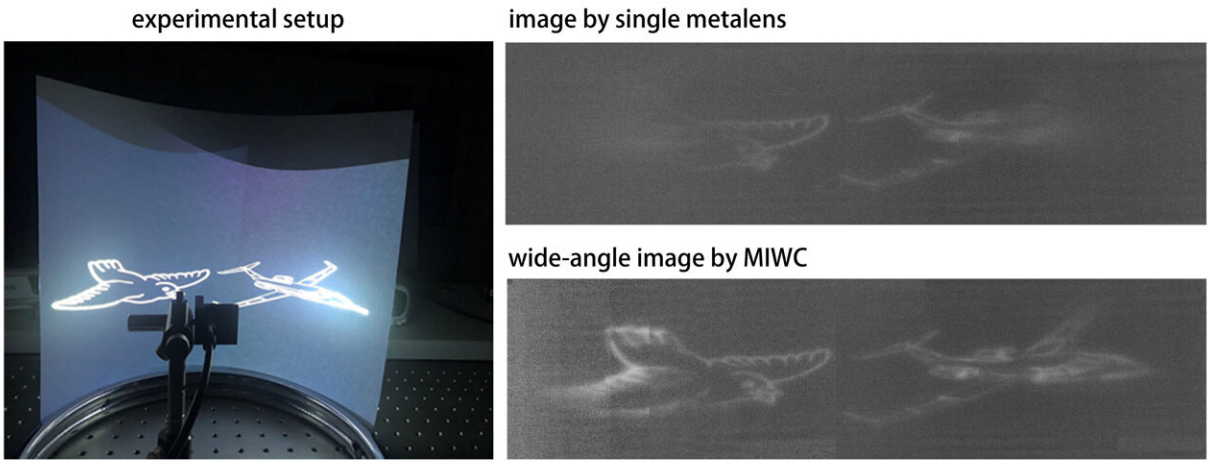
Researchers create miniature wide-angle camera with flat metalenses

April 14 2022



Researchers designed a new compact camera that acquires high-quality wide-angle images using an array of metalenses. Their new planar camera (MIWC) produced clearer images of pictures projected across a curved screen compared to a camera based on a single traditional metalens. Credit: Tao Li, Nanjing University

Researchers have designed a new compact camera that acquires wide-angle images of high-quality using an array of metalenses—flat nanopatterned surfaces used to manipulate light. By eliminating the bulky and heavy lenses typically required for this type of imaging, the new approach could enable wide-angle cameras to be incorporated into

smartphones and portable imaging devices for vehicles such as cars or drones.

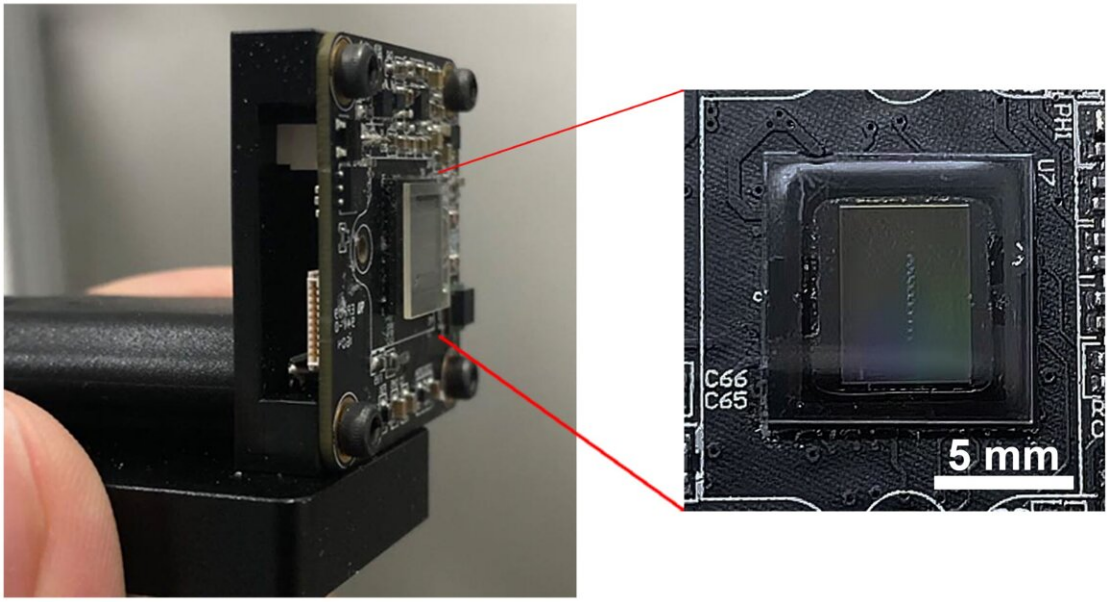
Tao Li and colleagues from Nanjing University in China report their new ultrathin camera in *Optica*. The new camera, which is just 0.3 centimeters thick, can produce clear images of a scene with a viewing angle of more than 120 degrees.

Wide-angle imaging is useful for capturing large amounts of information that can create stunning, high-quality images. For machine vision applications such as autonomous driving and drone-based surveillance, wide-angle imaging can enhance performance and safety, for example by revealing an obstacle you couldn't otherwise see while backing up in a vehicle.

"To create an extremely compact wide-angle camera, we used an array of metalenses that each capture certain parts of the wide-angle scene," said Li. "The images are then stitched together to create a wide-angle image without any degradation in image quality."

Miniaturizing the wide-angle lens

Wide-angle imaging is usually accomplished with a fish-eye compound lens or other type of multilayer lens. Although researchers have previously tried to use metalenses to create wide-angle cameras, they tend to suffer from poor image quality or other drawbacks.



The researchers fabricated a metalens array (enlarged on the right) and mounted it directly to a CMOS sensor. This created a planar camera that measured about 1 cm × 1 cm × 0.3 cm. Credit: Tao Li, Nanjing University

In the new work, the researchers used an array of metalenses that are each carefully designed to focus a different range of illumination angles. This allows each lens to clearly image part of a wide-angle object or scene. The clearest parts of each image can then be computationally stitched together to create the final image.

"Thanks to the flexible design of the metasurfaces, the focusing and imaging performance of each lens can be optimized independently," said Li. "This gives rise to a high quality final wide-angle image after a stitching process. What's more, the array can be manufactured using just one layer of material, which helps keep cost down."

Seeing more with flat lenses

To demonstrate the new approach, the researchers used nanofabrication to create a metalens array and mounted it directly to a CMOS sensor, creating a planar camera that measured about 1 cm × 1 cm × 0.3 cm. They then used this camera to image a wide-angle scene created by using two projectors to illuminate a curved screen surrounding the camera at a distance of 15 cm.

They compared their new planar camera with one based on a single traditional metalens while imaging the words "Nanjing University" projected across the curved screen. The planar camera produced an image that showed every letter clearly and had a viewing angle larger than 120°, more than three times larger than that of the camera based on a traditional metalens.

The researchers note that the planar camera demonstrated in this research used individual metalenses just 0.3 millimeters in diameter. They plan to enlarge these to about 1 to 5 millimeters to increase the camera's imaging quality. After optimization, the array could be mass produced to reduce the cost of each device.

More information: Ji Chen et al, A planar wide-angle-imaging camera enabled by metalens array, *Optica* (2022). DOI: 10.1364/OPTICA.446063

Provided by Optica