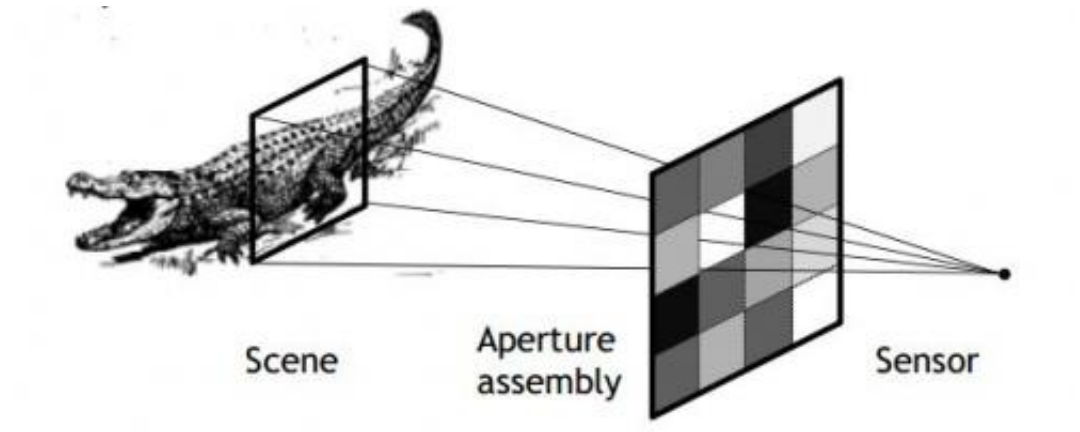
Bell Labs researchers build camera with no lens

June 4 2013, by Bob Yirka



The proposed architecture consists of two components: an aperture assembly and sensor of a single detection element. Credit: arXiv:1305.7181 [cs.CV]

(Phys.org) —A small team of researchers at Bell Labs in New Jersey has built a camera that has no lens. Instead, as they explain in their paper they've uploaded to the preprint server *arXiv*, the camera uses a LCD array, a photoelectric sensor and a computer to create always in-focus pictures.

Traditional cameras all use the same basic model: light coming through a lens is focused onto film, an array of sensors or in biological models, a retina. This process is based on capturing the most data possible to create the best looking image. In this new effort the Bell Labs team took very nearly the opposite approach, their imaging technique is based on the

idea that measurement of light as it's bounced off of an object carries a lot of redundancy—to take advantage of that, researchers use what is known as compressive sensing.

The new camera they built has just three main components: an LCD array that allows light to pass through, a RGB photoelectric sensor, and a computer to control the LCD and to process the data that is received from the sensor. To create an image, the LCD array is placed between an object to be "photographed" and the single pixel sensor. The computer sends signals to the LCD causing some of the crystals in the LCD to allow light to pass through—each serves as a tiny aperture. The crystals in the LCD are chosen by a random number generator—the end result is an LCD panel with a speckled pattern. The photoelectric sensor then captures the light that is allowed to pass through the LCD panel and sends the data to the computer. To create a single picture, multiple image-captures are taken with different random patterns generated on the LCD panel. The data from all of the image-captures is processed afterwards and the result is a single photograph—the more image-captures taken, the higher the resolution of the final product.

Prototype device. Top: lab setup. Bottom left: the LCD screen as the aperture assembly. Bottom right: the sensor board with two sensors, indicated by the red circle. Credit: arXiv:1305.7181 [cs.CV]

The process works because the image is built from light reflected off an object as measured from a slightly different perspective. Comparing the same view as seen through many different aperture array patterns allows for building a complete picture without the need for a lens.

The upside to such a camera is its low cost—the demo made by the team at Bell Labs was constructed from off-the-shelf parts. Also, adding more sensors allows for creating multiple images simultaneously (three sensors allows for building three dimensional images). The downside to the process is that it takes much longer to take a picture than a lens based camera, and it only works for capturing stills.

More information: Lensless Imaging by Compressive Sensing, arXiv:1305.7181 [cs.CV] arxiv.org/abs/1305.7181

Abstract

In this paper, we propose a lensless compressive imaging architecture. The architecture consists of two components, an aperture assembly and a sensor. No lens is used. The aperture assembly consists of a two dimensional array of aperture elements. The transmittance of each aperture element is independently controllable. The sensor is a single detection element. A compressive sensing matrix is implemented by adjusting the transmittance of the individual aperture elements according to the values of the sensing matrix. The proposed architecture is simple and reliable because no lens is used. The architecture can be used for capturing images of visible and other spectra such as infrared, or millimeter waves, in surveillance applications for detecting anomalies or extracting features such as speed of moving objects. Multiple sensors may be used with a single aperture assembly to capture multi-view images simultaneously. A prototype was built by using a LCD panel and a photoelectric sensor for capturing images of visible spectrum.

via Arxiv Blog