3-D CMOS Sensor

INVENTORS: PROF. ALYOSHA MOLNAR,

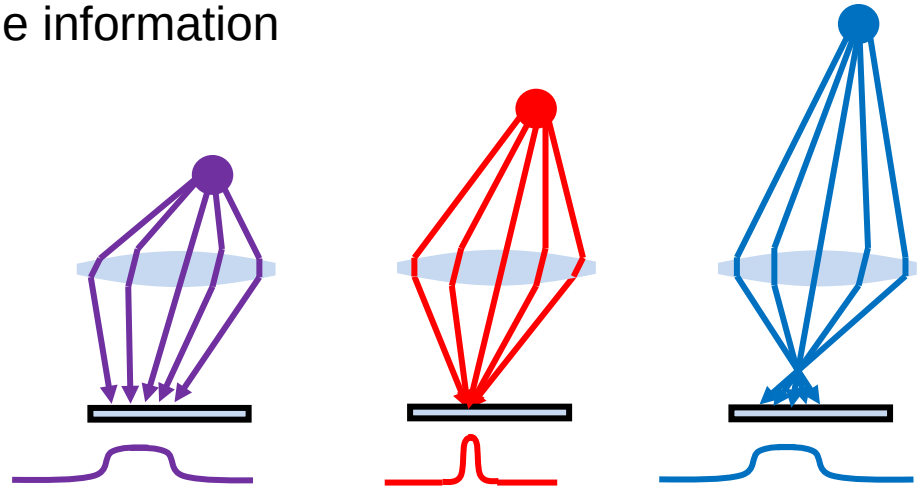
DR. PATRICK GILL, ALBERT WANG

Background

- Traditional solid-state image sensors use pixels which measure intensity of incident light.
- However, incident angle of light contains significant information about three-dimensional structure.
- In a lens system (i.e. camera), angle information informs us about focal depth.

Concept:

Use incident angle to extract 3-D structure in both lens-based and lens-less image sensor systems.



Too close: blurred image & converging angles

Focused: Sharp image & undefined angle

Too far: blurred image & diverging angles

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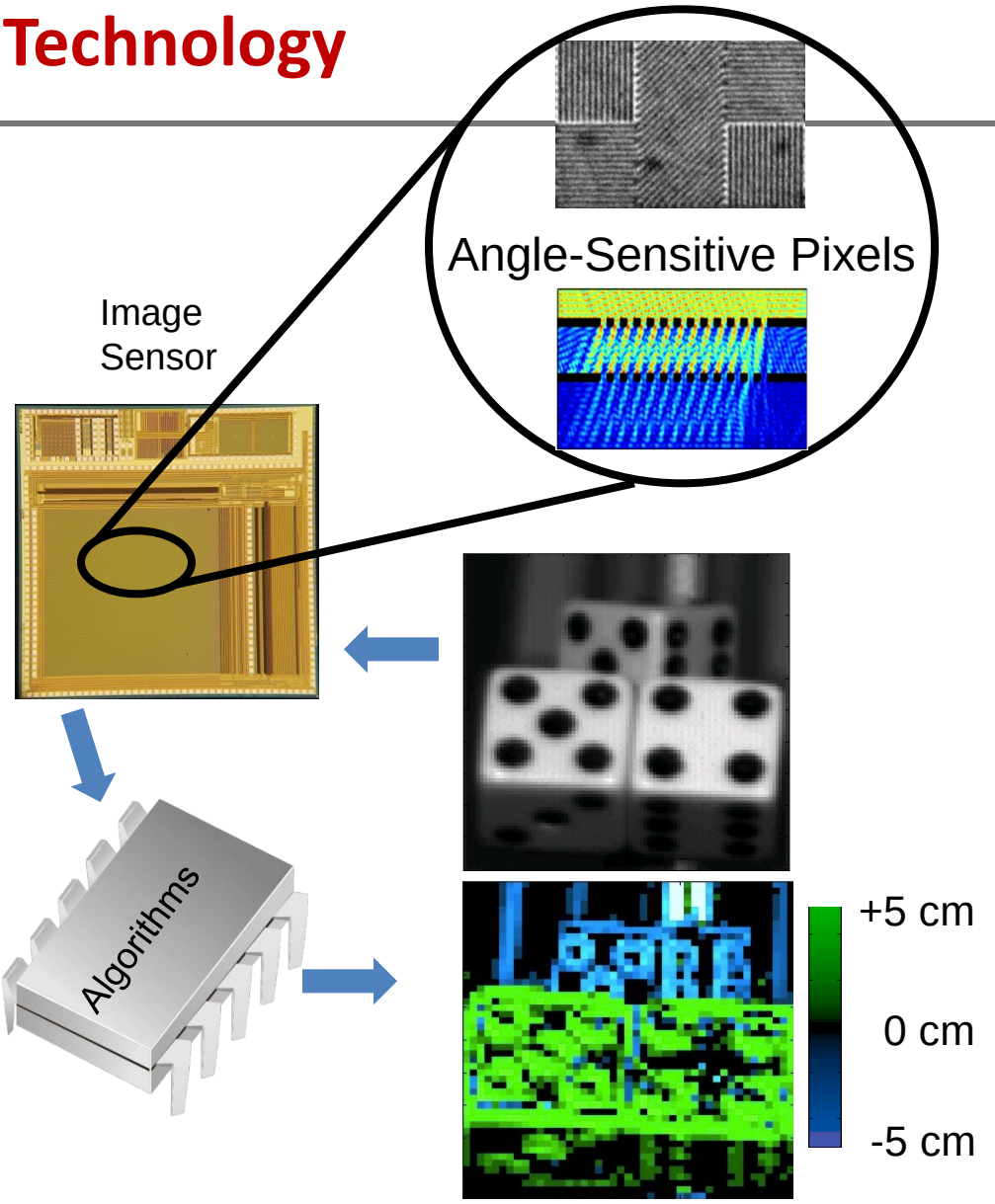
- New class of angle-sensitive CMOS image sensor chip based on integrated diffraction gratings.
- Compatible with existing microchip manufacturing processes.
- Together with proprietary algorithms, can perform single-lens 3D imaging.
- Cost-effective: Obviates the need for complicated optics.
- Captures not just an image, but metrics!



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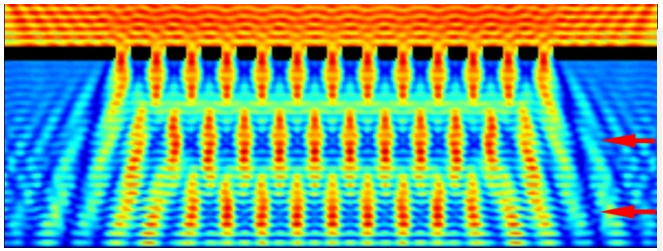
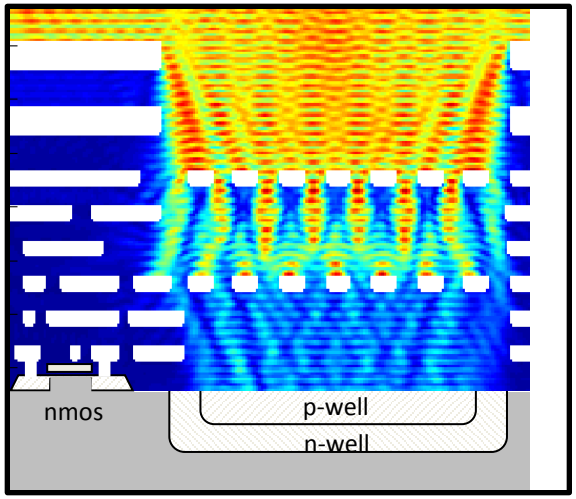
- Operating principle: Angle-sensitive Pixels (ASPs) based on integrated diffraction gratings.
- Diffraction gratings create periodic intensity patterns that shift laterally in response to changes in incident angle.
- A second diffraction grating measures these shifts, which then informs 3D reconstruction algorithm.



Operating Principle: The Talbot effect. Periodic intensity patterns occur at specific depths (red arrows)



CMOS implementation:

Zero added cost over standard CMOS imager

Market & Applications

- Personal electronic devices
  - Availability of depth information will drive apps development (e.g., measuring cup or tailor app)
  - Gesture control
- Mid/high-end digital cameras
  - Post-hoc refocusing
- Biomedical imaging
  - 3D localization of fluorescent cells
  - Low-cost flow cytometry
- Image compression
  - Entirely based on physics/optics
  - Low cost, low power
  - Interactive gaming, video conferencing
- Security, Surveillance & Defense

Status & Next Steps

- Patents
  - Issued US patents: 8,530,811; 8,809,758; 8,767,047
  - Patents pending and issued in China, Europe, Korea
- Technology
  - 3rd generation prototype chips available and demonstrated
  - 4th generation chips: improving manufacturing & design techniques
  - Application-specific proof-of-concept work in progress
- Contact
  - Martin Teschl, MS, CLP
    mt439@cornell.edu
    +1 (607) 254-4454
    Cornell Reference Number: 4337 -
    http://cornell.flintbox.com/public/project/21598/