Introduction to Computer Vision

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Lecture 2: Introduction
Goals for Today

What is vision?
What is computer vision?
What does it mean to see and how do we do it?
How can we make this formal (mathematical and computational)?
For next class

Reading: Ch 3.2.1 Linear Filtering – Monday

Background: 2.3.1 (sampling and aliasing), 3.3 intro (Fourier transform)

Reading ahead: 3.4.1, 3.4.2 (interpolation & pyramids)
What does it mean to see?
**see** | *sē*

verb (sees | *sēz|, seeing | *sē-i ng|; past saw | *sô|; past part. seen | *sēn|) [ trans. ]

1 **perceive** with the eyes; discern visually: *in the distance she could see the blue sea* | [ intrans. ]

*Andrew couldn't see out of his left eye* figurative

*I can't see into the future.*

• [with clause ] be or become aware of something from observation or from a written or other visual source.
**perceive** |pər'ˌsēv|

verb [ trans. ]

1 become aware or conscious of (something); come to realize or understand: *his mouth fell open as he perceived the truth* | [with clause ] *he was quick to perceive that there was little future in such arguments.*

• become aware of (something) by the use of one of the senses, esp. that of sight: *he perceived the faintest of flushes creeping up her neck.*
What does it mean for a computer to see?
Computer Vision

• Need a formal definition that can be implemented in software and hardware.
  – Mathematical and computational
• What properties (cues) of the visual world can we extract or measure?
• How can we use our (prior) knowledge about the world to understand it?
Your answer

Light energy

Image plane

Prediction process

Inference process

Internal model of world

Object recognition

Update over time
Digital Images

2.3 in Szeliski
How do we go from an array of numbers recognizing fruit?
Optical Flow

J. J. Gibson, The Ecological Approach to Visual Perception
Motion Parallax
Other cues

Accommodation: focusing.
Convergence
Computer Vision

First pass at a definition:

- take all the cues of artists and “turn them around”

- exploit these cues to infer the structure of the world

- need mathematical and computational models of these cues

- sometimes called “inverse graphics”
Example: Light

Source emits photons

Photons travel in a straight line

When they hit an object they:
• bounce off in a new direction
• or are absorbed

And then some reach the eye/camera.

David Jacobs
Imagine a perfect mirror sphere in a perfectly dark room. Illuminate it with a *point light source.*

What do you see?
Thought Experiments

Imagine the sphere now painted with a flat white paint.

What do you see?
Thought Experiments

Properties of the world (unknown variables):

1. Light source location, direction & intensity
2. Light source shape
3. Object shape
4. Object material
5. Location of camera

Approximate the physics:

\[ I_p = k_a i_a + \sum_{\text{lights}} k_d (L \cdot N) i_d \]

This picture is of an ash cone in the Hawaiian Islands (courtesy of W. Richards).