standard designed to include all the features needed in today's and tomorrow's most demanding compression applications," said Roger Smith, product line manager of the video products group at Analog Devices (ADI; Norwood, Mass.).

But others predict that to address motion-capture needs, digital still-camera vendors will likely be required to use both wavelet and DCT-based codecs for several years to come, a potentially expensive proposition.

Another stumbling block is the need for a JPEG2000 infrastructure buildout, said Daniel Lee, a JPEG standards official who is the chief technology officer at Yahoo! Asia. Besides silicon, he cited "reference software for the developer's community to develop applications; adoption by operating system and browser vendors; and adoption of JPEG2000 by digital camera vendors, especially on the high-end" — that is, cameras with a resolution of more than 2 Mpixels.

Other chip makers, such as Texas Instruments Inc. and Philips Semiconductors, are also working on JPEG2000-compliant ICs. And at least two companies — Image Power and LuraTech — are offering JPEG2000 development environments.

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Scalable resolution

JPEG2000 offers improved compression techniques to provide richer content and higher resolution, along with scalability to deliver image content at a variety of quality and resolution levels, from lossy to lossless, from within the same file. The standard also promises error resiliency for image transmission in noisy environments, and meta-data mechanisms for folding non-image data into a file.

"Consumers will first appreciate JPEG2000's ability to store more pictures," said ADI's Smith, and they'll welcome JPEG2000's flexibility and scalable features "once their images are uploaded to their Web sites."

The standard is capable of gradually peeling off most unimportant information, without reprocessing, from the same image file. This gives users control over image quality and memory use, depending on their needs and Internet connectivity speed.

Though neither Texas Instruments (Dallas) nor Philips Semiconductors (Eindhoven, Netherlands) has yet rolled commercial products, both have proven that a software-only JPEG2000 codec can run on their digital signal processors or media processors. The two are wrestling, however, with such fundamental engineering issues as how best to strike a balance between software and hardware co-design in JPEG2000 silicon.

Meanwhile, WIS Technologies Inc., a San Jose, Calif. startup that showed its homegrown JPEG2000 solution in an FPGA about 10 months ago, said it will delay its ASIC launch to 2002. The company blamed the delay on the size of the market, which it claims consists of only a handful of high-end customers, such as U.S. and U.K. defense contractors and some medical-system companies. WIS Technologies will wait until the market gets educated, said founder and chief executive Jack He Ouyang.

Wavelet savvy

ADI has leapfrogged others in the emerging JPEG2000 silicon market largely because its 15-member team — intact since 1994 — has accumulated an in-depth knowledge of the wavelet technology that underpins JPEG2000, the company said. In the MPEG boom of the 1990s, which attracted some 22 companies at its peak, the ADI team stayed focused on wavelet-based development, Smith said, and never rolled conventional JPEG or MPEG chips. Its wavelet chips today are successful in such applications as surveillance systems, he said.

The new JPEG2000-compliant chip, called ADV-JP2000, is designed to sit between an ASIC, which typically performs various image enhancements, and a RISC processor, both embedded inside a camera. It is designed as "a JPEG2000 coprocessor," supporting RISC chips, general-purpose DSPs or microcontrollers commonly used in digital still cameras, said Rich Green, chief architect for video products at ADI.

While the ADV-JP2000 performs heavy-duty processing such as wavelet transform and entropy coding, the camera's host CPU or microcontroller handles functions such as bit rate control and final creation of a JPEG2000 bit stream, said Green. "Camera manufacturers specifically told us not to put a microcontroller or real-time operating system in our JPEG2000-compliant IC," said Smith.

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"Because their digital still camera already has its own OS and CPU, anything newly added to our chip would cost them additional royalties."

Industry observers agreed that designing a cost-effective, high-performance JPEG2000 chip is no trivial task. Lee of Yahoo! Asia said the complexity lies in the entropy encoder. "The main attractiveness of JPEG2000 is the ability to have scalability in resolution as well as image quality," said Lee. "The technology that enables that is wavelet and the entropy coding. Chip designers may need to take more time to study and design that part."

Philips Semiconductors, which sees JPEG2000 as a necessary intellectual-property block for larger system ICs, acknowledged that the JPEG2000 codec has to be designed from scratch. "Due to the enormous flexibility of the standard, with its huge memory and bandwidth requirements, it is very difficult to find a cost- and performance-efficient solution while at the same time meeting all the requirements of the market," said Detlef Goettling, system engineer in the company's system lab.

Power consumption, chip complexity, difficulty in pipelining the arithmetic coding and memory usage are four key factors that make JPEG2000 chip development formidable, said Ouyang at WIS Technologies.

ADI developed a patented implementation of wavelet filters that reduces the number of arithmetic computations and cuts the on-chip memory requirement to 750 kbits of SRAM. Fabricated in 0.18-micron CMOS, the ADV-JP2000 consumes 100 mW when active and less than 100 microamps in power-down mode. Operating voltage is 1.5 to 1.8 V, with 3.3-V I/O. The chip, available now, is priced at $14 each in lots of 10,000.

For its part, Philips is working on a hardware/software co-design. "While the software is used for flexibility, the hardware is used to accelerate the most demanding parts of the standard," said strategic product manager Pim Korving. Philips will use the block "to build up a system-on-a-chip as well as an autonomous JPEG2000 codec IC," he said.

TI sees JPEG2000 becoming more prevalent in coming years, but declined to say when its first JPEG2000 chip may come out. Gorden Cook, worldwide manager of marketing and business development for TI's digital still-camera unit, said the most likely approach is adding to its DSP core programmable subsystems that enhance JPEG2000 performance. But "running JPEG2000 completely in software, or hardwiring the whole thing, still remains as an option," he said.

Image Power Inc. (Vancouver, British Columbia), a third-party software developer, last month announced that its JPEG2000 software codec now runs on TI's TMS320C5000 DSP platform. The codec is expected to offer hardware and software developers an easy-to-use environment for rapid prototyping of imaging and video systems based on the C5000.

Separately, LuraTech Inc. (Berlin) earlier this month unveiled JPEG2000 software development kits, based on a beta version of LuraTech's own JPEG2000 implementation.

Still in flux

Cook said that JPEG2000 implementation issues remain in flux, making it difficult to finalize design choices. Philips' Goettling agreed. "Even though no technical changes are allowed to the standard, there are still open and misunderstood points," he said.

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The JPEG2000 committee is working on amendments and compliance definitions "for setting the right kinds of profiles and parameters for digital still cameras," said Lee of Yahoo! Asia. The Final Draft Amendment stage occurs in July, with ratification expected in October.

In transitioning to JPEG2000, one of the toughest questions for camera makers is the motion issue. "JPEG2000 today can offer very high-quality images, but at high cost with no motion," said WIS Technologies' Ouyang.

But the JPEG2000 committee, is working on a Motion JPEG2000 standard. Noting that Motion JPEG2000 uses the same coding technique as standard JPEG2000, ADI's Smith said that "our chip will support this with no problem." He cautioned, however, that Motion JPEG2000 should not be viewed as competing with MPEG. Much effort has gone into keeping the charters of the two groups from overlapping. MPEG standards are better suited for higher-frame-rate video applications such as broadcast, DVD or VideoCD, while Motion JPEG2000 is ideal for low-frame-rate applications.

Many in the industry agree that digital still cameras in the transition period will feature both DCT and wavelet codecs. Since there is no overlap in the two technologies, it would be expensive to support both standards with optimized hardware in one device. "The only short-term solution," said Philips' Korving, "might be a DSP-based software solution for JPEG2000 and JPEG."

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