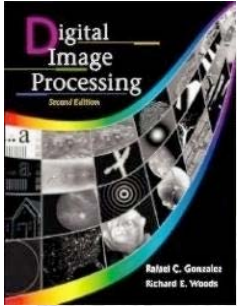


EECS490: Digital Image Processing

EECS 490 Image Processing

References:

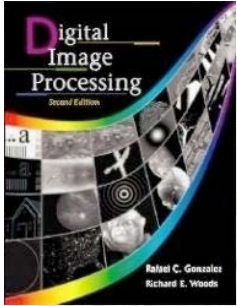
1. Ballard & Brown, Computer Vision
2. Gonzalez & Woods, Digital Image Processing, 2/e
3. Kelly, Robot Vision
4. EECS 253 Image Processing slides, Richard Alan Peters II, Vanderbilt



EECS490: Digital Image Processing

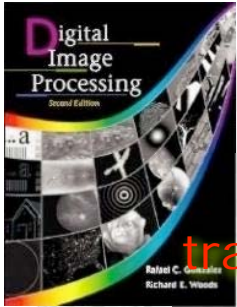
Lecture #1

- Image processing applications
- Image processing hardware
- Course topics
- Image formation
- Image representation
- Image types & test images



Applications of Image Processing

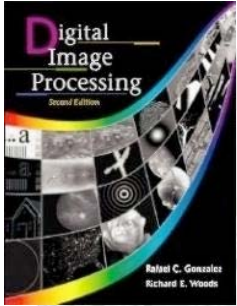
- Document processing
- Remote Sensing
- Industrial Inspection
- Robotics
- Medicine
- Motion Pictures
- Digital Photography



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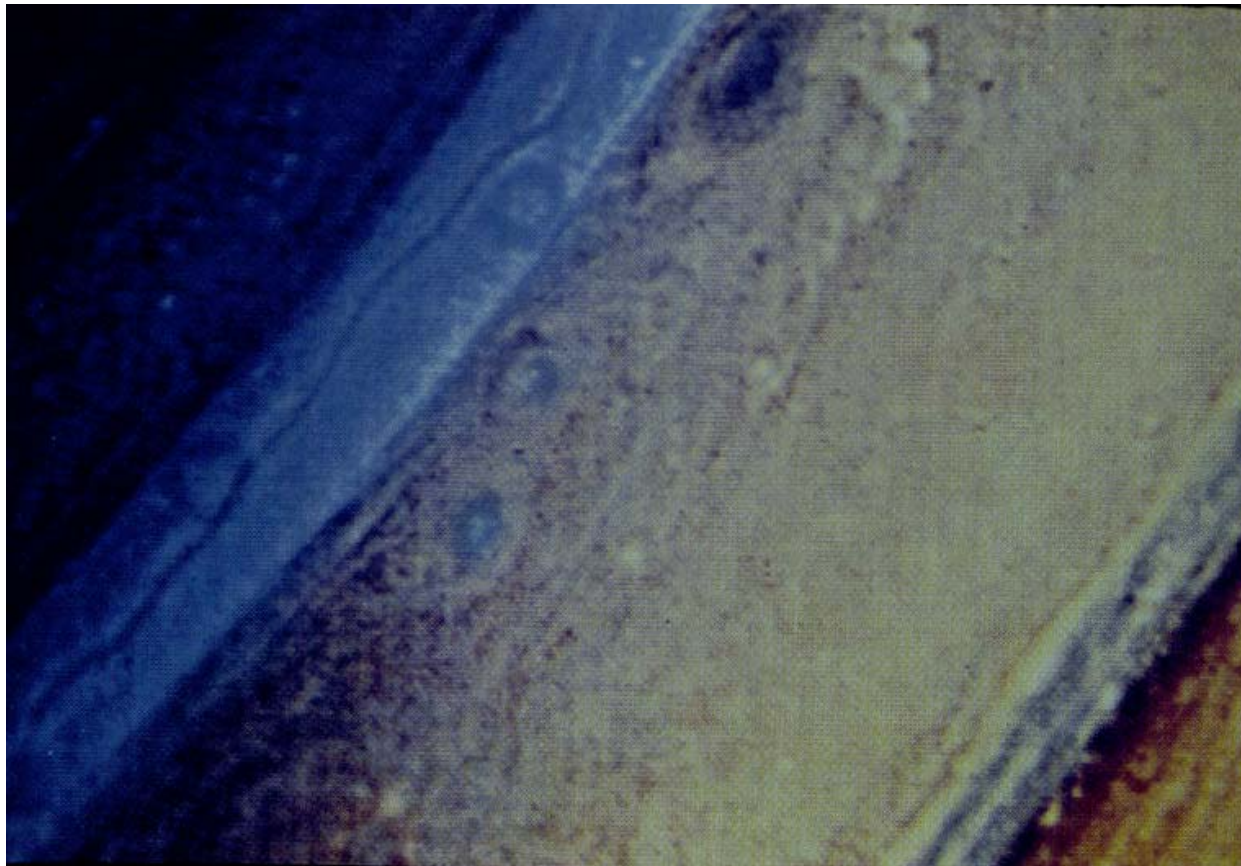
Unretouched cable picture of Generals Pershing and Foch, transmitted by tone equipment from London to New York. (From McFarlane [1972].)

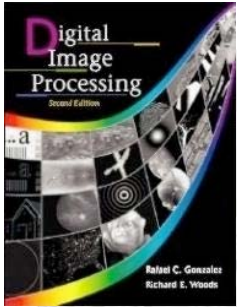




EECS490: Digital Image Processing

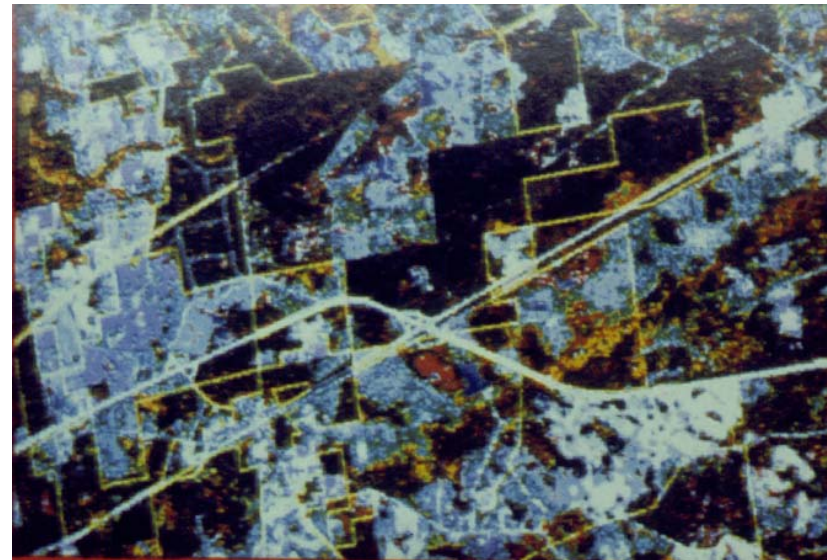
NASA Image of Jupiter

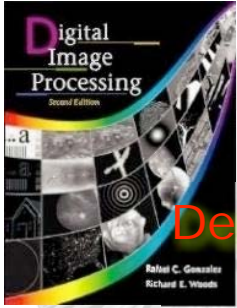




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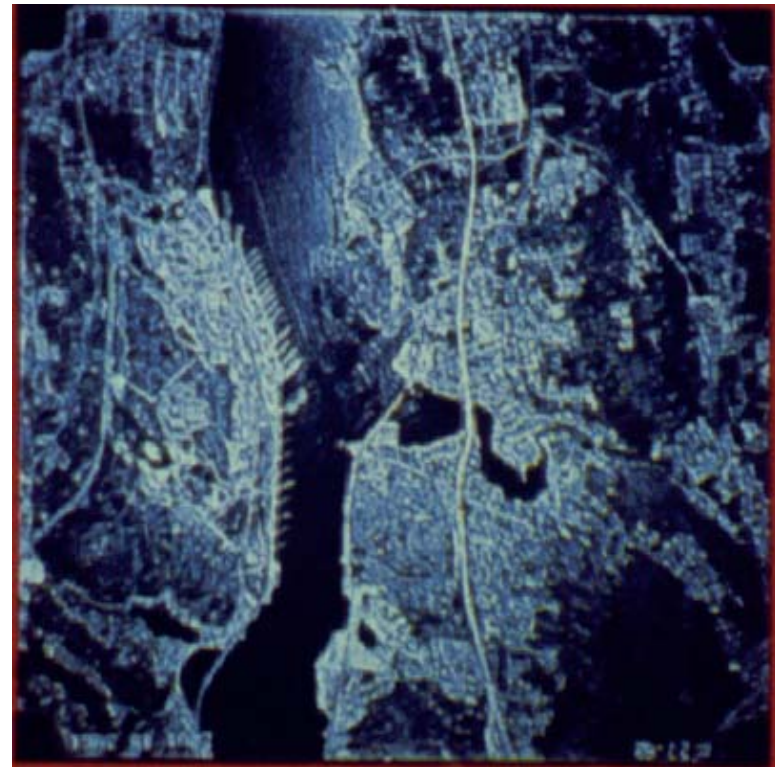
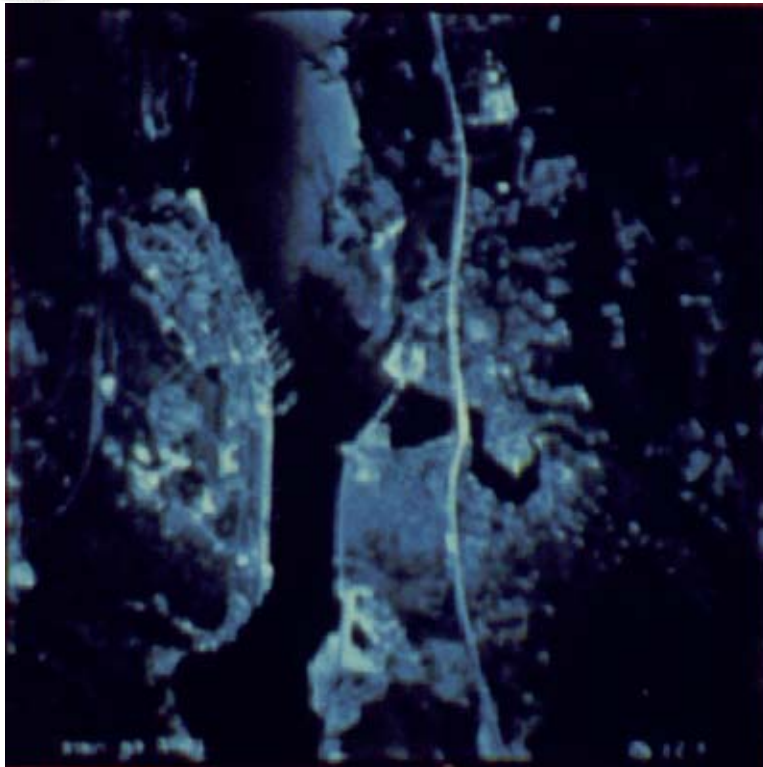
- Pseudocolors differentiate between vegetation, pavement and buildings, and graphic plane overlays plot property lines.

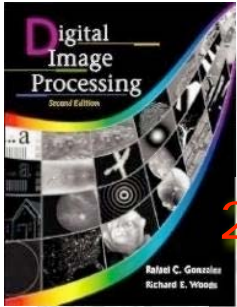




EECS490: Digital Image Processing

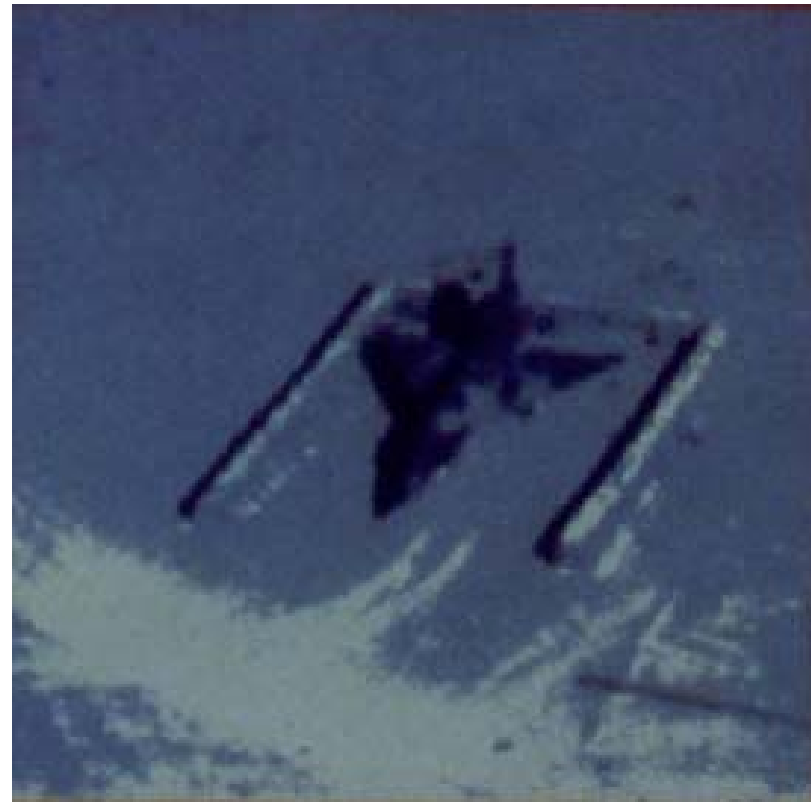
Detail not evident in the original, left, is brought out by high pass laplacian filtering, right.

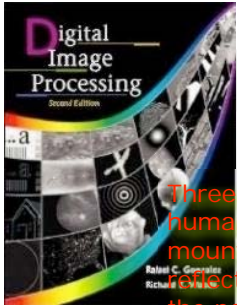




EECS490: Digital Image Processing

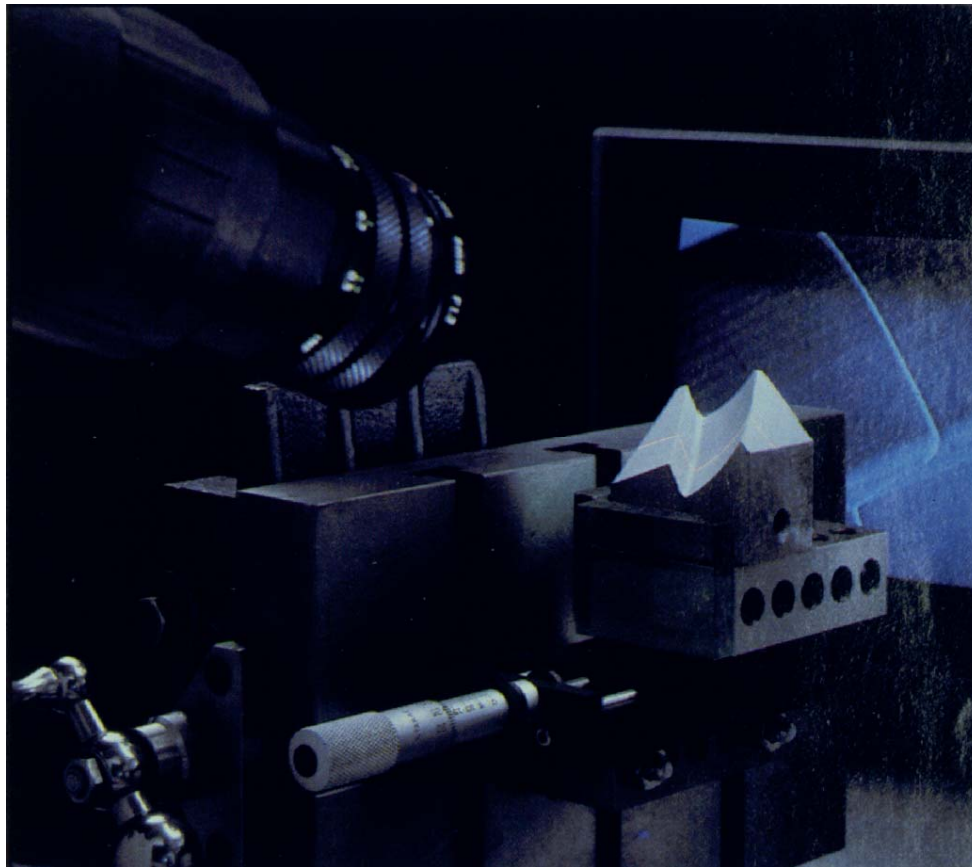
2X zoom provides detail, left, while filtering reveals tire tracks, right.

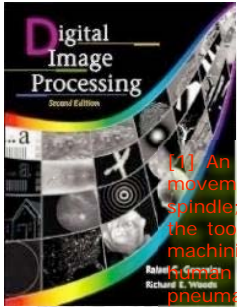




EECS490: Digital Image Processing

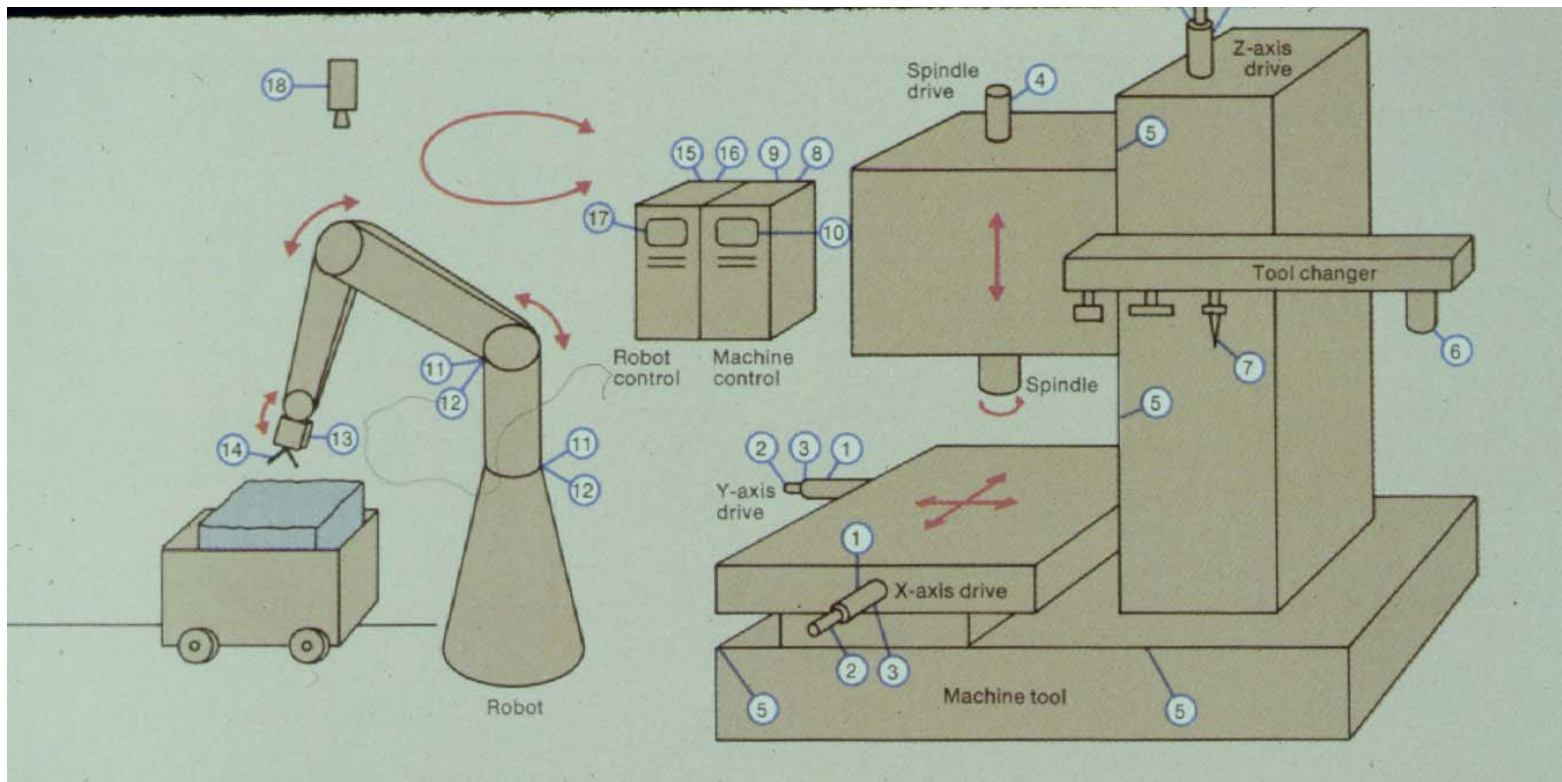
Three-dimensional machine vision system performs 100-percent inspection of mass-produced stamped metals parts without human assistance. In the system, developed by Perceptron, Inc. of Farmington Hills, Mich., a sensor, camera, and light source are mounted at a fixed angular relationship and distance. Introduction of a part into the field of view shifts the position of the reflected light beam on the imaging cells of the camera. Using high-speed triangulation, the system's microcomputer determines the parts contour to within 0.0001 inch.

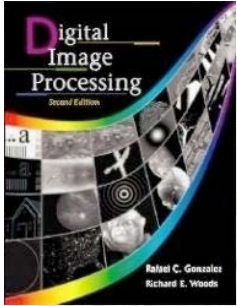




EECS490: Digital Image Processing

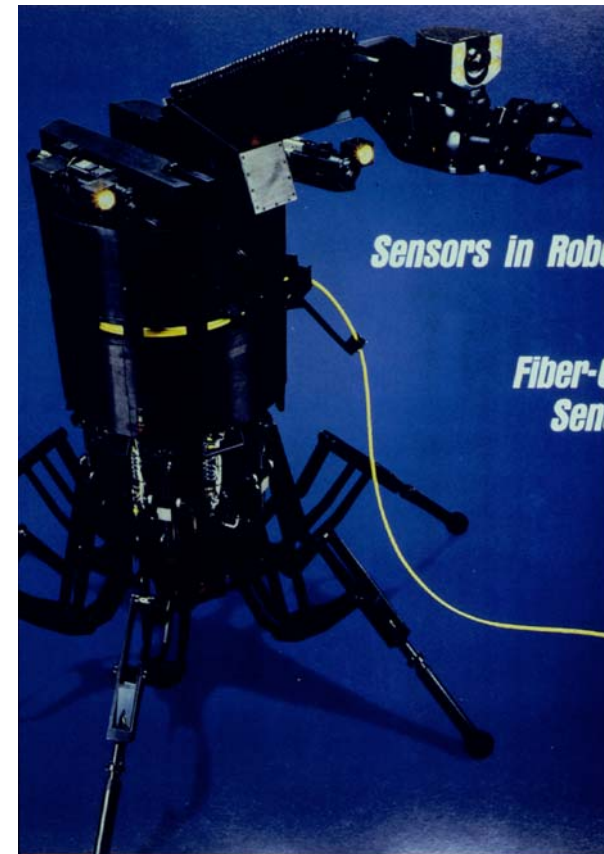
[1] An automatic milling machine with a loading-unloading robot relies on diverse sensors, actuators, and displays. On the machine tool, dc motors (1) provide movement on the x, y, and z axes; tachometers (2) sense the speeds of the axis motors; resolvers (3) sense axis-motor shaft position; an ac motor (4) drives the tool spindle; and limit switches (5) sense when the milling table is approaching its maximum allowable bounds and thus prevent overtravel. A stepping motor (6) positions the tool changer so that the spindle can accept a new tool at the appropriate moment, and a tactile probe (7) measures the dimensions of the workpiece at each machining step. In the machine-control unit, servo amplifiers (8) regulate the machine drives, a computer (9) exercises overall control, and a display (10) keeps a human supervisor informed of the machine status. On the robot, hydraulic servo valves (11) actuate the arm, optical encoders (12) sense the position of the arm, a pneumatic control valve (13) actuates the robot's gripper, and a tactile sensor (14) measures the gripper force. The robot control contains servo amplifiers (15), a computer (16), and a display (17). Overhead, a TV camera (18) identifies parts and guides the robot.

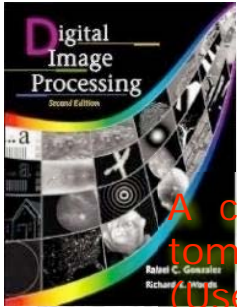




EECS490: Digital Image Processing

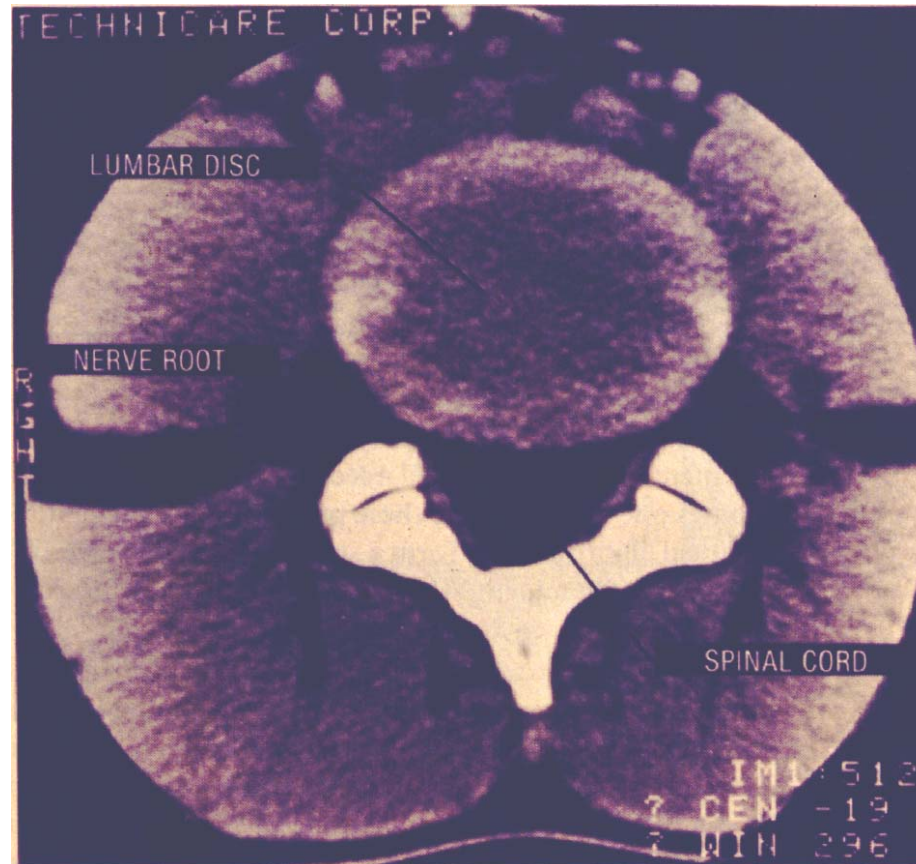
Vision guided robot
used for nuclear
reactor repairs.

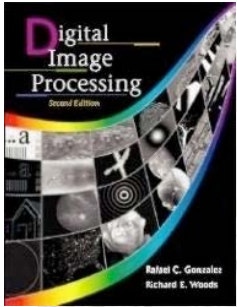




EECS490: Digital Image Processing

A computed tomography scan reconstructed image. High-resolution computed tomography shown here is being used to diagnose the causes of lower back pain. (Used with permission from Technicare Corp., 1982).

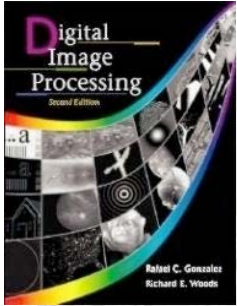




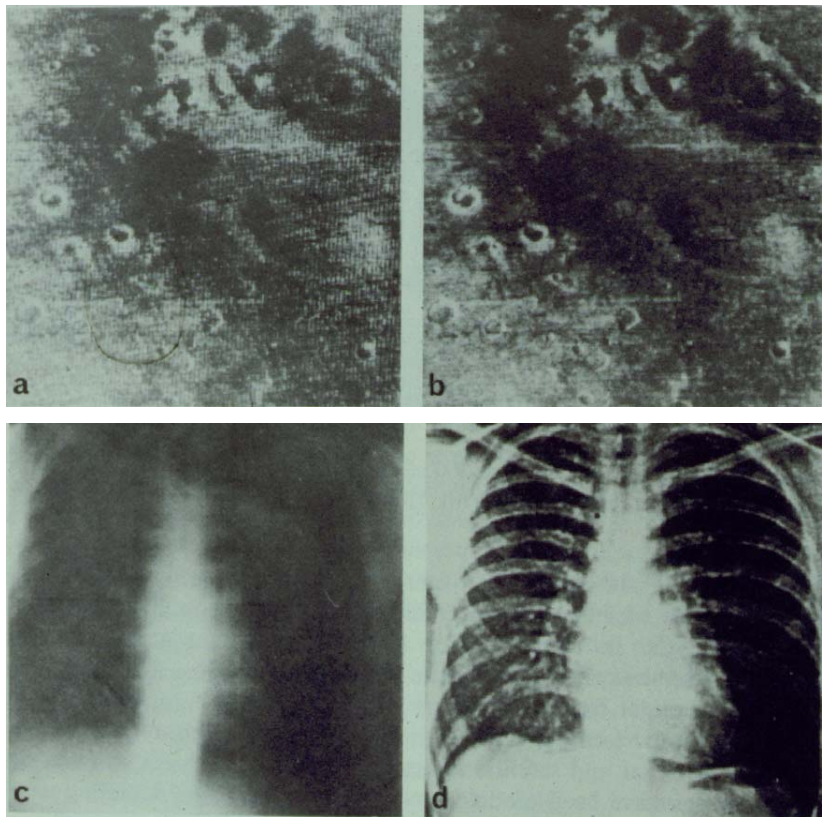
EECS490: Digital Image Processing

Colorization





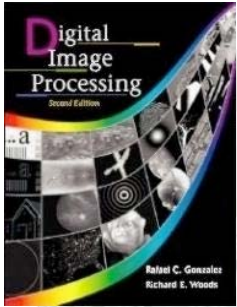
Computer enhanced images



(a) and (b) represent a sharpened image;

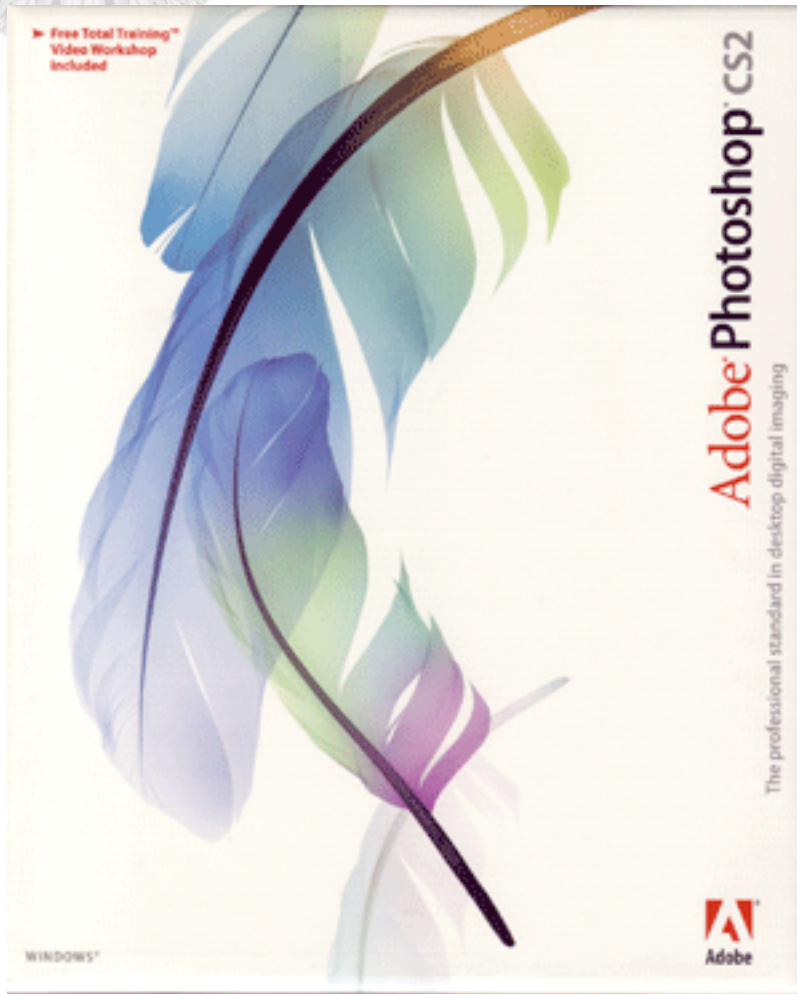
(c) and (d) show the result of histogram equalization;

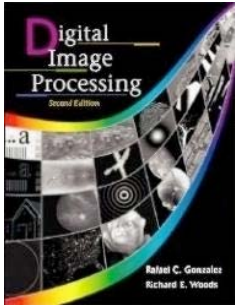
(e) and (f) show the result of motion compensation.



EECS490: Digital Image Processing

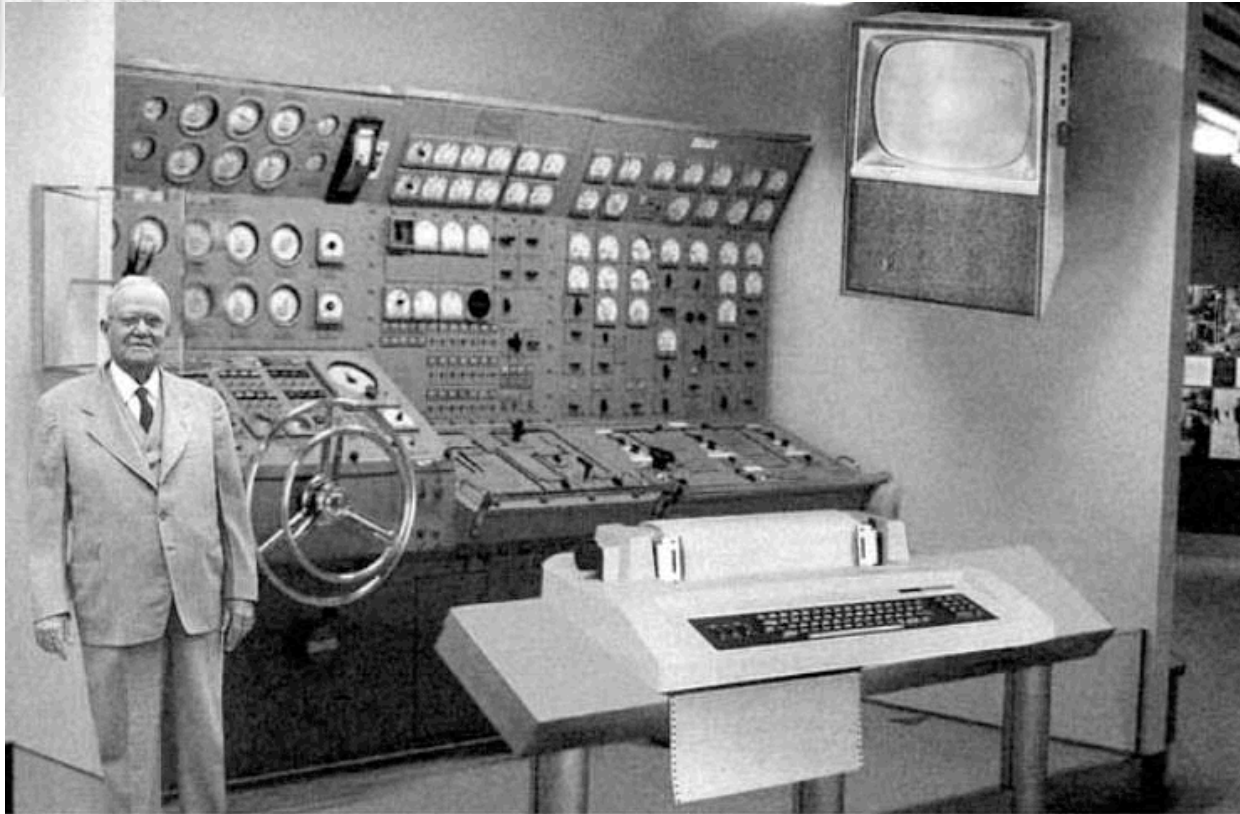
Digital Photography





EECS490: Digital Image Processing

Image Manipulation



Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.

According to an article on the Popular Mechanics web site, the picture is a hoax. The picture was actually created by a man named Troels Eklund Andersen, a Danish tech support technician. He started with a picture of a mock submarine maneuvering room, added an old TV hanging from the wall, a 1970's teletype, and threw in a picture of a hardware store owner from Ohio. He entered the picture in a photo manipulation contest. He never intended for it to be treated as a real picture.

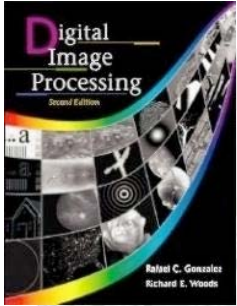
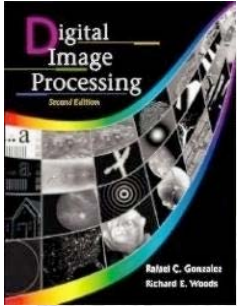


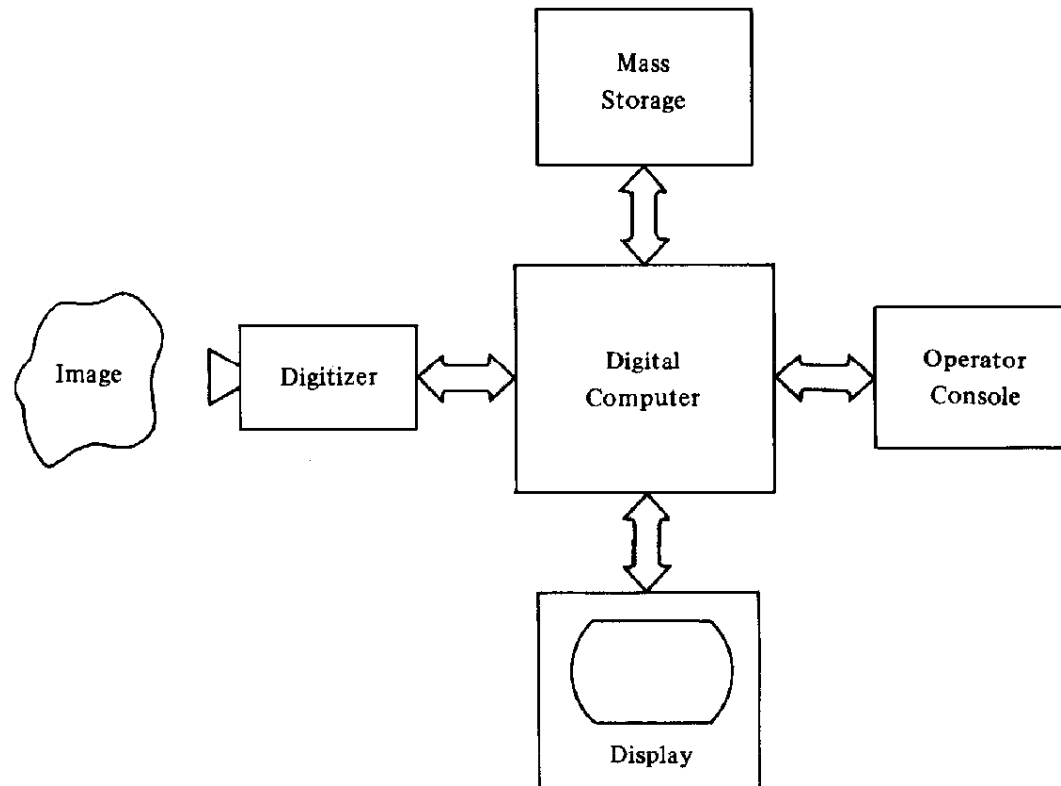
Image Processing Hardware

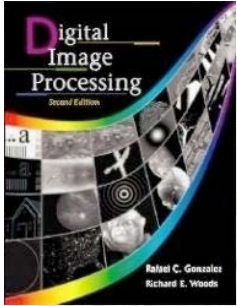
- simple pc's
- specialized image processing hardware



EECS490: Digital Image Processing

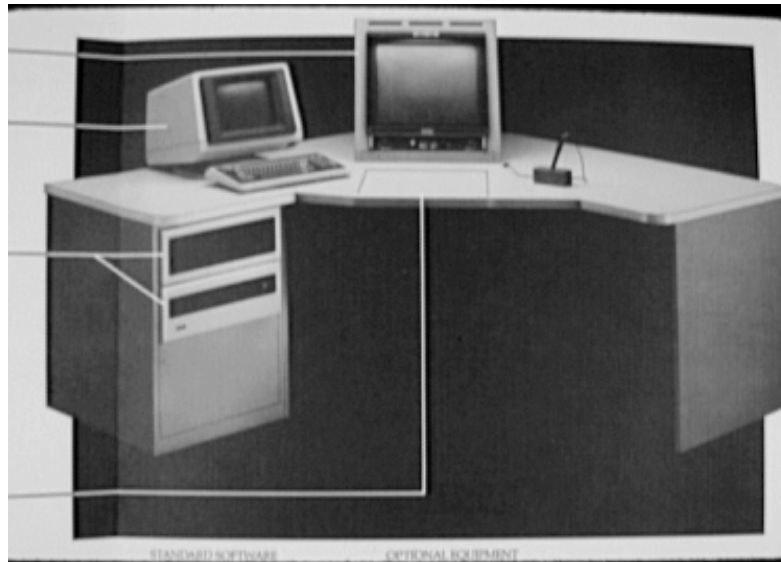
basic digital image processing system

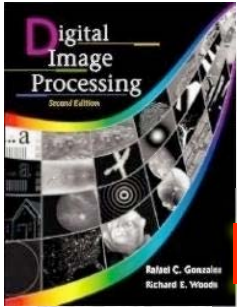




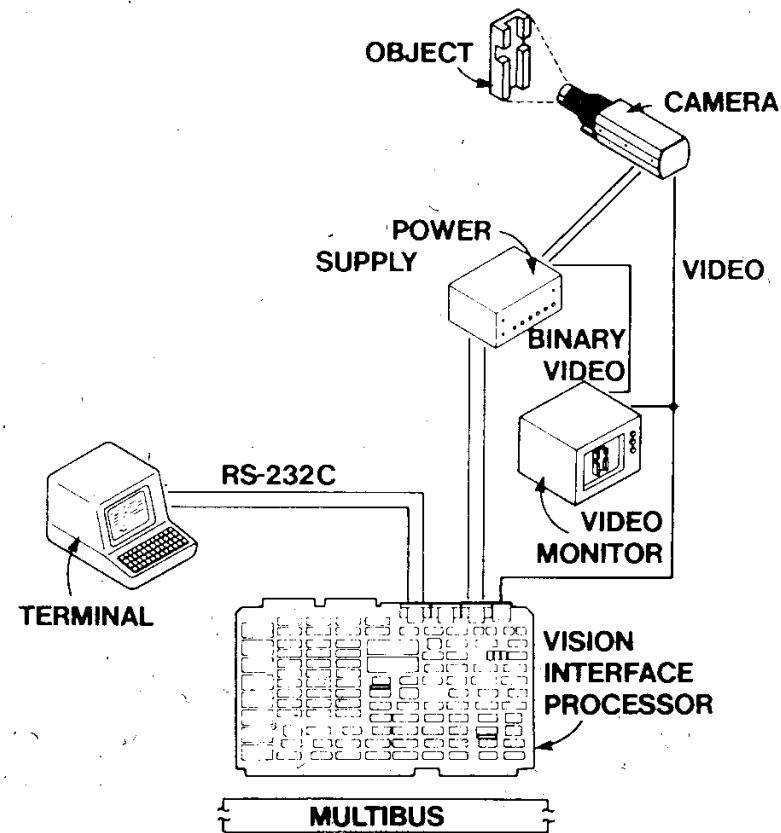
EECS490: Digital Image Processing

Dedicated IP (image processing)
workstation (circa 1980's)





IP often uses specialized hardware



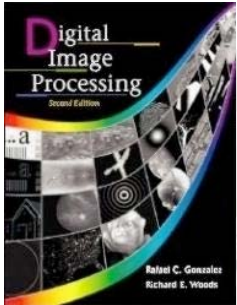
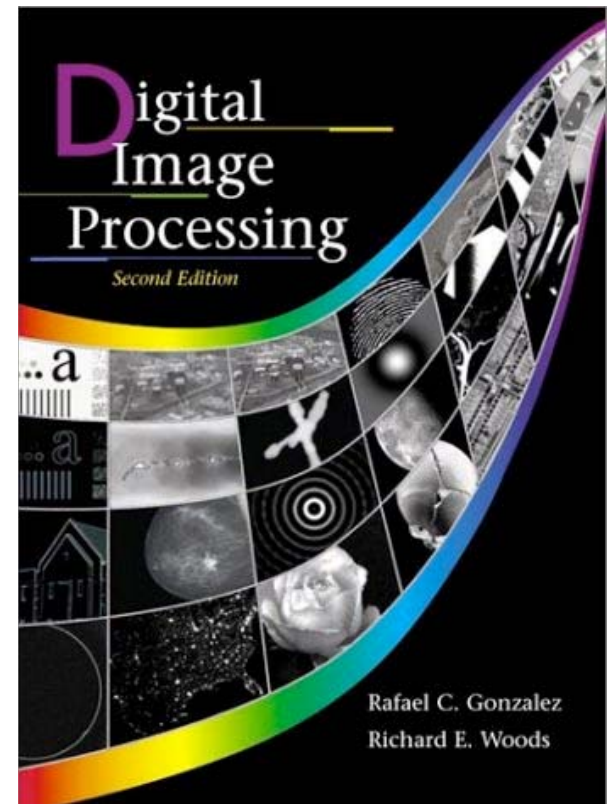
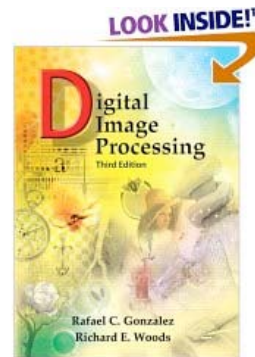
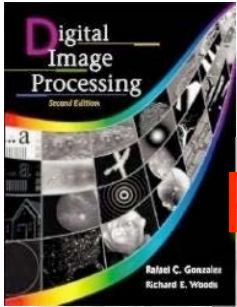


Image Processing Topics

1. image formation
2. image sampling, geometric transformations and warping
3. spatial processing
 - a) point transforms and equalization
 - b) spatial filtering
4. frequency domain processing
 - a) the fourier transform
 - b) convolution
 - c) noise reduction
5. color images
 - a) color representation
 - b) color processing
6. mathematical morphology
7. image compression
8. image representation and pattern recognition
9. texture
10. wavelets





Physiological basis of vision/image processing

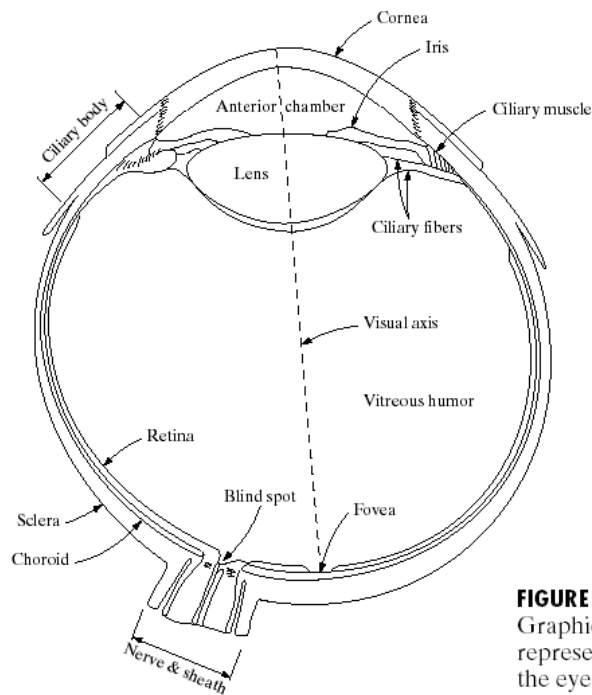
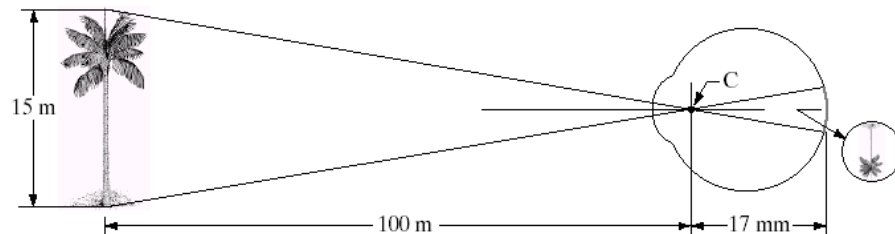
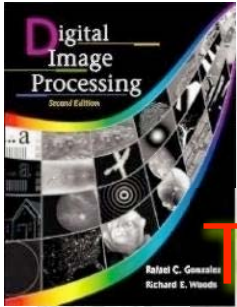


FIGURE 2.1
Simplified diagram of a cross section of the human eye.

FIGURE 2.3
Graphical representation of the eye looking at a palm tree. Point C is the optical center of the lens.





Typical Model for Image Acquisition

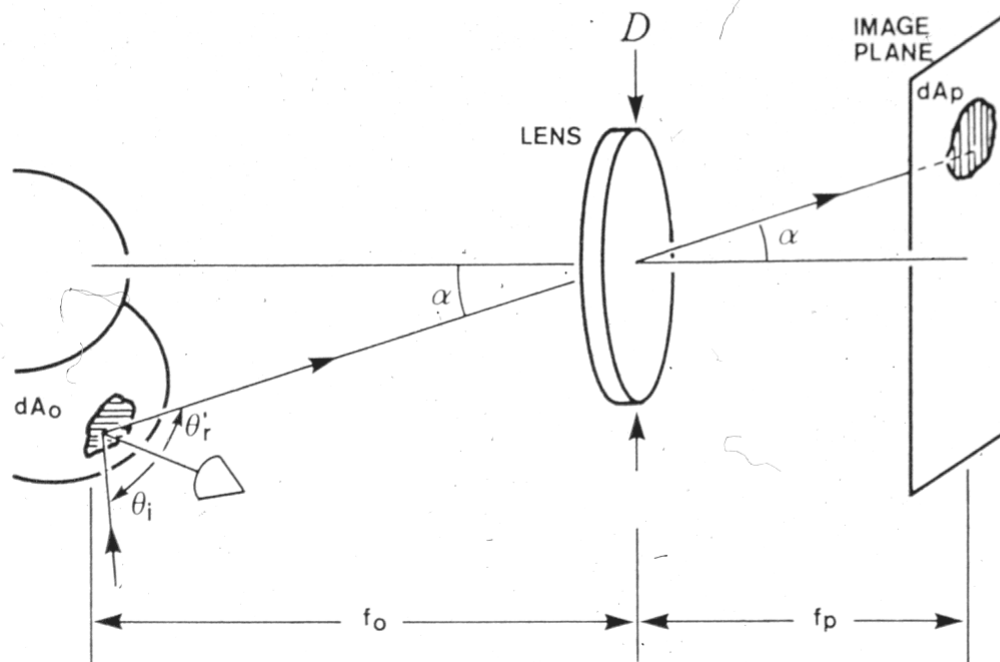
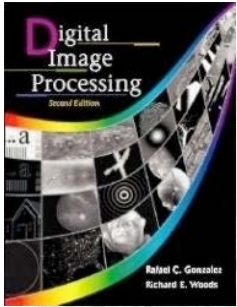


Fig. 2.4 Geometry of an image forming system.



Geometric Camera Models

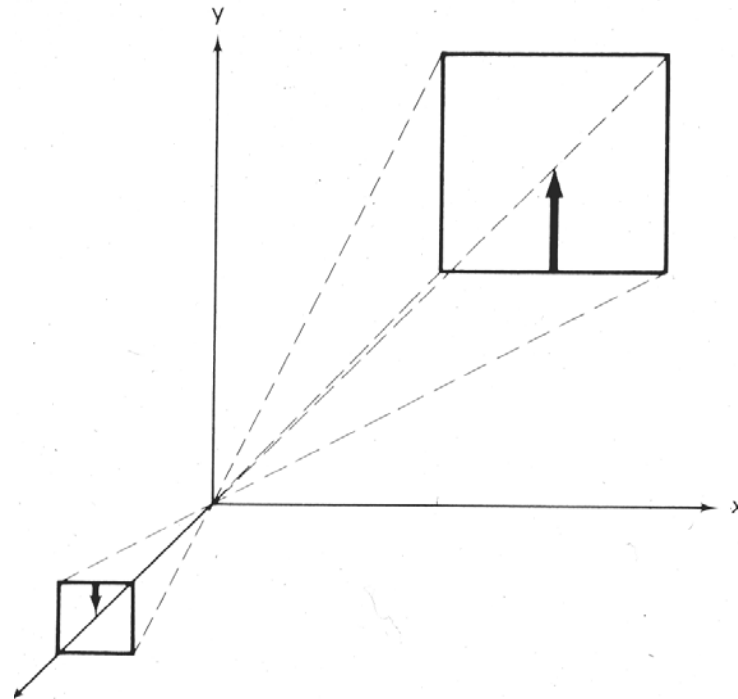
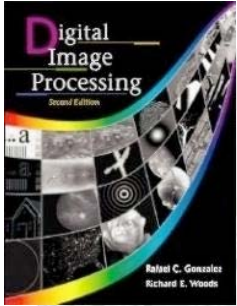


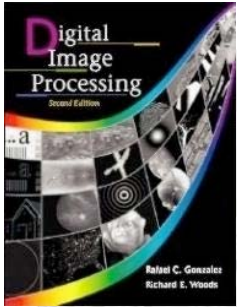
Fig. 2.1 A geometric camera model.



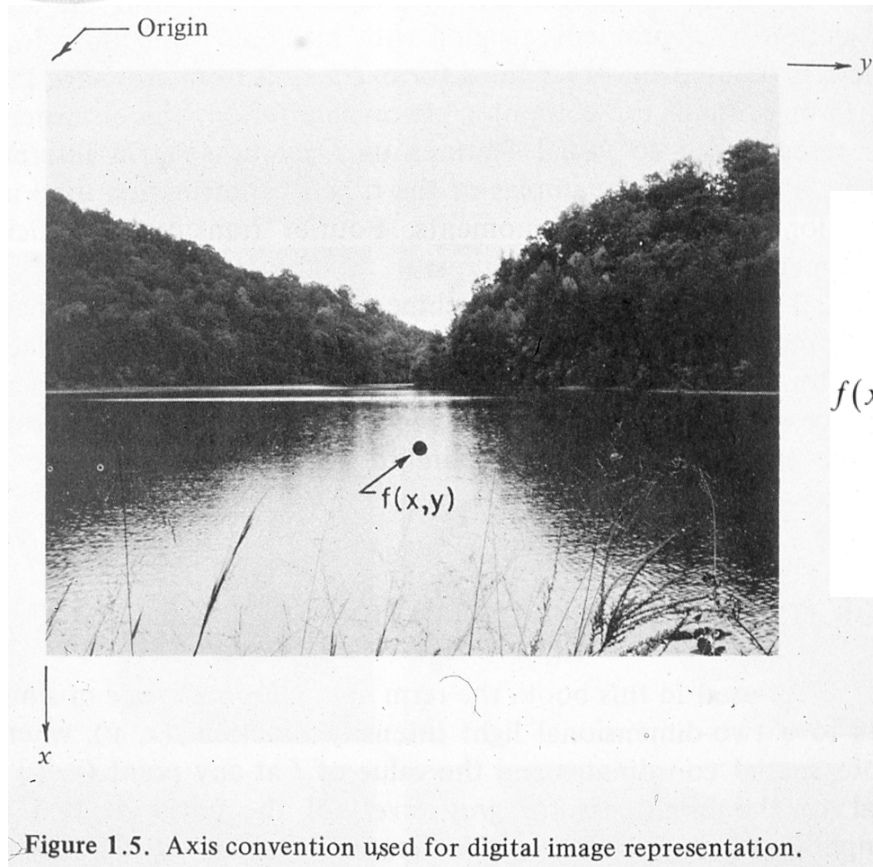
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Homogeneous Coordinate Transformation

$$T = \begin{bmatrix} R_{3 \times 3} & p_{3 \times 1} \\ f_{1 \times 3} & 1 \times 1 \end{bmatrix} = \begin{bmatrix} \textit{rotation_matrix} & \textit{position_vector} \\ \textit{perspective_transform} & \textit{scaling} \end{bmatrix}$$



Computer Image Representation



$$f(x, y) \approx \begin{bmatrix} f(0, 0) & f(0, 1) & \dots & f(0, N-1) \\ f(1, 0) & f(1, 1) & \dots & f(1, N-1) \\ \vdots & \vdots & \ddots & \vdots \\ f(N-1, 0) & f(N-1, 1) & \dots & f(N-1, N-1) \end{bmatrix}$$

Figure 1.5. Axis convention used for digital image representation.

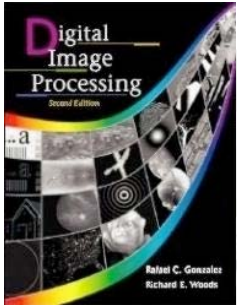


Image Representation

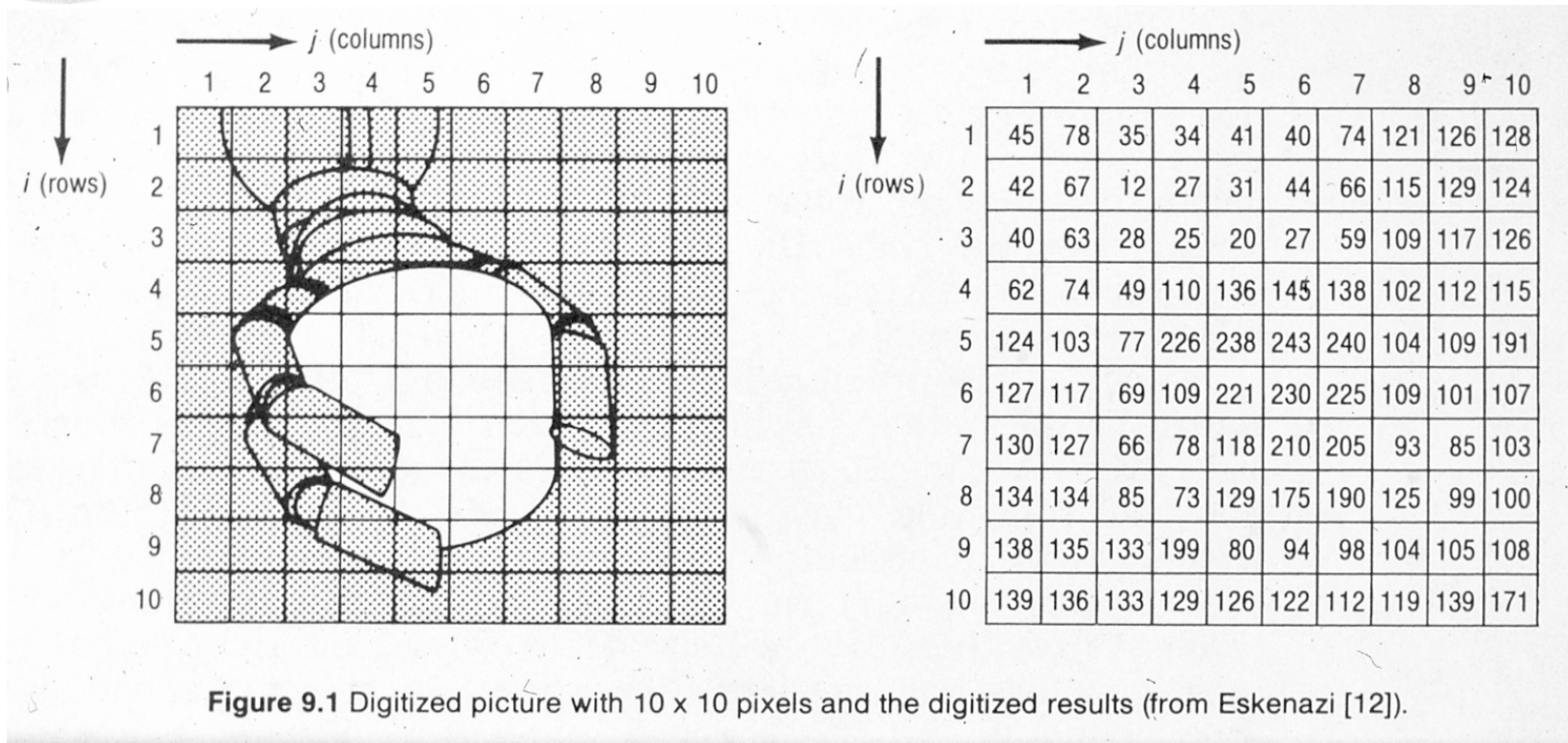
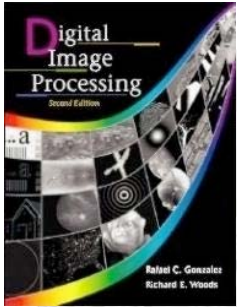
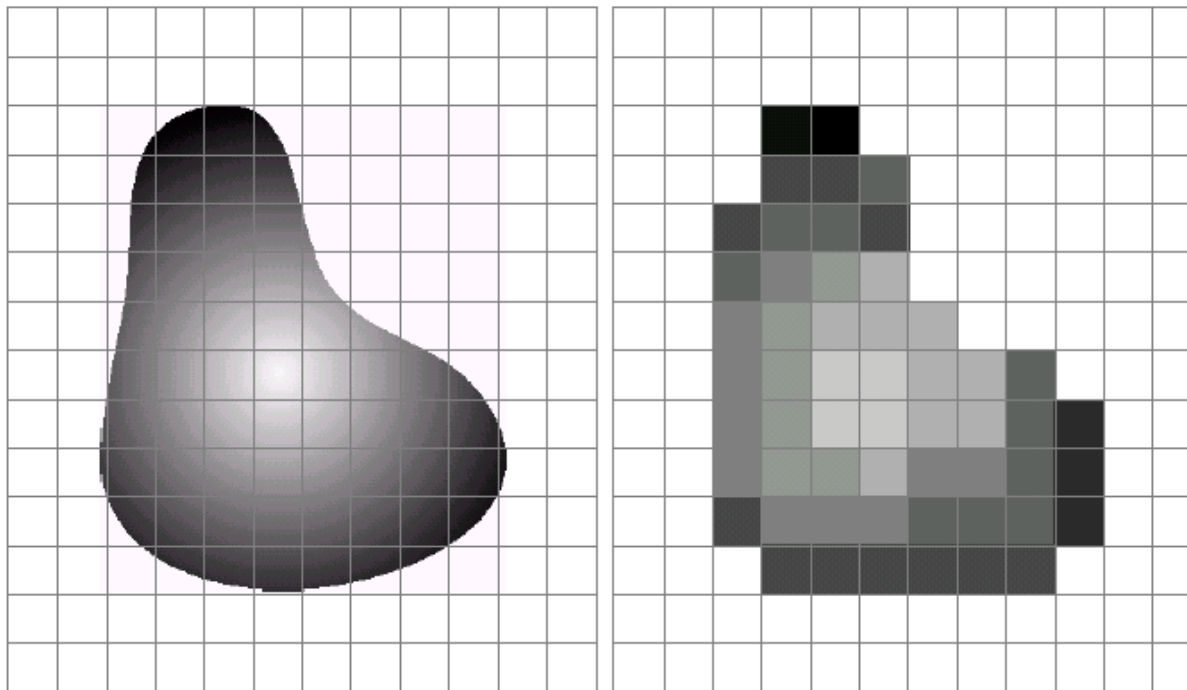


Figure 9.1 Digitized picture with 10 x 10 pixels and the digitized results (from Eskenazi [12]).

0=black; 255=white

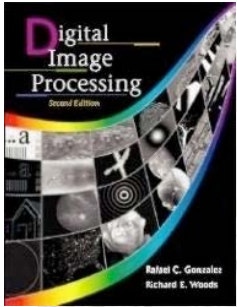


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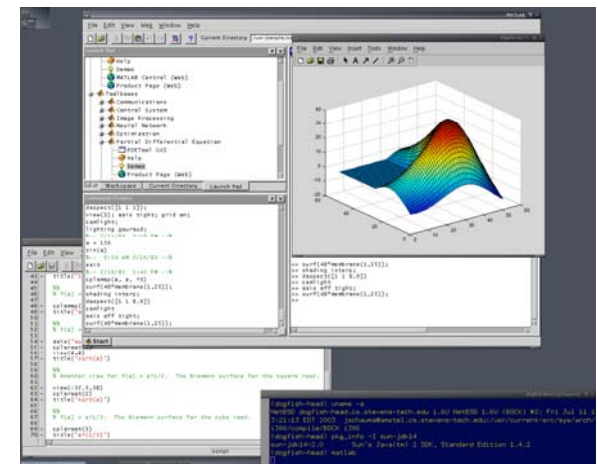
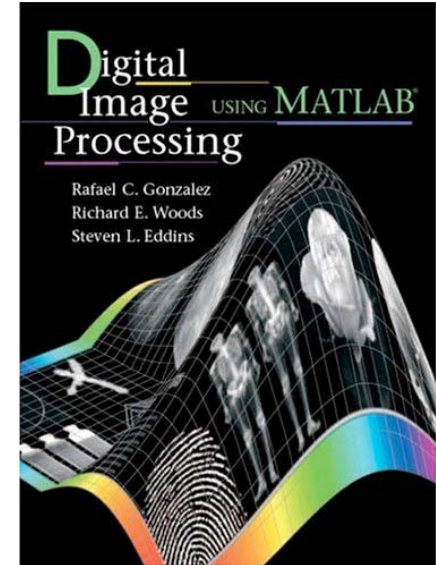
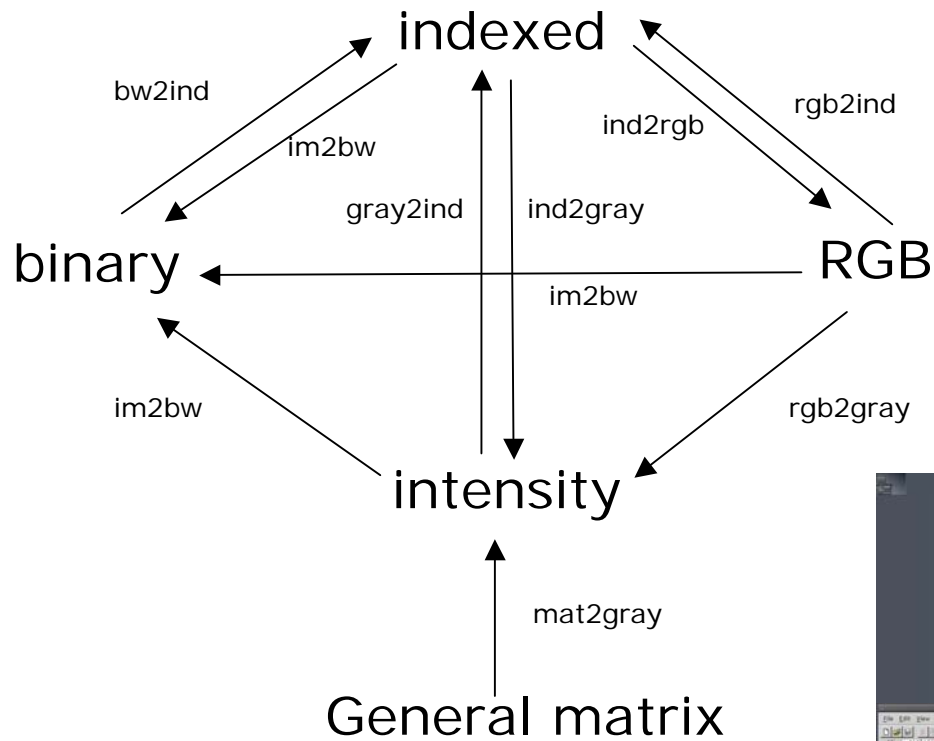
a b

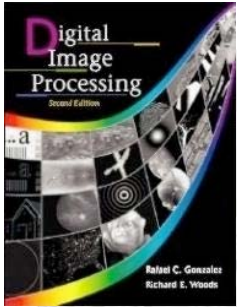
FIGURE 2.17 (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.



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MATLAB® Image Types





EECS490: Digital Image Processing

Test Images

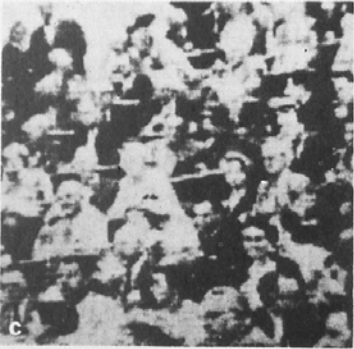
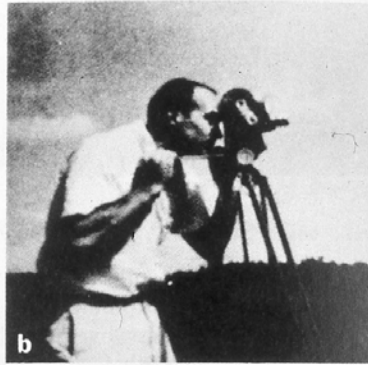
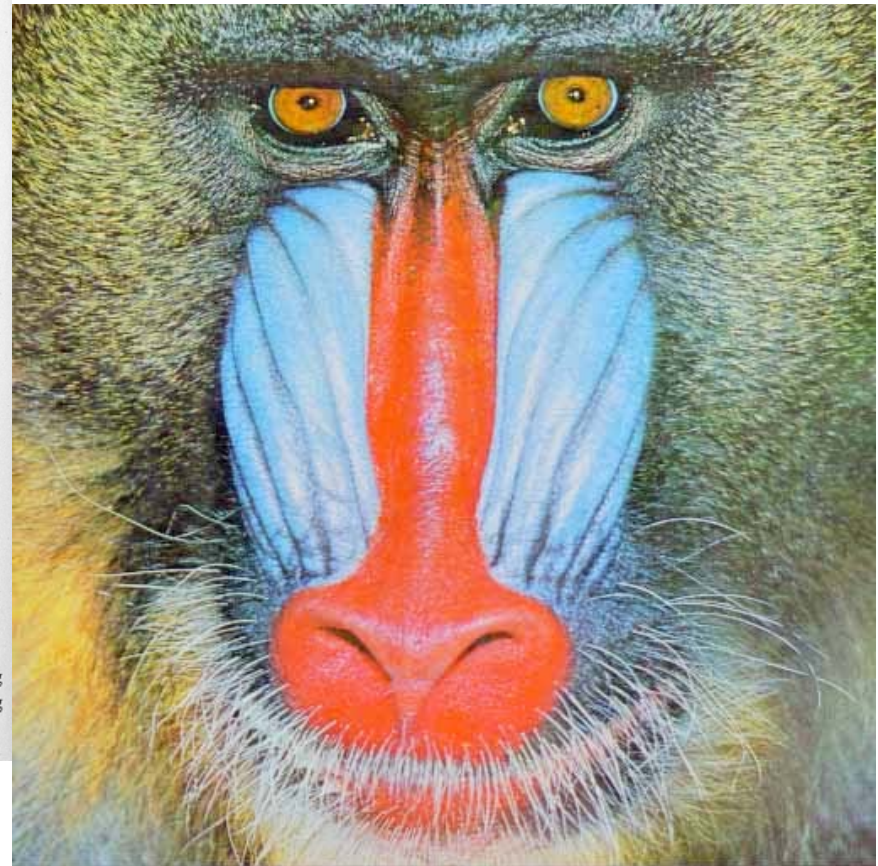
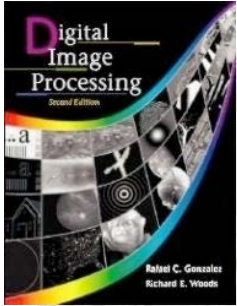


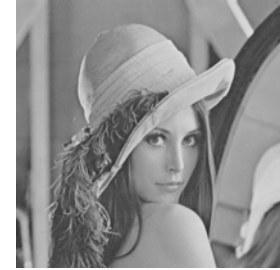
Figure 2.9. Test images used in evaluating subjective image quality. (From Huang [1965].)





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The "Lena" Image

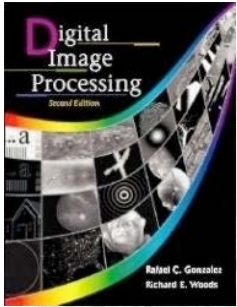


comp.compression FAQ:

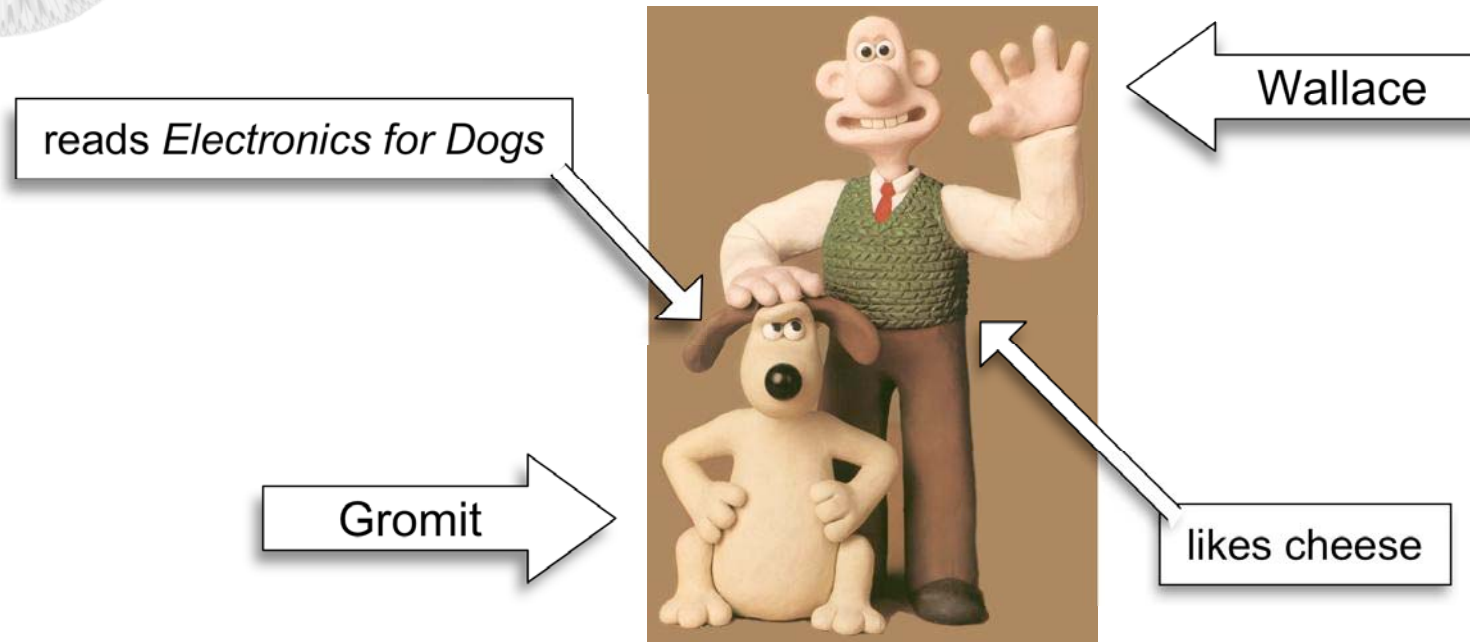
For the curious: 'lena' or 'lenna' is a digitized Playboy centerfold, from November 1972. (Lenna is the spelling in Playboy, Lena is the Swedish spelling of the name.) Lena Soderberg (ne Sjooblom) was last reported living in her native Sweden, happily married with three kids and a job with the state liquor monopoly. In 1988, she was interviewed by some Swedish computer related publication, and she was pleasantly amused by what had happened to her picture. That was the first she knew of the use of that picture in the computer business.

A scan of the original Lenna from Playboy is available from <http://www.lenna.org>

The editorial in the January 1992 issue of Optical Engineering (v. 31 no. 1) details how Playboy has finally caught on to the fact that their copyright on Lena Sjooblom's photo is being widely infringed. However Wired mentioned that: "Although Playboy is notorious for cracking down on illegal uses of its images, it has decided to overlook the widespread distribution of this particular centerfold".



Wallace and Gromit



Wallace and Gromit will be subjects of some of the imagery in this introduction.

Visit: <http://www.aardman.com/wallaceandgromit/index.shtml>