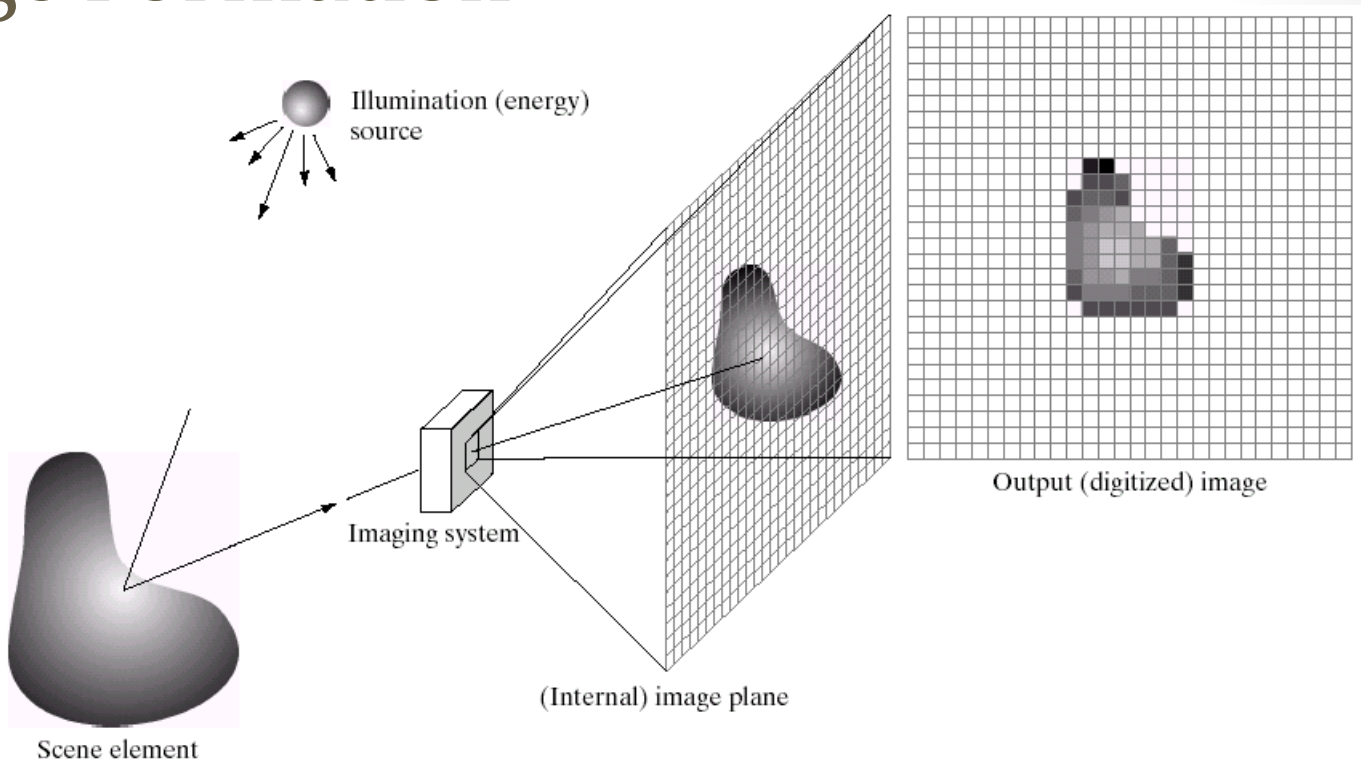
Digital Image Processing Introduction and Application

Image Formation



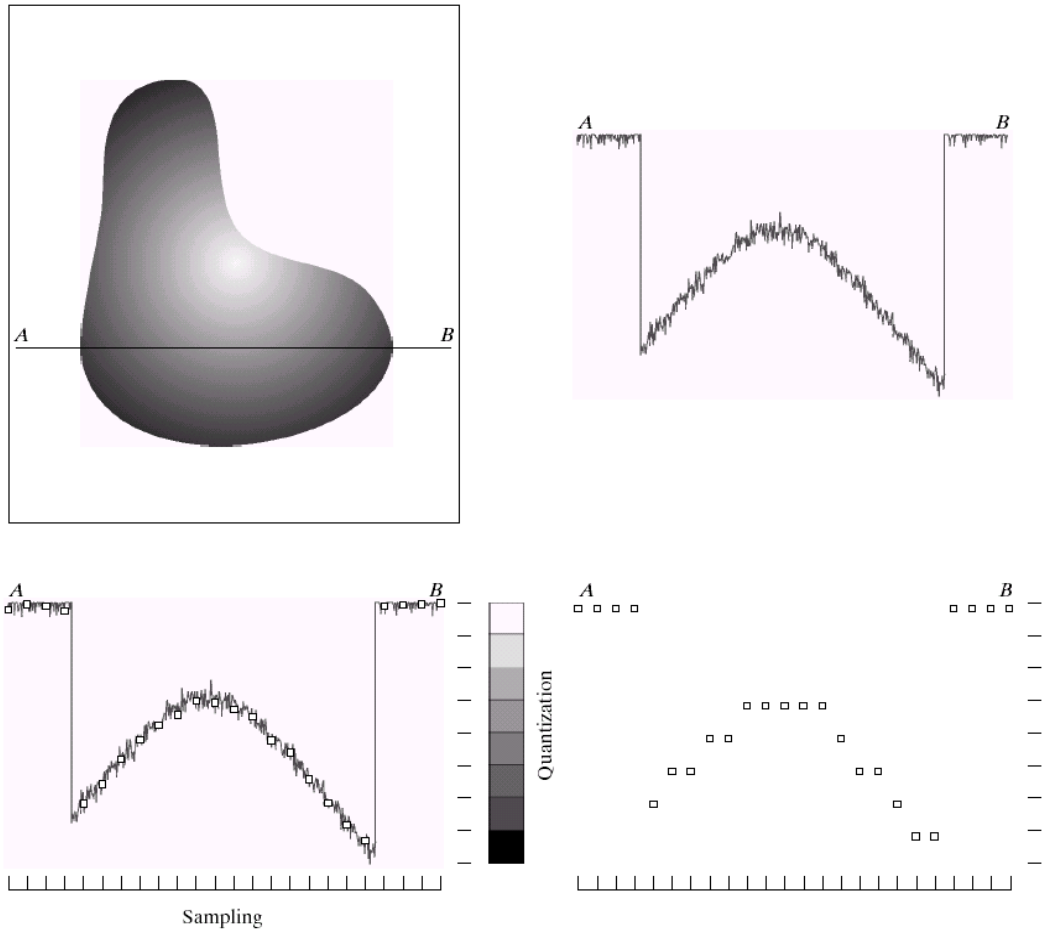
a
b c d e

FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

*f(x,y) = reflectance(x,y) * illumination(x,y)*

Reflectance in [0,1], illumination in [0,inf]

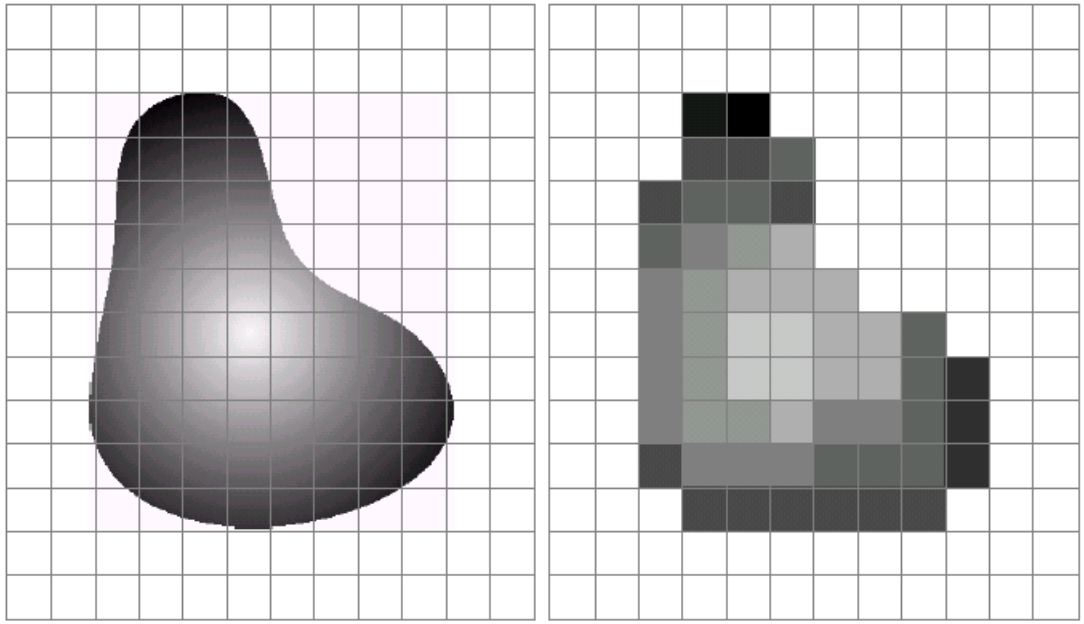
Sampling and Quantization



a b
c d

FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from *A* to *B* in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

Sampling and Quantization



a b

FIGURE 2.17 (a) Continuos image projected onto a sensor array. (b) Result of image sampling and quantization.

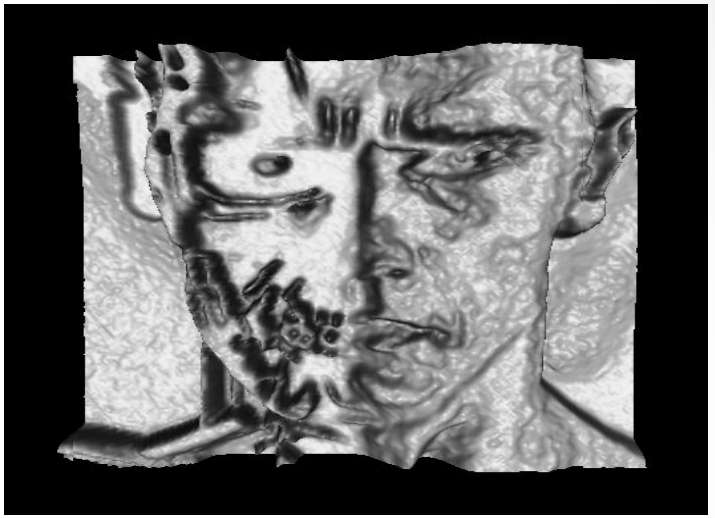
What is an image?

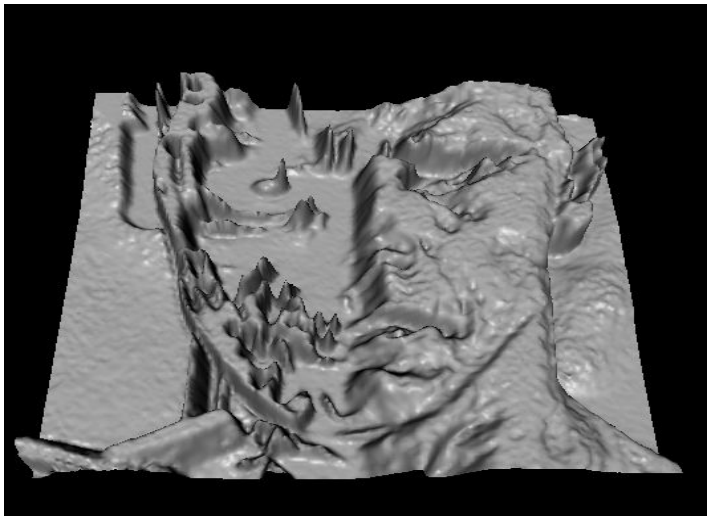
- We can think of an **image** as a function, f, from R^2 to R:
  - $f(x, y)$ gives the **intensity** at position (x, y)
  - Realistically, we expect the image only to be defined over a rectangle, with a finite range:
    - f: $[a,b]$x$[c,d]$ → $[0,1]$

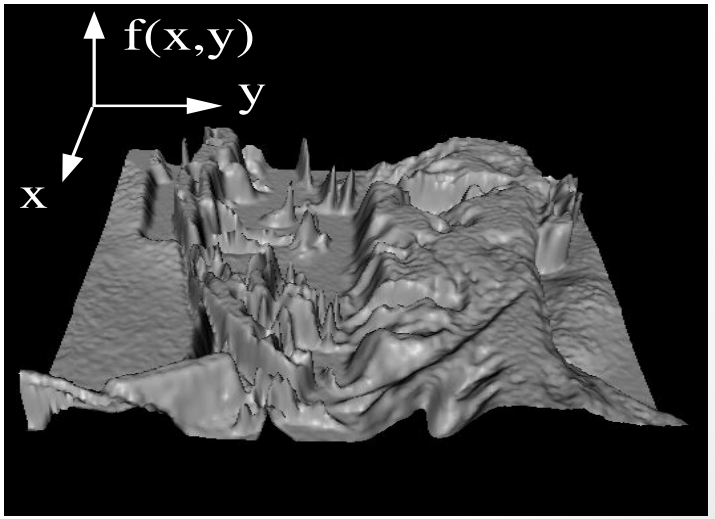
- A color image is just three functions pasted together. We can write this as a "vector-valued" function:

$$f(x, y) = \begin{bmatrix} r(x, y) \\ g(x, y) \\ b(x, y) \end{bmatrix}$$

Images as functions



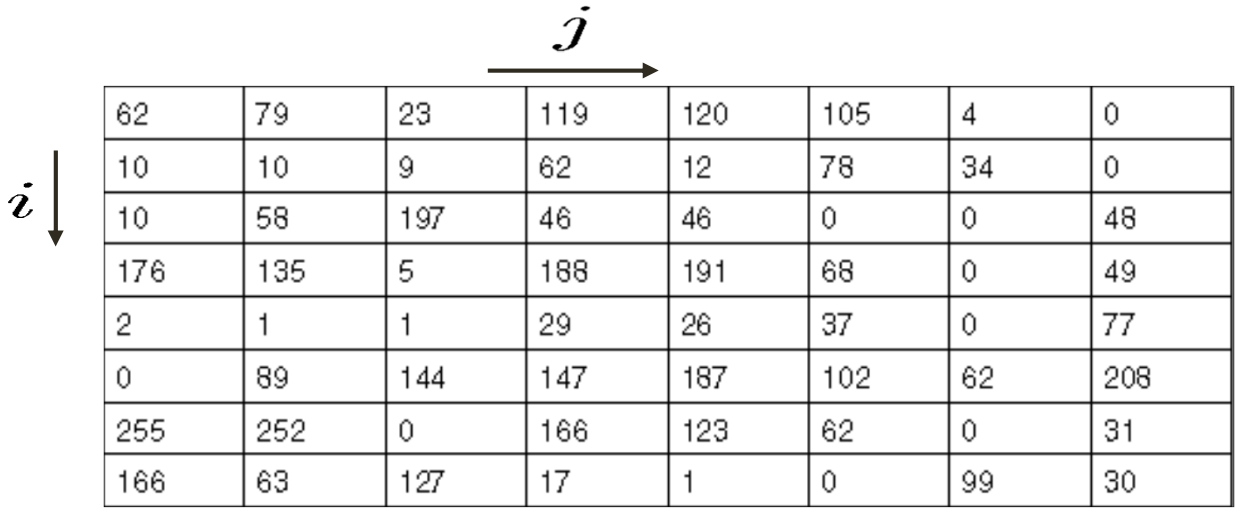




What is a digital image?

- We usually operate on **digital** (**discrete**) images:
  - **Sample** the 2D space on a regular grid
  - **Quantize** each sample (round to nearest integer)
- If our samples are Δ apart, we can write this as:

  $f[i, j] = \text{Quantize}\{ f(i\,\Delta, j\,\Delta) \}$
- The image can now be represented as a matrix of integer values



62	79	23	119	120	105	4	0
10	10	9	62	12	78	34	0
10	58	197	46	46	0	0	48
176	135	5	188	191	68	0	49
2	1	1	29	26	37	0	77
0	89	144	147	187	102	62	208
255	252	0	166	123	62	0	31
166	63	127	17	1	0	99	30

Image processing

- An **image processing** operation typically defines a new image g in terms of an existing image f.
- We can transform either the range of f.

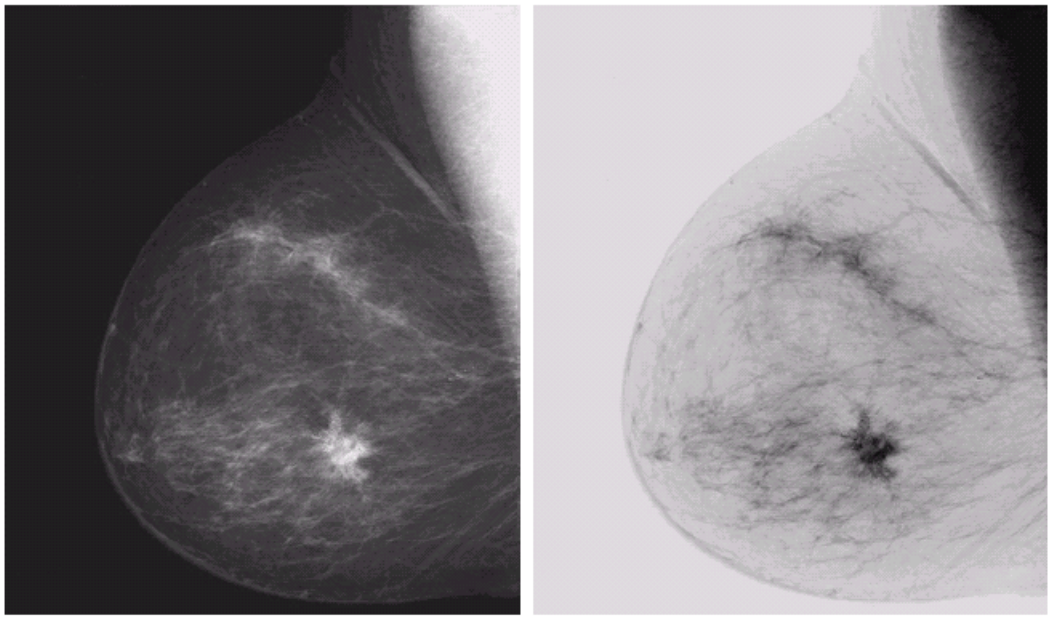
$$g(x, y) = t(f(x, y))$$

- Or the domain of f:

$$g(x, y) = f(t_x(x, y), t_y(x, y))$$

- What kinds of operations can each perform?

Negative



a b

FIGURE 3.4
(a) Original digital mammogram. (b) Negative image obtained using the negative transformation in Eq. (3.2-1). (Courtesy of G.E. Medical Systems.)

Log

a b

FIGURE 3.5
(a) Fourier spectrum.
(b) Result of applying the log transformation given in Eq. (3.2-2) with $c = 1$.

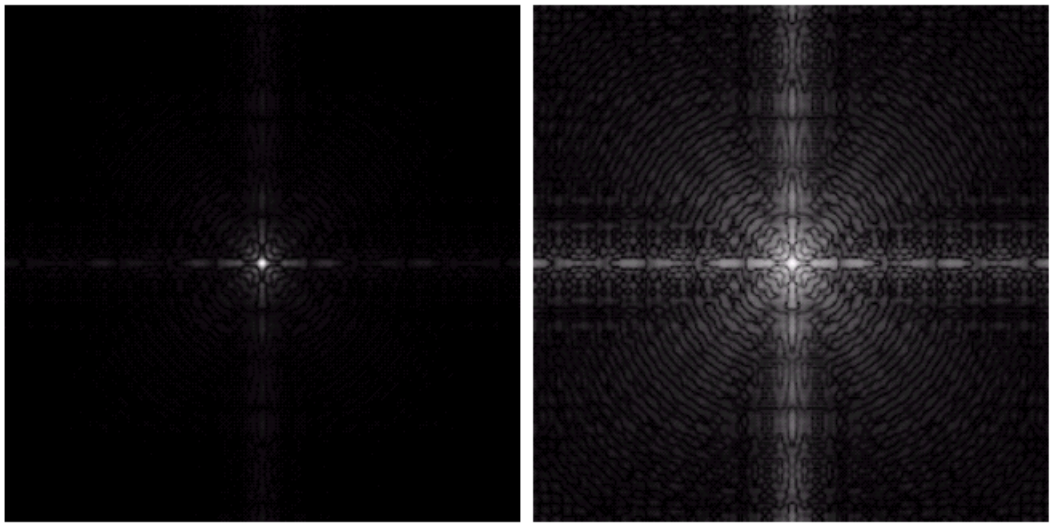
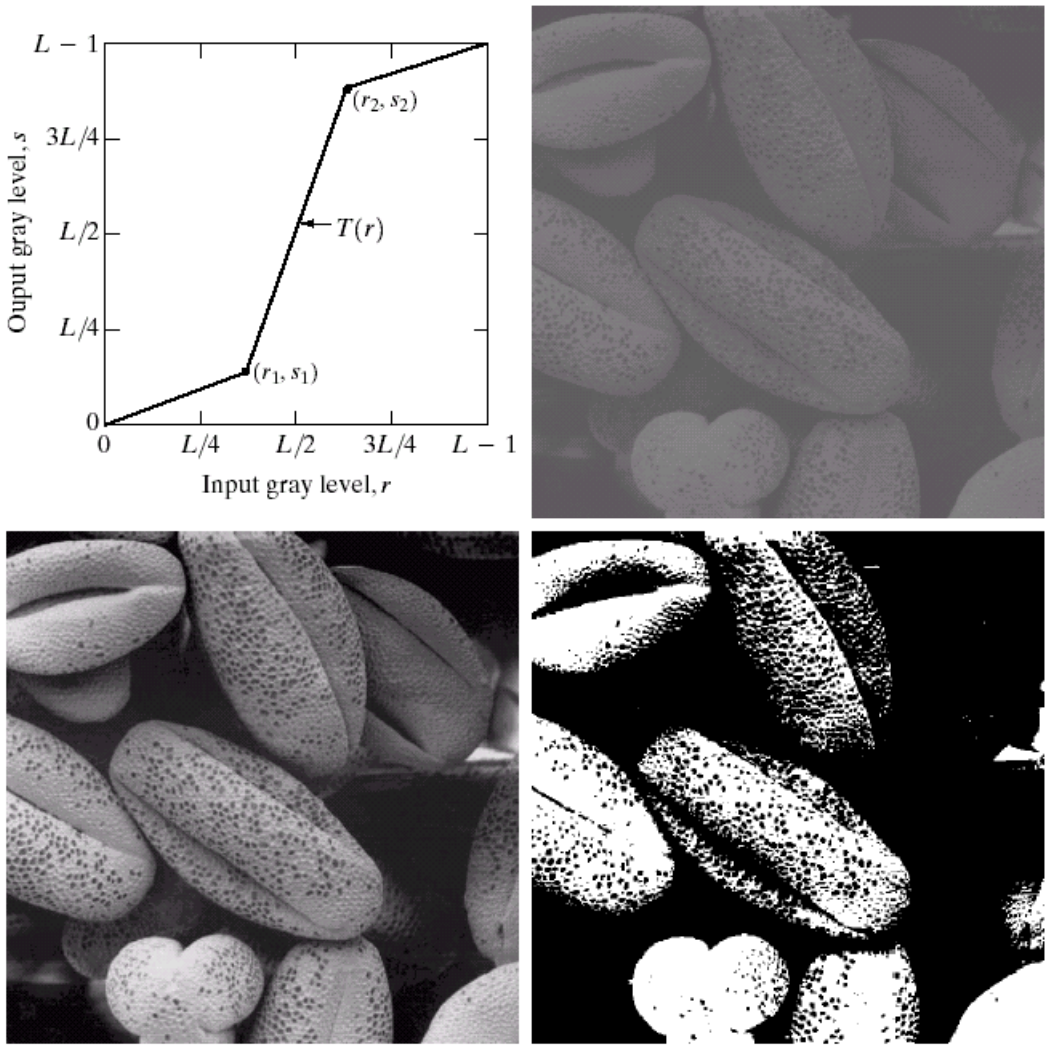


Image Enhancement

a b
c d

FIGURE 3.9
(a) Aerial image. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 3.0, 4.0,$ and 5.0, respectively. (Original image for this example courtesy of NASA.)

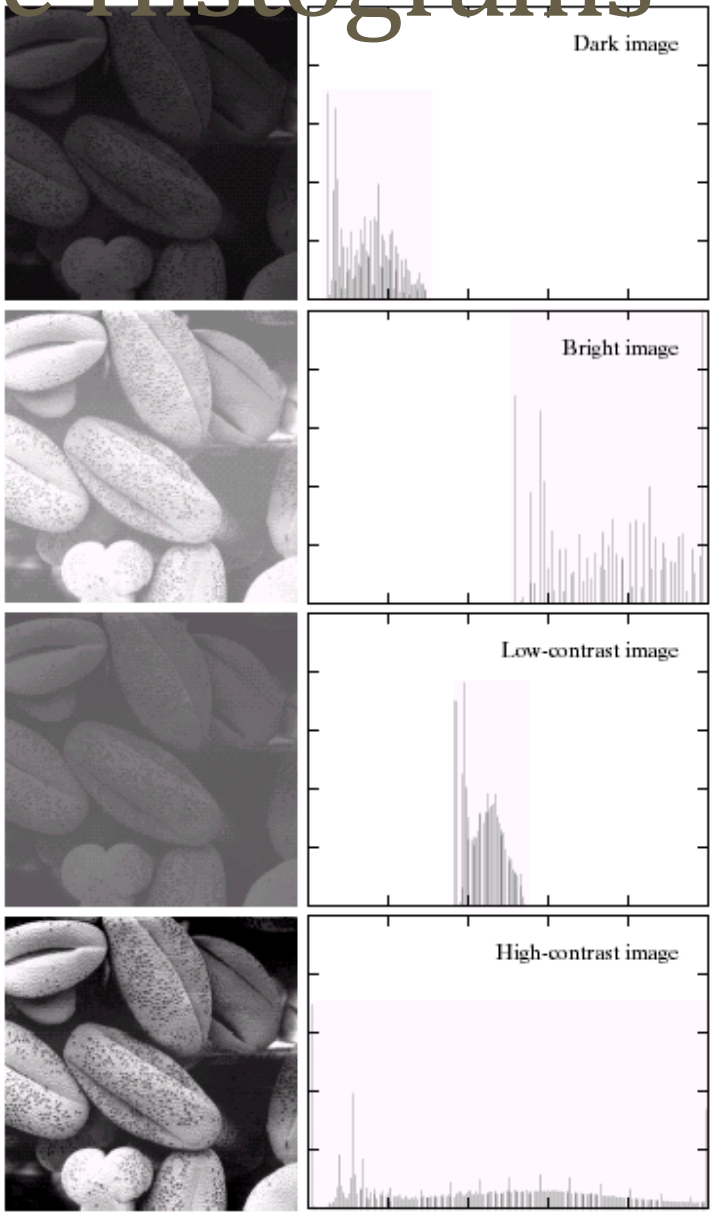
Contrast Streching



a b
c d

FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

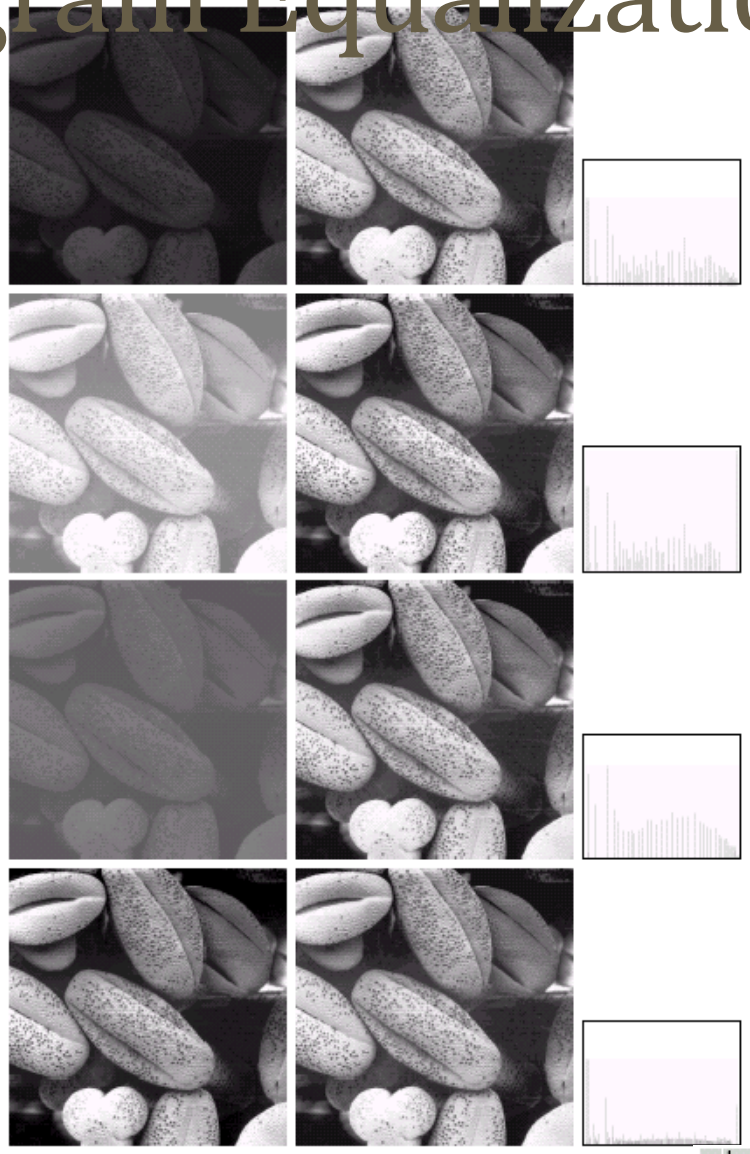
Image Histograms



a b

FIGURE 3.15 Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

Histogram Equalization

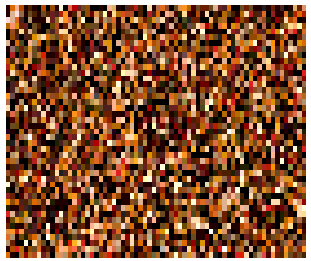


a b c

FIGURE 3.17 (a) Images from Fig. 3.15. (b) Results of histogram equalization. (c) Corresponding histograms.

Neighborhood Processing (filtering)

- Q: What happens if I reshuffle all pixels within the image?



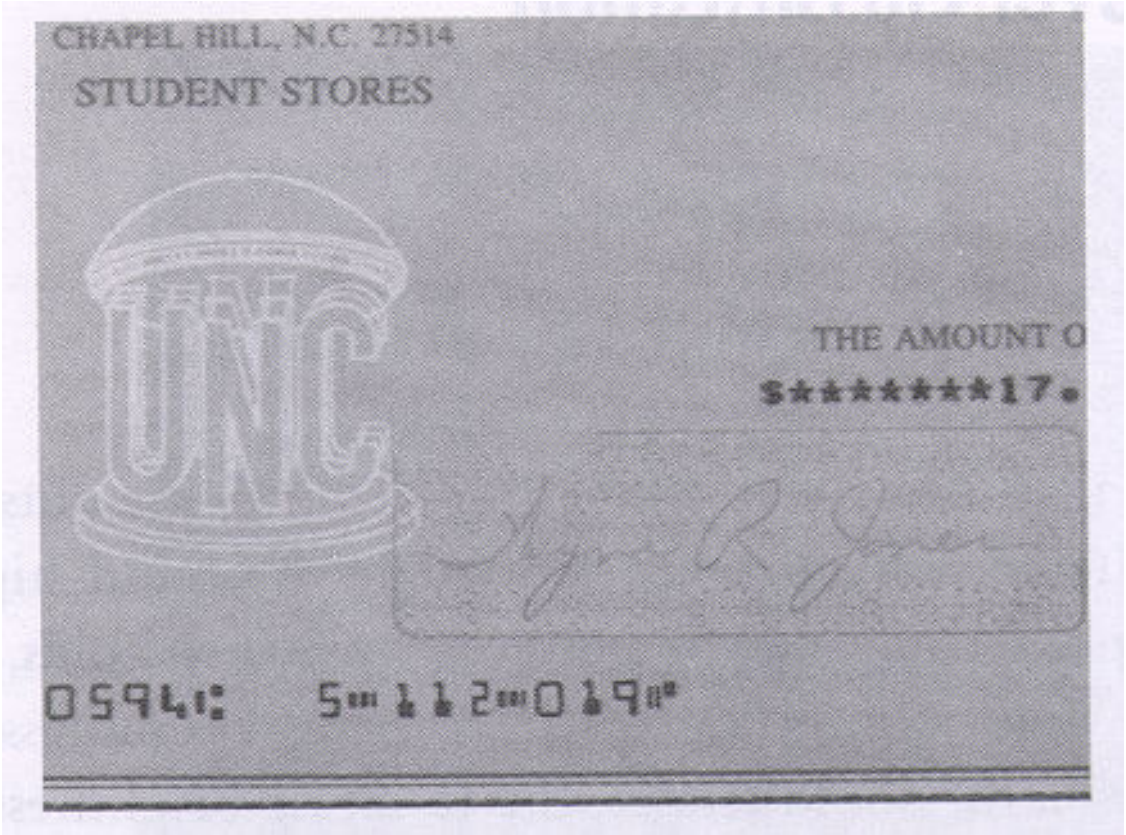
- A: It's histogram won't change. No point processing will be affected…
- Need spatial information to capture this.

Programming Assignment #1

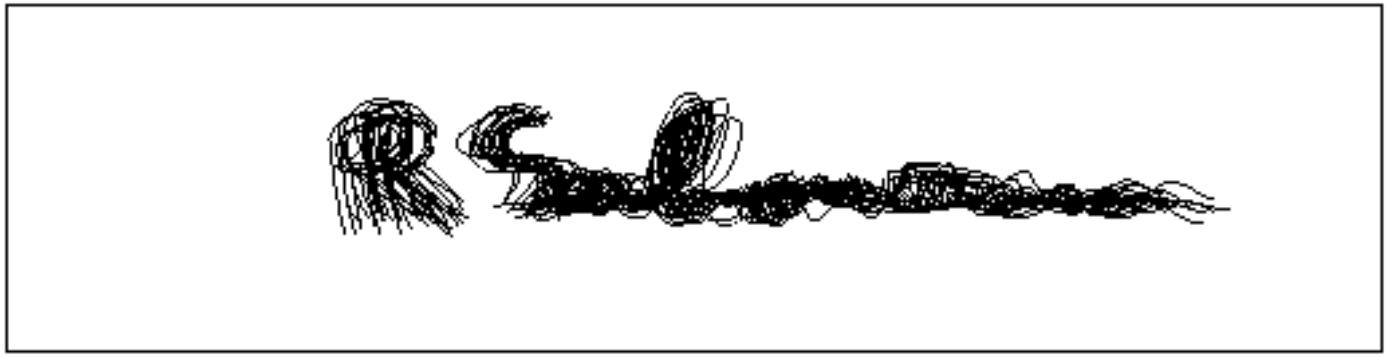
- Easy stuff to get you started with Matlab
  - Shobhit will hold your first tutorial
- Topics will be from next 2 lectures

Applications
&
Research Topics

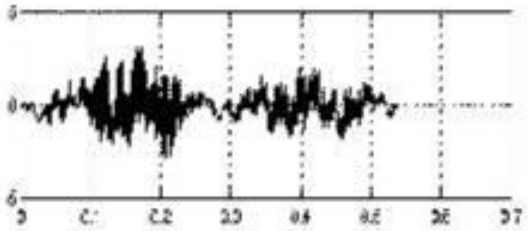
Document Handling



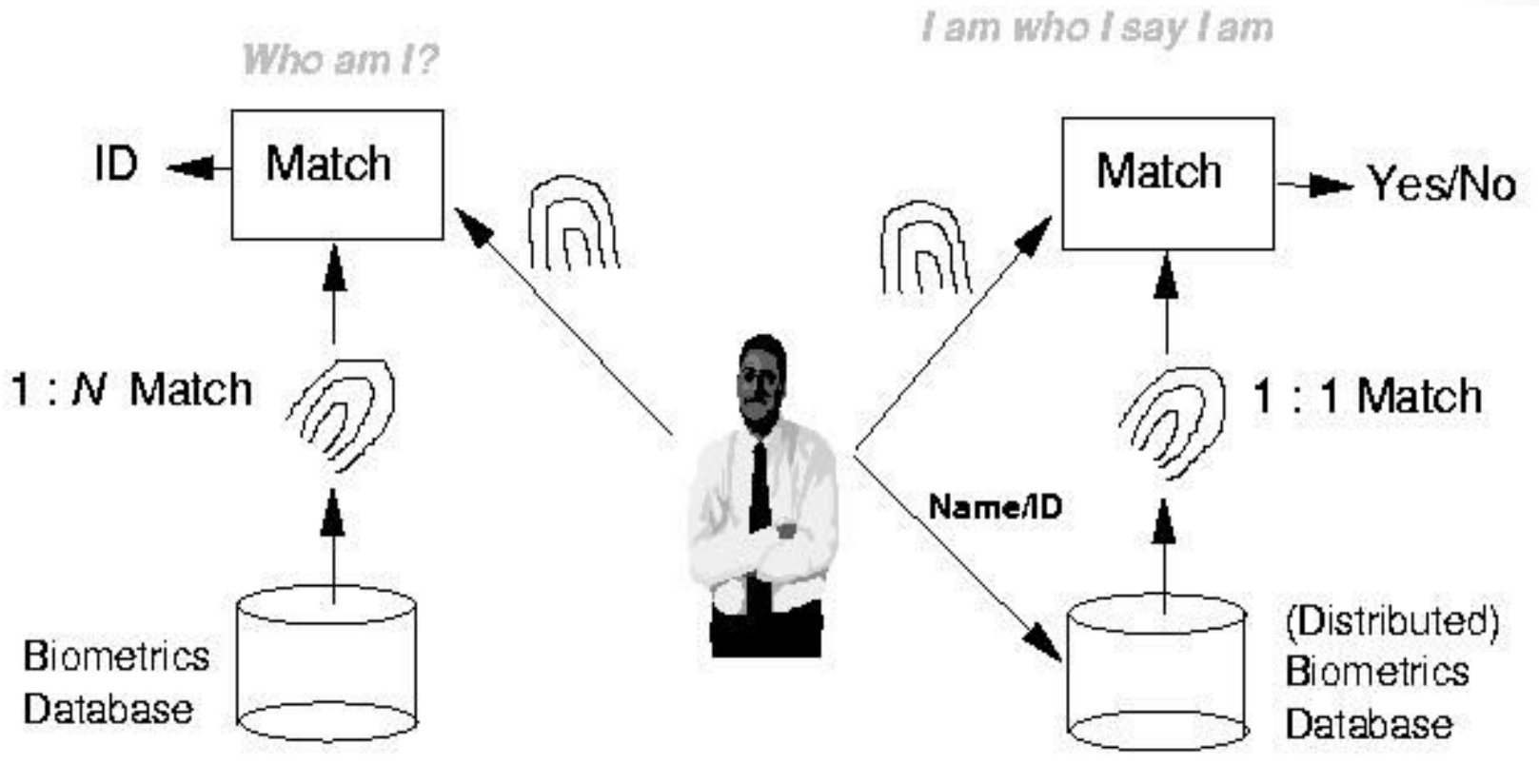
Signature Verification



Biometrics

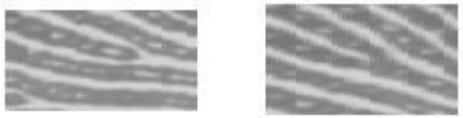


Fingerprint Verification / Identification



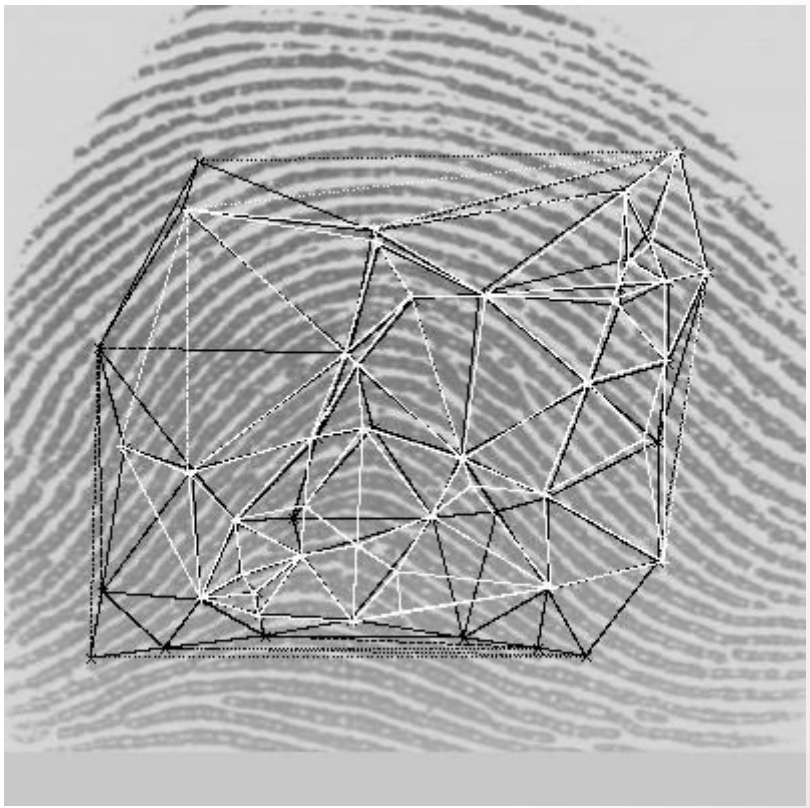
Fingerprint Identification Research at UNR

Minutiae

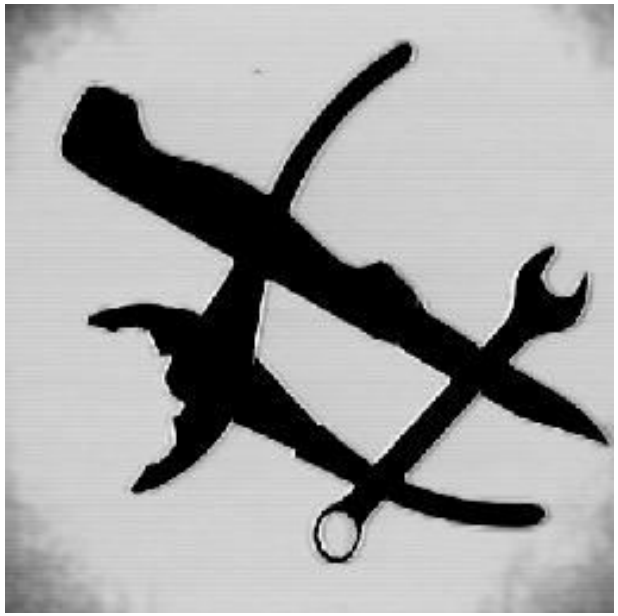


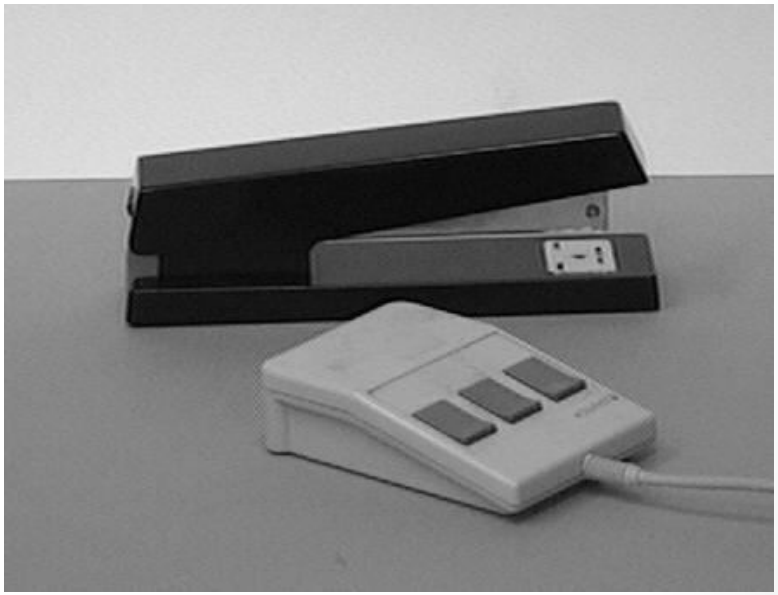
Delaunay Triangulation

Matching



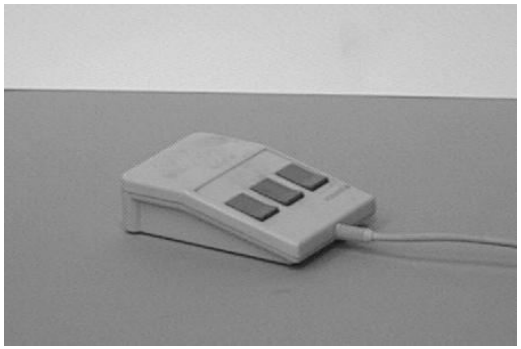
Object Recognition



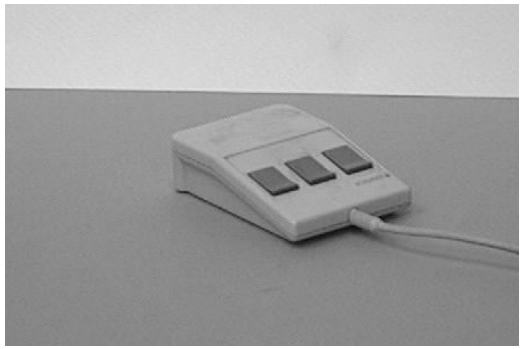


Object Recognition Research

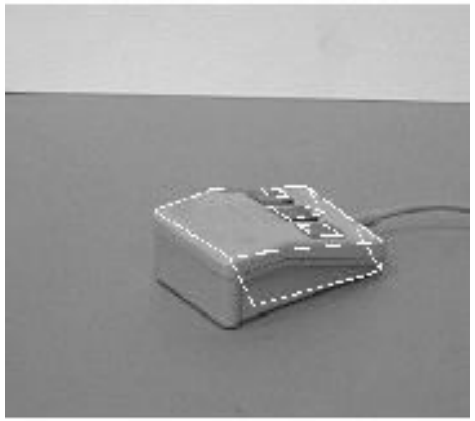
reference view 1



reference view 2

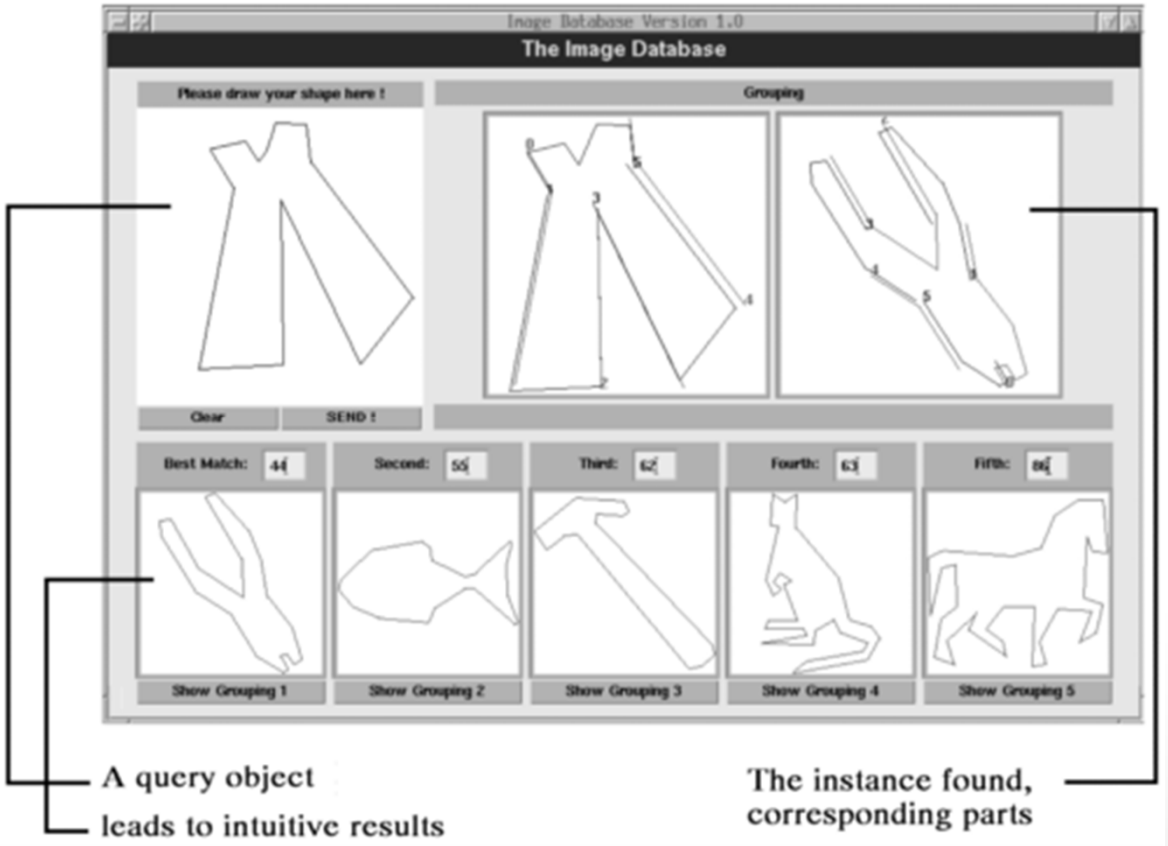


novel view recognized



Indexing into Databases

- Shape content



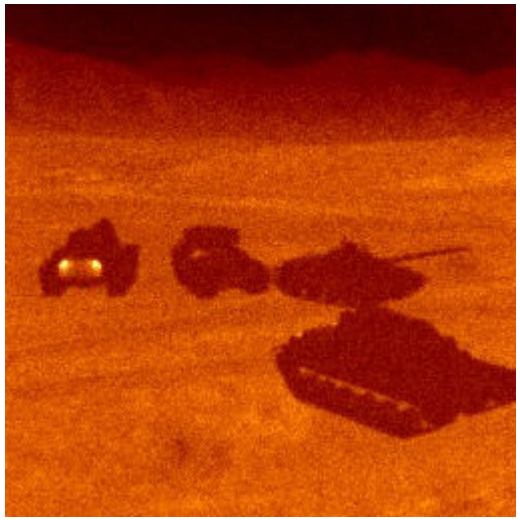
Indexing into Databases (cont'd)

- Color, texture

$T = 33.6\text{s}$, found 2 of 2

Target Recognition

- Department of Defense (Army, Airforce, Navy)

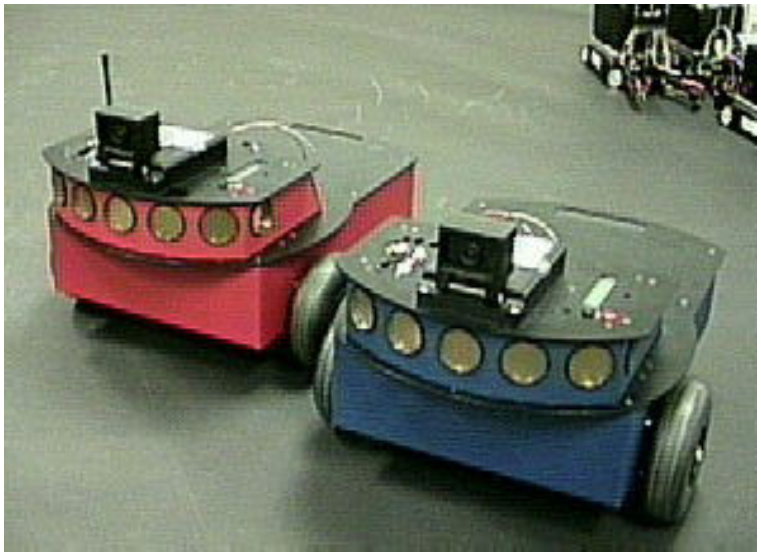


Interpretation of Aerial Photography

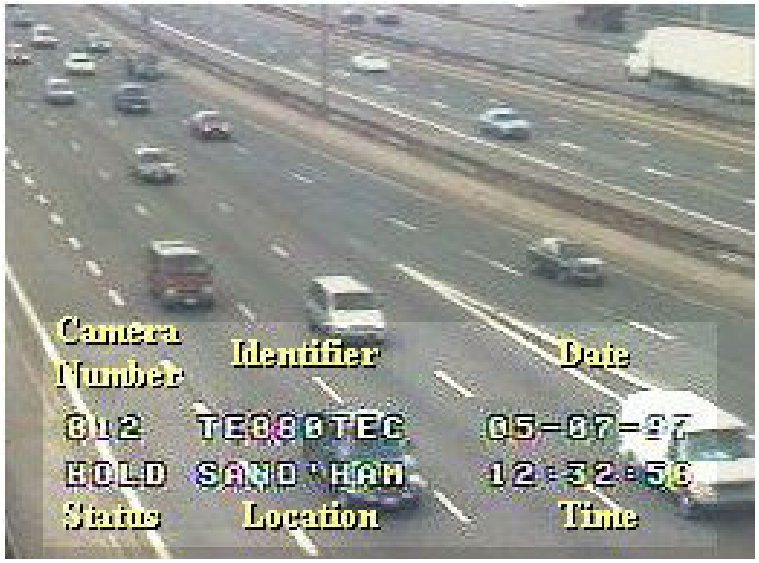
Interpretation of aerial photography is a problem domain in both computer vision and registration.

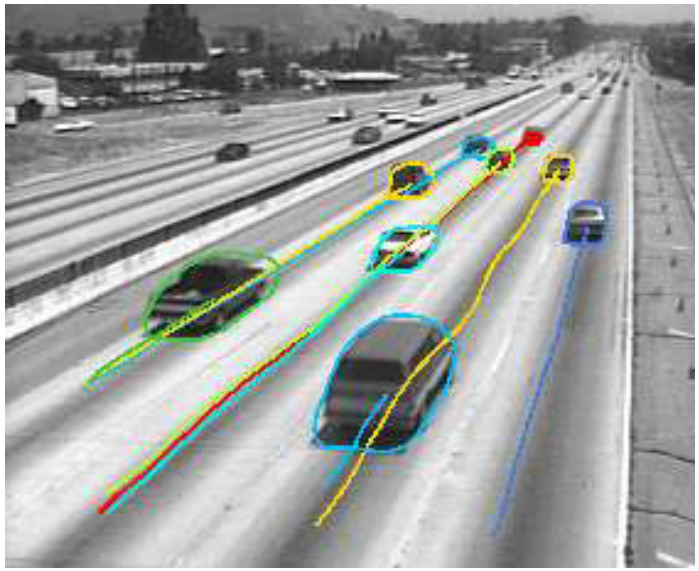
Autonomous Vehicles

- Land, Underwater, Space

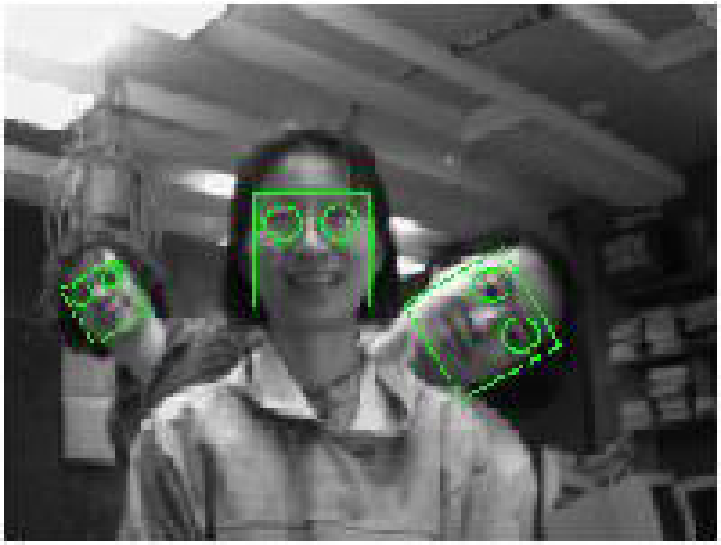


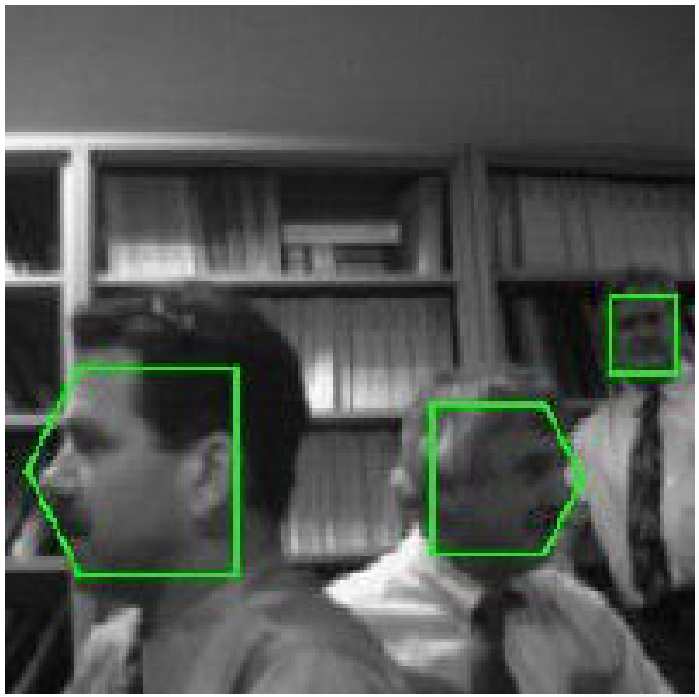
Traffic Monitoring





Face Detection

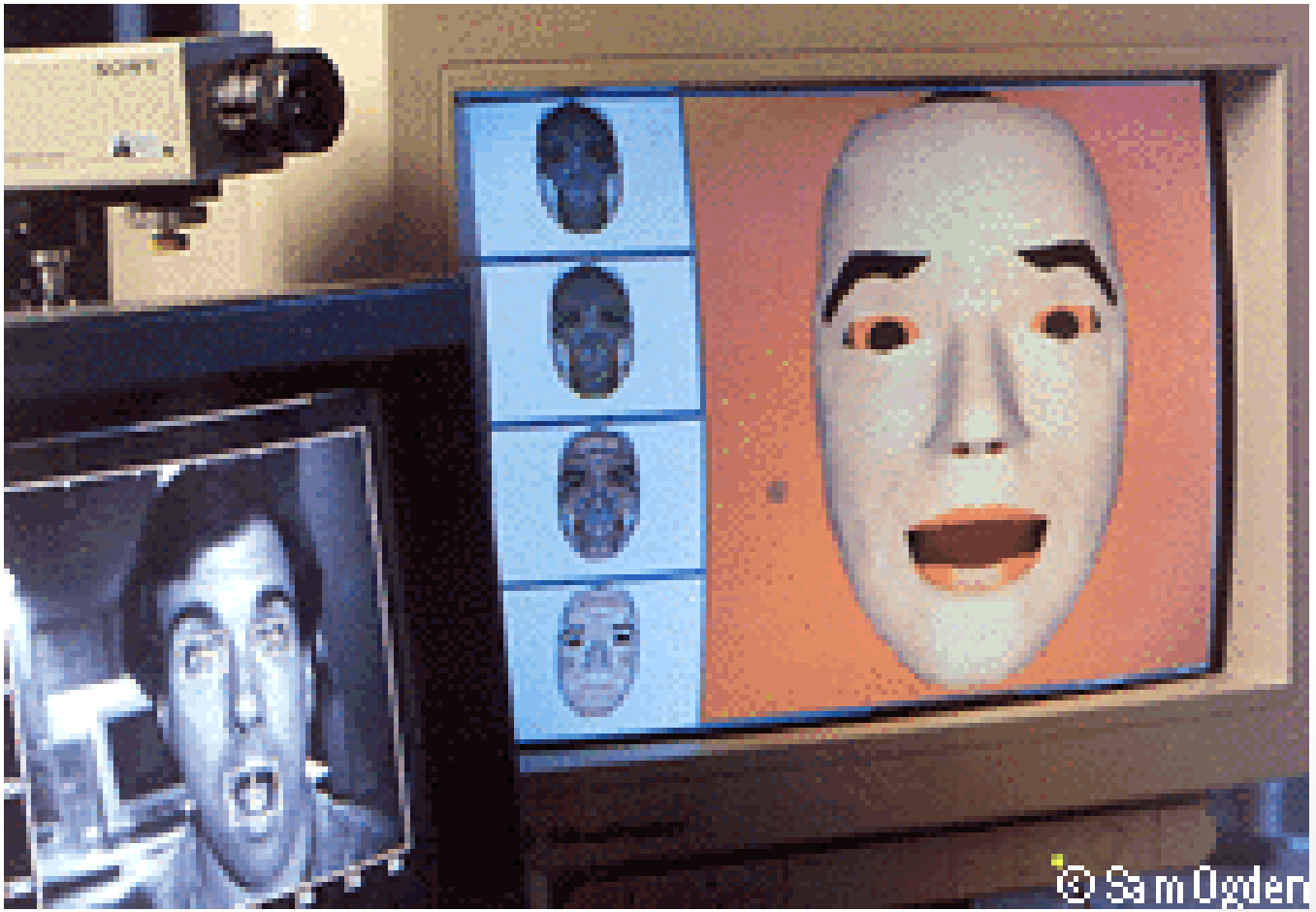




Face Recognition

Face Detection/Recognition Research at UNR

Facial Expression Recognition

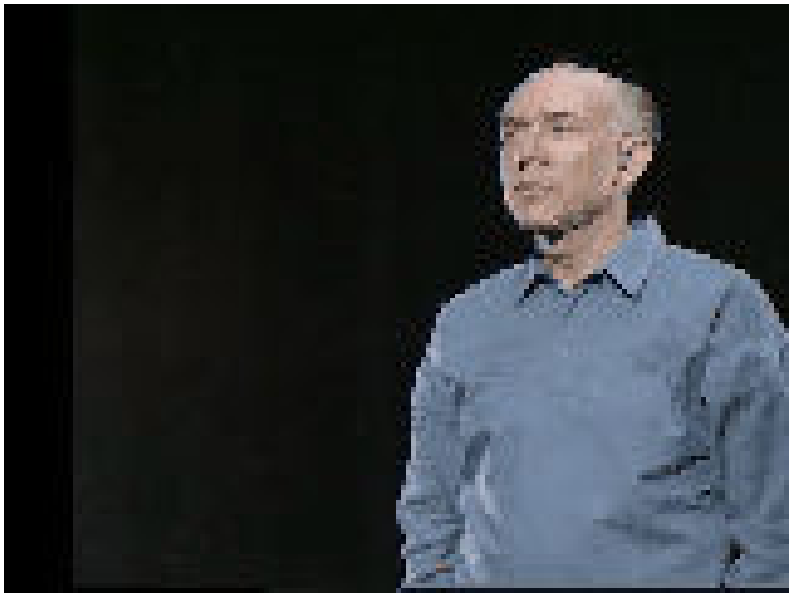


Face Tracking

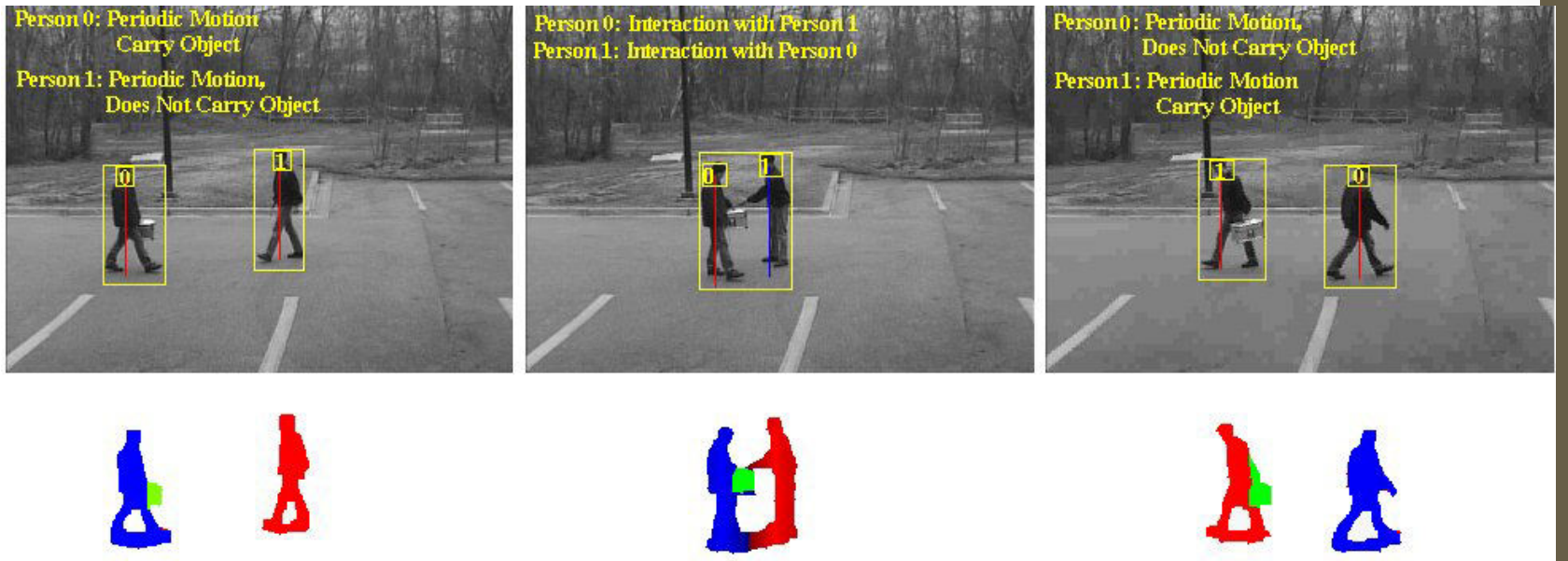
Face Tracking (cont'd)

Hand Gesture Recognition

- Smart Human-Computer User Interfaces
- Sign Language Recognition

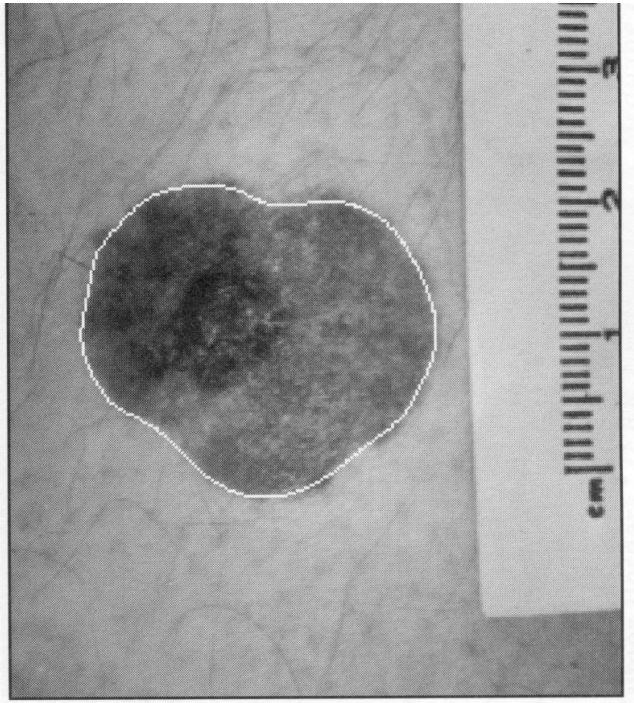


Human Activity Recognition



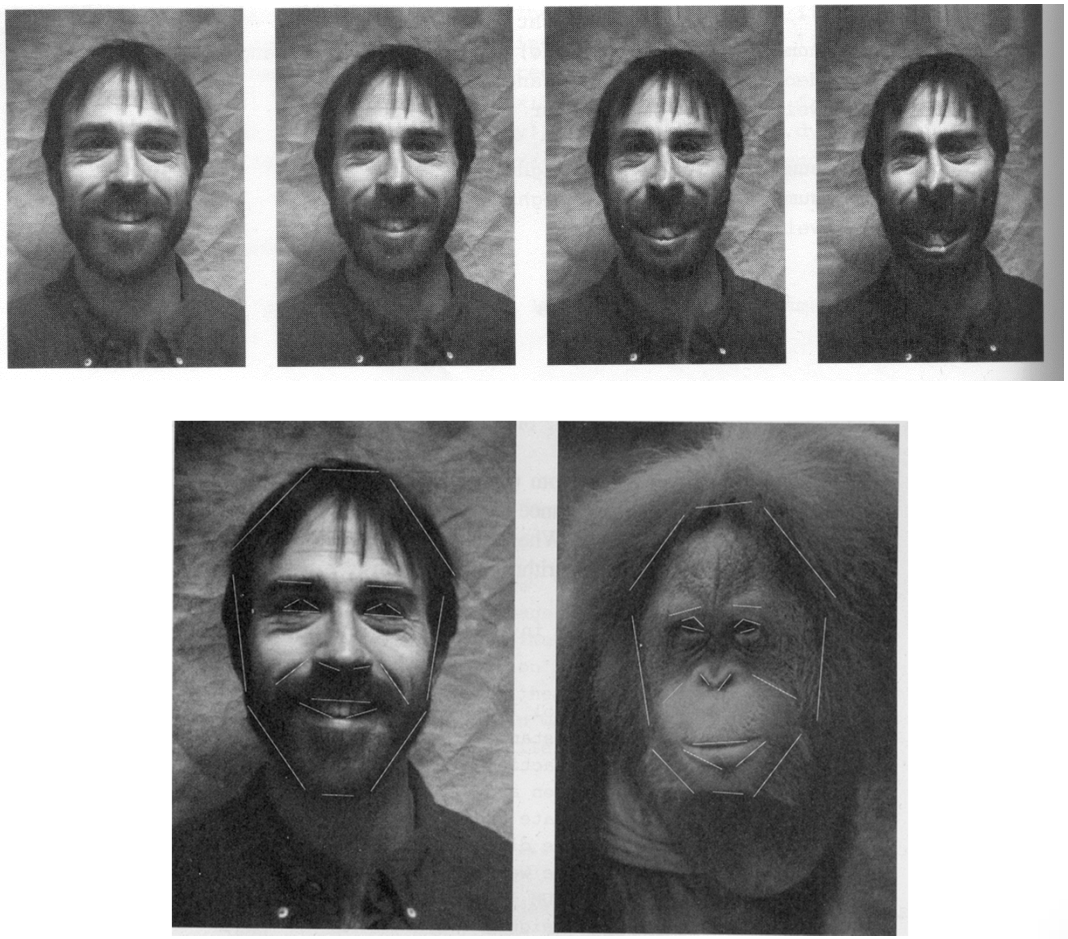
Medical Applications

- skin cancer

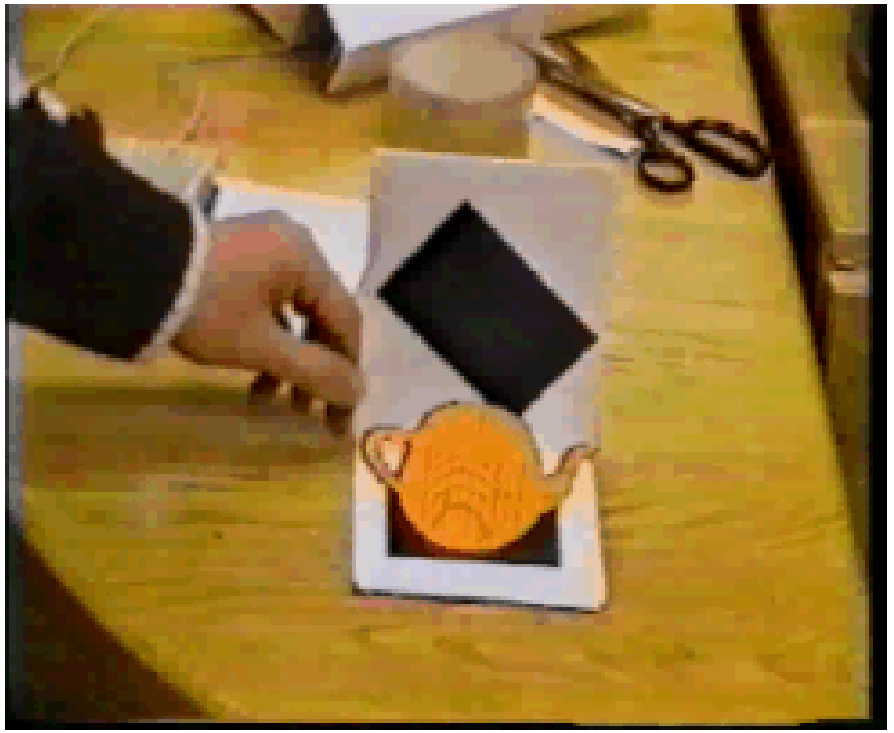


breast cancer

Morphing



Inserting Artificial Objects into a Scene



Some Companies In this Field In India

- Sarnoff Corporation
- Kritikal Solutions
- National Instruments
- GE Laboratories
- Ittiam, Bangalore
- Interra Systems, Noida
- Yahoo India (Multimedia Searching)
- nVidia Graphics, Pune (have high requirements)
- ADE Bangalore, DRDO

Links for Self Study and a little Play

- http://undergraduate.csse.uwa.edu.au/units/233.412/
- http://www.netnam.vn/unescocourse/computervision/computer.htm
- Book: Digital Image Processing, ***2nd Edition***
  by Gonzalez and Woods, Prentice Hall