CPSC 4040/6040 Computer Graphics Images

Joshua Levine
levinej@clemson.edu

Lecture 01
Introduction

Aug. 20, 2015

Slide Credits:
Kenny A. Hunt

Today's Agenda

- Register / Waitlists? See me after class.
- Course webpage:
  - http://people.cs.clemson.edu/~levinej/courses/6040/
- Go over syllabus and introduce the course

Course Syllabus

Personnel and Contact

- Office hours: by appointment
- Open Lab time at Tues. 6-8pm. 110B McAdams
- Grader: Dachao Sun (dachaos@g.clemson.edu)
- Piazza is the BEST way to contact us.

The Lab is OPTIONAL, But…

Five Reasons to Consider Attending the Lab

1. **Before you start:** you can take this time to read lab instructions and clarify confusion in person.

2. **Already starts:** if you have prepared questions to ask or discuss, you can make sure you're on the right track

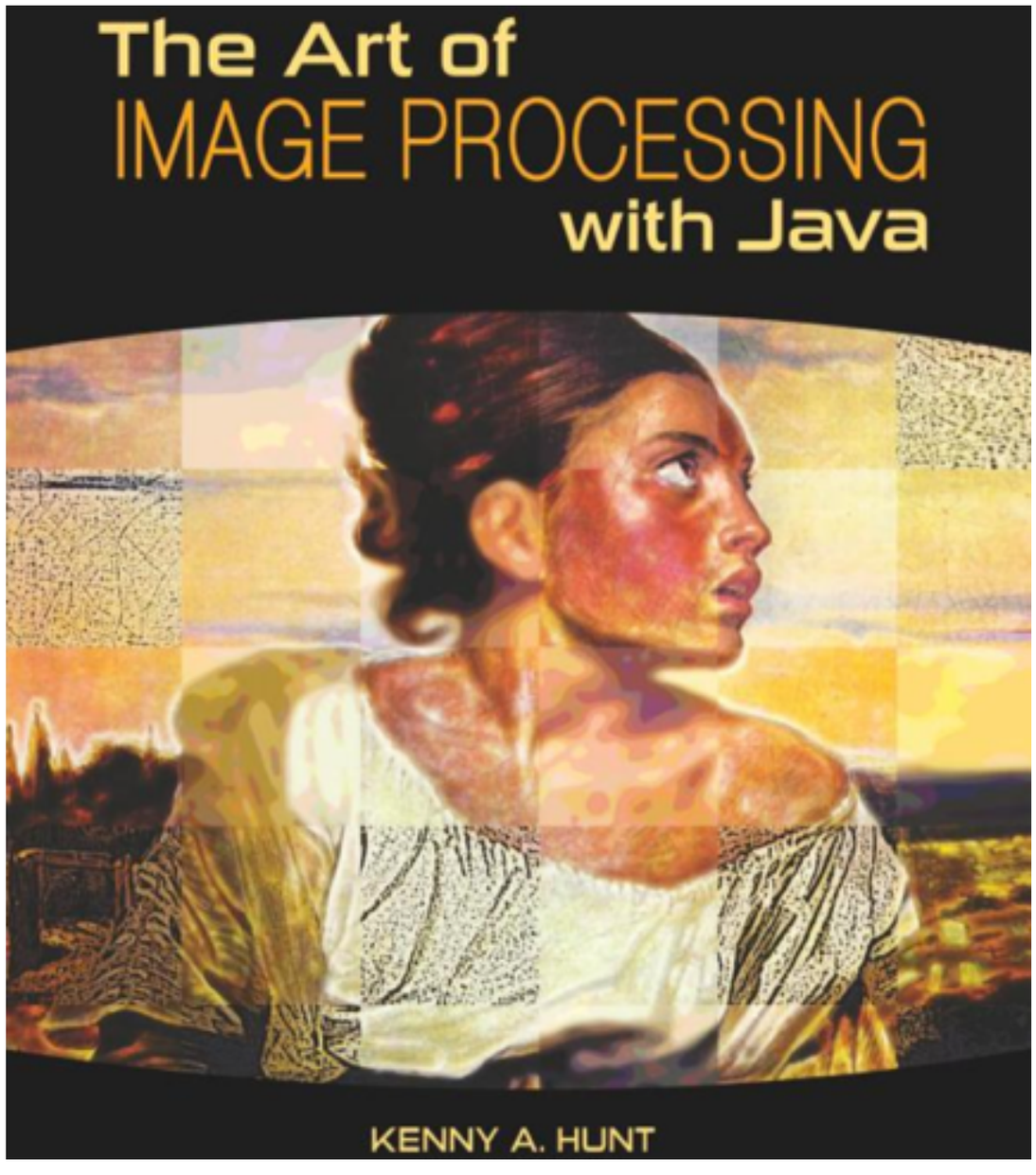
3. **About to finish**: you can test your code on the lab machines, and check if anything is missing or could be improved (for extra credit)

4. **Feedback in detail:** you can check with the TA/instructor about grading questions for the current or even previous assignments

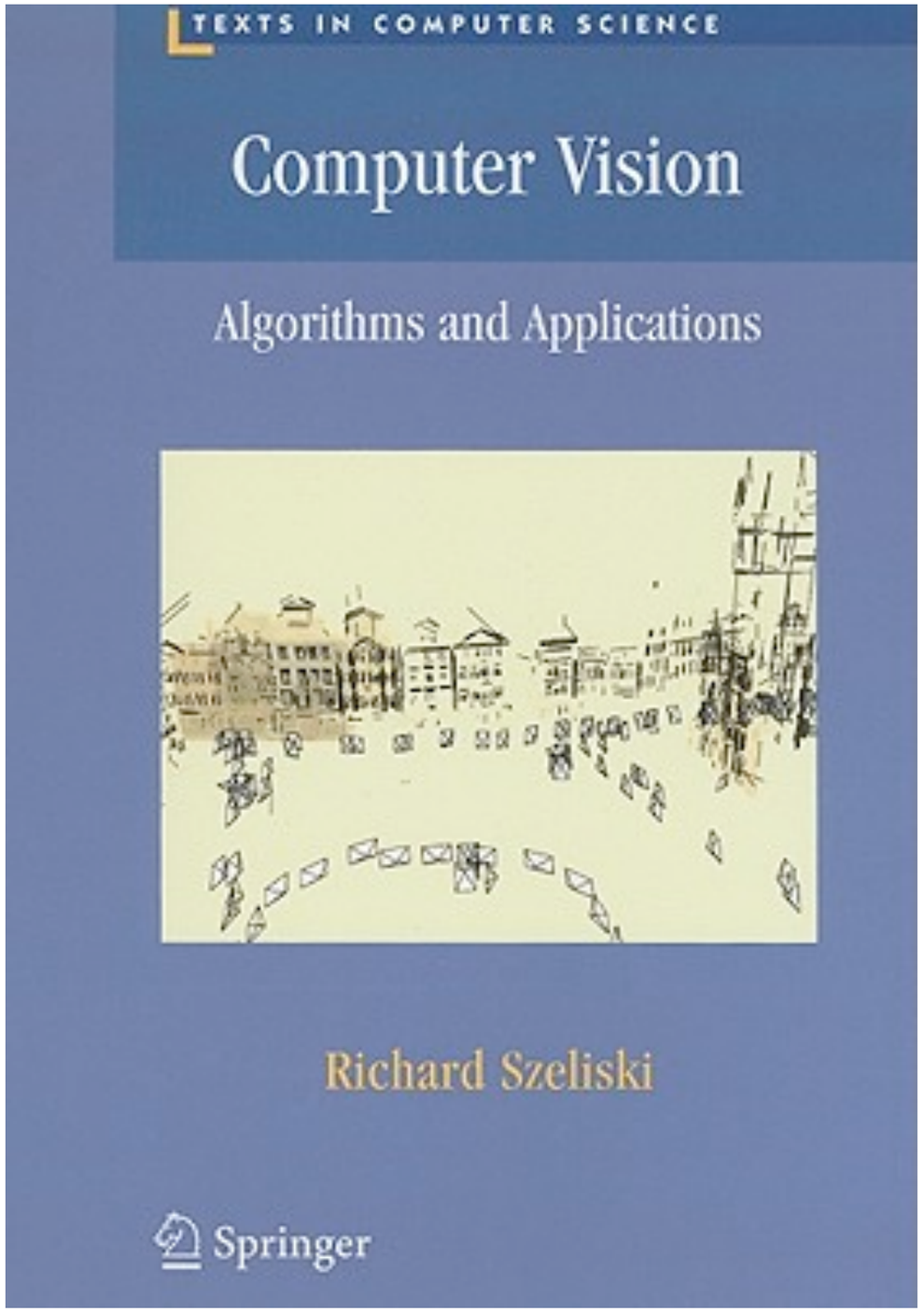
5. **Flexibility:** you can come and go as you please during the time.

Required Course Materials

- The Art of Image Processing with Java by Kenny A. Hunt
- ISBN 9781568817170
- First chapter available online:
  - http://charity.cs.uwlax.edu/artofimageprocessing/index.html

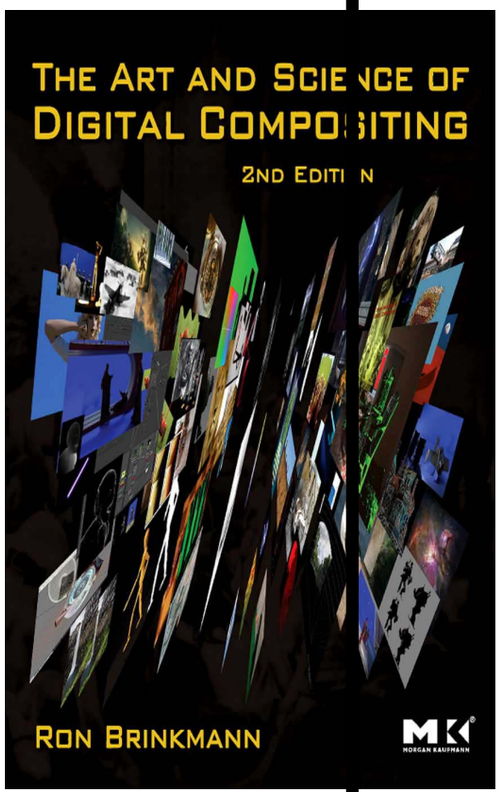


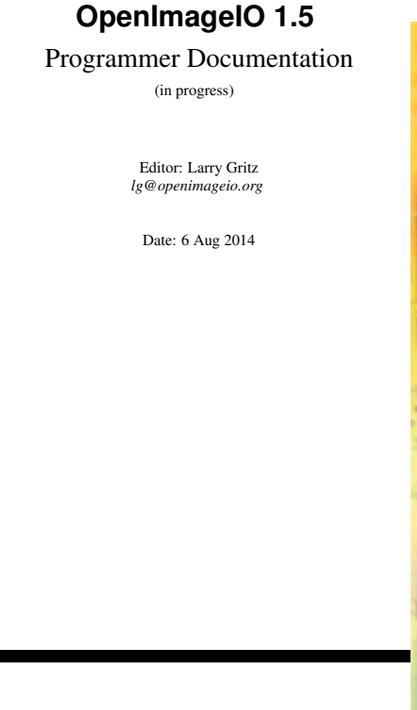
Required Course Materials, Part 2

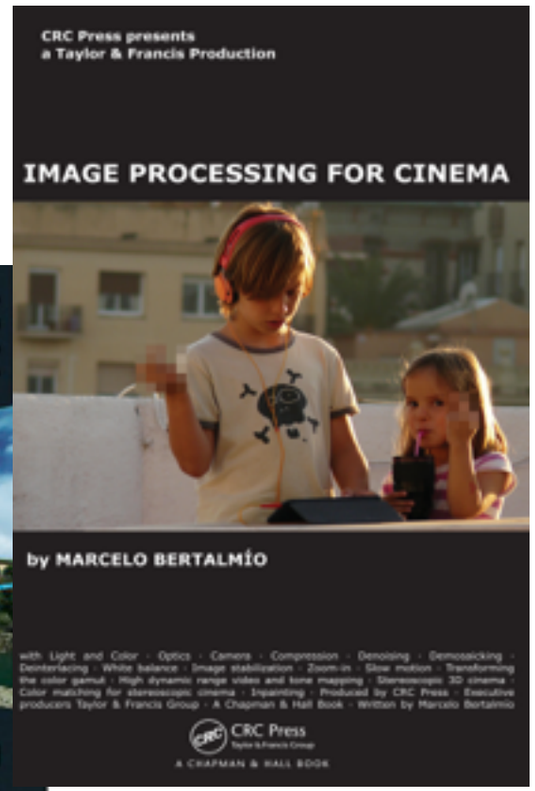


- Computer Vision Algorithms and Applications by Richard Szeliski
- ISBN 9781848829343
- eBook available through Clemson University library

Supplemental Course Materials







- Plus many other handouts, research papers, etc.

Course Requirements

- Coding Projects (40% for undergrads / 24%+16% for grads)
- Quizzes (30%)
- Final Project (10%)
- Class Participation (10%)
- Final Exam (10%, optional skip)
- Various Extra Credit Opportunities

Course Policies

- **Do**:
  - Come to class and participate
  - Write clean, correct code
  - Contact me if you have any special needs
  - Be considerate of Dachao's and my time
  - Discuss problems with classmates **before** starting.
- **Don't**:
  - Steal code, share answers (from both others in the class and outside of it
  - Steal copyrighted materials
  - Be dishonest
  - Complain unnecessarily
  - Violate university policies (academic integrity, title IX, etc.)

About Me

Where the Parks Are

North, South, East, Midwest, West—each section of the United States has at least one national park to call its own. You don't have to visit the parks to enjoy their splendors, for this book is filled with their sights and their sounds. But if a trip is in the offing, this map and the chart on the two following pages will serve as your guide.

Course Expectations

What will you accomplish?

Course Goals

- Understand theory and practice related to digital images;
- Understand the ubiquitous role that images play in computer graphics and visualization fields;
- Develop software and tools to create, store, manipulate, and transform images;
- Undertake creative work and be familiar with basic research topics associated with images.

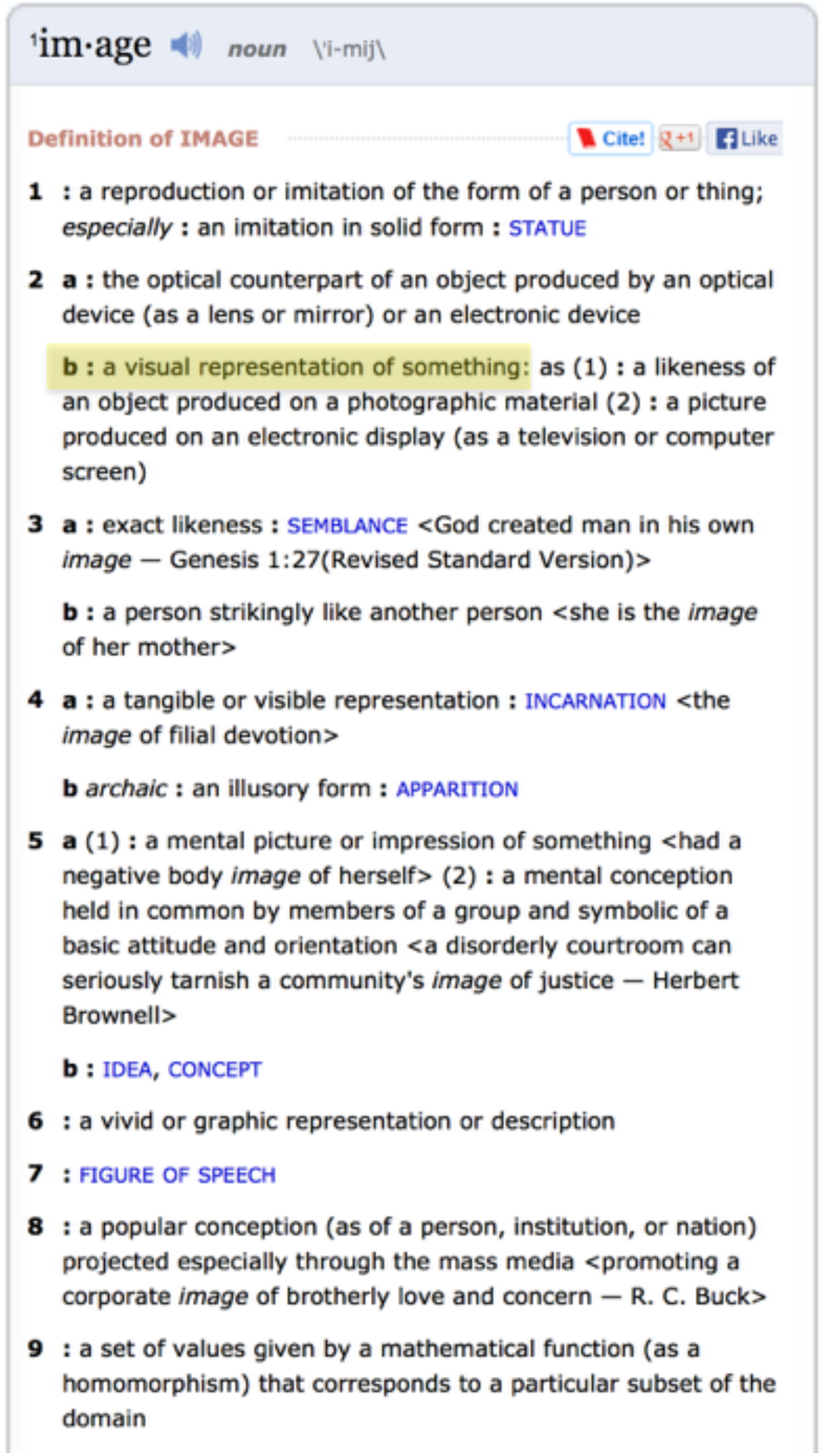
About You

What are your backgrounds?
Why are you taking this course?

Digital Images

im · age

a visual representation of something



¹im·age *noun* \'i-mij\

Definition of IMAGE

Cite! +1 Like

1 : a reproduction or imitation of the form of a person or thing; *especially* : an imitation in solid form : STATUE

2 **a** : the optical counterpart of an object produced by an optical device (as a lens or mirror) or an electronic device

b : a visual representation of something: as (1) : a likeness of an object produced on a photographic material (2) : a picture produced on an electronic display (as a television or computer screen)

3 **a** : exact likeness : SEMBLANCE <God created man in his own *image* — Genesis 1:27(Revised Standard Version)>

b : a person strikingly like another person <she is the *image* of her mother>

4 **a** : a tangible or visible representation : INCARNATION <the *image* of filial devotion>

b *archaic* : an illusory form : APPARITION

5 **a** (1) : a mental picture or impression of something <had a negative body *image* of herself> (2) : a mental conception held in common by members of a group and symbolic of a basic attitude and orientation <a disorderly courtroom can seriously tarnish a community's *image* of justice — Herbert Brownell>

b : IDEA, CONCEPT

6 : a vivid or graphic representation or description

7 : FIGURE OF SPEECH

8 : a popular conception (as of a person, institution, or nation) projected especially through the mass media <promoting a corporate *image* of brotherly love and concern — R. C. Buck>

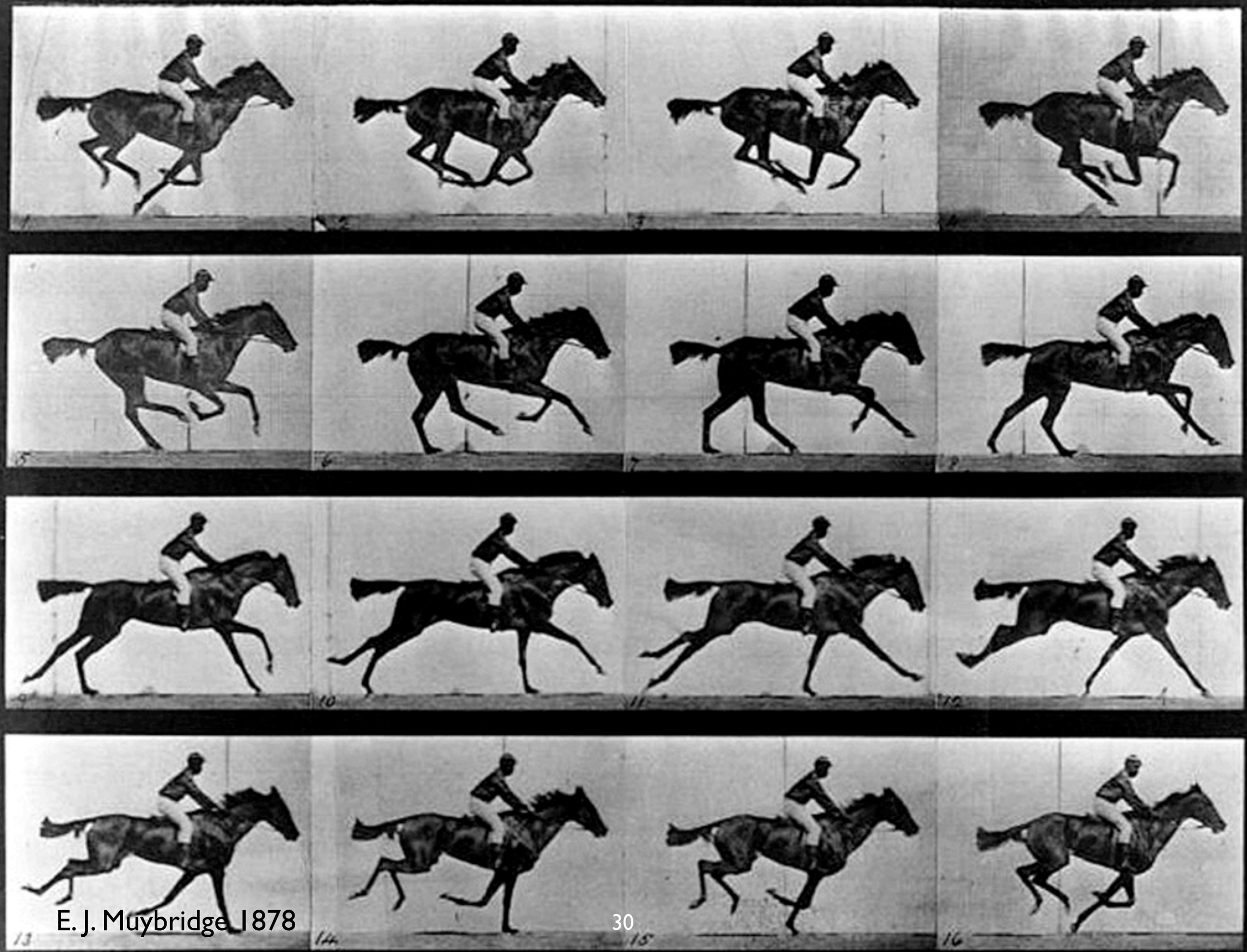
9 : a set of values given by a mathematical function (as a homomorphism) that corresponds to a particular subset of the domain

http://www.merriam-webster.com/dictionary/image

Google Image Search: Image

Design for a Two-Wheeled Hoist with a Caged Gear

Leonardo da Vinci 1485



E. J. Muybridge 1878

Digital Images

- Images which can be stored on in a digital form.
- Examples: data from scanners, digital cameras, output of software.
- Storage (images): papyrus, paper, film, canvas, stone
- Storage (digital images): files on computers

http://commons.wikimedia.org/wiki/File:AncientEgyptianRelief-BeeHieroglyph-ROM.png

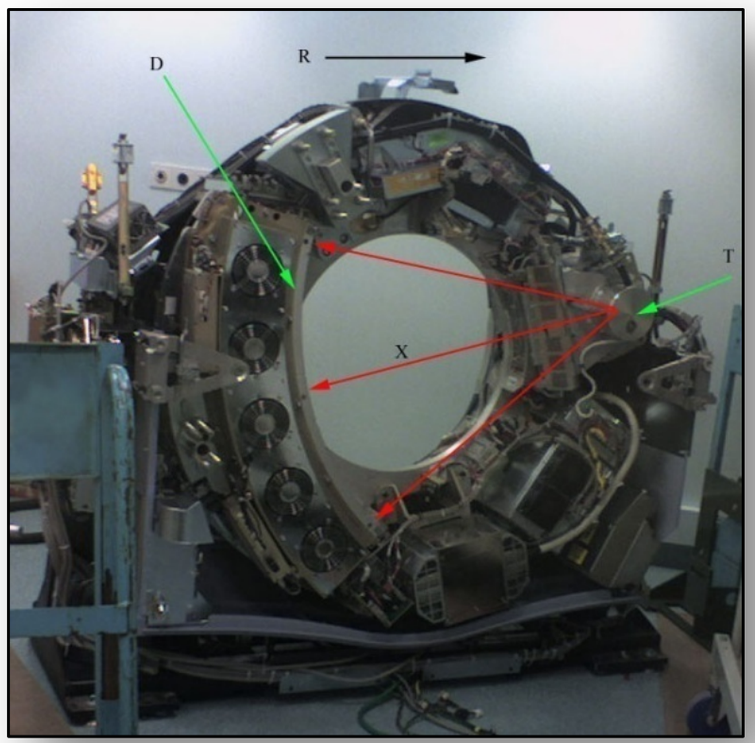
Benefits of Digital Images

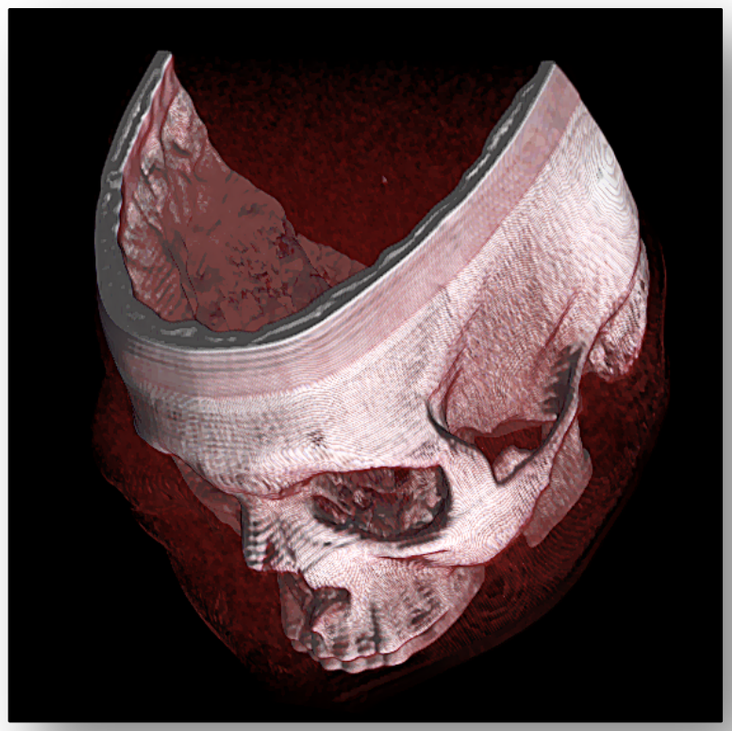
Contrast "digital" and "non-digital" images

Task	Non-Digital	Digital
Creation	Rough approximation of reality	Accurate approximation of reality
Editing	Difficult: erase, over-paint, chisel, …	Easier: use a photo editing suite
Quality over Time	Degrades with exposure to light and environment	No degradation
Copying	Slow process yields inexact copies	Fast process yields exact copies
Transmission	Slow	Fast

Applications: Medicine

- Non-invasive 3D imaging of internal physical structure
  - Computed tomography (CT)
  - Magnetic Resonance Imaging (MRI)
  - X-Rays



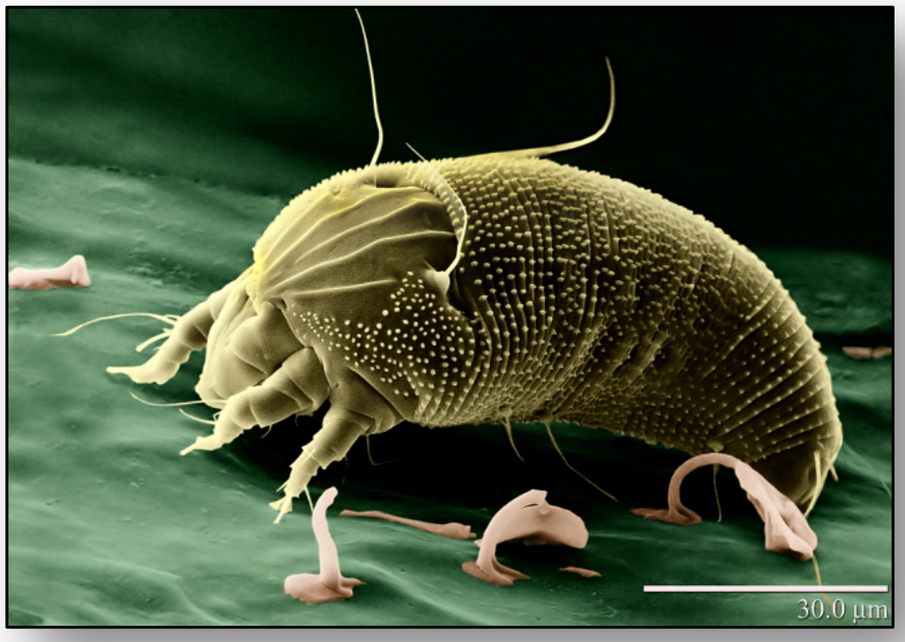


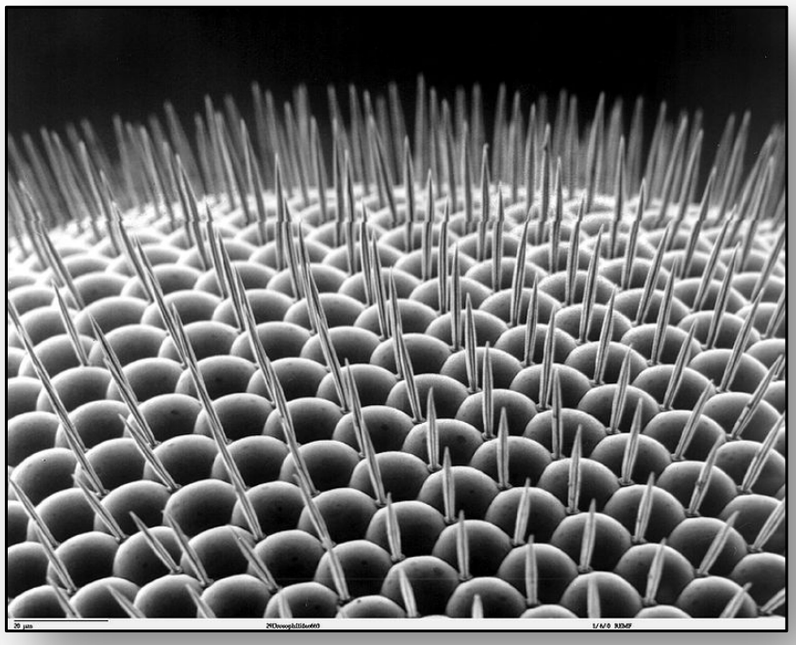
- Physicians must be knowledgeable of image processing as it relates to the display and interpretation of the visual data

http://en.wikipedia.org/wiki/File:Ct-internals.jpg

Applications: Biology

- Biology: a natural science that studies living organisms
  - Includes a vast array of specialized sub disciplines such as botany, zoology, cell biology, microbiology and biochemistry.
  - Each of these disciplines relies to some degree on sophisticated computing systems to acquire and analyze image-based data



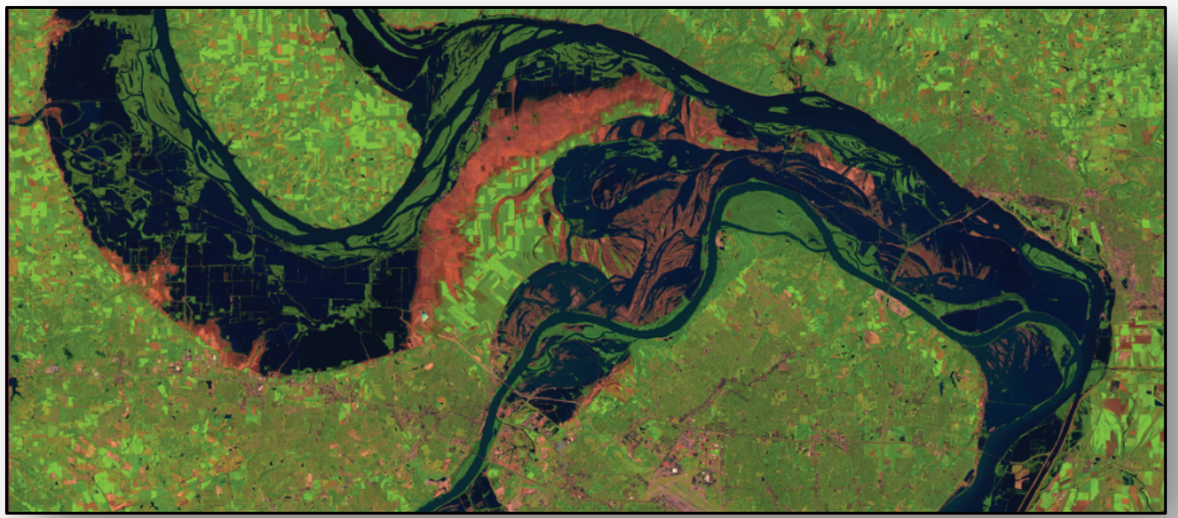


- Biologists must be knowledgeable of image processing as it relates to the acquisition of image-based data and the automation of image-based analysis

http://en.wikipedia.org/wiki/File:Rust_Mite,_Aceria_anthocoptes.jpg , http://upload.wikimedia.org/wikipedia/commons/thumb/8/89/Drosophilidae_compound_eye_.jpg/751px-Drosophilidae_compound_eye_.jpg

Applications: Environmental Science

- Environmental science includes meteorology, oceanography, ecology and geosciences.
- Each of these disciplines relies on satellite imaging and remote sensing

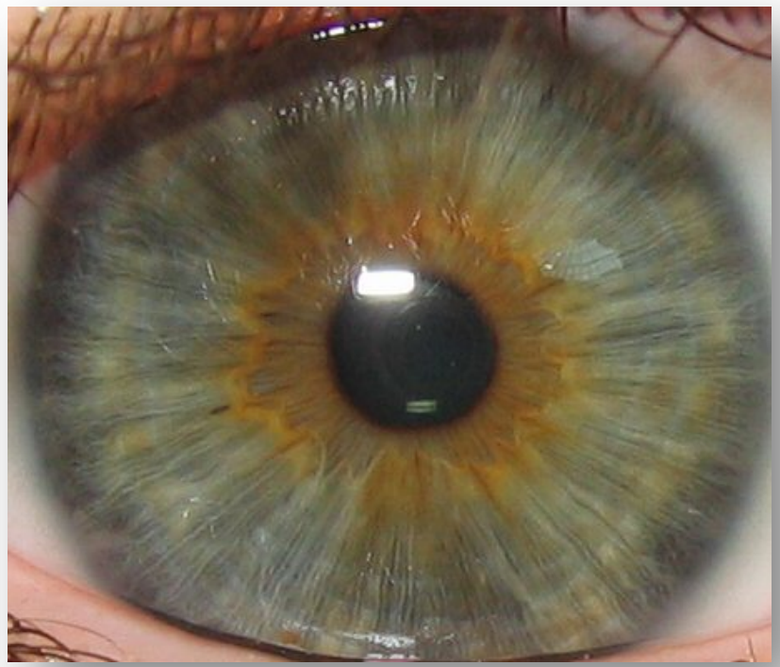


St. Louis Flood of 1993

St. Louis in 1994

Applications: Biometrics

- Biometrics: seeks to verify the identity of individuals by measuring and analyzing biological characteristics such as fingerprints, voice patterns, gait, facial appearance or retinal scans.
- In most of these techniques, with the exception of voice recognition, the biological traits are obtained by analysis of a digital image



Professional Sports

- Football (American)
  - Uses instant replay from multiple angles to determine possession, in/out bounds
  - Telecasts project down markers on the field

- Tennis and Major League Baseball (America)
  - use cameras to track ball trajectories

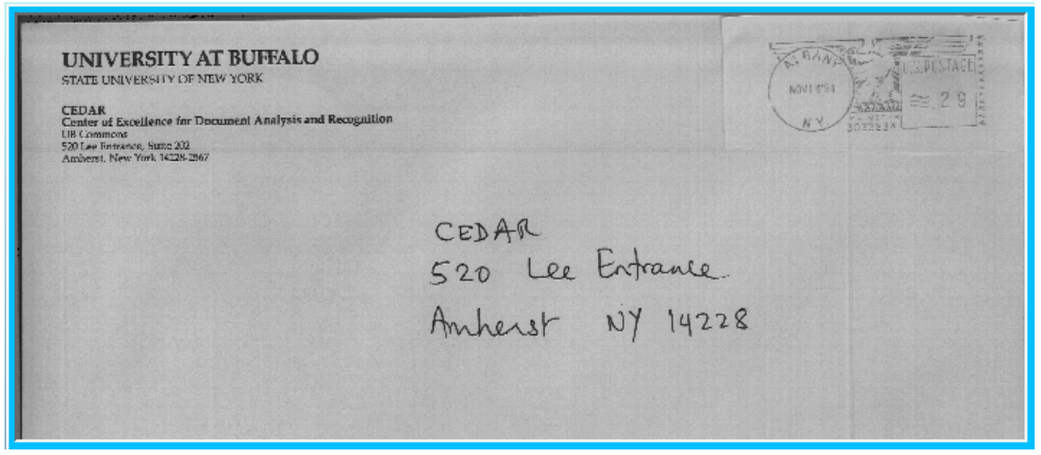
Applications: Astronomy

- Heavy reliance on digital imaging.
  - Compton Gamma Ray Observatory captures digital images primarily in the gamma ray spectrum
  - Chandra X-Ray Observatory and the Space Infrared Telescope Facility (also known as the Spitzer Space Telescope) provide coverage of the x-ray and infrared portions of the spectrum respectively.
  - The Hubble Telescope, launched in 1990, orbits the earth with a reflector style optics system and a mirror of 2.4 meters in diameter. The focal length is 57.6 meters and it is able to take infrared images as well as images in the visible spectrum

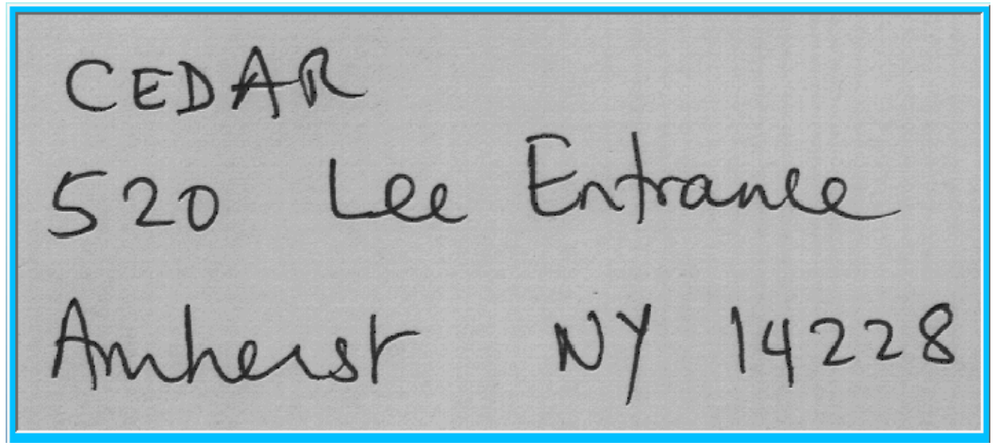
Hubble Image
M51 Spiral Galaxy
60,000 Light Years Across
http://www.spacetelescope.org/images/heic0506a/

Application: Mail Delivery

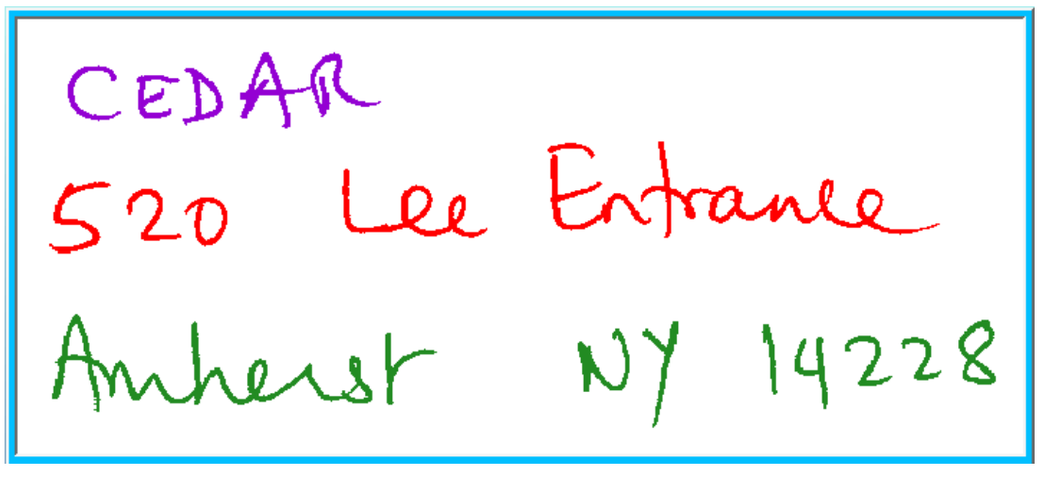
- Most parcels, letters are routed automatically



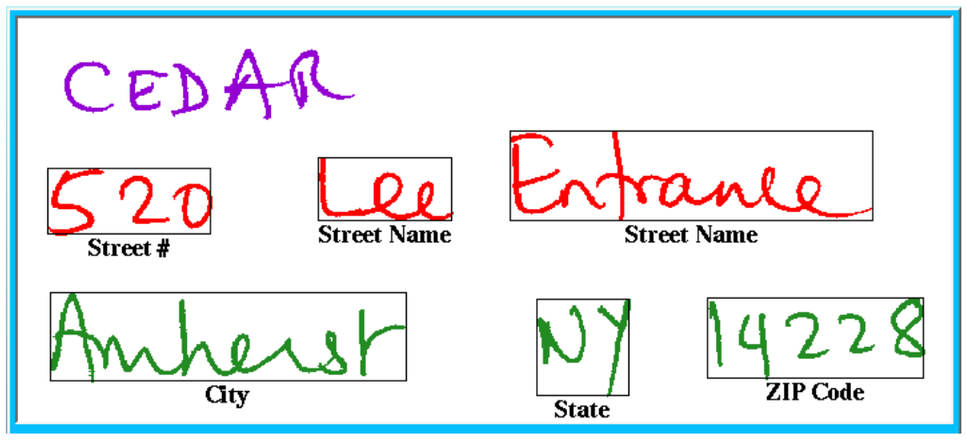
Letter is scanned



Destination address identified



Address is segmented



Segments are analyzed

Any Others?

Image Processing Pipeline

- Acquisition: creation of digital image
- Processing: enhancement or other processing
- Archival: storage of image
- Transmission: exchange of digital image data
- Display: visualization of digital image

Image Processing Pipeline

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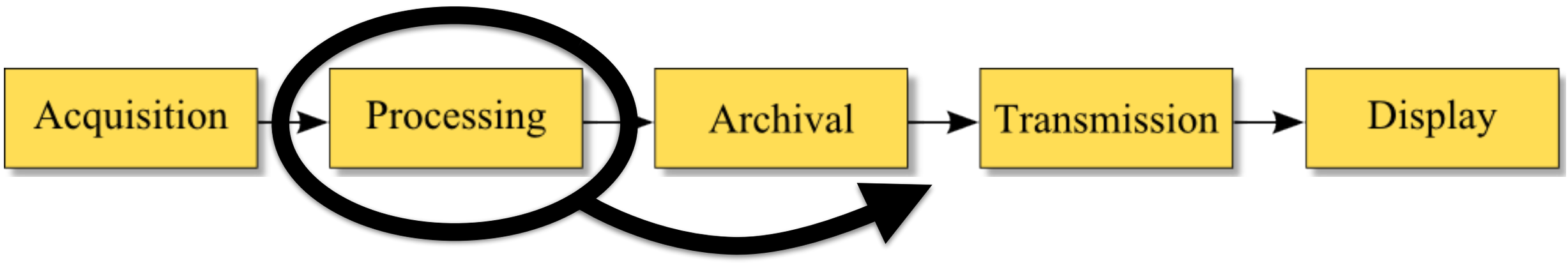
Image Processing Pipeline



- Acquisition: creation of digital image
- Processing: enhancement or other processing
- Archival: storage of image
- Transmission: exchange of digital image data
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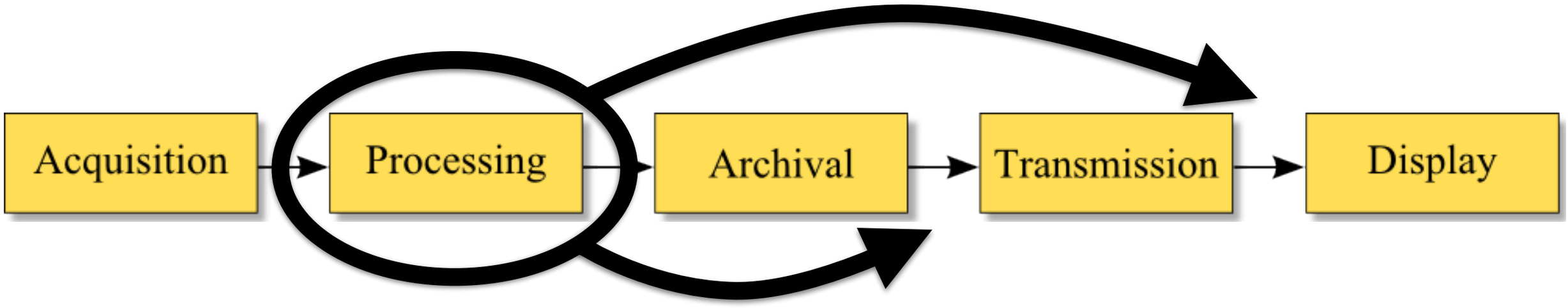
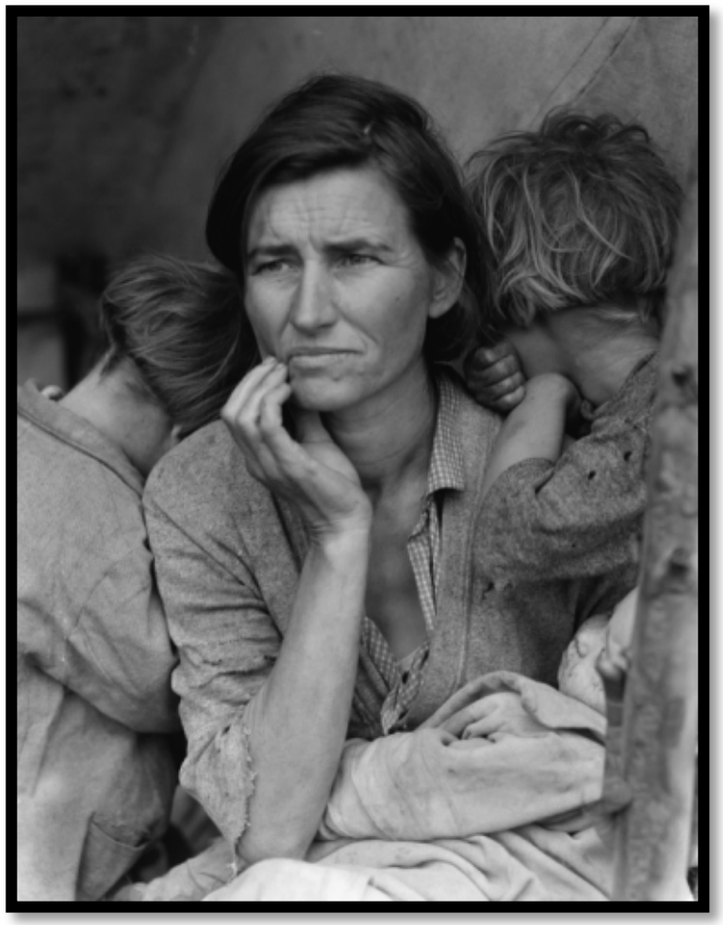
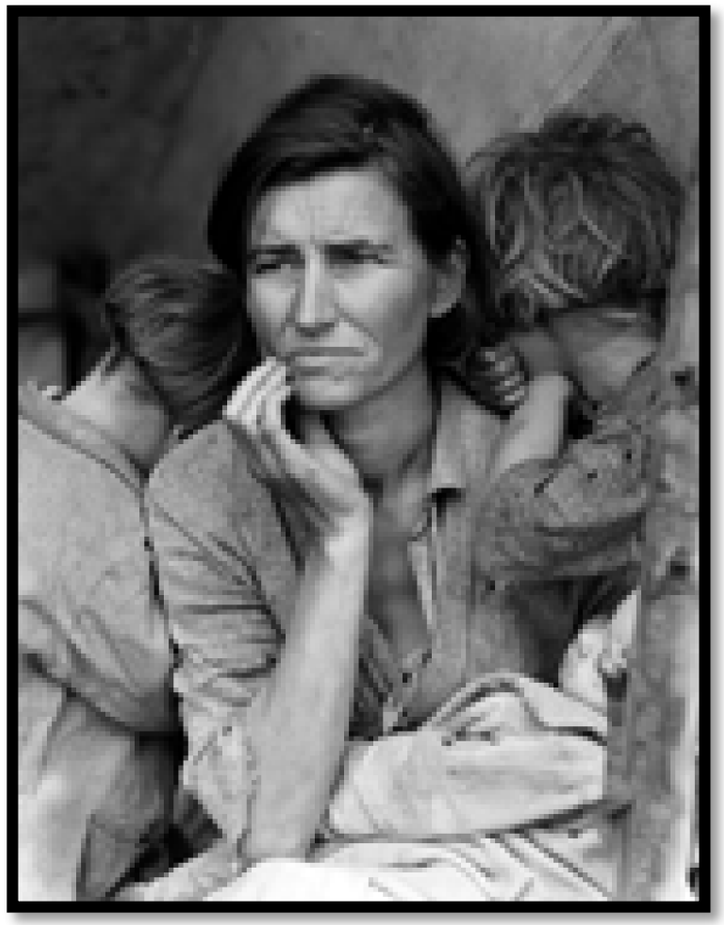
Image Processing Pipeline

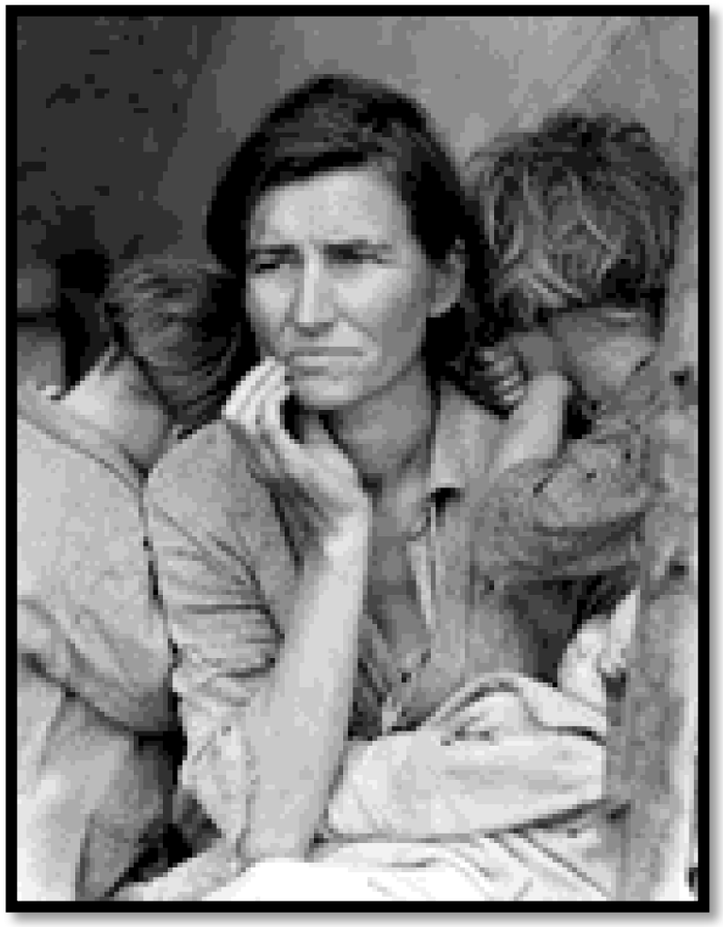


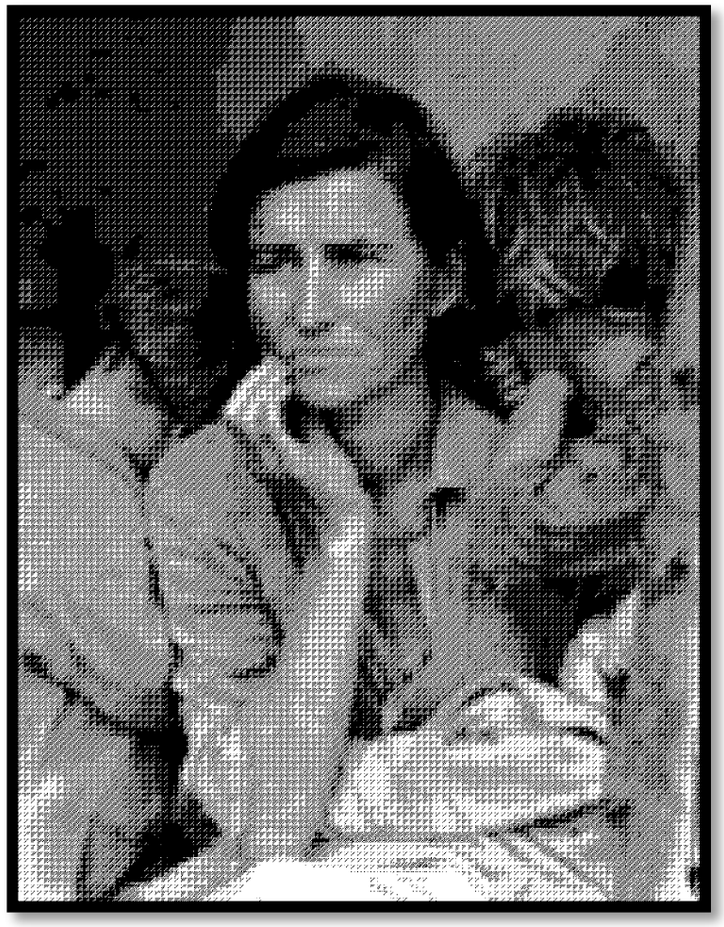
- Acquisition: creation of digital image
- Processing: enhancement or other processing
- Archival: storage of image
- Transmission: exchange of digital image data
- Display: visualization of digital image





Example(s) of Image Processing “Concerns”

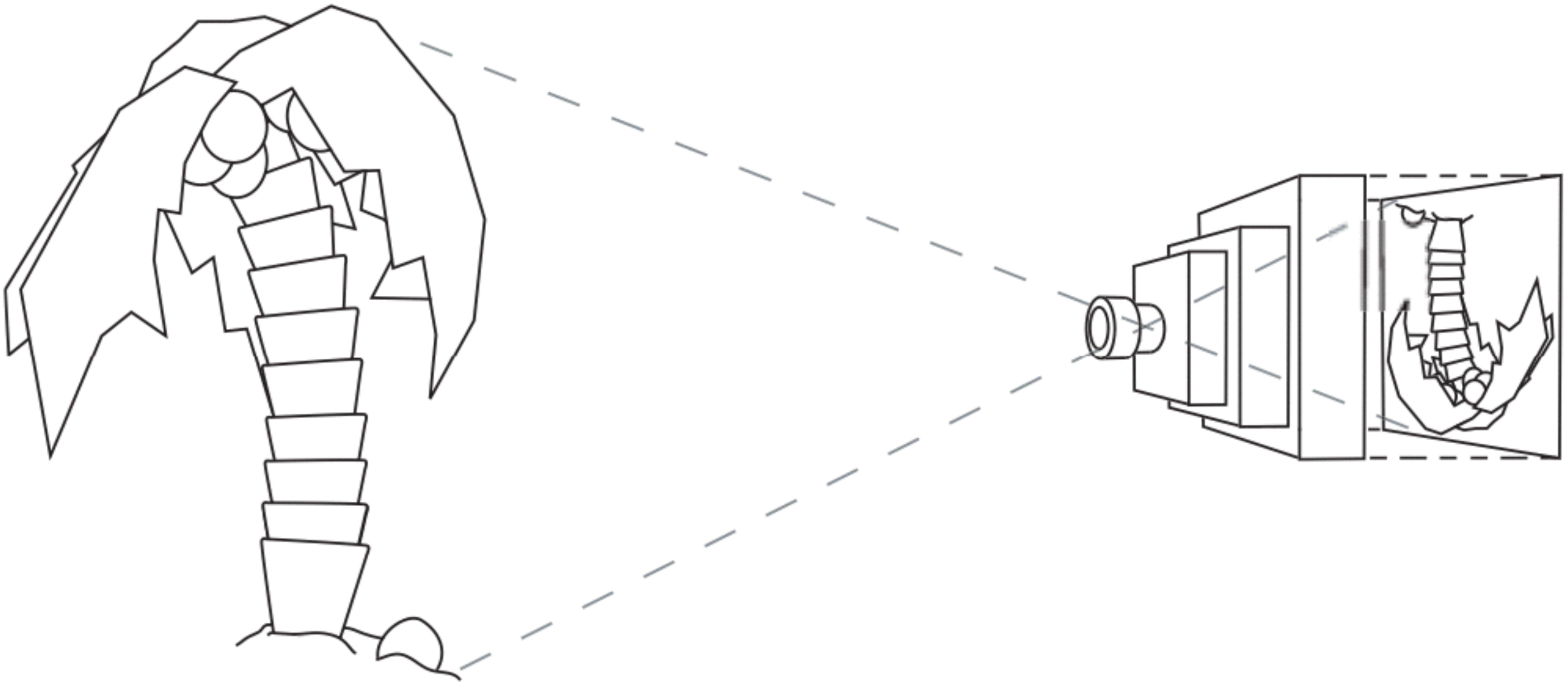




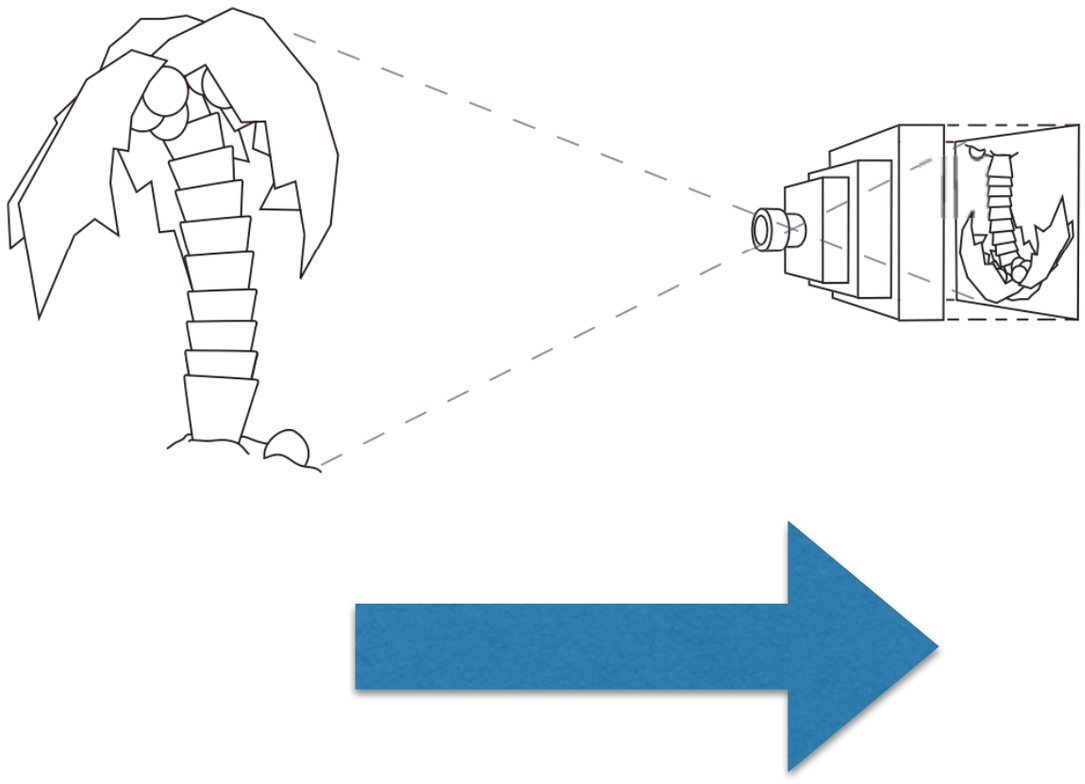
Input Scene	Acquired
Archived	Displayed

Acquiring Digital Images

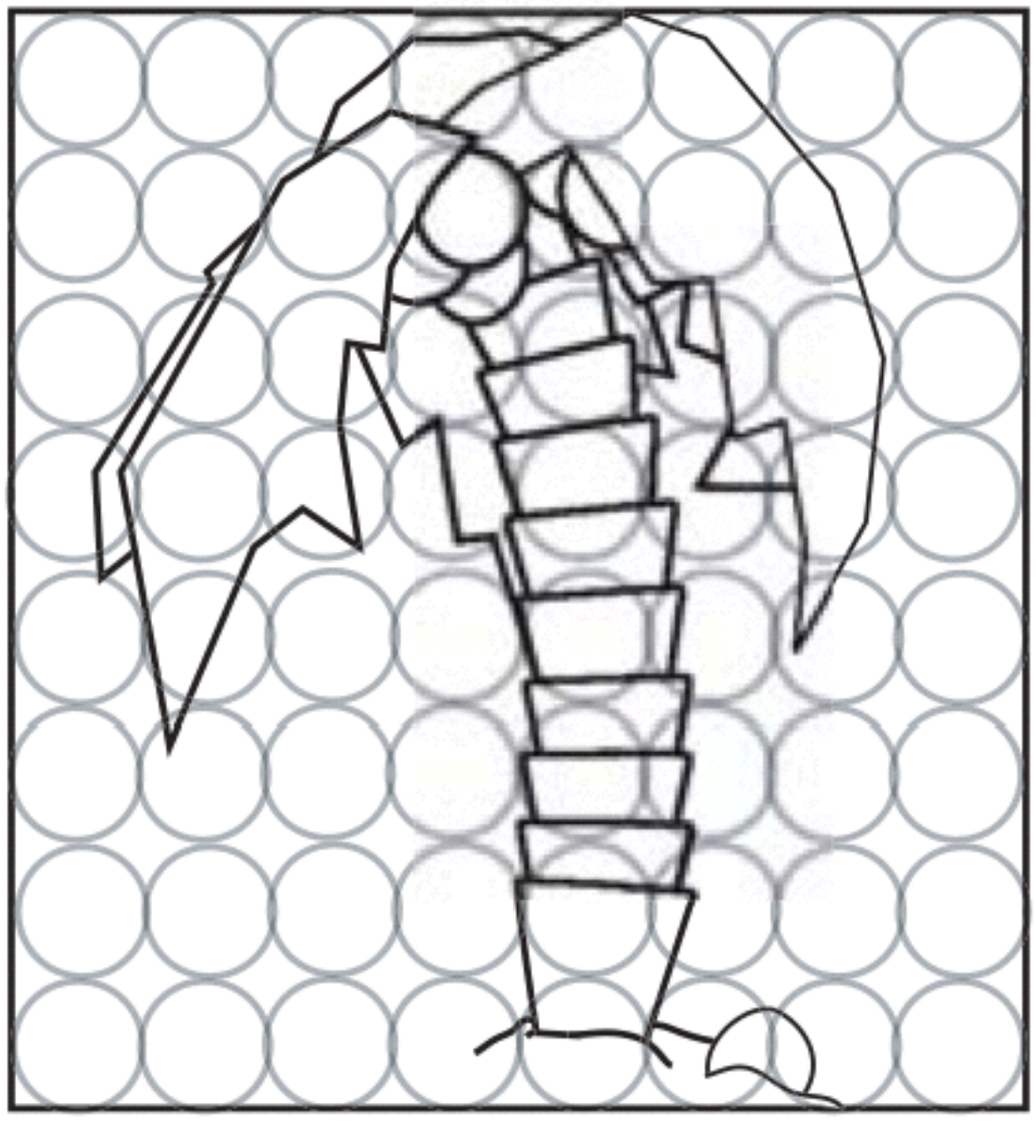
Conceptual Model of a Camera



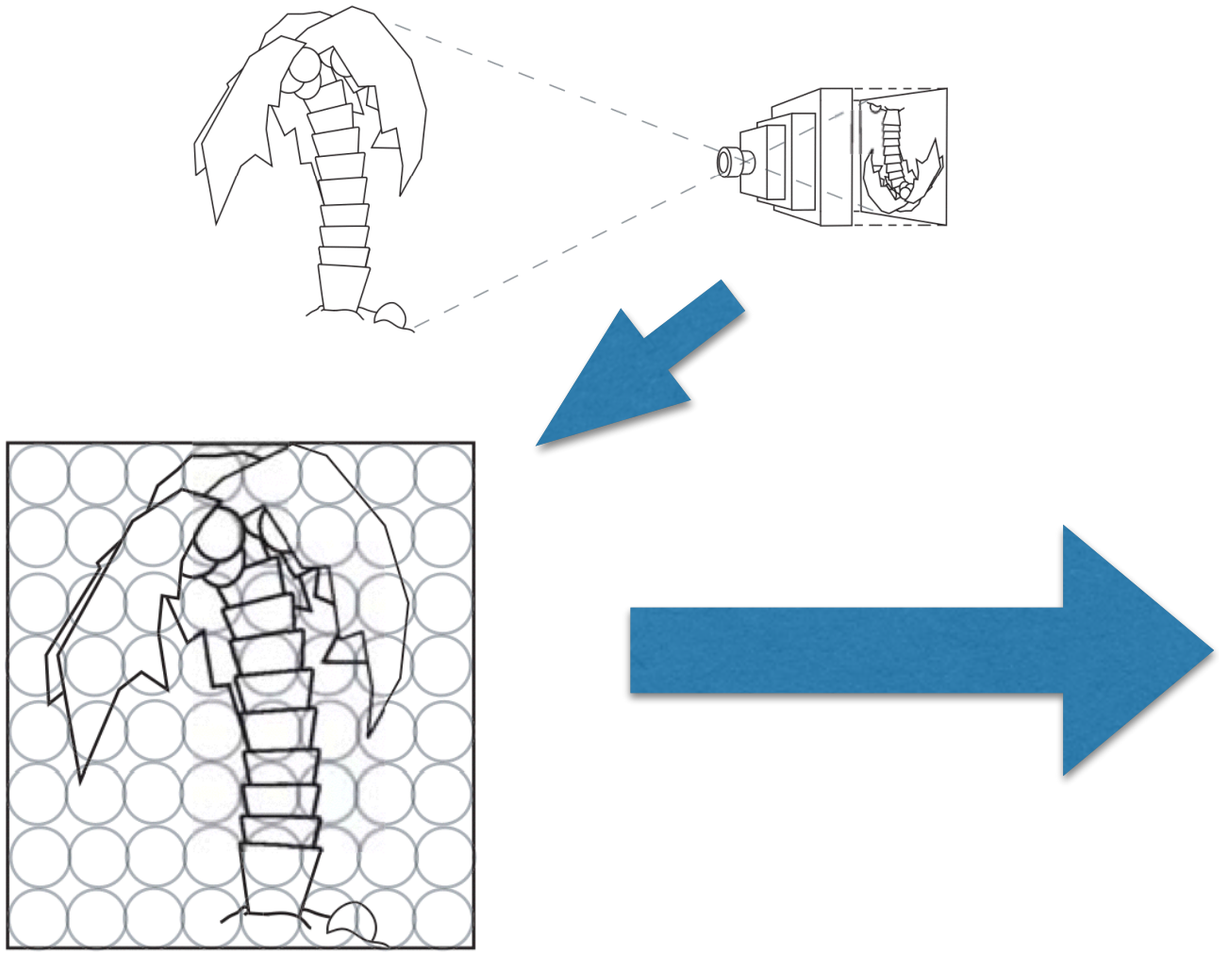
Digitization



Photosensors record a finite region of light



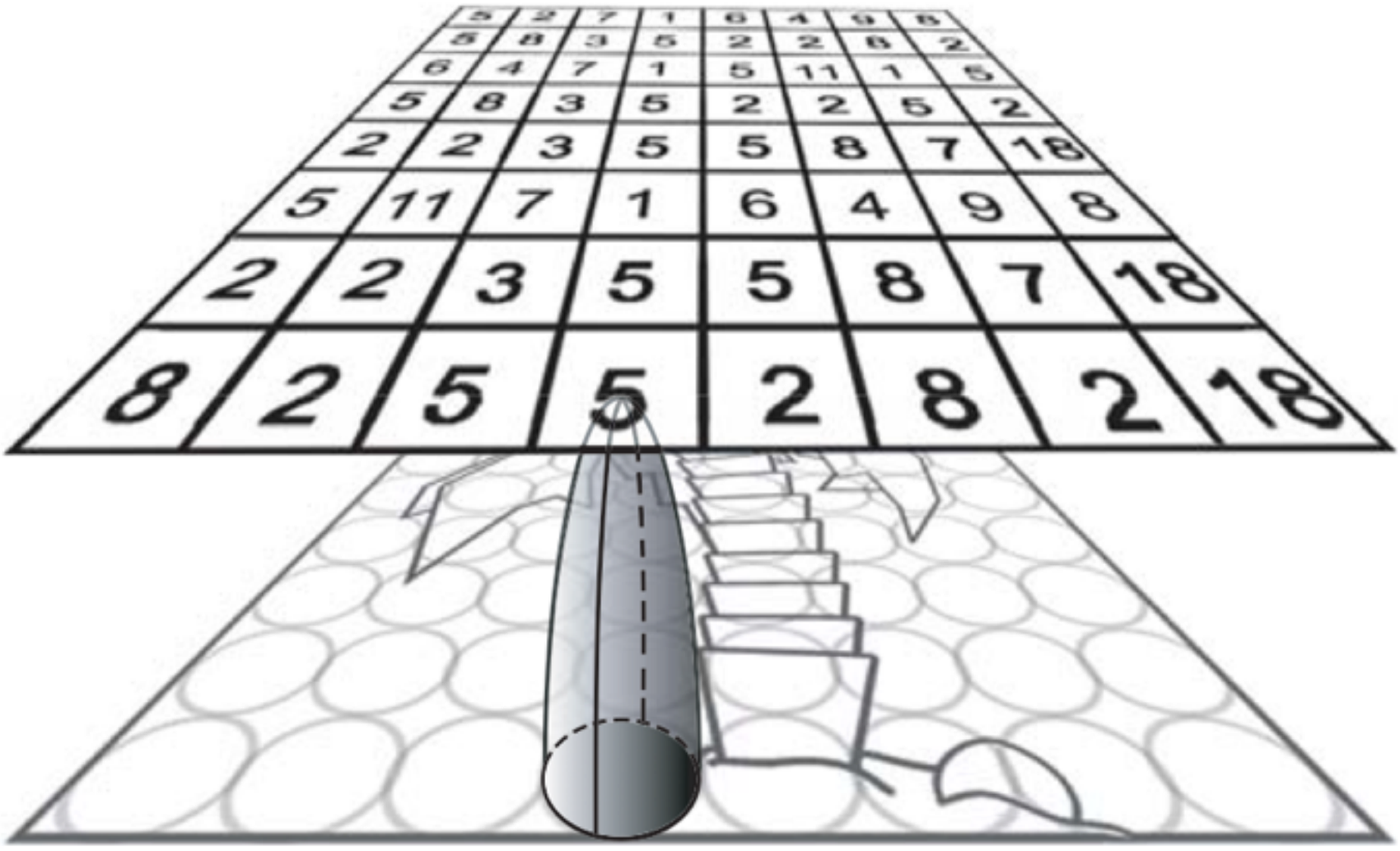
Digitization (part 2)



5	2	7	1	6	4	9	8
5	8	3	5	2	2	8	2
6	4	7	1	5	11	1	5
5	8	3	5	2	2	5	2
2	2	3	5	5	8	7	18
5	11	7	1	6	4	9	8
2	2	3	5	5	8	7	18
8	2	5	5	2	8	2	18

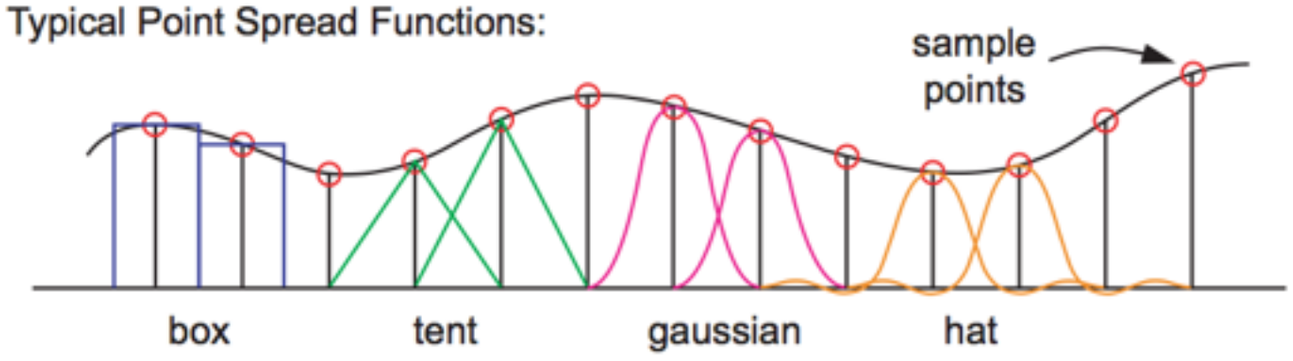
Region of light data turned into a single value via a point spread function

Display Reverse Acquisition



Digital Image Data

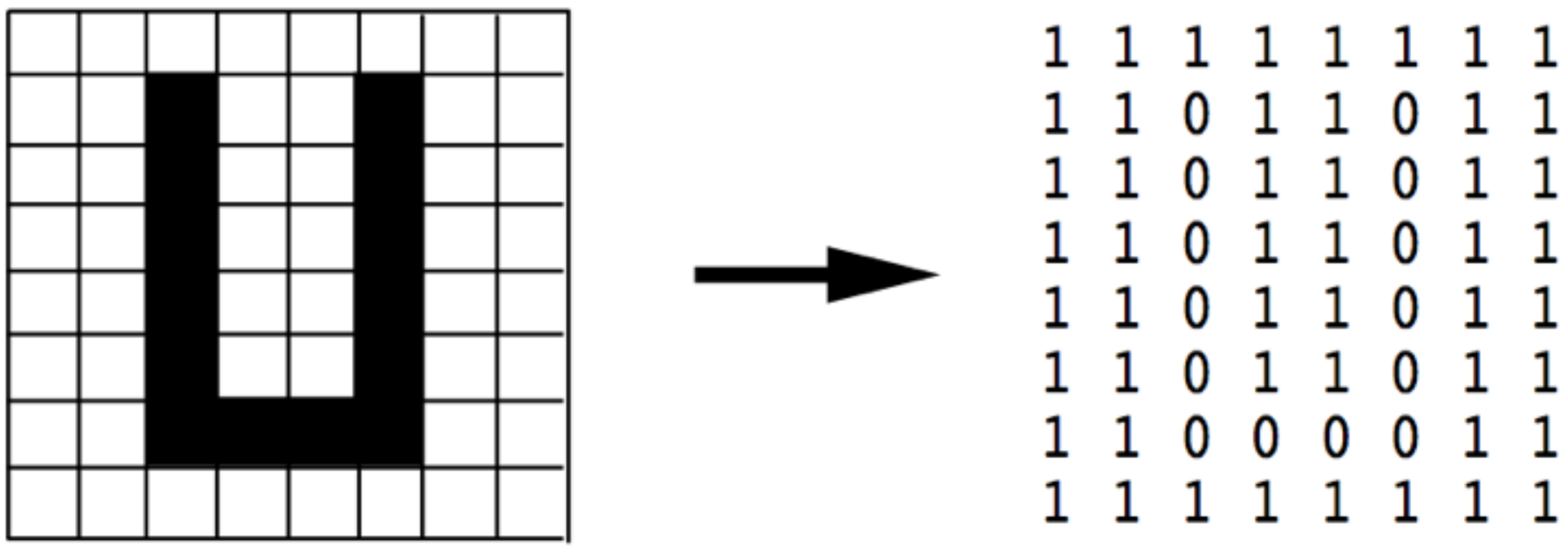
Reconstructed Media



NOTE : There are many PSFs, we'll come back to them in a future lecture

Encoding Digital Images

Bitmaps



- Bitmap: digital image that is a 2d array of **pixels** that each store one bit.
  - Pixel: **pic**ture **el**ement, individual sample of an image.
  - Simplest digital image, a representation of a black and white image.
- Bit: ones/zeros, convention is 0 = black & 1 = white.
- Scanline: a row in the 2d array (terminology from acquisition).

Digital Images Linearized

```
1 1 1 1 1 1 1 1
1 1 0 1 1 0 1 1
1 1 0 1 1 0 1 1
1 1 0 1 1 0 1 1
1 1 0 1 1 0 1 1
1 1 0 0 0 0 1 1
1 1 1 1 1 1 1 1
```

- While we think of images as 2-dimensional, in memory they are 1-dimensional.

11111111	11011011	11011011	11011011	11011011	11011011	11000011	11111111

“U” in 8 bytes, binary + hexadecimal

FF	DB	DB	DB	DB	DB	C3	FF

Review (?): Number Systems

- Computer uses binary numbers, or base 2.
- Hexadecimal numbers are base 16, represent a four digit binary number

http://en.wikipedia.org/wiki/Hexadecimal

Hex	Binary
$0_{hex} = 0_{dec} = 0_{oct}$	0 0 0 0
$1_{hex} = 1_{dec} = 1_{oct}$	0 0 0 1
$2_{hex} = 2_{dec} = 2_{oct}$	0 0 1 0
$3_{hex} = 3_{dec} = 3_{oct}$	0 0 1 1
$4_{hex} = 4_{dec} = 4_{oct}$	0 1 0 0
$5_{hex} = 5_{dec} = 5_{oct}$	0 1 0 1
$6_{hex} = 6_{dec} = 6_{oct}$	0 1 1 0
$7_{hex} = 7_{dec} = 7_{oct}$	0 1 1 1
$8_{hex} = 8_{dec} = 10_{oct}$	1 0 0 0
$9_{hex} = 9_{dec} = 11_{oct}$	1 0 0 1
$A_{hex} = 10_{dec} = 12_{oct}$	1 0 1 0
$B_{hex} = 11_{dec} = 13_{oct}$	1 0 1 1
$C_{hex} = 12_{dec} = 14_{oct}$	1 1 0 0
$D_{hex} = 13_{dec} = 15_{oct}$	1 1 0 1
$E_{hex} = 14_{dec} = 16_{oct}$	1 1 1 0
$F_{hex} = 15_{dec} = 17_{oct}$	1 1 1 1

Lec02 Required Reading

- Today we covered:
  - Hunt: Ch.1
- For Lec02:
  - OIIO: Ch.2, 3.1, 4.1
  - House: Ch.2