



Development of an Imaging System that Creates a High-Speed Imaging World

Welcome to the World of High-Speed Imaging !

Sony created the IMX017 *1 high-speed CMOS sensor making it possible to “capture the instant”, something that was previously impossible, and then developed the IMX032*2, which features further miniaturization and higher resolution. High-speed imaging systems that combine the CXD4109AGG high-speed image processing engine with these sensors not only achieve even faster continuous imaging performance, but also create new imaging experiences and open the door to a world of high-speed imaging. In this world of high-speed imaging, previously unknown applications, such as time machine imaging, which never misses the best instant, multiplane image stabilization, which makes handheld photography at night possible, and multiplane wide dynamic range imaging, which significantly improves image quality in backlit situations can be included in digital still cameras and digital video cameras. In this article, we introduce the new imaging world that is created

by this high-speed imaging system.

*1: Diagonal 9.10 mm (Type 1/1.8) 6.40M-effective pixel color CMOS sensor

*2: Diagonal 7.63 mm (Type 1/2.3) 9.29M-effective pixel color CMOS sensor

System Overview

This high-speed imaging system implements a digital camera by combining a high-speed CMOS sensor, either the IMX017 or the IMX032, with the CXD4109AGG high-speed image processing engine, memory, and other peripheral devices. (See figure 1.) The most significant feature of this system is applications that extend along the direction of continuous, high-speed RAW image capture. To achieve high-speed RAW image capture, it is necessary to store, in real time, the high-speed data output from the high-speed CMOS sensor in a high-speed/large-capacity image memory. In this system, up to four 2G-bit DDR2 memory chips can be connected. When this maximum amount of memory is used, up to 100 6M-

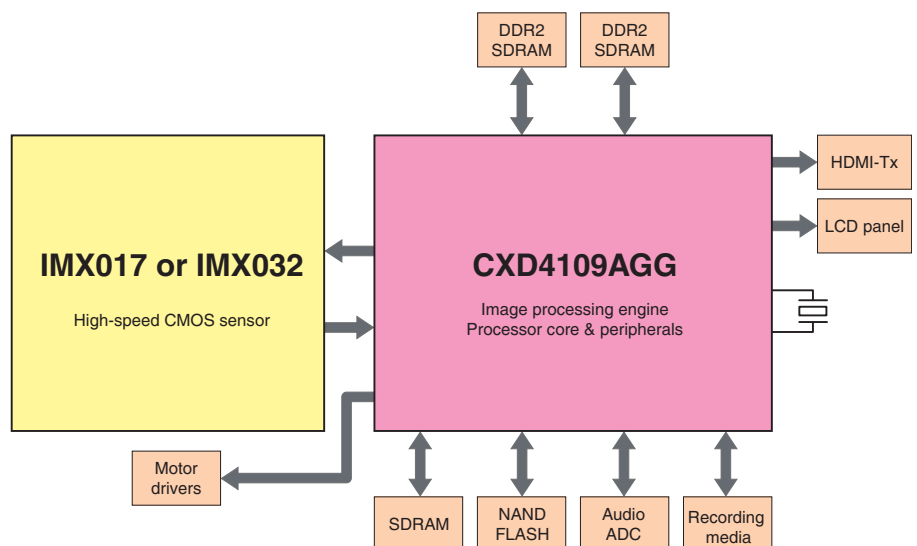
Time machine imaging: Never missing the best instant

Multiplane synthesis: Creating new functions and superb picture quality

Ultrahigh-speed imaging: Seeing things that cannot be seen

Seamless video and still imaging: Fusing video and still imaging

Figure 1 System Structure



pixel RAW images (one 6M-pixel RAW image requires about 6M bytes) can be stored in the memory.

Here we present high-speed imaging applications made possible by Sony's high-speed imaging system and detailed information on the technologies that support this system.

Time Machine Imaging: Never Missing the Best Instant

Capturing the best shot is one of the most difficult imaging techniques. In current cameras, the only way to handle the time from the point something is sensed by a human until the shutter is pressed, is for the photographer to predict that time based on experience and feeling, and to press the shutter at the point s/he feels is right. But it is hard to predict things such as people's expressions and the motions of children and animals, and it is always difficult to capture the best possible shot. At the same time as radically improving the continuous imaging performance to above the speed of human responses with 60 frame/s at 6.4M pixels (IMX017) and 40 frame/s at 8M pixels (IMX032), Sony's high-speed imaging system makes it possible to capture the best possible shot by starting to record data from before the point the shutter is pressed. This is what we call "time machine imaging".

To allow the best image captured in the past to be acquired, the camera system continuously records RAW images output from the sensor before the shutter is pressed to a ring buffer area set up in image memory and this RAW image recording operation is terminated when the shutter is pressed. (See figure 2.)

Figure 3 shows the operation while saving to the recording media. The best shot is saved by applying camera and compression processing to the RAW images in the ring buffer. Also, this camera system is capable of 30 frame/s and higher monitor display during continuous imaging. This allows framing to be verified in real time. As a result, even though it was difficult with earlier cameras, it is now easy to capture the best image.

Figure 2 Operation During RAW Recording

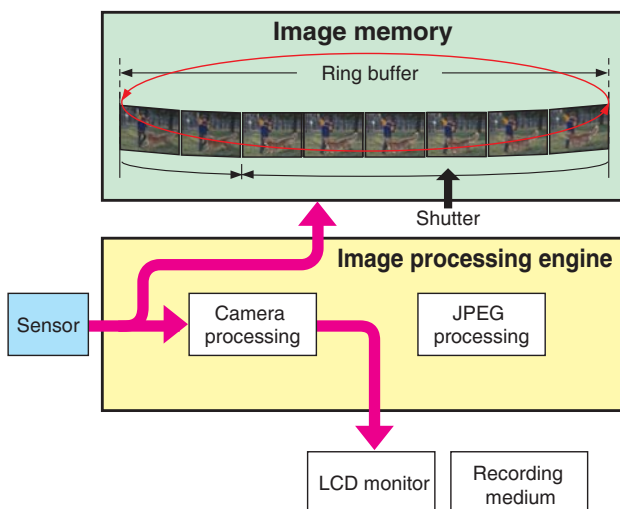
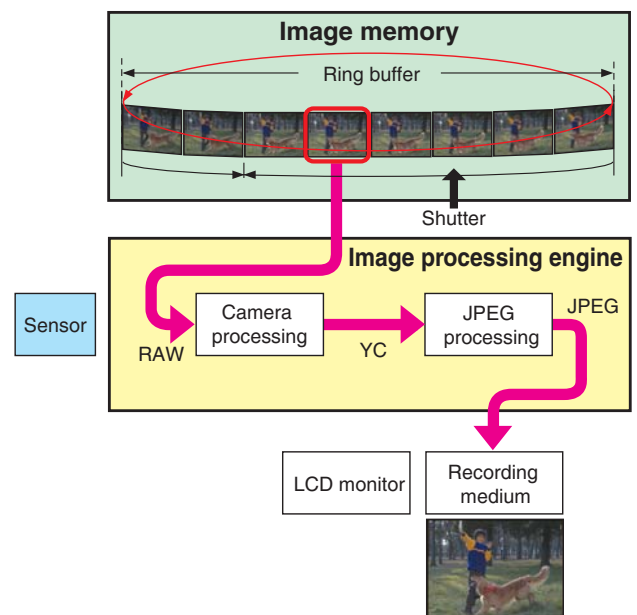


Figure 3 Operation when Saving



Multiplane Synthesis: Creating New Functions and Superb Picture Quality

Multiplane image stabilization achieves long handheld exposures

Although use of a tripod is common in photography with longer exposure times, Sony's multiplane image stabilization makes handholding possible in such situations. The multiplane image stabilization provided by this high-speed imaging system captures, using a shutter speed much faster than normal, several frames that do not have blur (for example, 8 frames) and creates a single image synthesized from the reference image by matching the positions. (See figure 4.) To implement this function, the CXD4109AGG includes both a high-precision motion vector detection engine that calculates the amount of blur and a multiplane synthesis engine that combines multiple images while matching their positions. The affine transformation model is adopted for position matching and can perform rotation correction, which is impossible with optical image stabilization systems such as lens shift and sensor shift methods. This makes it possible to retain high resolution even after

synthesis. Furthermore, it is possible to achieve extended-period handheld photography with exposure times up to one second by combining multiplane image stabilization and optical image stabilization. In combination with the noise reduction effect due to the multiplane synthesis, this system can perform extremely high-precision image stabilization, and make handheld photography possible.

Multiplane wide dynamic range: significantly improved image quality in backlit situations

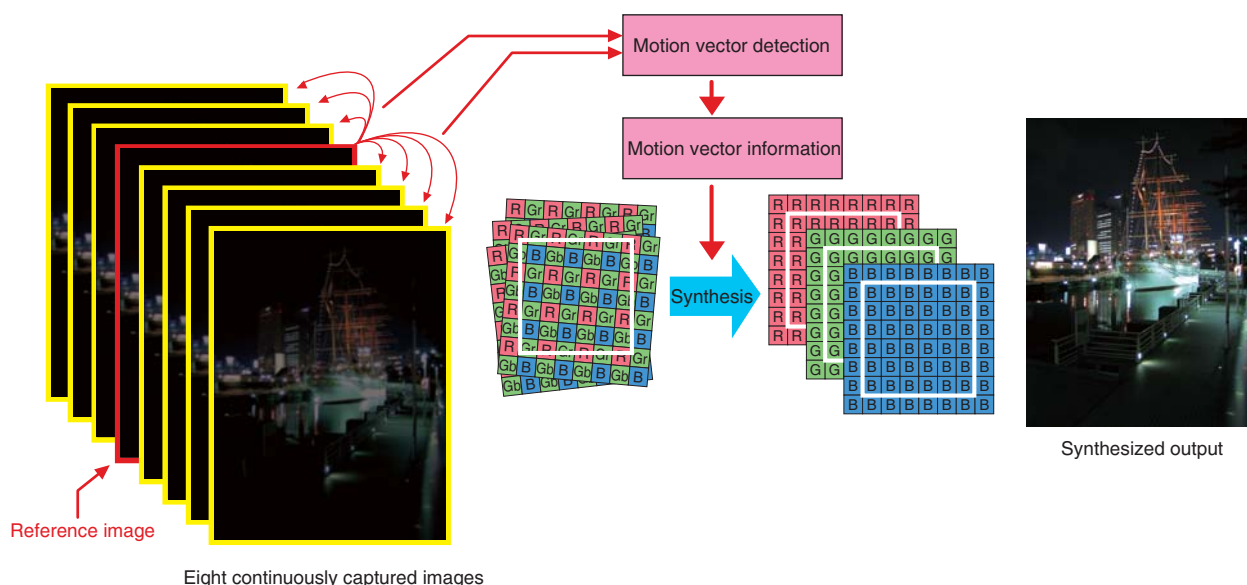
The multiplane wide dynamic range function makes it possible to obtain a dynamic range correction effect while maintaining a high signal-to-noise ratio even in conditions when the subject is dark and other parts of the image are bright, for example when the subject is backlit. This high-speed imaging system achieves wide dynamic range imaging by combining multiplane synthesis with this dynamic range correction function.

Figure 5 shows comparison images for normal imaging and multiplane wide dynamic range imaging.

Since the subject in figure 5A is backlit, in this normal imaging example the main subject, the doll, is relatively dark. Normally, to show the main subject, one would apply an exposure compensation of around +2EV as shown in figure 5B. Although the main subject will be correctly exposed by this method, the background will be overexposed to the point of saturation. If the dynamic range correction function provided by this system is used, it is possible to show both the background and the main subject at the same time under backlit conditions as shown in figure 5C. Figure 5D shows a multiplane wide dynamic range imaging example in which these two functions are combined. The main subject and the background are both faithfully rendered by the dynamic range correction signal processing, and furthermore, a high signal-to-noise ratio image is created by multiplane synthesis.

It is now possible to record the whole brightness scale as seen with no degradation of picture quality even for subjects that have such a large difference between their dark and bright areas that the bright areas would be overexposed by earlier cameras.

Figure 4 Multiplane Image Stabilization



Ultrahigh-Speed Imaging: Seeing Things that Cannot be Seen

The CXD4109AGG includes an image processing engine that is capable of continuous processing through the generation of JPEG data at 400 frame/s for 640 × 480 (VGA) size video. It also includes a hardware sequencer that controls the data flow to support this ultrahigh-speed video processing. Using these functions, it can perform video processing at rates over 1000 frame/s without incurring any CPU load. That is, the CXD4109AGG can process the ultrahigh-speed video output by a high-speed CMOS sensor up to the limits of the capabilities of the sensor.

When motion JPEG video captured at ultrahigh speeds by these functions is played back at TV frame rate, the result is ultraslow playback, and phenomena that could not be seen can now be caught by the human eye.

Seamless Video and Still Imaging: Fusing Video and Still Imaging

The CXD4109AGG can generate high picture quality high-definition video by performing reduction, cropping, and other operations on the output from a high-speed CMOS sensor and creating 1920 × 1080-pixel images. Figure 6 shows the mechanism for seamless video and still imaging. Inside the image processing engine, the device includes a function for reducing RAW images to the video recording size at the same time as storing the RAW image to memory. Using this function, the device implements simultaneous recording of full size still images without dropping even a single frame from the video.

Future Developments

Sony's high-speed imaging system makes it possible to create new applications by combining a high-speed CMOS sensor with a high-speed image processing engine. Sony is developing its CMOS sensor technology, signal-processing technology, and control technology at a high level in a balanced manner to develop even more attractive applications and to contribute to the evolution of the digital camera. Keep your eye on Sony's high-speed imaging system as it continues to expand the world of photographic imaging.

Figure 5 Multiplane Wide Dynamic Range Imaging Example

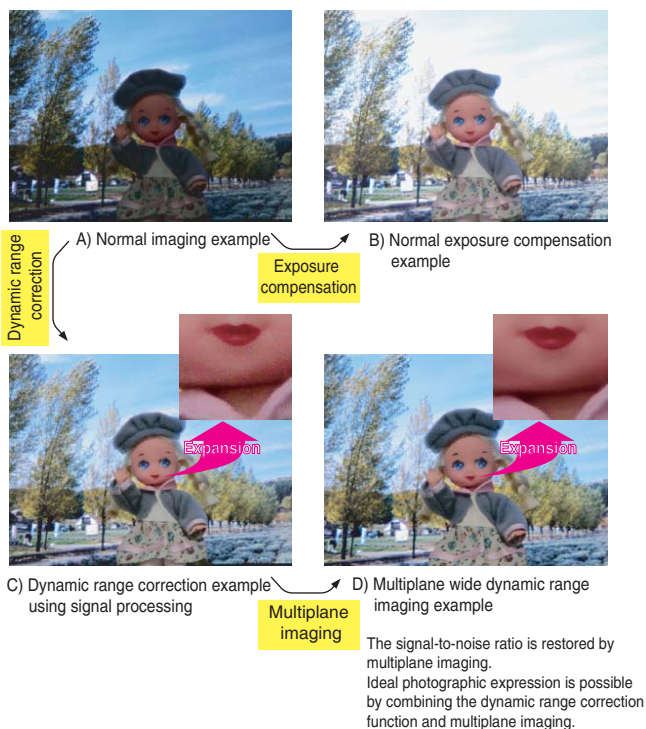


Figure 6 Mechanism for Seamless Video and Still Imaging

