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THE EDITORIAL VIEW

MEMORY: THE ELEPHANT IN THE ROOM

By Tom R. Halfhill {3/30/09-02}

Memory prices have fallen so dramatically that flash-memory cards are now cheaper than film—even if you use them only once. And that comparison doesn't even add the cost of processing the film. But therein lies a paradox. Eventually, this trend will drive memory cards into obsolescence before film.

How's that again? Bear with me. My analysis may influence your future system designs.

First, the math. You can buy 4GB Secure Digital (SD) or Compact Flash (CF) cards for about $10. In my 10.2-megapixel DSLR, a 4GB card holds 530 photos in the highest-quality JPEG format. A roll of 35mm film (color or black-and-white) costs about $5 and takes 36 photos. So the cost per photo is about 2 cents for digital and 14 cents for film (without processing). Although it may seem extravagant to use a rewritable memory card only once, shooting a roll of film is at least seven times more extravagant—and the disparity keeps growing.

The 530 photos that fit on a 4GB memory card are equivalent to shooting 15 rolls of 36-exposure film. That's more film than most snapshooters use in a year. An 8GB card stores twice as many photos; a 16GB card, four times as many. According to Moore's law, memory capacities will continue doubling every 24 months. Within 10 years, a single memory card will hold 50,000 to 100,000 pictures—more than most amateurs shoot in their entire lives.

Someday soon, it will no longer make sense to build memory-card slots into digicams intended for the mass market. (Professional photographers and advanced amateurs may still want removable cards.) Indeed, some low-end digicams today rely wholly on internal memory. Most

MP3 players have already crossed this threshold. They don't need card slots, because their internal flash memory or hard drive has enough room to store a person's entire music library. Slotless digicams will transfer their photos to PCs, printers, and commercial kiosks over a wired or wireless USB interface, eliminating another justification for removable memory cards.

At that point, memory cards will become niche products for advanced amateurs and pros—just like film! In this not-too-distant future, only specialty shops will carry memory cards, shelved alongside their dusty rolls of Fujicolor and Kodak Tri-X, waiting for the occasional customer.

Can you spot the soon-to-be-obsolete image-recording medium in this picture? Don't be too quick with your answer.

How Cameras and Cards Will Change

Three factors may delay the obsolescence of memory cards for digicams. One is that people tend to shoot more pictures with digicams than they did with film cameras. Another is that megapixel resolution is still growing. And the third factor is that almost all digicams can shoot full-motion video with audio, which uses much more memory than still photos do.

First, consider shooting habits. In the past, the cost of film and processing was a major constraint for amateurs. One of my grandmothers was a prolific shooter for a casual amateur of her era, but even so, she took fewer than 1,500 photographs during her lifetime of nearly 92 years. (We found all her negatives stashed in a shoebox after she died.) Lately, I've heard about amateurs shooting that many pictures over a big weekend. Wild shooting is affordable with digital, because the vast majority of those photos are never printed. Screen viewing is adequate for many people, especially young folks, who are less inclined to make traditional photo albums.

Second, consider the megapixel race. These days, even some low-end digicams surpass 10 megapixels. However, megapixel inflation will be limited by the digital noise inherent in cameras with tiny image sensors and by growing consumer awareness that more megapixels aren't necessarily better. A 10-megapixel camera is useful for making 11- × 14-inch prints, but most people don't make 11- × 14-inch prints. Most digital pictures aren't even made into 4- × 6-inch prints. Eventually, consumers will realize that having more megapixels simply creates bigger files and noisier pictures.

The greater amount of memory storage required for video is the third factor that could delay the transition to slotless digicams, at least for users who regularly shoot video. High-definition video eats even more memory than standard definition does. And I'm noticing a trend toward shooting nothing but video, then grabbing individual frames if a still photo is desired. In fact, some newspapers now equip their photographers with digital camcorders instead of still cameras. These papers post video clips on their websites and grab still images for both web and print publishing. Remember that photojournalists are trendsetters—they were among the first to convert from film to digital.

Eventually, however, the relentless advance of Moore's law will expand internal memory to the point where even copious amounts of video won't fill it up. When that happens, most people will regard memory cards as a quaint anachronism, like 4- × 5-inch film packs or reels of Super-8 film.

Write Once, Keep Always

Although pros and advanced amateurs may continue to demand removable memory cards, their needs will change, too. As memory prices keep dropping and capacities keep rising, rewritable memory will seem unnecessary, especially if it compromises nonvolatility. Today, we generally regard flash memory as nonvolatile. Actually, flash-memory cells can lose their data retention in about 20 years (depending on numerous variables). This deterioration makes flash memory a risky bet for archival storage.

As a result, serious photographers who prefer memory cards over built-in memory will demand write-once memory cards that have greater permanence, even if the photographers back up their files on another medium. This development is foreshadowed today by the marked preference for write-once CD-R and DVD-R discs over rewritable CD-RW and DVD-RW media.

Therefore, the next 10 years will likely bring two or three important changes to those embedded systems we call digital cameras. One is the transition to slotless amateur digicams, and perhaps to videography replacing on-the-scene still photography. Another is the transition to write-once memory for higher-grade cameras that retain card slots. In both cases, the steady advance of memory technology will be the catalyst. And keep in mind that these changes are in addition to other trends driven by the steady advances in microprocessors, image sensors, and image processing.

Memory Trends Alter System Design

Although memory technology heavily influences system design, we rarely cover it in *Microprocessor Report*. One reason is that microprocessors are obviously our primary focus. (Otherwise, our publication might be named *Memory Report*.) Another reason is that memory is less interesting than logic, because advances are measured mainly in terms of rising capacity and falling prices, not new capability. A third reason is that memory is well covered elsewhere. Sometimes, we do cover memory technology that is genuinely new. (See *MPR 9/11/06-01*, "MRAM: A New Spin on Memory.")

However, our preference for logic doesn't mean we ignore the elephant in the room that is memory. Sometimes, a difference of degree becomes so great that it becomes a difference of kind.

Consider what happened when hard drives became small enough and flash memory became cheap enough to enable the design of portable MP3 players. Those gradual improvements, incremental on the surface, have nearly demolished the market for removable-media portable music players. Cassette-based Sony Walkmans and portable CD players have been largely superseded by Apple's iPod and similar devices. At the same time, this memory-driven transition is upending the record industry, whose business model has centered on removable media since Thomas Edison invented the phonograph in the 19th century.

Most embedded systems are derivatives of previous designs that were predicated on certain assumptions about the cost and capacity of memory. Occasionally, system designers need to step back from their projects and reevaluate those assumptions. The steady drip-drip-drip of falling

prices and rising capacity may have changed the game. A follow-on system design that merely adds more memory at a lower cost could miss a sea change that radically redefines the very nature of the product. Nobody wants to get stuck with a warehouse full of improved cassette players when consumers are switching to MP3 players.

Lesson: the slow creep of memory capacity and the slow decline of memory prices may appear insignificant from one year to the next. Over time, however, they inspire huge changes. ◇

Tom R. Halfhill