

# Lensless camera technology for adjusting video focus after image capture

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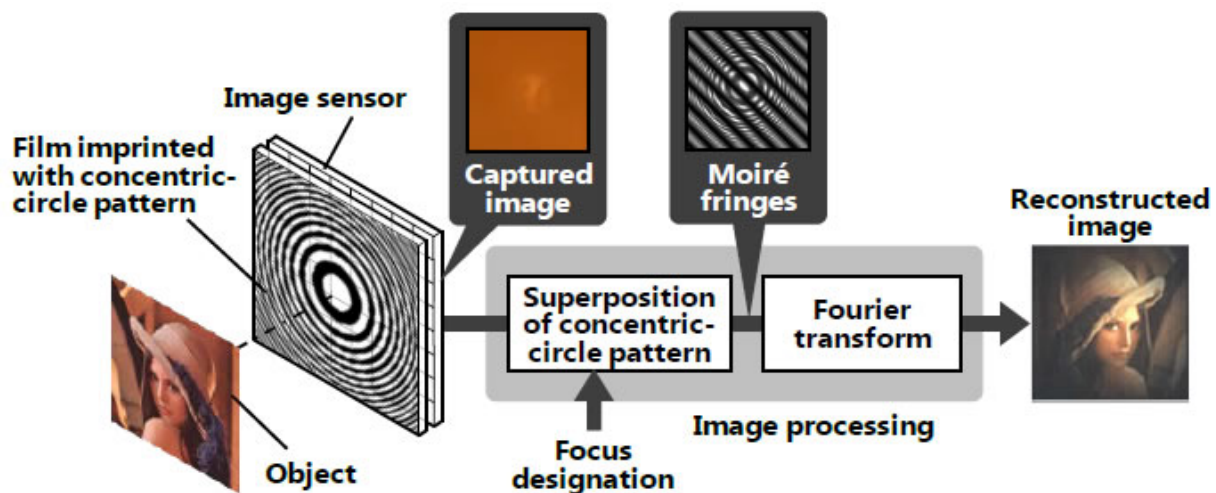


Figure: Principle of newly developed lensless camera technology. Credit: Hitachi

Hitachi today announced the development of a camera technology that can capture video images without using a lens and adjust focus after image capture by using a film imprinted with a concentric-circle pattern instead of a lens. This camera technology makes it possible to make a camera lighter and thinner since a lens is unnecessary and allow the camera to be more freely mounted in devices such as mobile devices and robots at arbitrary positions without imposing design restraints. Moreover, since it acquires depth information in addition to planar information, it is possible to reproduce an image at an arbitrary point of

focus even after the image has been captured. Focus can be adjusted anytime to objects requiring attention, so Hitachi is aiming to utilize this technology in a broad range of applications such as work support, automated driving, and human-behavior analysis with mobile devices, vehicles and robots.

As for cameras mounted in mobile devices represented by smartphones and robots, which require designability, making them thinner and lighter while providing higher performance—without imposing restrictions on where they can be mounted—is being demanded. As a [camera technology](#) to meet that demand, there is an increasing anticipation of applying a technology called "computational photography" which is a scheme used in an optical system under the presupposition that [image processing](#) will be used after images are captured. As a camera utilizing this technology, a light-field camera, which records position and direction of light beams simultaneously and whose focus can be adjusted after images are captured, is well-known. However, a light-field camera is considerably thick since it needs a special lens. On the other hand, a lensless camera which is thin and light because it has no lens has been developed. Even so, processing of images captured by the camera incurs a heavy computational load.

Aiming to overcome the difficulties described above, Hitachi has developed a camera technology—based on the principle of Moiré fringes (that are generated from superposition of concentric circles)—that combines a function for adjusting focus after images are captured in the same manner as a light-field camera and features of thinness and lightness of a lensless camera which computational load incurred by image processing is reduced to 1/300. The two main features of the developed camera technology are described as follows.

## **(1) Image processing technology using Moiré fringes**

A film patterned with concentric circles (whose interval narrow toward the edge of the film) is positioned in front of an image sensor, and the image of a shadow formed by a [light beam](#) irradiated onto the film is captured by the image sensor. During the image processing, a similar concentric-circle pattern is superimposed on the shadow and Moiré fringes with spacing dependent on the incidence angle of a light beam are formed. By utilizing the Moiré fringes, it is possible to capture images by simple and commonly used image processing called "Fourier transform." (Figure)

## **(2) Focus adjustment technology of captured images**

The focal position can be changed by changing the size of the concentric-circle pattern superimposed on the shadow formed on the image sensor by a light beam irradiated onto the film. By superposing the concentric-circle pattern by image processing after image capturing, the focal position can be adjusted freely.

To measure the performance of the developed technology, an experiment with a 1-cm<sup>2</sup> [image sensor](#) and a film imprinted with a concentric-circle pattern positioned 1 mm from the sensor was conducted. The results of the experiment confirmed that video [images](#) could be captured at 30 frames per second when a standard notebook PC was used for image processing.

To contribute to the "super-smart society" based on IoT (Internet of Things) technologies, Hitachi is aiming to apply this newly developed lensless camera technology to all kinds of devices, starting with [mobile devices](#), vehicles, and robots.

This camera technology will be presented at the International Workshop on Image Sensors and Imaging Systems (IWISS16) being held at the Tokyo Institute of Technology from November 17th to 18th, 2016.

Provided by Hitachi

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