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One sensor does the work of many

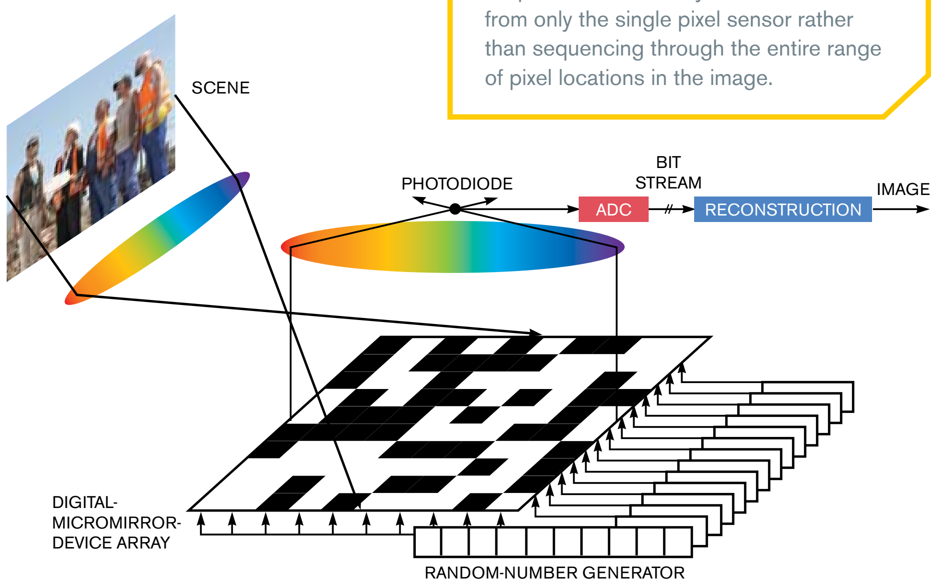
Digital cameras, still relatively inexpensive devices, have exponentially increased the number of pixels they can capture. Because silicon, a primary material in CCD (charge-coupled devices) and CMOS imagers, is sensitive to the same wavelengths as the human eye, digital cameras have been able to double their pixel resolution roughly in step with the doubling in memory sizes.

Rice University is now demonstrating a camera that uses a single sensor to capture images that conventionally require an array of sensors (image courtesy Richard Baraniuk, Rice University). The researchers direct a captured image at a single sensor and use the resulting stream of measurements to reconstruct the image. They accomplish this task without making individual measurements of each pixel.

The second lens captures the reflected light from the DMD array and focuses all of the light to a single pixel-sensor collector. Because all of the reflected light goes toward the sensor, it effectively receives a summation of all of the reflected light. This approach differs from a conventional sensor array in which each pixel sensor receives only a fraction of the total light because each one receives only the light corresponding to a specific pixel location.

The analog-to-digital-conversion step is simpler because the system converts data from only the single pixel sensor rather than sequencing through the entire range of pixel locations in the image.

The system sends the image through a lens much as a conventional camera does; however, instead of directing the light from the captured image to an array of sensors, the light goes to a Texas Instruments (www.ti.com) DMD (digital-micromirror-device) array that comprises bacterium-sized mirrors that correspond in position to the pixels in a conventional image.



TI based the DMD on its DLP (digital-light-processing) technology, which digital televisions and projectors typically use. Using a pseudorandom-number generator, the system configures a random set of half the DMDs in the array so that they reflect the incoming light to a second lens. The remaining DMDs reflect none of the light directed toward them. Each image snapshot uses a different random mix of reflecting and nonreflecting positioning of the DMD.

By tracking the random, half-reflecting-DMD-array configuration with the detected summation of light at the single-pixel sensor, the system applies a compressive-sensing-recovery algorithm across a series of snapshots to reconstruct the image. With this approach, the number of measurements of the scene necessary for adequate reconstruction of the image is only, say, 10, 20, or 40% of the total number of pixels in the image. A seed value for the pseudorandom-number generator manages the random configuration of the DMDs. The system uses this seed value to reconstruct and associate each configuration of the DMD array with the reflected-light-summation value.