

Week-long live technology demonstration, at invitation of Walt Disney Animation Studios



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"Origami Optics" for Ultra-Thin Imagers

Theme: Impact on Society
Hall H



Most camera lenses refract light, leading to the familiar cylindrical package geometry. For some applications in which extended focal length or reduced track length are required, concentric mirrors can be used to effectively reduce barrel length. Recent advances in diamond machining and image processing make it possible to take this approach to a new extreme.

With up to eight reflections, large ray angles, and a lens shaped more like a lens cap than a tube, this so-called Origami Optics approach allows us to squeeze long focal lengths into a thin package and still collect enough light for fast, sharp exposures.

This new class of imagers was developed under the MONTAGE program of the US Defense Advanced Research Projects Agency (DARPA). The resulting prototypes have yielded images comparable to images provide by much larger commercial "compact" cameras.

Enhanced Life

This project could make long-focal-length lenses practical and potentially less expensive in applications where space is at a premium and bulky refractive lenses are unsuitable. For example, this approach could be used to create a slim telephoto camera for cell phones.

Goal

The goal of this project was to fit telephoto lenses (20 mm and 40 mm focal length) into a 5 mm thickness while maintaining image quality and light collection comparable to those provided by large conventional refractive lenses.

Innovations

This project demonstrates that extremely precise modern fabrication techniques (in this case, single-point diamond turning) support creation of radically thin multi-element optics for imaging systems. The folded optics approach allows for optics up to 10x thinner than conventional refractive optics with high resolution and low F-numbers for sharp, fast exposures.

Vision

"Arc-sectioned" folded optics may be applied in conjunction with standard miniature refractive optics to create switched-zoom lenses for cell phones and other ultra-compact cameras. Full-aperture folded optics may be used for ultra-thin surveillance systems on UAV aircraft, and this technique could provide lightweight, fast, and less expensive lenses for thermal imaging systems.

Browse Program

By Format

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Advance Program PDF

Schedule of Programs & Events

Convention Center Map

Registration

Travel & Housing

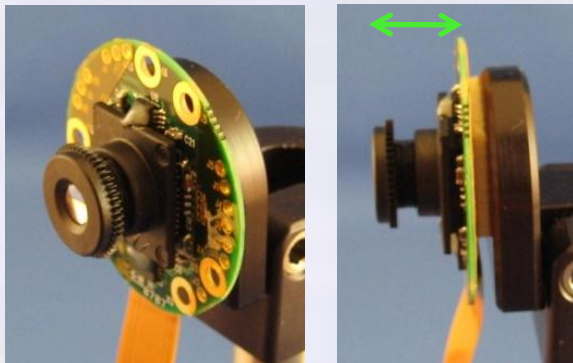
Merchandise

This new class of imagers was developed under the MONTAGE program of the US Defense Advanced Research Projects Agency (DARPA). The resulting prototypes have yielded images comparable to images provide by much larger commercial "compact" cameras.



Conventional Low-Profile Mini Lens

Low Resolution and Thin



Marshall Electronics Low profile Miniature Lens V-4106ID
& Forza/Sunplus 1.92 Mpix CMOS sensor

Lens Thickness = 9.4 mm

Focal length = 6 mm

F/2.8

53° full field of view (1600x1200 pixels)

**Miniature cameras readily
available - just look on your
cellphone**

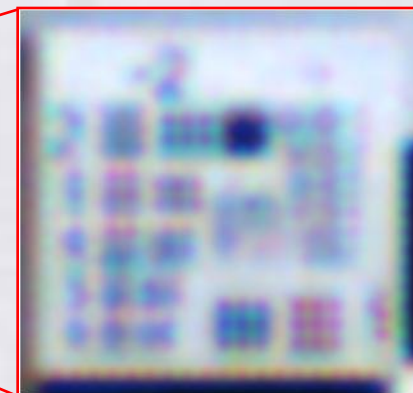


**Problem: Limited to short focal
lengths and small apertures-
blurred “digital zoom” images**

Full Field (53° over 1.92 Mpixels)

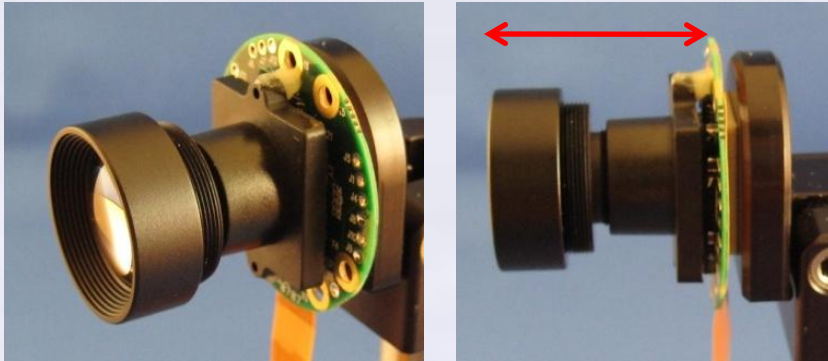


Digital zoom



Conventional Long Focal Length Lens

High Resolution but Thick



Marshall Electronics High Resolution Miniature Glass Lens V-4416.0-1.2-HR
& Forza/Sunplus 1.92 Mpix CMOS sensor

Lens Thickness = 24.3 mm

Focal length = 16 mm

F/1.2

21° full field of view (1600x1200 pixels)

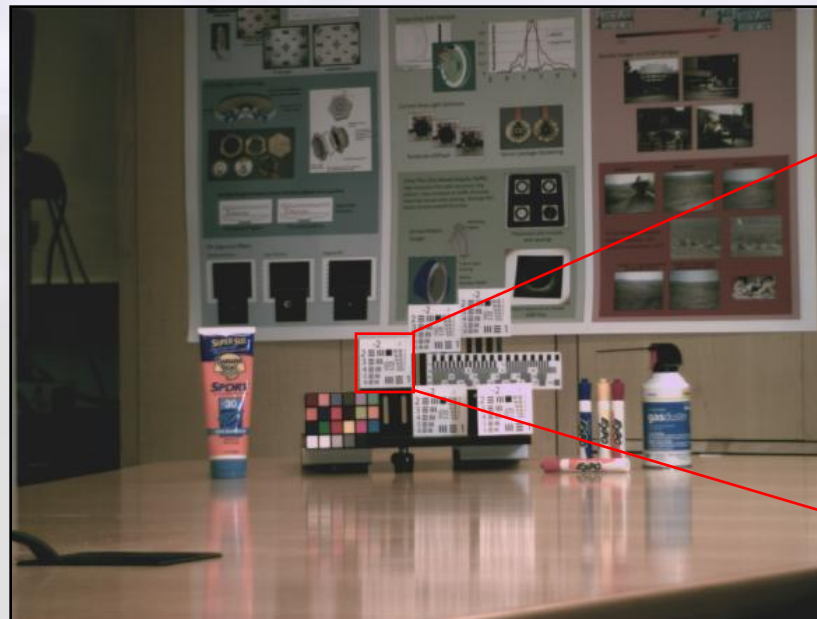
Long Focal length
provides optical
magnification (high
resolution)

Problem: cannot be fit
into short track lengths.
Impractical for many
applications

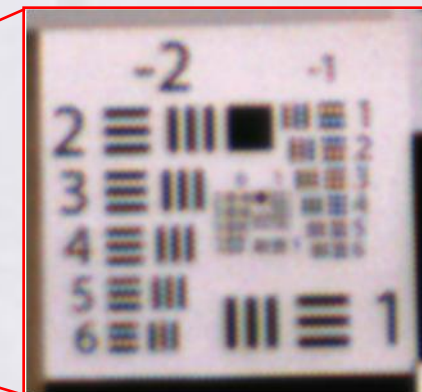


A commercial cell phone
zoom lens

Full Field (21° over 1.92 Mpixels)

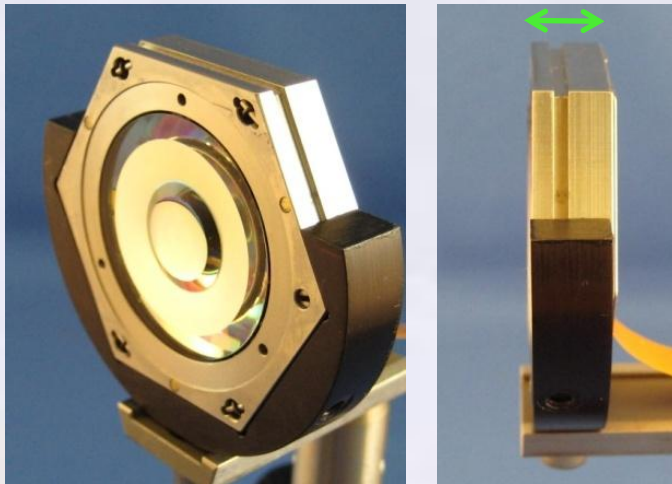


Digital zoom



Ultrathin Four-Reflection Origami Lens

High Resolution and Thin



Four-Reflection Origami Lens (Full aperture)
& Forza/Sunplus 1.92 Mpix CMOS sensor

Lens Thickness = 5.5 mm

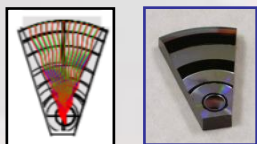
Focal length = 18.6 mm

F/1.15 (full aperture), F/3 (demo)

17° full field of view (1600 x 1200 pixels)

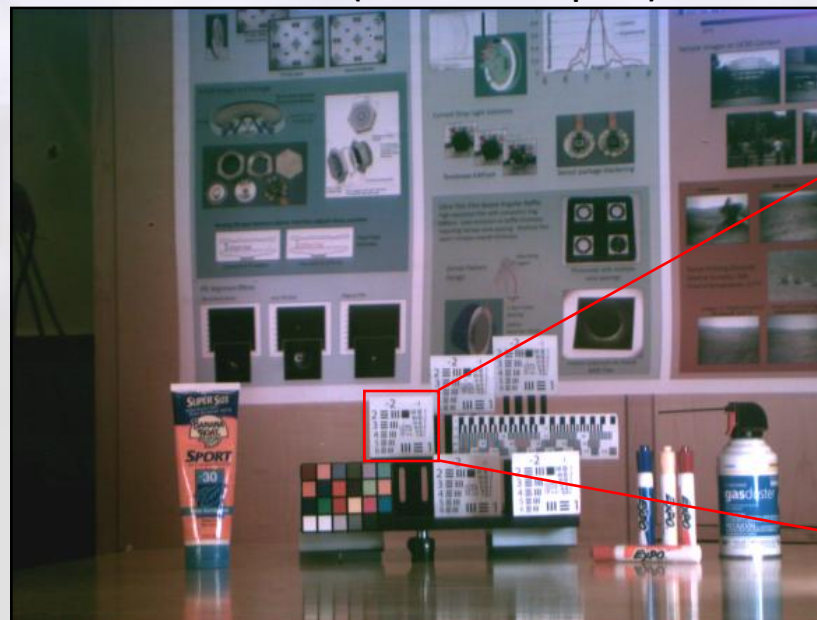
Provides long focal length
(magnification) in a short optical
track

Can be “sectioned” to further
reduce volume and increase
depth of field for small portable
device applications

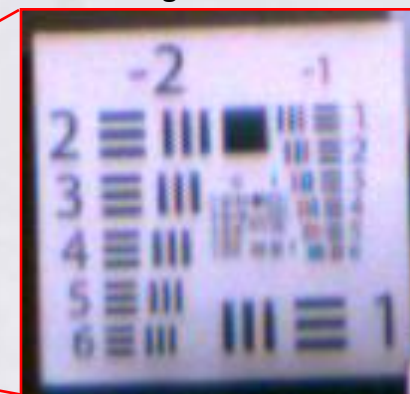


50° wedge of an Eight-reflection
Origami Lens

Full Field (17° over 1.92 Mpixels)



Digital zoom

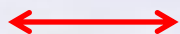
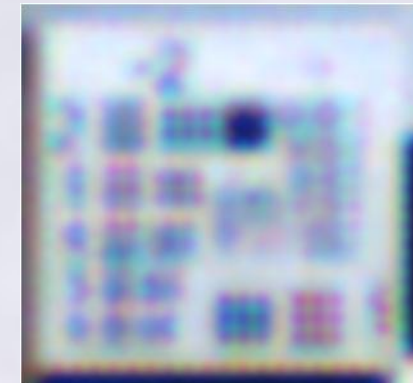




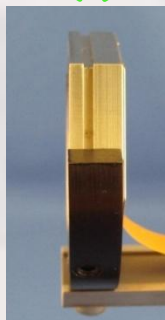
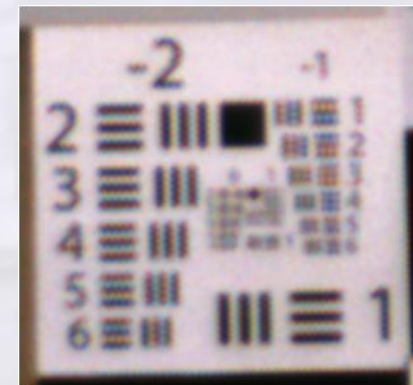
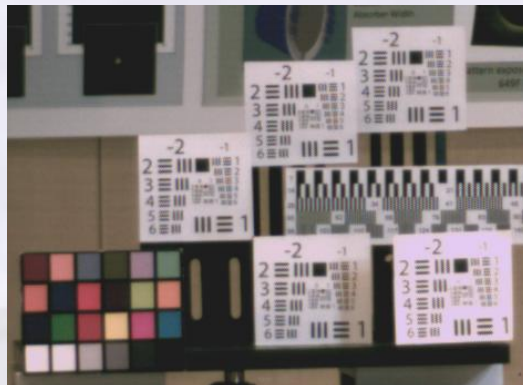
Comparisons



Conventional Mini Lens



Conventional Long Lens



Origami Lens



Full-Field



Digital Zoom #1



Digital Zoom #2