Technology Institute

Mobile Technologies Index
Image sensor: Steady growth for new capabilities

By Raman Chitkara, Global Technology Industry Leader

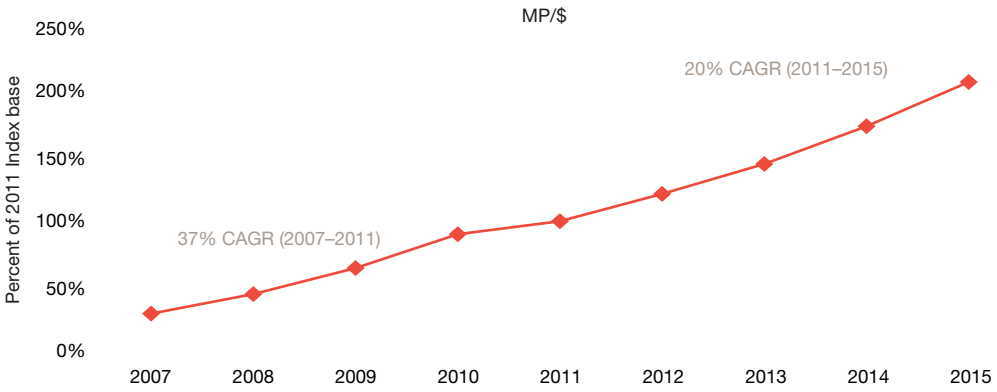
Introduced in 2000, camera phones—combined with social media—continue to redefine what it means to communicate. The early camera phones produced low-quality images, but now, thanks to Moore's Law, they are competing with point-and-shoot cameras and camcorders. How much more can camera phones do?

Quite a bit more, it turns out. The innovation curve will continue to produce camera phones that capture higher quality still images and videos with better sound. These improvements will result from image sensor improvements and increasingly from technology around the sensor, especially the use of microelectronic mechanical systems (MEMS), as discussed below.

Over the longer term, compelling new use cases that rely on tighter integration between the camera module and the operating system will lead to new capabilities more aptly classified as machine vision. We introduce this topic below, but anticipate a deeper analysis in a future article. The main focus of this article is the image sensor, which is a component of the PwC Mobile Technology Index. The Index comprises seven technologies that enable mobile innovation.

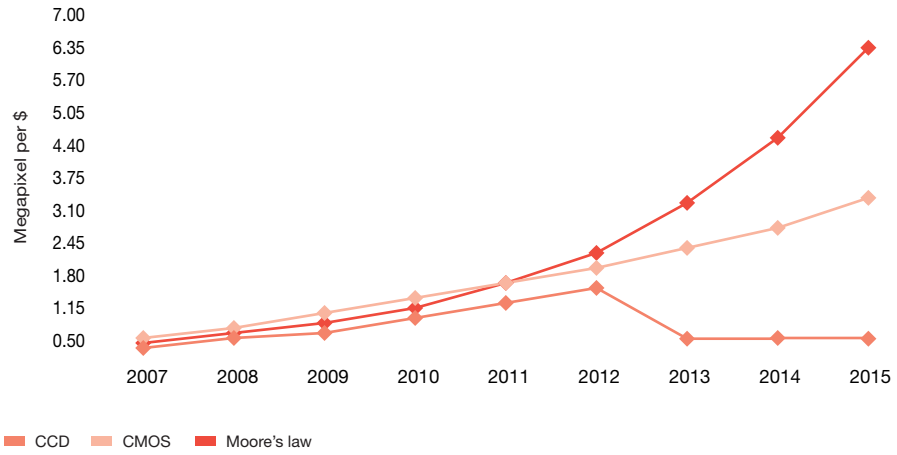
PwC forecasts a compound annual growth rate (CAGR) of 20 percent for image sensors as measured in megapixels per dollar (MP/$) through 2015. [See Figure 1] Since 2007, image sensors have followed Moore's Law, doubling megapixel density per dollar every two years for a CAGR of 37 percent. The MP/$ will continue to grow, but at a slower rate. [See Figure 2] This, however, will not reduce or depreciate the image sensor's importance to mobile innovation. To understand the future of image capture, it is useful to review the evolution of imaging in smartphones.

Figure 1: Image sensor, compound annual growth rate (CAGR)



Source: IHS iSuppli Mobile and Wireless Communications Service

Figure 2: Price performance compared to Moore's Law



Source: IHS iSuppli Mobile and Wireless Communications Service

The image sensor is part of a camera module for the mobile device that also includes the lens and MEMS for various (and a growing number of) functions, plus interfaces to the application processor, memory and storage.

The first camera modules for cell phones used charge-coupled device (CCD) sensors. As recently as 2006, 4MP CCD-based modules cost US$22, which included US$8 for the image sensor. Camera module suppliers charged as much as US$15 more for 'integration' of this subsystem into the handset. Aside from being costly, the early camera modules came in only one size (large) and used significant amounts of power, consuming the battery faster.

The lower quality images from early camera phones were relegated to viewing on the phone screen because the resolution was not high enough for printing or displaying on a computer screen. As well, sharing photos on 2G/2.5G broadband cellular networks was much slower, and most camera phones didn't yet support WiFi or Universal Serial Bus (USB) standards.

As a result, there were many hurdles to sharing, posting and permanently saving images. Despite these obstacles, camera phones served a practical purpose and became a standard feature in 80 percent of all handsets manufactured—increasing to 90 percent within our forecast period.

CCD-based handsets have been slowly phasing out since the introduction of complementary metal-oxide semiconductor (CMOS) sensors in 2006. CMOS sensors consume less power than CCD sensors. They also enable lower cost, smaller form factors and much higher image quality.

Consumers now expect to capture higher-quality photos and to more easily share them in email, on social networks and as prints. They can look forward to the quality of images and video to continue to improve year after year. By 2015, high-end smartphones, which already have 8MP image sensors, will enter the 14MP to 20MP range.

Higher resolution image sensors equal to or approaching those of the point-and-shoot digital camera are only one part of the formula for image improvement. Through software manipulation and various MEMS devices, smartphones will continue to deliver improvements in image stabilisation; auto focus; zoom; light sensitivity; low-light performance; noise reduction; reduced power use;

integrated image processing hardware; sound recording for video and lens improvement. Software will also become a differentiator in image collection, compression, picture editing, video editing and searching.

MEMs are crucial. They are made with standard semiconductor manufacturing processes and benefit from the predictable price-performance curve of those processes.

Software and MEMs have already enabled new or improved functions in some smartphones: autofocus[1] (MEMs), panoramas from multiple photos (software) and high-definition image capture (MEMs and software).

Improvements in image sensors, MEMS and software will enable future-generation camera phones to offer 3D imaging. 3D will not only provide a richer, more realistic photographic image, but the 3D depth map will be crucial to the sensing required for hands-free gesture control of the device and improved facial recognition.

1 http://www.doc.com/Actuator/Pages/Actuator.aspx

Due to these continuing improvements in mobile device imaging—still and video—the market for point-and-shoot digital cameras is likely to contract. In 2011, the average handset had 30 percent of the MP count of the average digital still camera. By 2015, handsets will have 60 percent of the MPs in digital still cameras on average, with some having more than 80 percent. [See Figure 3]

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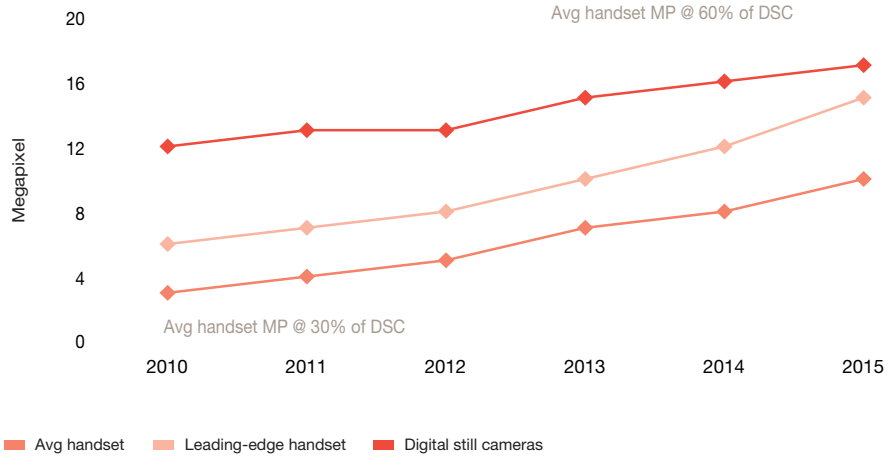
"In the near future, smartphones will have more than enough raw pixel resolution and capabilities to meet most users' needs, and those users will become less willing to pay a premium for additional megapixels, unless new capabilities, like machine vision, are added," says Robert A. Chinn, a principal in the Semiconductor Advisory Practice at PricewaterhouseCoopers LLP.

Figure 3: Megapixels in handsets vs. digital still cameras (DSC)



Source: IHS iSuppli Mobile and Wireless Communications Service

As noted earlier, improved image sensors and camera modules will factor into machine vision capabilities that are just now appearing on the horizon. Machine vision broadly comprises the translation of light (visible to the human eye or not) into digital information, and the analysis of that digital data for the purposes of identifying and extracting information about objects of interest. To date, machine vision has mainly been associated with manufacturing for quality control and other industrial uses. In smartphones, machine vision will involve the use of the image sensor to capture information that is analysed in the device or in the cloud (or both), and put to some personal purpose. For example, there already is a smartphone app that uses the image sensor to help it detect and measure gamma rays—radiation—in the immediate area.[2]

Machine vision capabilities in mobile devices will use the image sensor in different ways than photo capture does. Some machine vision applications will use less information than required for photos; for example, make determinations based on examining the contours of objects in an image but without needing a full color rendering of it.

Machine vision use cases supported by all the anticipated advances in image sensors, MEMs and software could include hands-free gesture control, facial recognition and mobile industrial and medical applications. Another recently announced non-photo use of the image sensor is an infrared (IR) sensor that takes the body's temperature. The IR sensor, which is a MEMs device, is designed to sit next to the image sensor in the smartphone and use its viewfinder to target the correct spot of the object or subject to take a temperature. We will explore machine vision use cases like this in depth in future articles.

Because the camera modules will move from commodity parts with limited functionality to multi-purpose modules capable of wide ranging uses, the modules will require deeper integration with the operating system. PwC anticipates consolidation in the vendor space within our forecast period as fewer suppliers will be likely to meet the higher threshold for functionality and OEMs will look to establish long-term relationships with individual suppliers. In 2012, the supply base included 40 image sensor suppliers and 40 camera module suppliers.

Whatever new use cases image sensors end up supporting, camera modules will clearly evolve within our forecast period to support everything needed for higher quality video and still photography, and use cases associated with recording scenes for later viewing or playback.

2 http://www.vision-systems.com/articles/2012/05/smartphones-measure-radioactivity.html

Let's talk

If you have any questions about the Mobile Innovations Forecast, or would like to discuss any of these topics further, please reach out to us.

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