Image Capture and Representation

C306

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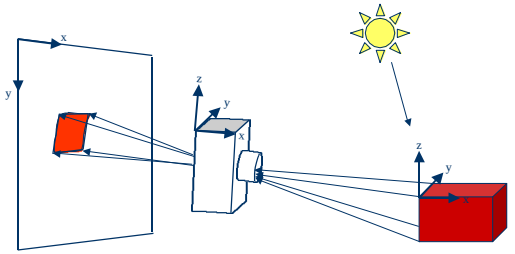
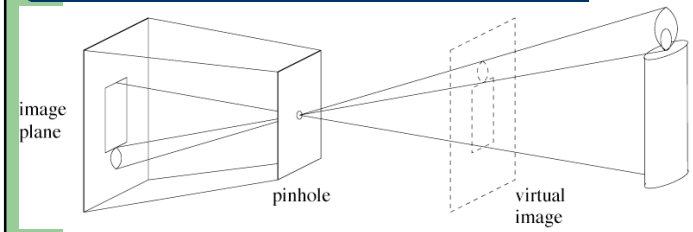
Readings: Gonzalez Ch 2.3,4,5.

How the 3D physical world is captured on a 2D image plane



Pinhole cameras



- Abstract camera model - box with a small hole in it
- Image formation described by geometric optics
- Note: equivalent image formation on virtual and real image plane

Pinhole cameras: Historic and real

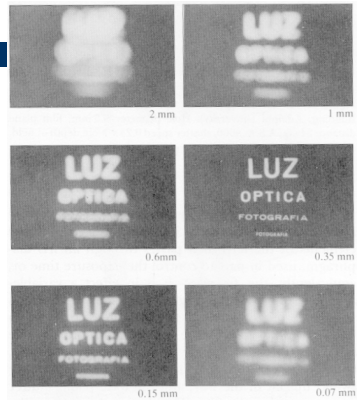
- First photograph due to Niepce,
- First on record shown - 1822
- Basic abstraction is the pinhole camera
  - lenses required to ensure image is not too dark
  - various other abstractions can be applied

Real Pinhole Cameras

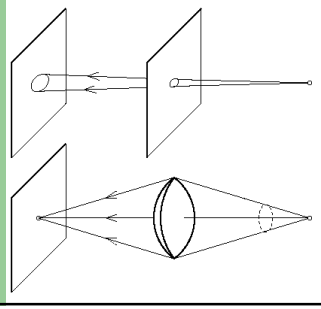
many directions are averaged, blurring the image

Pinhole too small- diffraction effects blur the image

Generally, pinhole cameras are *dark*, because a very small set of rays from a particular point hits the screen.



Lenses: bring together more rays

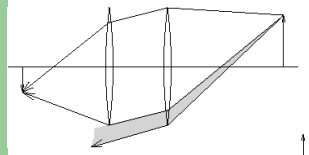


Note: Each world point projects to many image points.

With a 1mm pinhole and f=10mm how many points at 1m distance?

Lens Realities

Real lenses have a finite depth of field, and usually suffer from a variety of defects



vignetting

Spherical Aberration

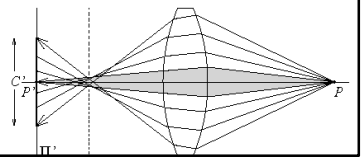
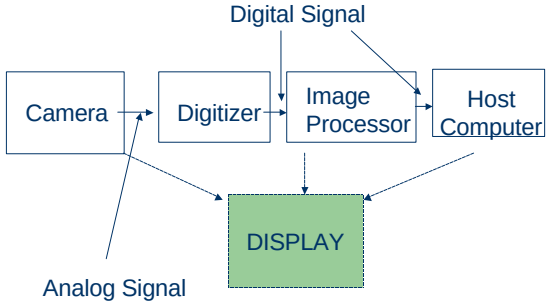
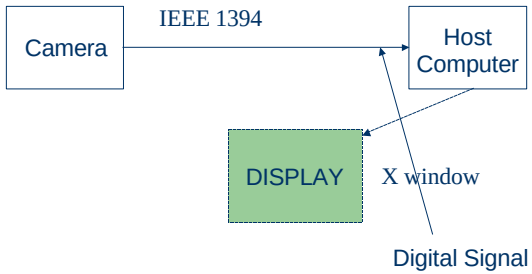


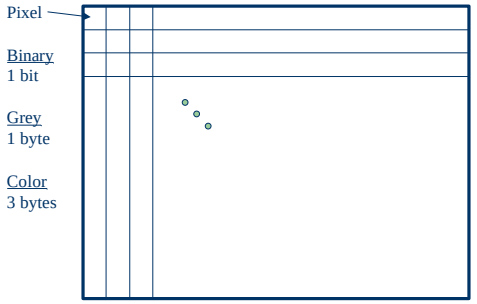
Image streams -> Computer



A Modern Digital Camera (Firewire)



THE ORGANIZATION OF A 2D IMAGE



Mathematical / Computational image models

- Continuous mathematical:

  I = f(x,y)
- Discrete (in computer) adressable 2D array:

  I = matrix(i,j)
- Discrete (in file) e.g. ascii or binary sequence:

  023 233 132 232

  125 134 134 212

Sampling

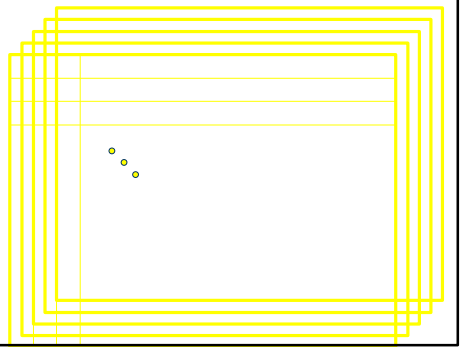
- Standard video: 640x480
- Subsample ½, ¼…
- Quantization: typ 8 bit, sometimes lower

THE ORGANIZATION OF AN IMAGE SEQUENCE

Frames

Frames are acquired at 30Hz (NTSC)

Frames are composed of two *fields* consisting of the even and odd rows of a frame



BANDWIDTH REQUIREMENTS

Binary
1 bit * 640x480 * 30 = 9.2 Mbits/second

Grey
1 byte * 640x480 * 30 = 9.2 Mbytes/second

Color
3 bytes * 640x480 * 30 = 27.6 Mbytes/second (actually about 37 mbytes/sec)

Typical operation: 3x3 convolution
9 multiplies + 9 adds → 180 Mflops
Today's PC's are just getting to the point they can process images at frame rate

Digitization Effects

- The "diameter" d of a pixel determines the highest frequency representable in an image

$$l = 1/2d$$

- Real scenes may contain higher frequencies resulting in aliasing of the signal.
- In practice, this effect is often dominated by other digitization artifacts.

Other image sources:

- Optic Scanners (linear image sensors)
- Laser scanners (2 and 3D images)
- Radar
- X-ray
- NMRI

Image display

- VDU
- LCD
- Printer
- Photo process
- Plotter (x-y table type)

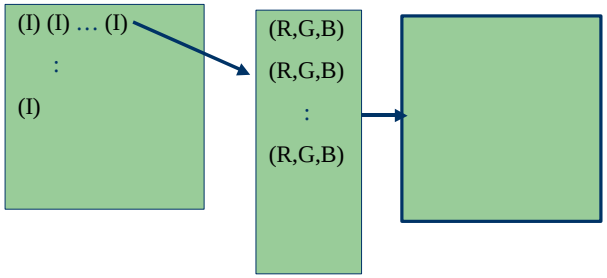
Image representation for display

- True color, RGB, ….

(R,G,B) (R,G,B) … (R,G,B)
:
(R,G,B)

Image representation for display

- Indexed image



Matlab Programming

Raw Material: Images = Matrices

Themes: Build systems, experiment, visualize!

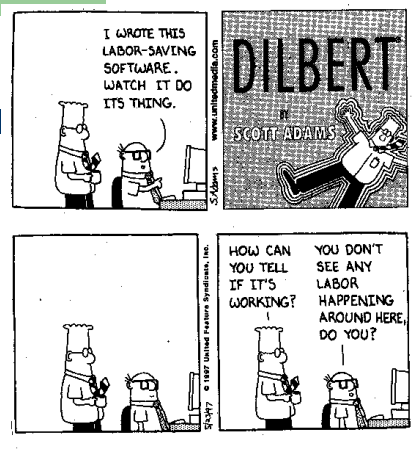
Platform: Matlab (“ matrix laboratory ”)

- Widely-used mathematical scripting language
- Easy prototyping of systems
- Lots of built-in functions, data structures
- GUI-building support
- All in all, hopefully a labor-saving tool

Matlab availability

- In lab, csc2-35 machines (obviously)
- For remote logins: on “ohaton”
- Also in numerical analysis lab csc 1-21. Can use machines when lab unoccupied.
- For your own use: Can buy student edition

Homework: Go though exercises in matlab compendium posted on lab www-page.



Matlab Basics

- Starting, stopping, help, demos, math, & variables
- Matrix definition and indexing

```
>> A = [ 1  2  3 ; 4  5  6 ; 7  8  9 ]   or   [ 1 2 3 ; 4 5 6 ; 7 8 9 ]
>> A(3,2)
>> A(3,:)
>> A(3,1:2) = [ 0  0 ]
>> A'
```

How would you set the middle row to be the first column?

```
>> A(:,:,2) = A
>> size(A)
```

See Assignment 1, part 1 for a more thorough introduction.

Image ⟷ Matrix

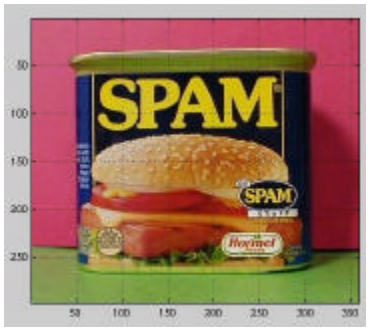
Matlab matrix A

A(1:10,1:10,:)

A(200, 50:300, 3)

The large “M”?

The spam’s location?



Matlab Built-Ins

for, if, while, switch -- execution control

who, whos, clear -- variable listing and removing

save, load <file> -- saving or restoring a workspace

diary <file> -- start recording to a file
diary off ; diary on

path, addpath -- display or add to search path

close, close all, clc -- close windows, clear console

- double vs. uint8 -- data casting functions
- zeros(x,y,) -- creates an all-zero x by y … matrix used for basic memory allocation

Images in Matlab (& Functions)

Built-in functions:

A =imread(<filename>, <type>) -- pull from file

imwrite(A, <filename>, <type>) -- write to file

image(A) -- display image

Types
'tif'
'jpg'
'bmp'
'png'
'hdf'
'pcx'
'xwd'
single-quoted strings

c306 functions: Add:

show(A) -- display and tools for c306