

Computational Photography



Dr. Irfan Essa

Professor

School of Interactive Computing

Study the basics of computation and its impact on the entire workflow of photography, from capturing, manipulating and collaborating on, and sharing photographs.

Why Study Computational Photography?

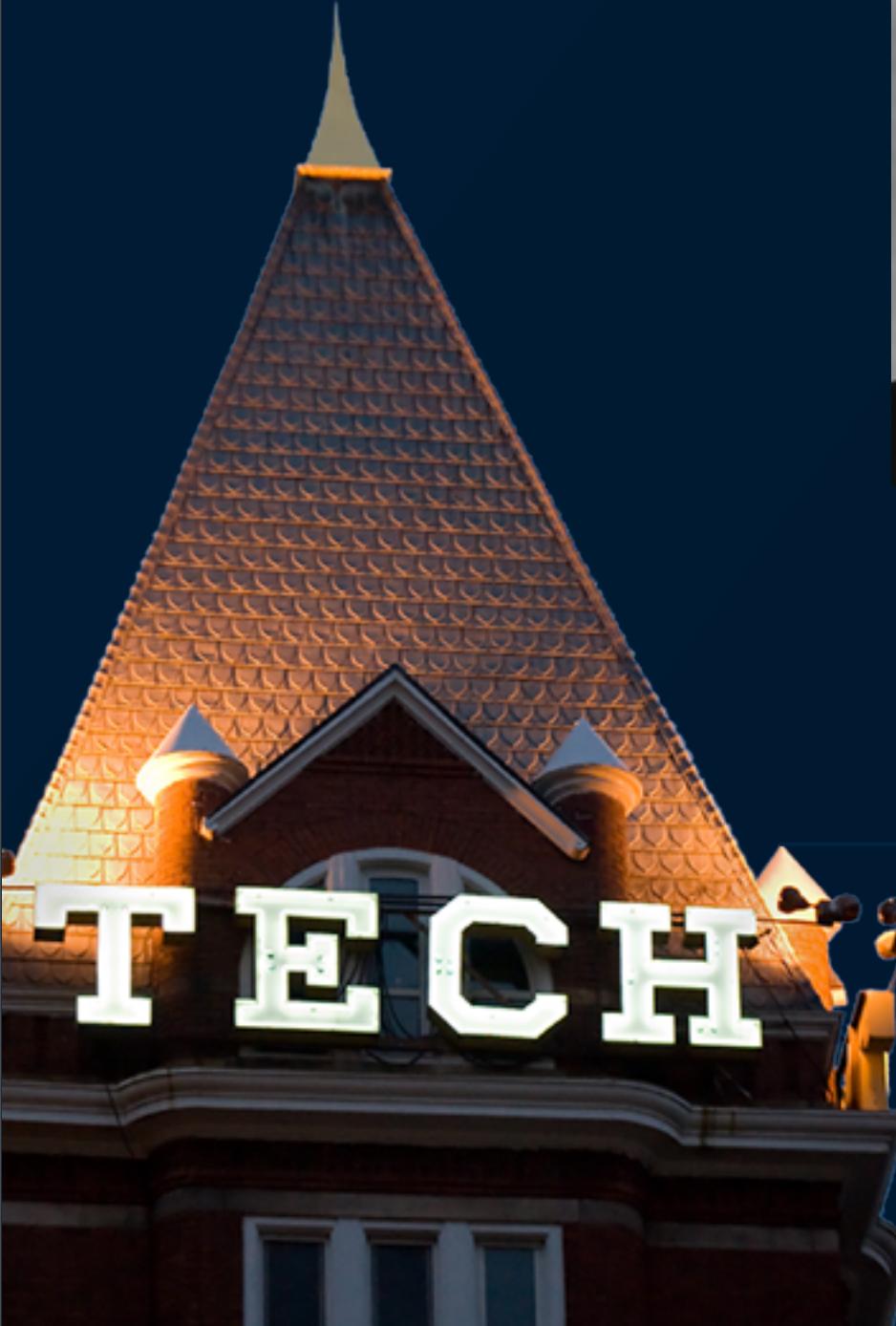


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The Context of the Field of Computational Photography and Its Future



Lesson Objectives

- ★ Describe in your own words one (1) relationship that computational photography has to each of the four (4) disciplines (computer vision, computer graphics, image processing, and optics/sensors).

- ★ Identify at least three (3) fundamental differences between traditional (film) photography and digital photography which are enhanced by computational photography.



Comparison of Film and Digital Cameras/Photography

★ Film and Digital Cameras have roughly the same Features and Controls:

- Zoom and Focus
- Aperture and Exposure
- Shutter Release and Advance
- One Shutter Press = One Snapshot

★ However, what are reasons for using Computational Photography over using Film Photography and Digital Photography? Let's explore this further.



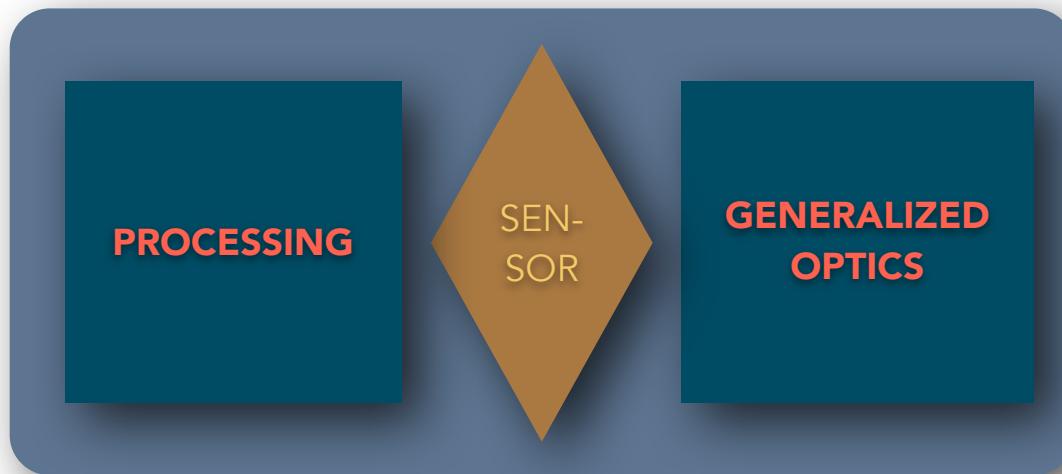
Computational Photography (CP) Extends FP / DP

- ★ For FP/CP we can USE, but CP allows us to CHANGE:
 - Optics, Illumination, Sensor, Movement
 - Exploit Wavelength, Speed, Depth, Polarization, etc.
 - Probes, Actuators, Network
- ★ Current FP/DP Technologies have exhausted Bits in Pixels
- ★ Compared to FP/DP, CP has Better Specification and Support for:
 - Dynamic Range
 - Vary Focus Point-by-Point
 - Field of View vs. Resolution
 - Exposure Time and Frame Rate
 - Bursts



Traditional Film/Digital Camera Processes

Novel Camera



Schematic Similar to one used by Shree Nayar and Ramesh Raskar

Traditional Film/Digital Camera Processes

Schematic Similar to one used by Shree Nayar and Ramesh Raskar

Traditional Film/Digital Camera Processes

Sensor/Detector



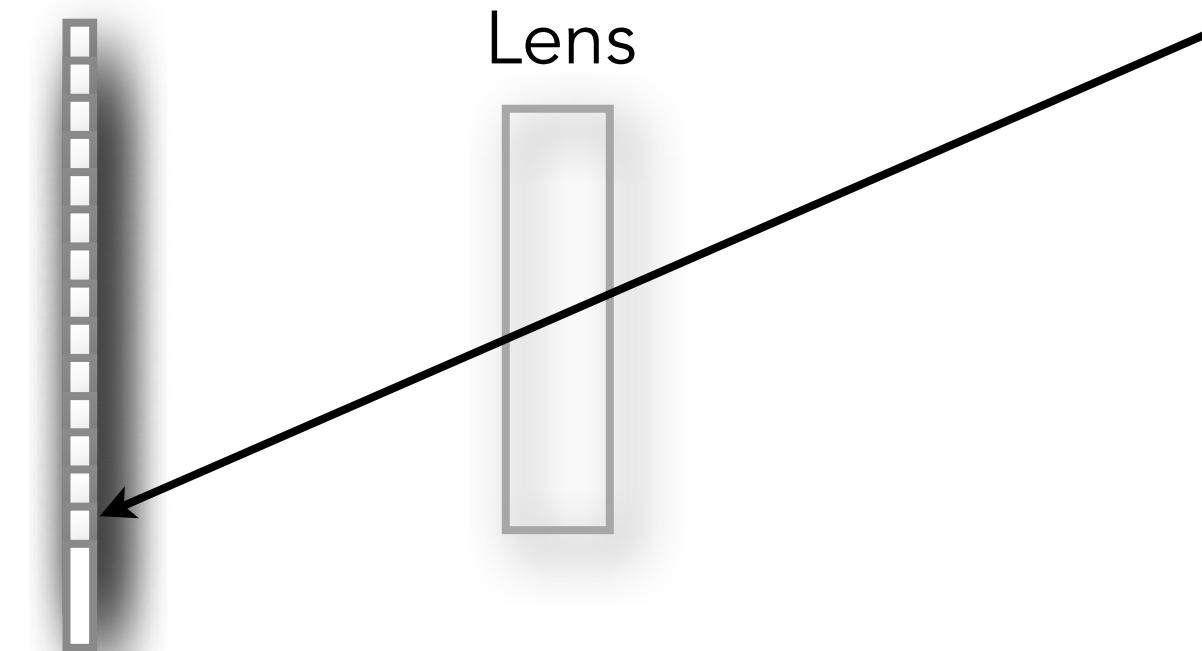
Lens



Schematic Similar to one used by Shree Nayar and Ramesh Raskar

Traditional Film/Digital Camera Processes

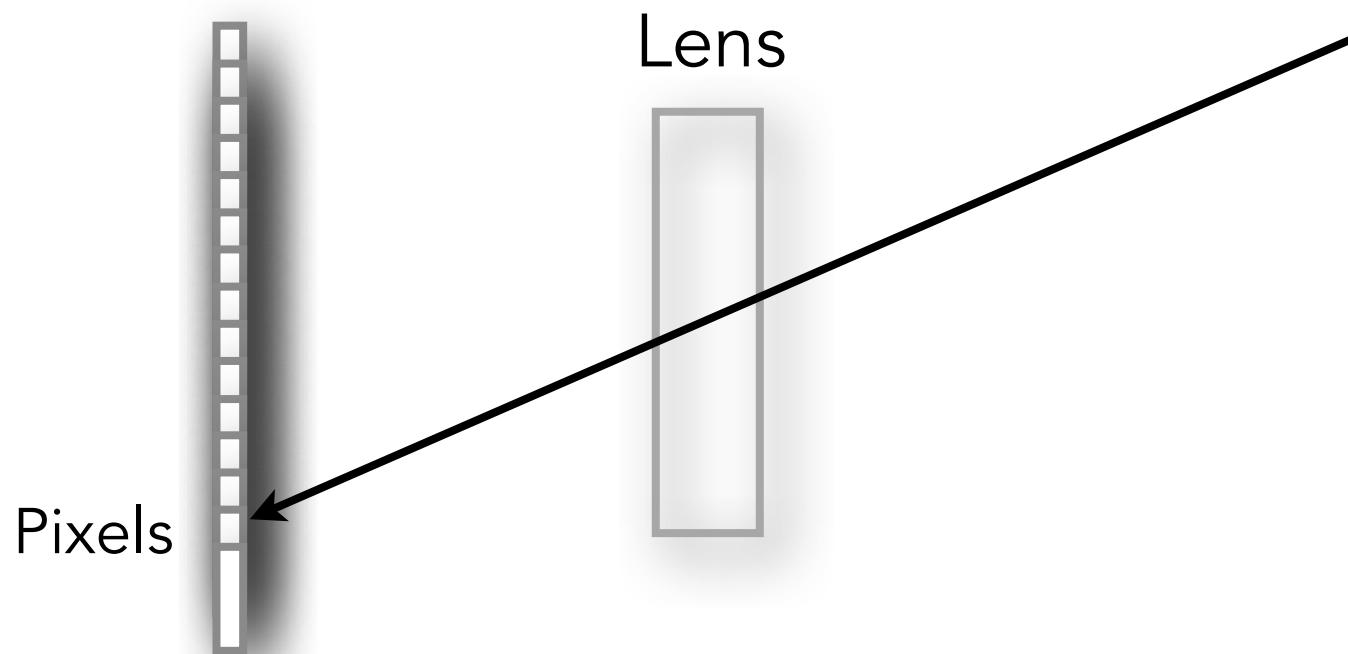
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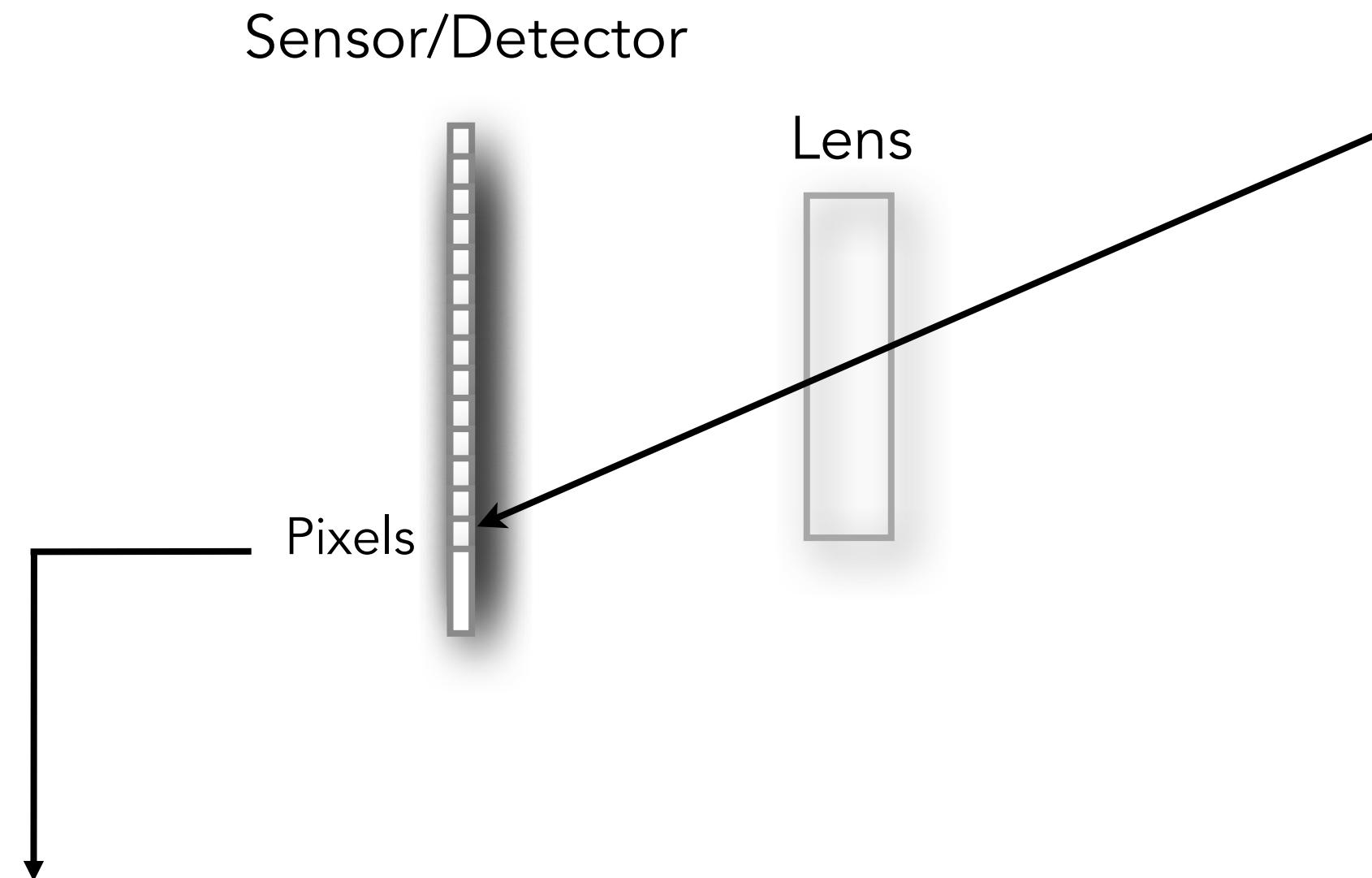
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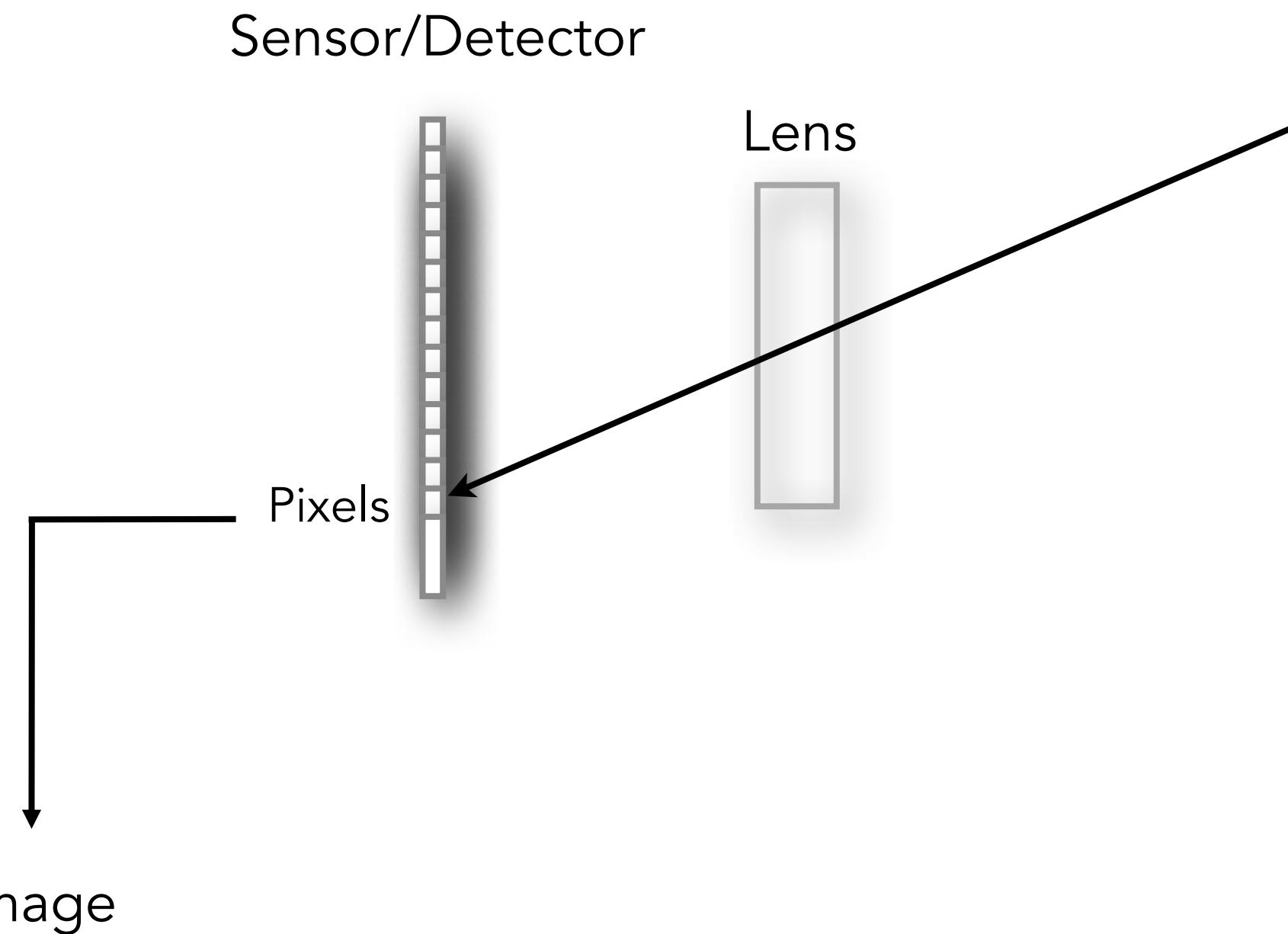
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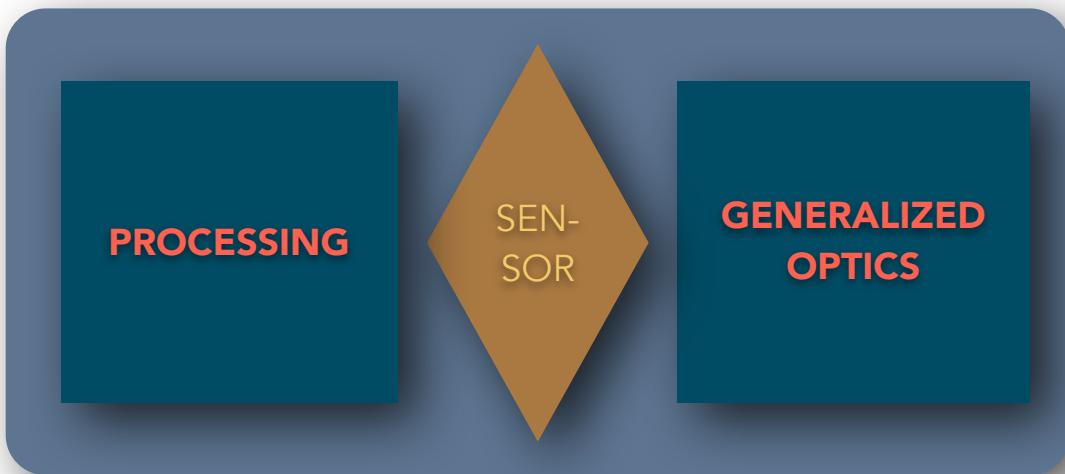
Traditional Film/Digital Camera Processes



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Computational Camera Process

Novel Camera



Slide schematic based on slides by Raskar and Tumblin

Computational Camera Process

Slide schematic based on slides by Raskar and Tumblin

Computational Camera Process

Generalized
Sensor



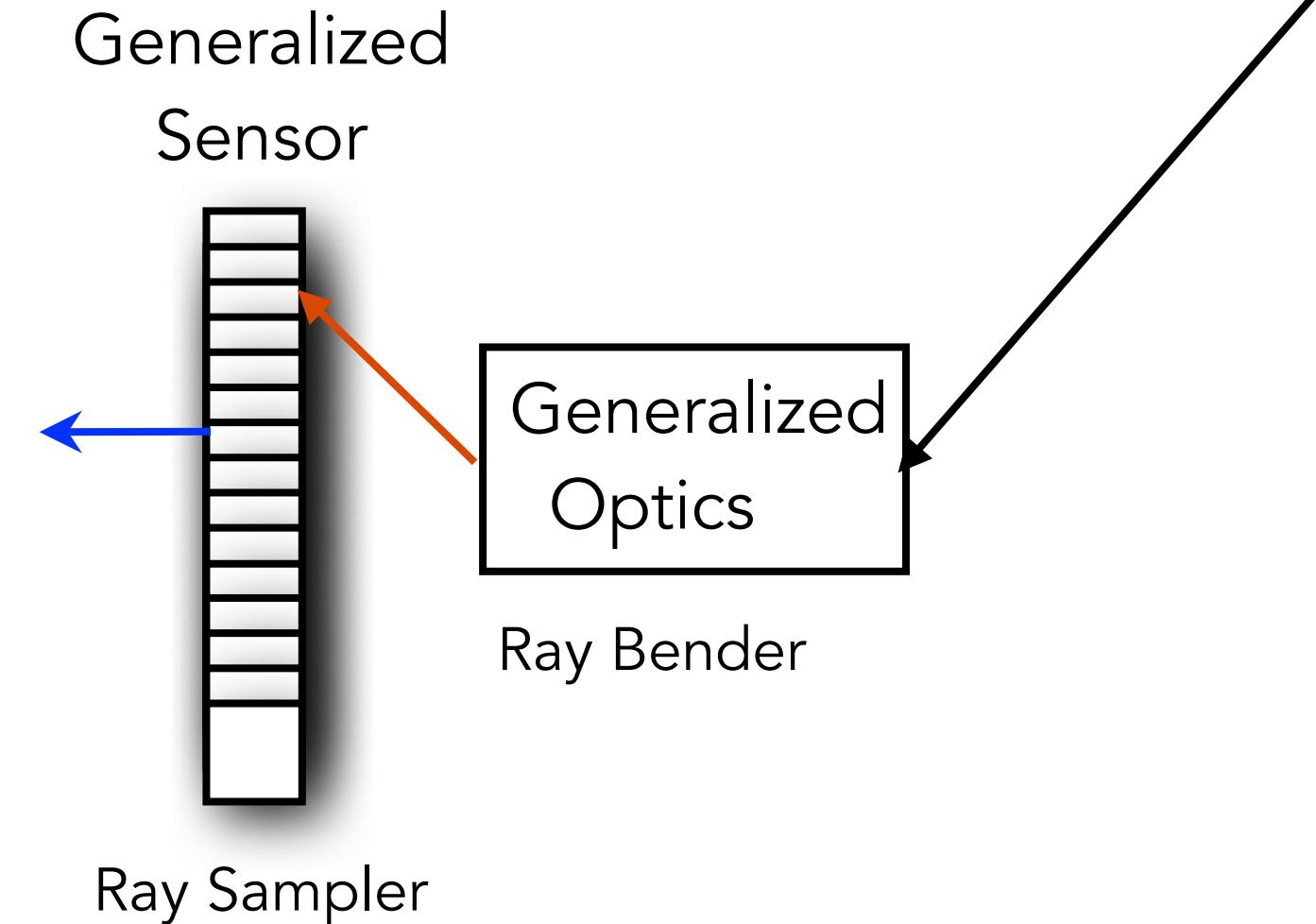
Generalized
Optics

Ray Bender

Ray Sampler

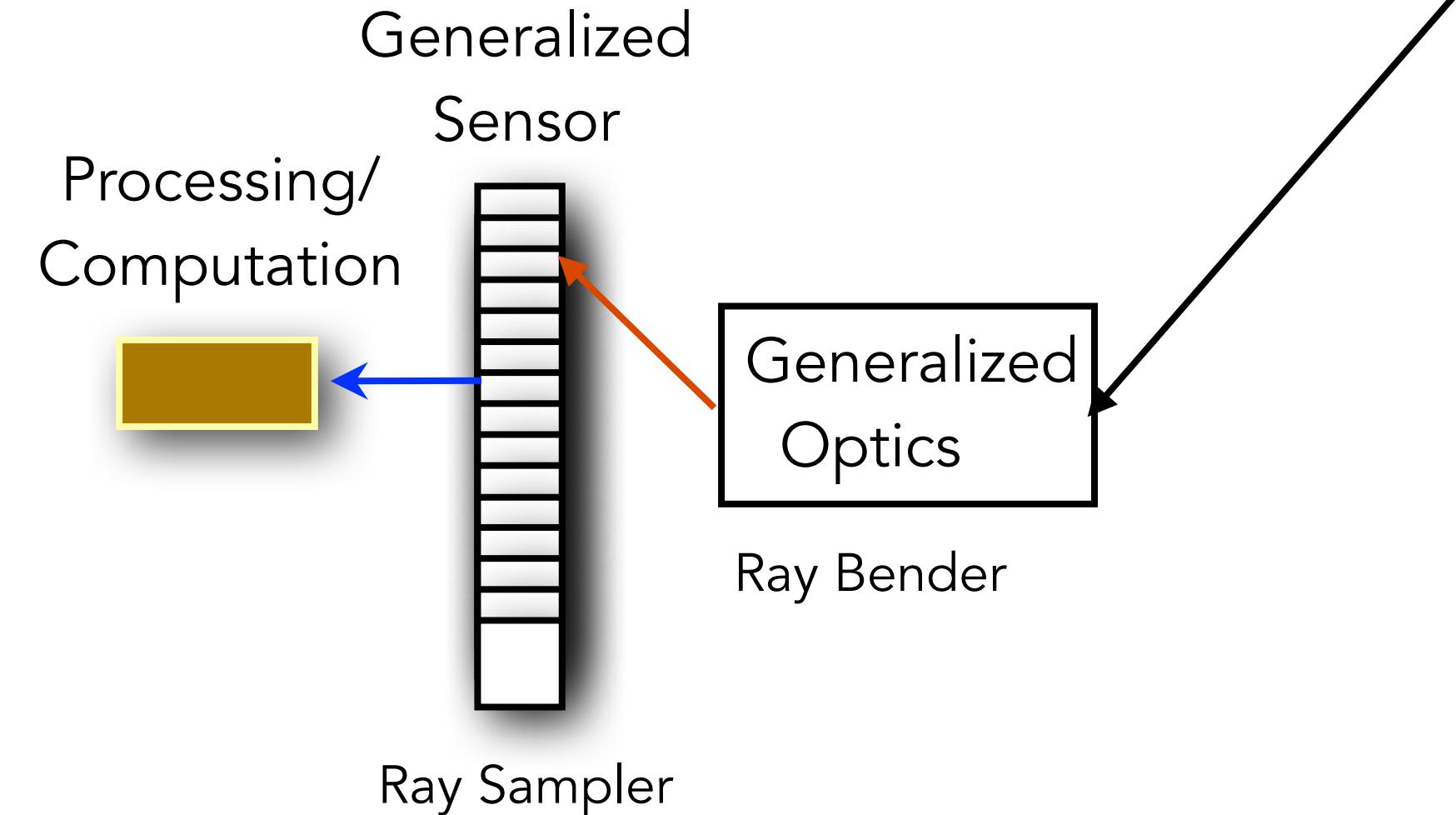
Slide schematic based on slides by Raskar and Tumblin

Computational Camera Process



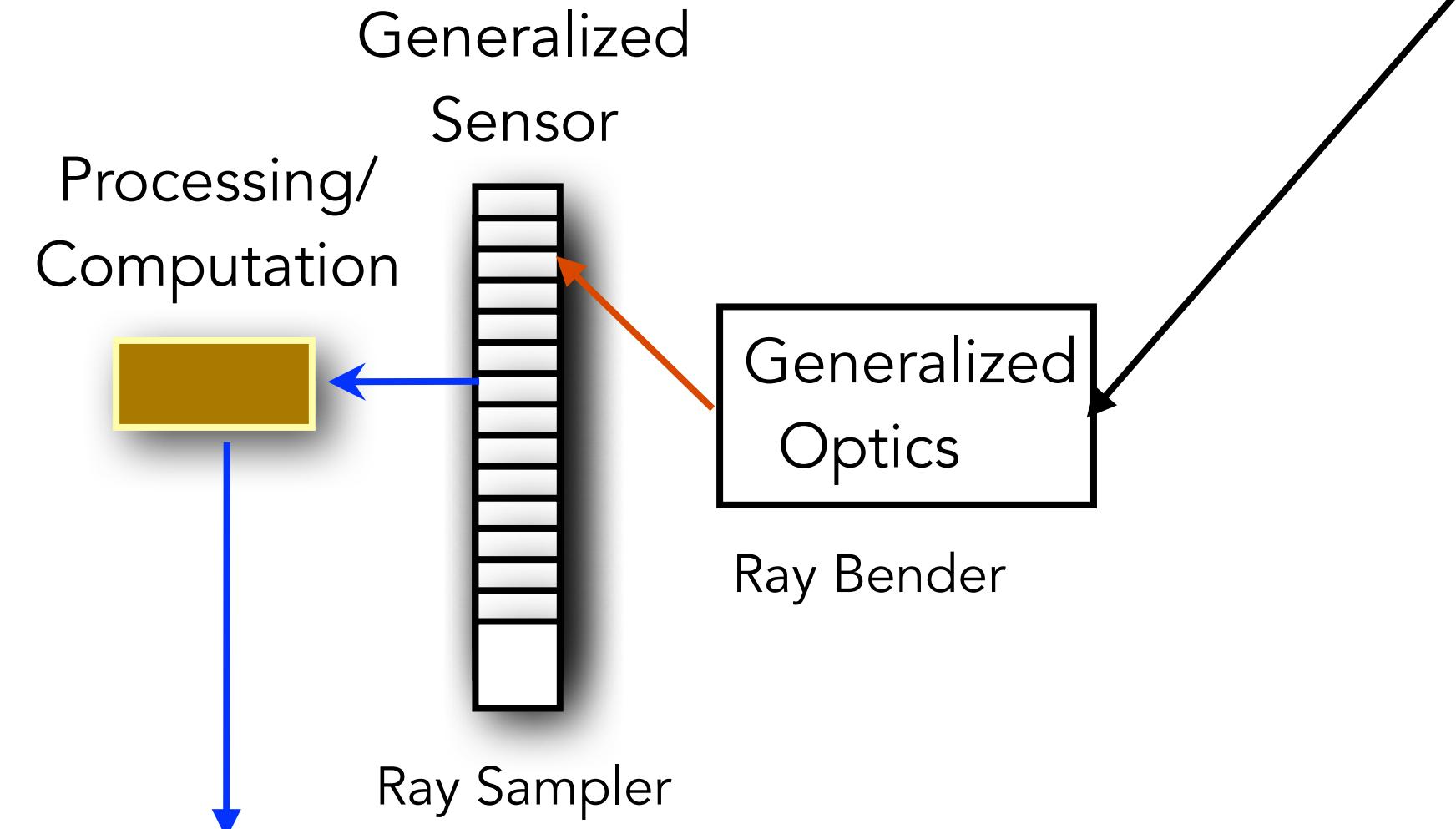
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Computational Camera Process



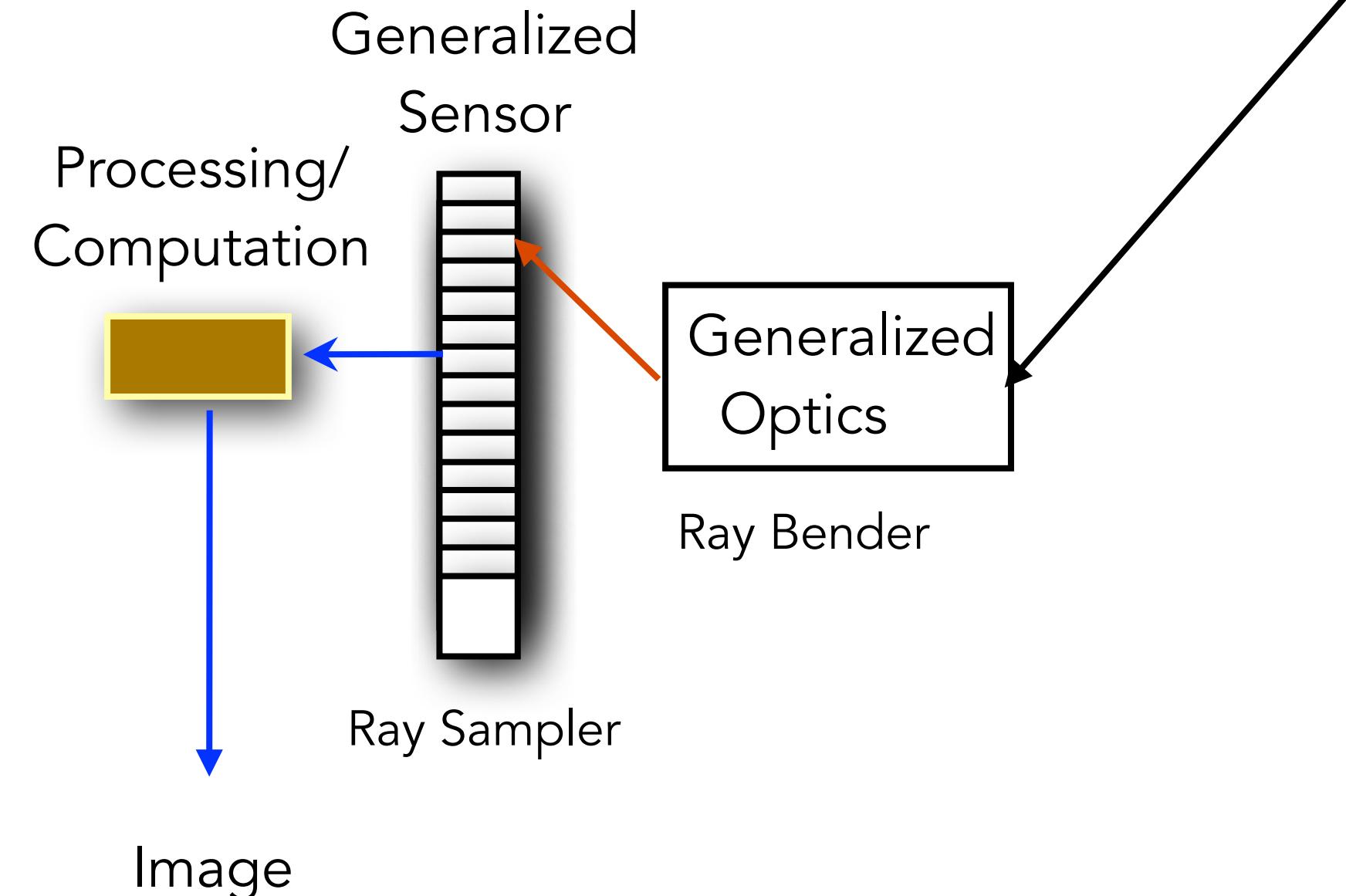
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Computational Camera Process



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Computational Camera Process



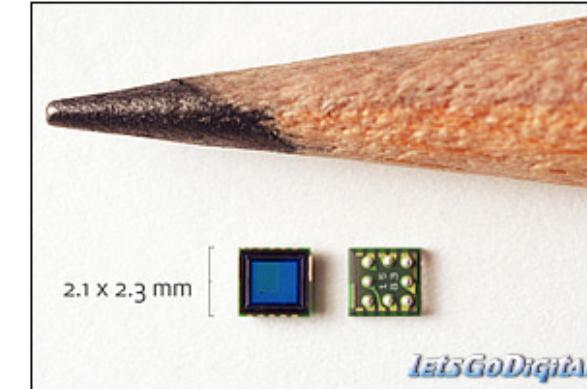
Slide schematic based on slides by Raskar and Tumblin

So Why Study Cameras?

- ★ Almost Everyone has a Camera
 - e.g., Smaller, Ubiquitous
- ★ Significant Improvements in Optics
 - Field of Applied Optics has studied every aspect of the Lens
- ★ Better, Cheaper Sensors (CCD/CMOS)
 - Sensor Electronics has its own Field

So Why Study Cameras?

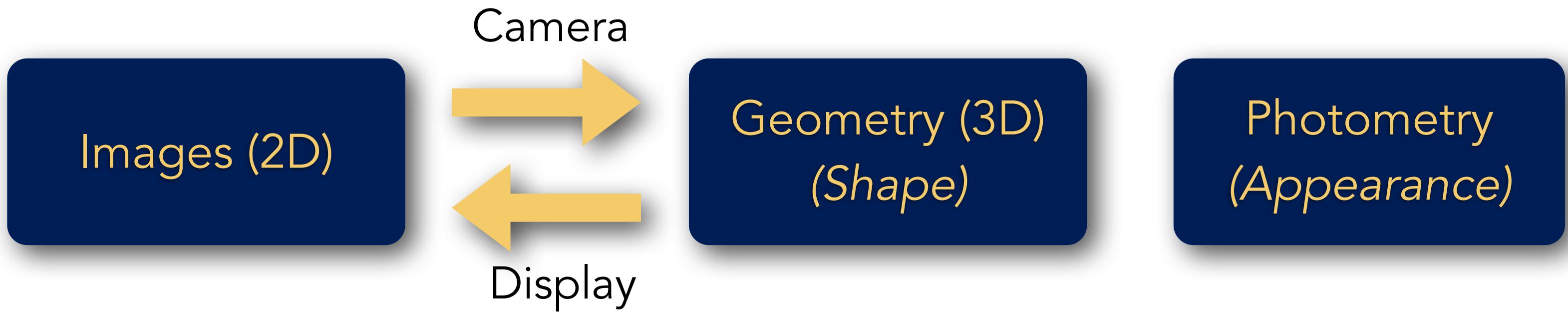
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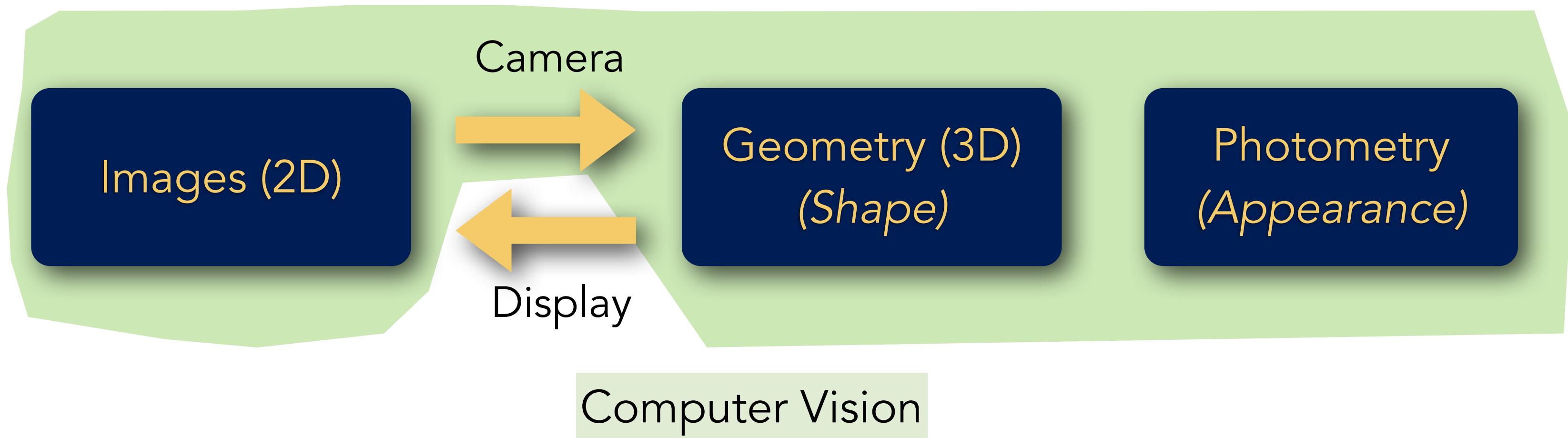
Cameras are Everywhere

- ★ 500 Million Camera phones, and soon to cross over 1 Billion
 - Widest selling electronic platform
- ★ Further expanded by new platforms:
 - Google Earth, YouTube, Flickr ..
 - Text, Speech, Music, Images, Video, 3D, ..
- ★ Key element for art, research, products, social-computing ..

Computer Vision and Computer Graphics



Computer Vision and Computer Graphics



Computer Vision and Computer Graphics

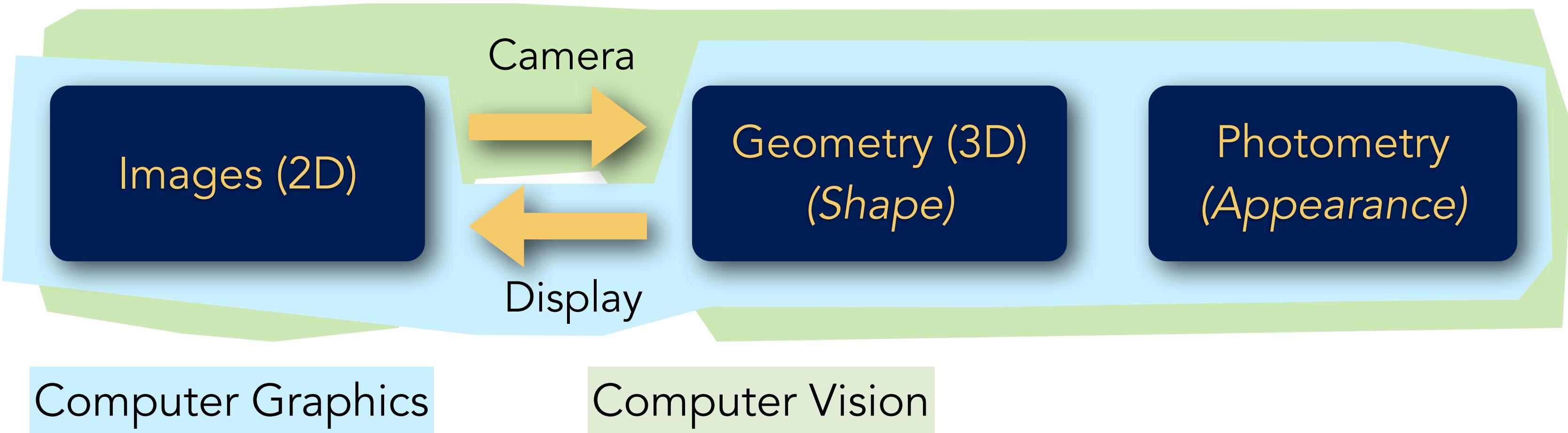


Image Processing and Optics/Sensors

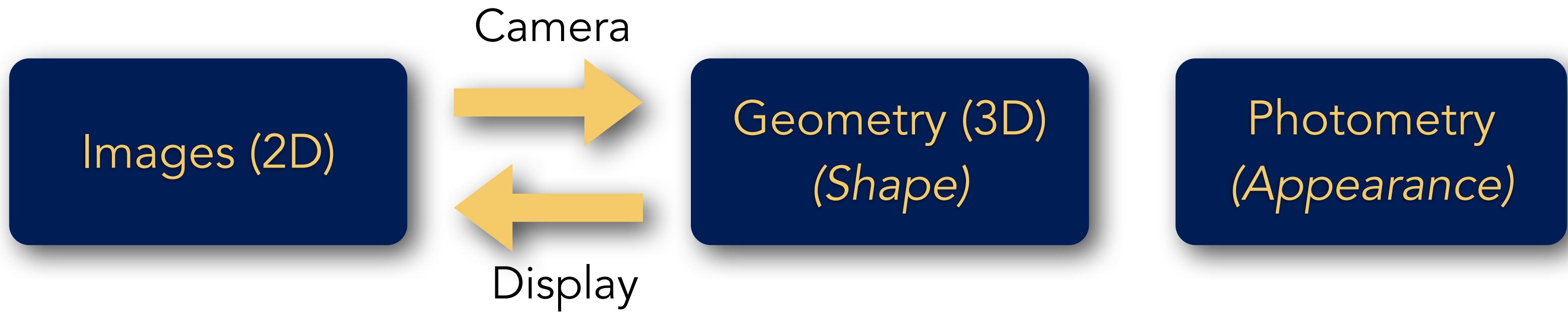


Image Processing and Optics/Sensors

Images (2D)

Camera



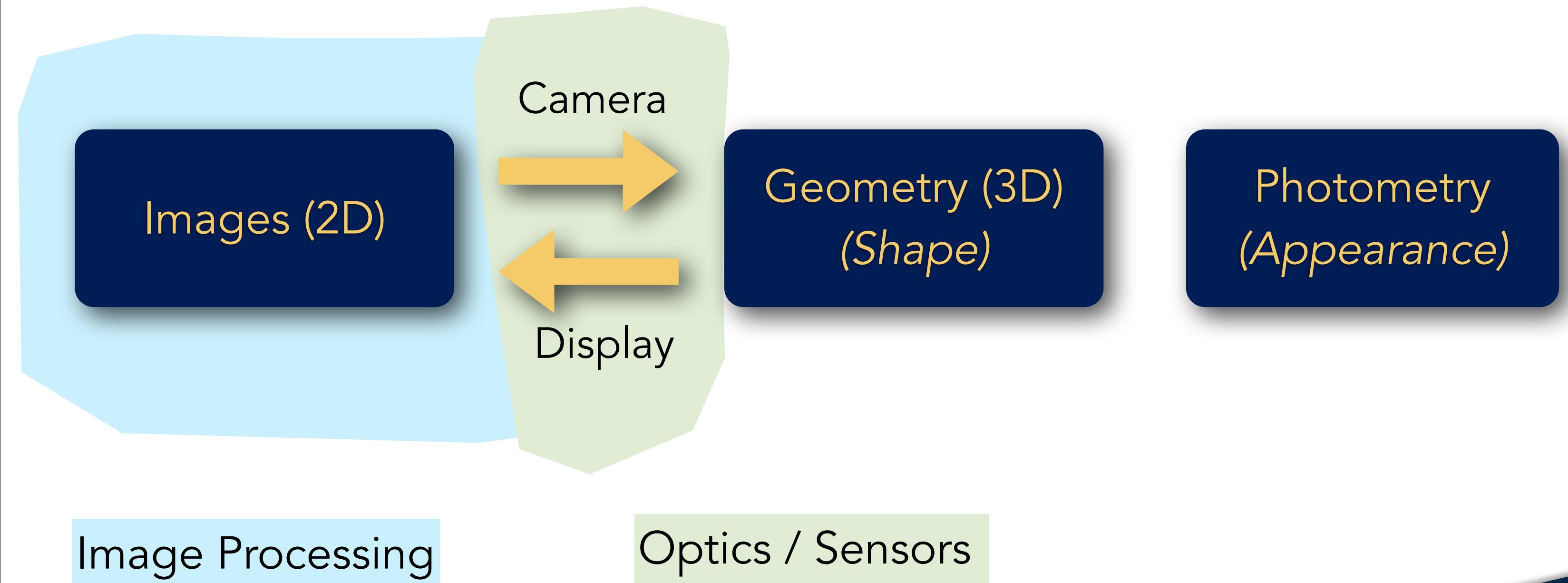
Display

Geometry (3D)
(*Shape*)

Photometry
(*Appearance*)

Image Processing

Image Processing and Optics/Sensors



Emerging Field of Computational Photography

- ★ What will a camera look like in 10 years? 20 years?
- ★ What novel images can we get? What are their Uses?
- ★ How will the next billion cameras change the social culture?
- ★ How can we augment the camera to support best 'image search'?
- ★ What are the opportunities in pervasive, experiential recording?
- ★ How will ultra-high-speed/resolution imaging change us?
- ★ How should we change cameras for movie-making, news reporting?



Summary

- ★ Discussed Computational Photography in the context of Computer Graphics, Computer Vision, Image Processing and Optics/Sensors.
- ★ Provided Comparisons of Computational Photography to Traditional Photography and Digital Photography.
- ★ Listed the Factors that are Creating a Need to Study Computational Photography.



Next Class

- ★ What is an Image?
- ★ Creation of Digital Representation of Images:
 - to compute with them
 - to process them



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