Introduction to Computer Vision

Michael J. Black

Sept 2009

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 |pərˈsēv|
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.*

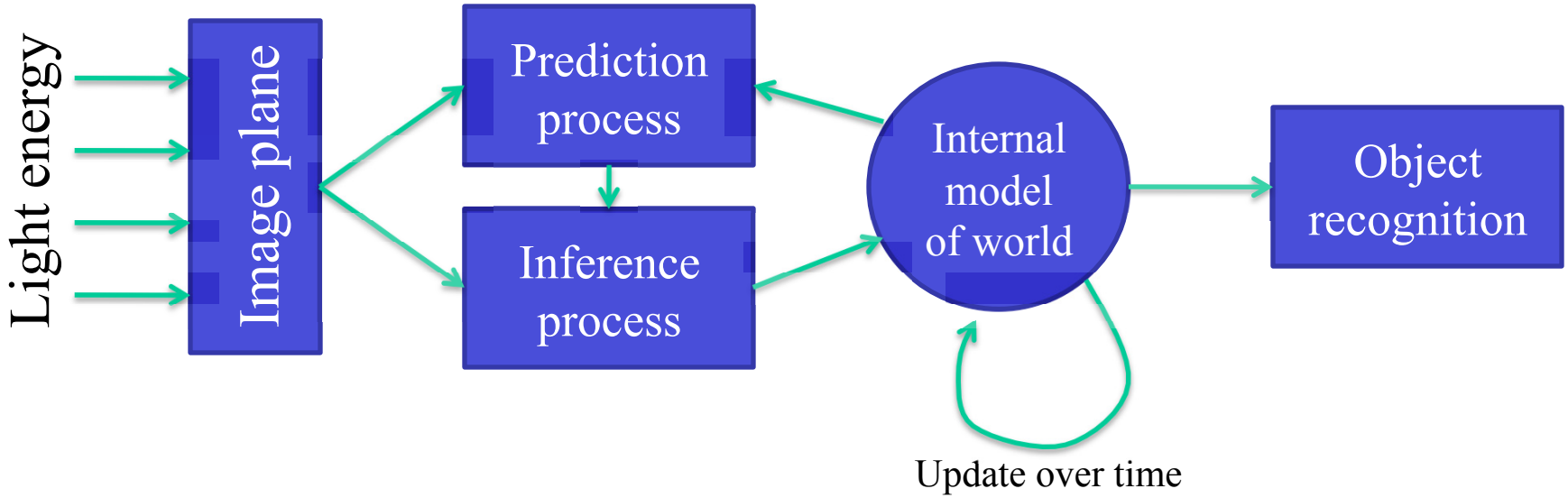
• become aware of (something) by the use of one of the senses, esp. that of sight *: he perceived the faintest of flushes creeping up her neck.*

What does it mean for a computer to see?

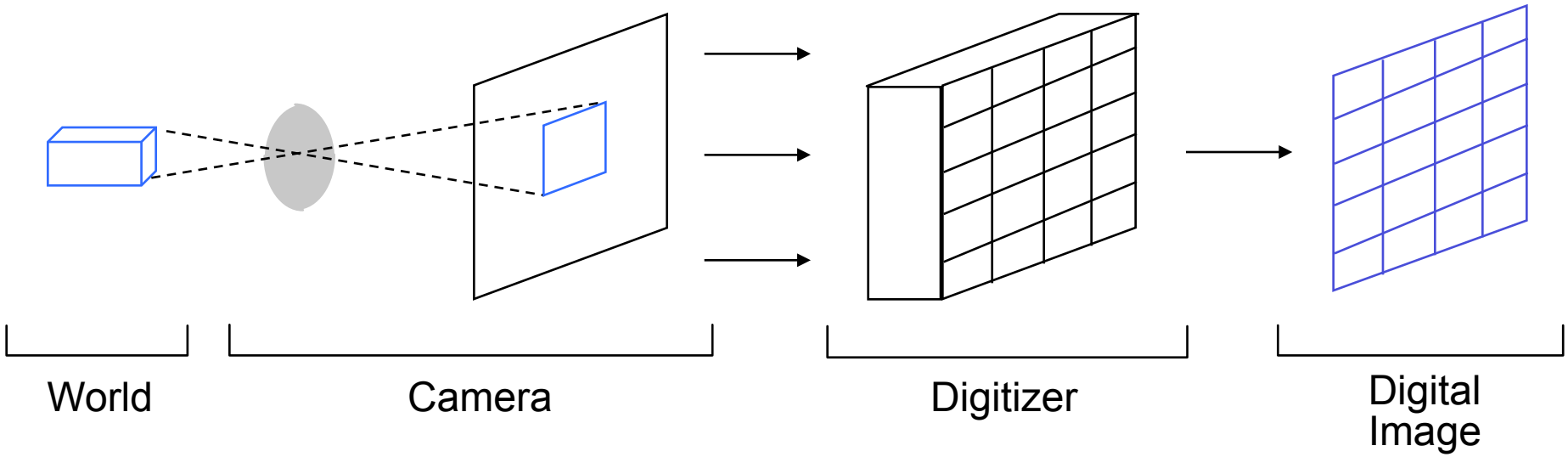
Computer Vision

- 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

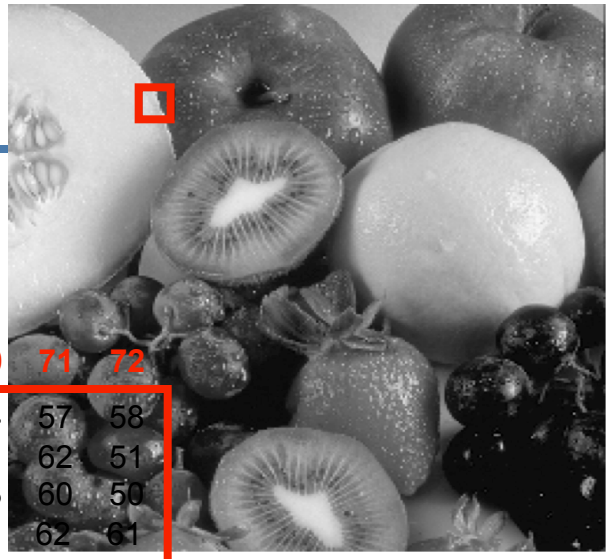


Digital Images



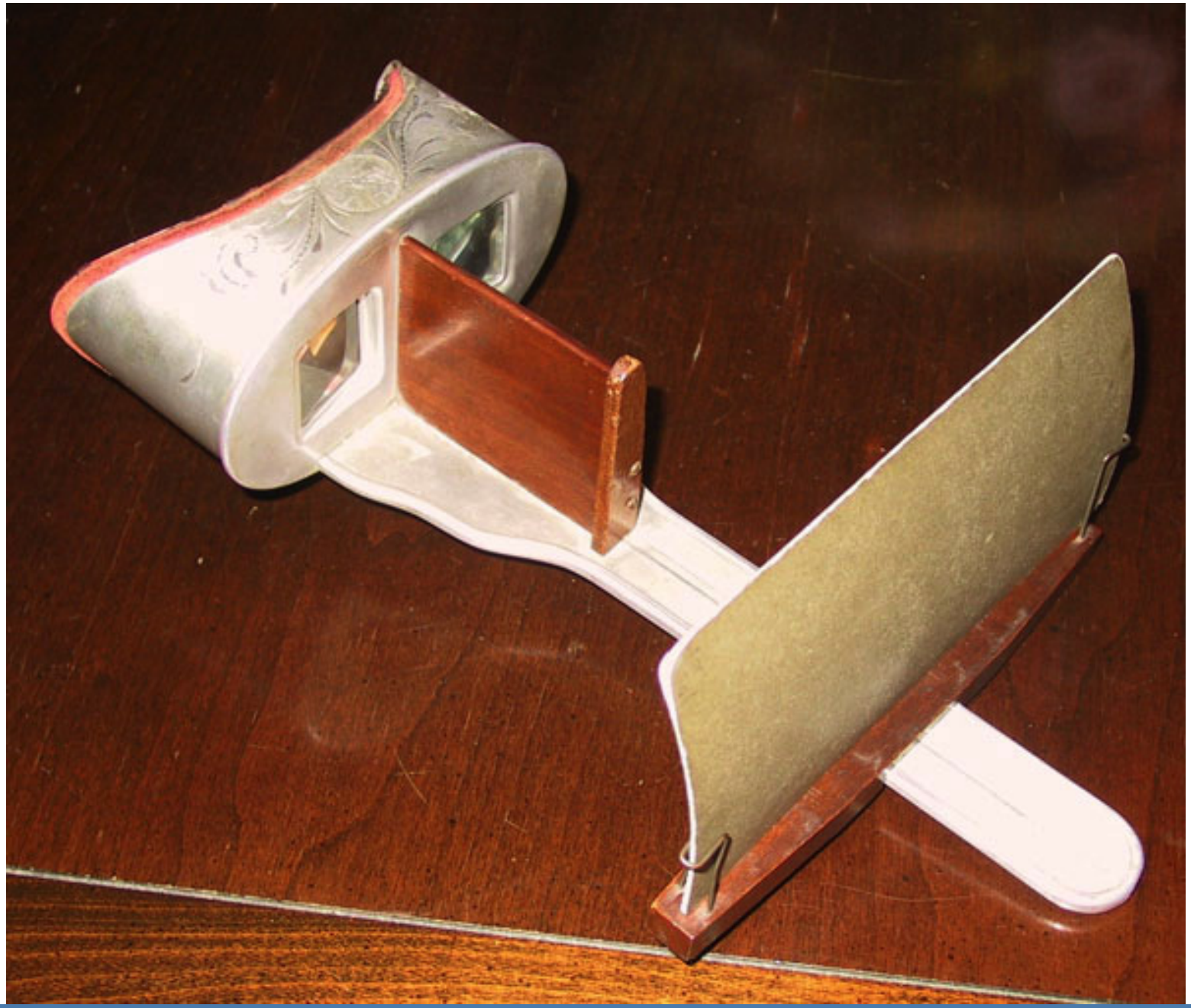
2.3 in Szeliski

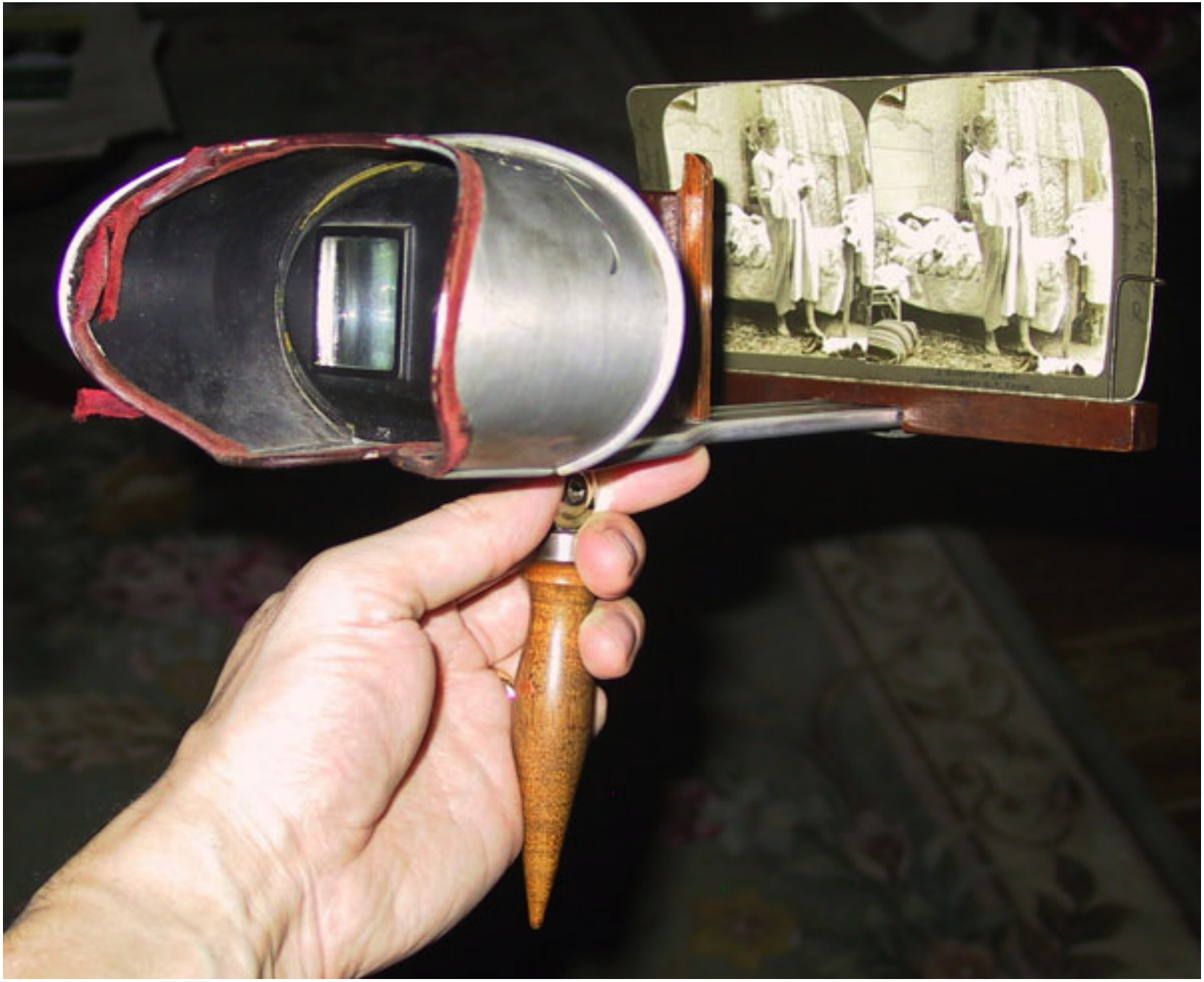
Grayscale Image

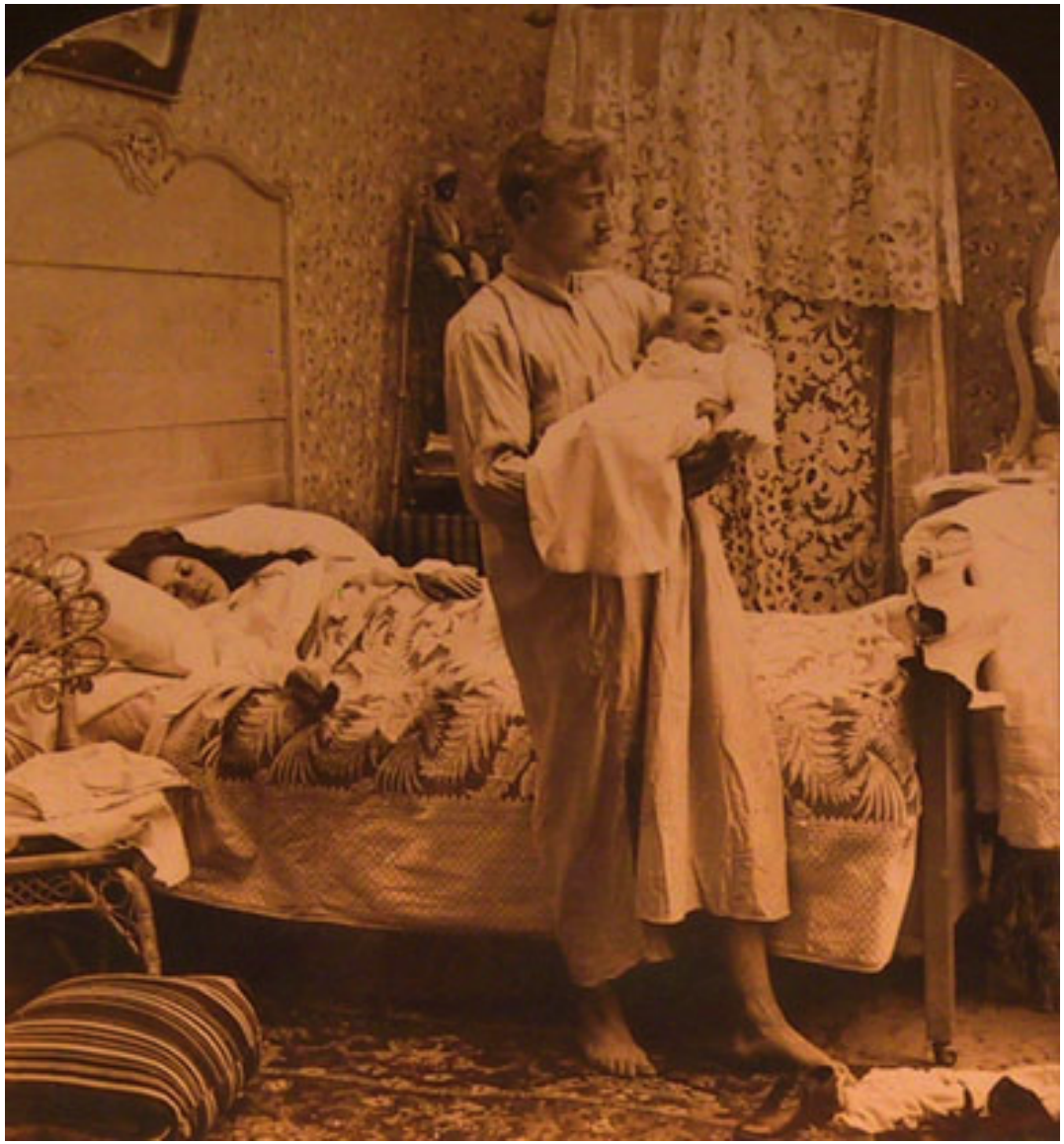


	x = 58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
y = 41	210	209	204	202	197	247	143	71	64	80	84	54	54	57	58
42	206	196	203	197	195	210	207	56	63	58	53	53	61	62	51
43	201	207	192	201	198	213	156	69	65	57	55	52	53	60	50
44	216	206	211	193	202	207	208	57	69	60	55	77	49	62	61
45	221	206	211	194	196	197	220	56	63	60	55	46	97	58	106
46	209	214	224	199	194	193	204	173	64	60	59	51	62	56	48
47	204	212	213	208	191	190	191	214	60	62	66	76	51	49	55
48	214	215	215	207	208	180	172	188	69	72	55	49	56	52	56
49	209	205	214	205	204	196	187	196	86	62	66	87	57	60	48
50	208	209	205	203	202	186	174	185	149	71	63	55	55	45	56
51	207	210	211	199	217	194	183	177	209	90	62	64	52	93	52
52	208	205	209	209	197	194	183	187	187	239	58	68	61	51	56
53	204	206	203	209	195	203	188	185	183	221	75	61	58	60	60
54	200	203	199	236	188	197	183	190	183	196	122	63	58	64	66
55	205	210	202	203	199	197	196	181	173	186	105	62	57	64	63

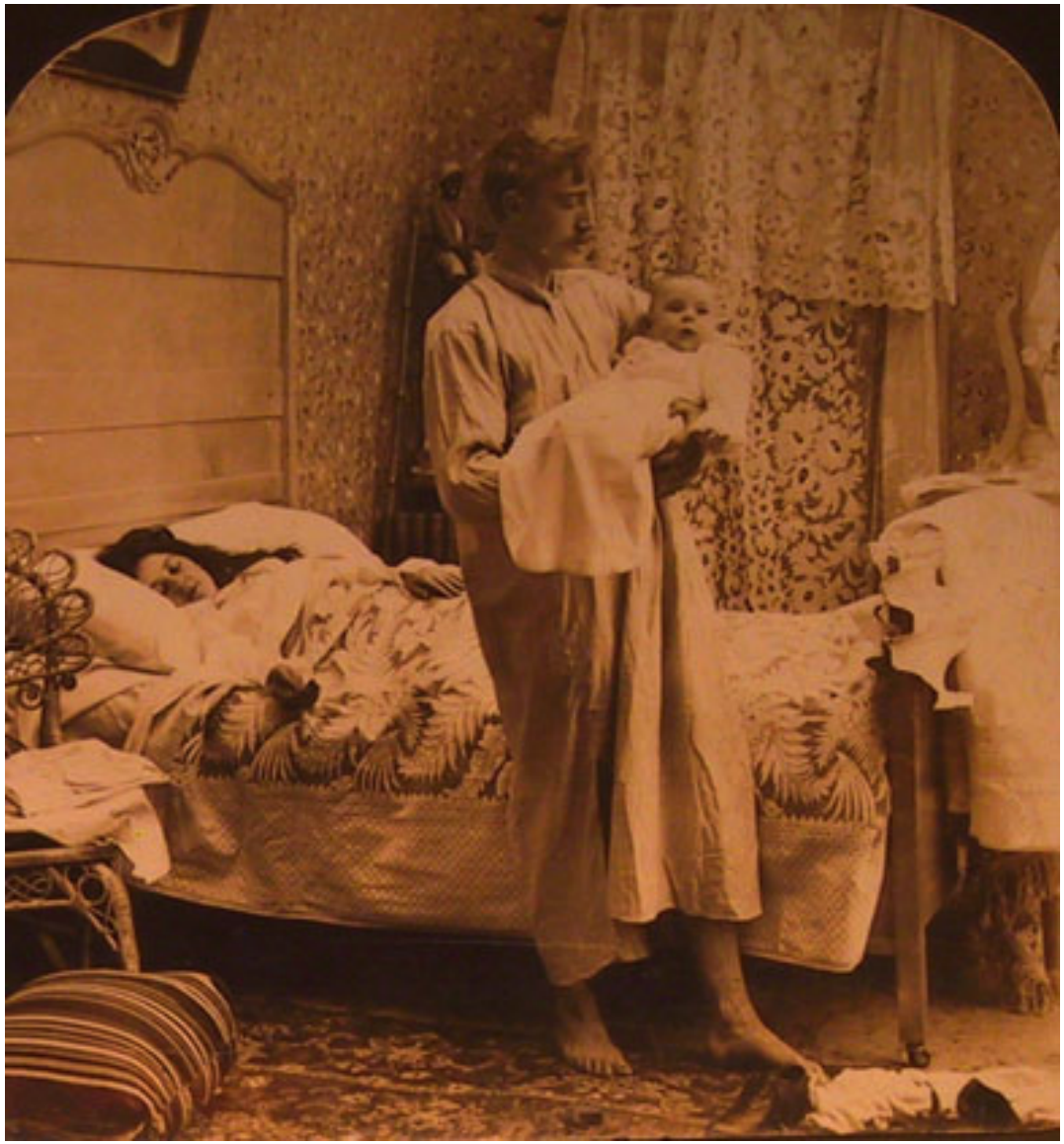
How do we go from an array of numbers recognizing fruit?





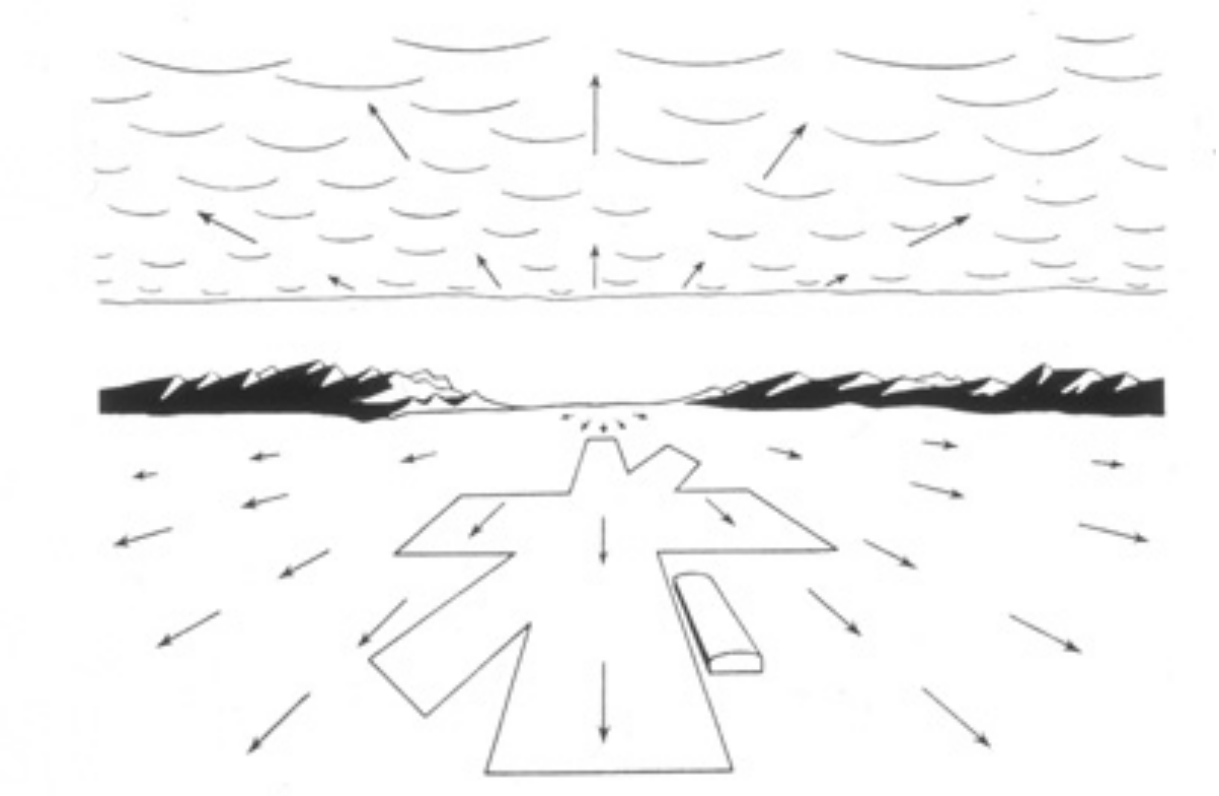


Left image



Right image

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

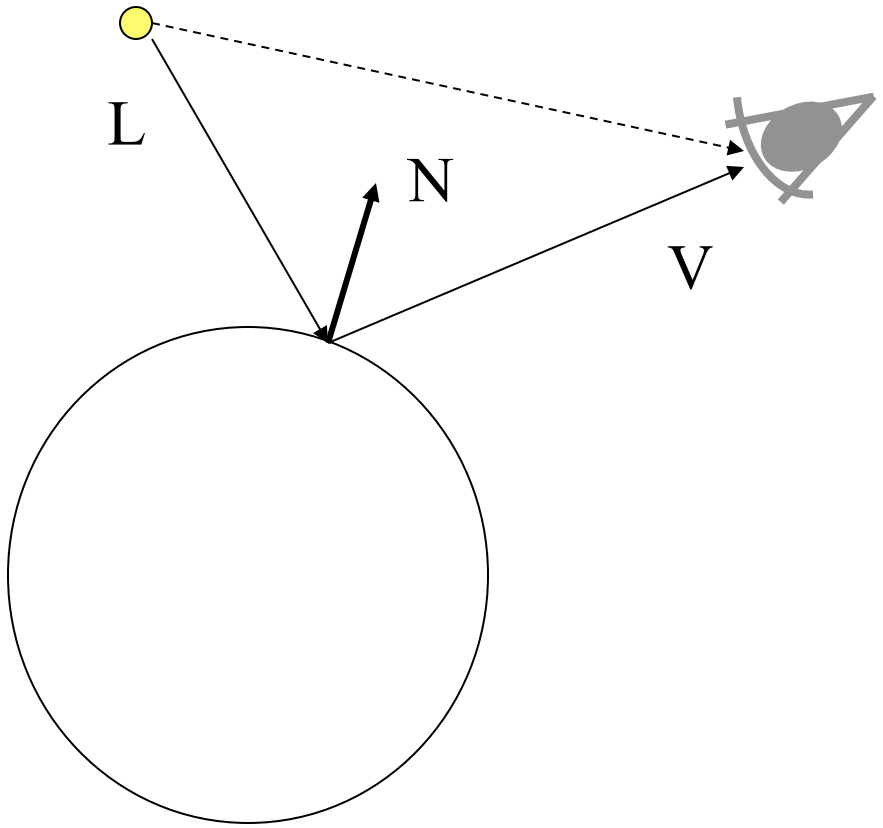
And then some reach the eye/ camera.

When they hit an object they:

- bounce off in a new direction
- or are absorbed

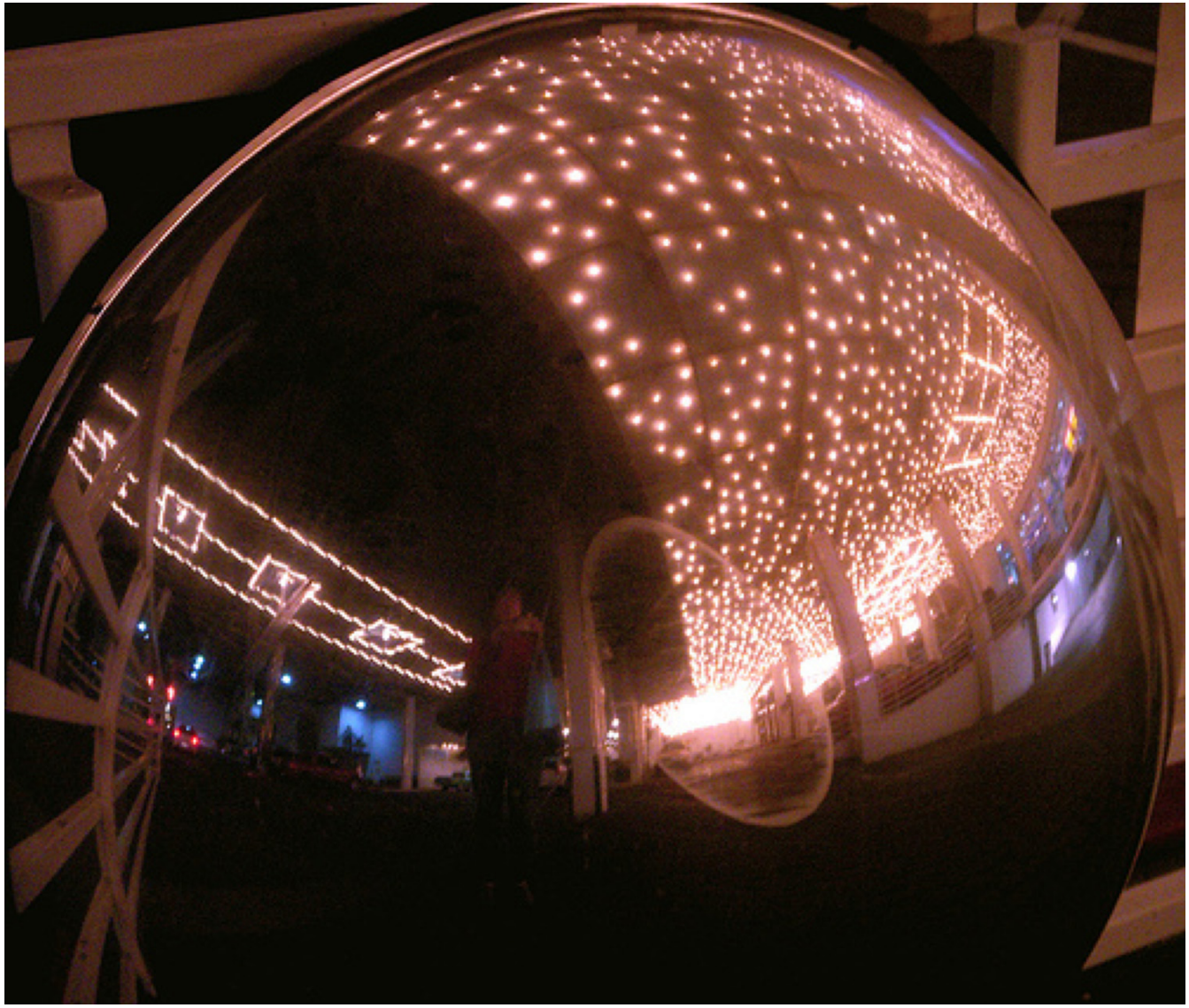
David Jacobs

Thought Experiments



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

What do you see?

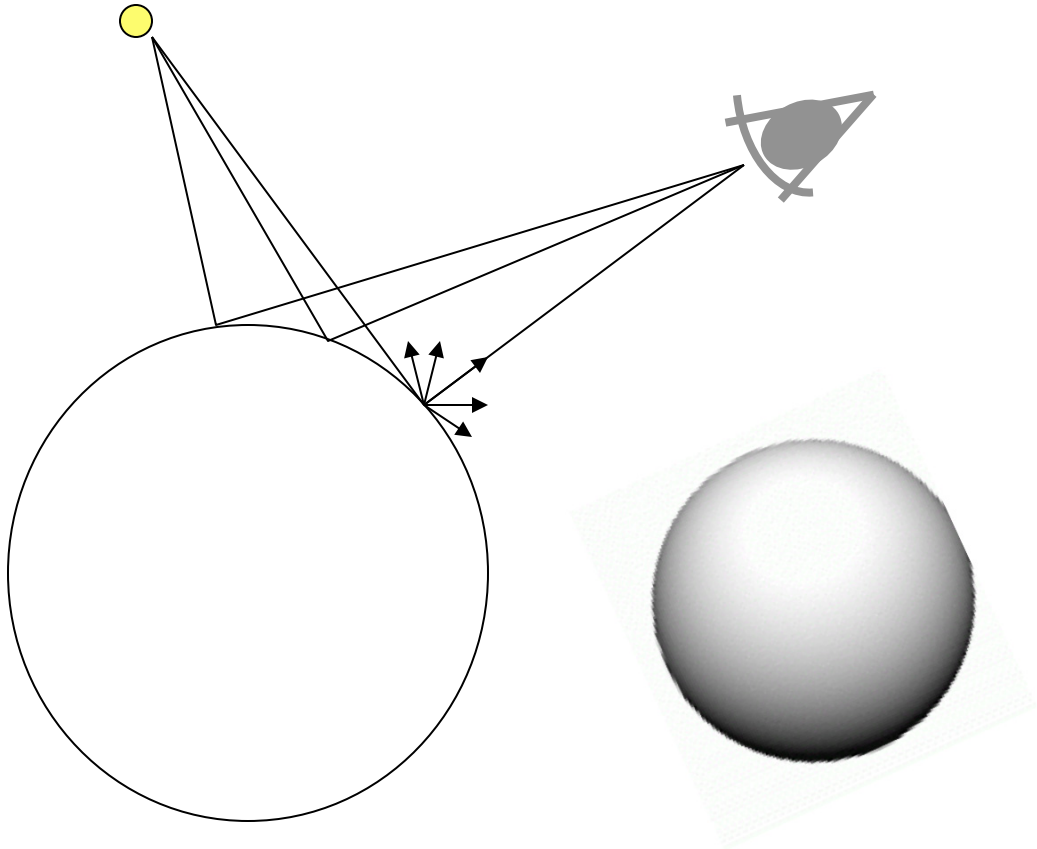


flicker, cobalt123

Thought Experiments

Imagine the sphere now painted with a flat white paint.

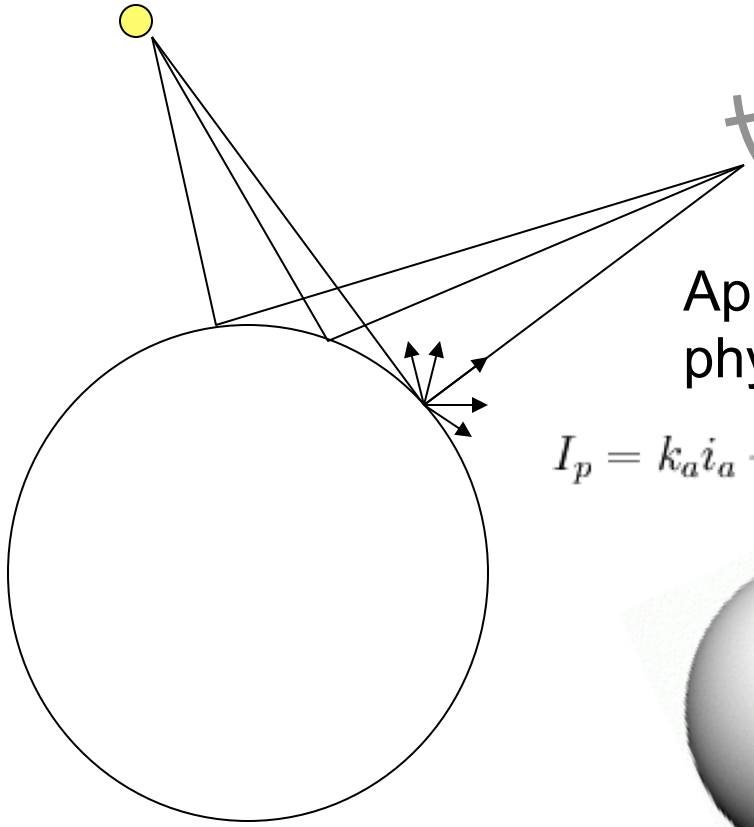
What do you see?



Thought Experiments

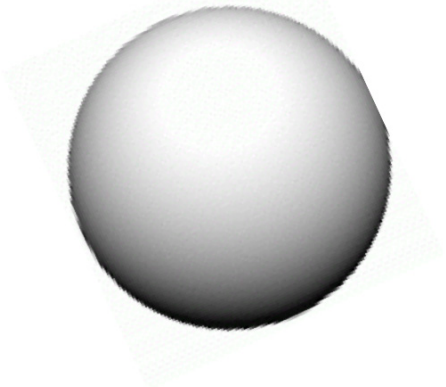
Properties of the world (unknown variables):

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

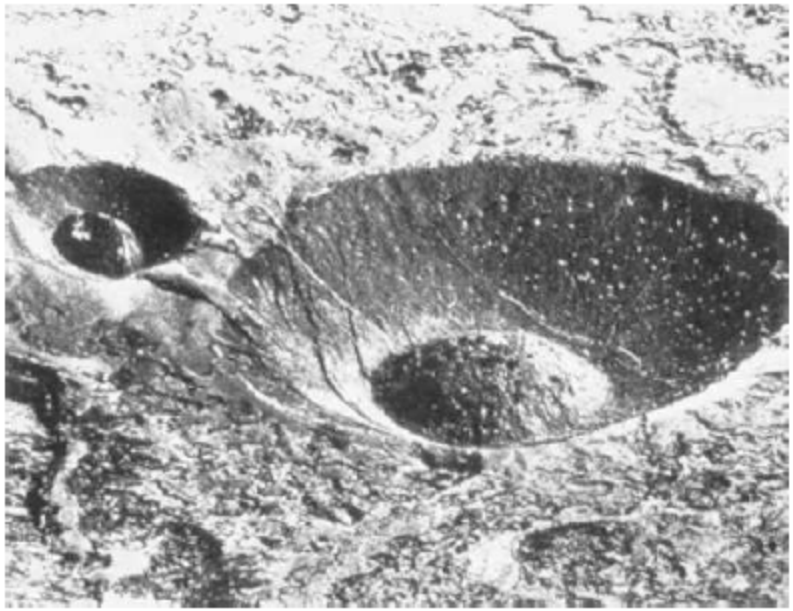


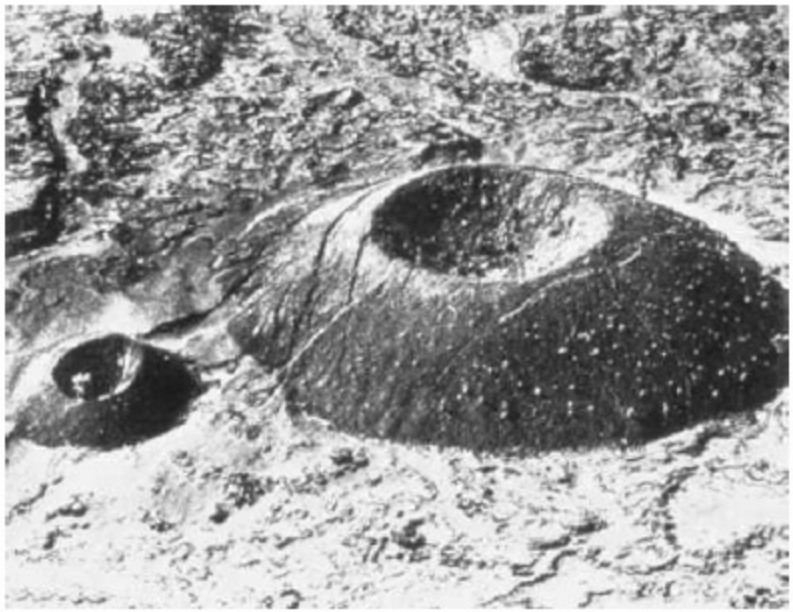
Approximate the physics:

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



Crater illusion





A. Pentland. Local shading analysis. *Trans. PAMI*, 6:170–187, 1984.

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