Lens-less Imaging with Controllable Apertures

Technology #m05-064

“Lead Inventors: Shree K. Nayar, Ph.D., Assaf Zomet, Ph.D.

Digital camera without standard lens can photograph moving objects: Conventional cameras use lenses to focus light and to form images. Despite desirable features, these lenses constrain the mapping from the scene to the image and thus, conventional cameras provide limited control over their imaging properties. Instead of using lenses, conventional pinhole cameras use small apertures for light collection. Although geometric distortion is prevented, these pinhole cameras also suffer from inflexibility facing lens cameras.

Recently, cameras including lenses and an array of micro-mirrors, or a light attenuator, are proposed to obtain pixel-wise multiplications in the optics and instantaneous changes of viewing directions. These proposed cameras, while highly controllable, still need lens to focus a scene on an image detector.

Lens-less camera consists of an image detector and a aperture with parallel light attenuating layers: This invention presents a novel, highly flexible lens-less camera. The imaging device consists of an image detector and a special aperture, consisting of a set of parallel light attenuating layers. A light attenuating layer consists of a liquid crystal sheet, a digital micro mirror device and a liquid crystal on silicon device, each having a controllable transmittance. The light attenuating layer controller simultaneously controls the transmittance of each element of the light attenuating layer, independent of each other. By applying different transmittance patterns, it is possible to modulate the incoming light and capture images that are impossible with conventional lens-based cameras. The imaging functionalities can be implemented with the same physical camera and the device can switch between different functionalities via software. A prototype camera has been built based on this approach.

Applications:
• The proposed lens-less digital camera can be used for detecting and analyzing moving objects over large area
• The imaging technology is specially useful in surveillance system
• Can provide lens-less camera with programmable functionalities
• Can also be used as a computational sensor, where the detector measures the end result of computations performed by the attenuating layers on the scene radiance values

Advantages:
• Provides a method for tracking of the moving objects effectively, by dynamically changing the transmittance of the layers based on position or motion of the objects in a scene
• Provides control over camera properties without motion
• Can capture images impossible with conventional lens-based cameras, for example, disjoint regions of interest in the scene without the regions in between them

Licensing Status: Available for Licensing and Sponsored Research Support


Inventors

Shree Kumar Nayar