1.
2.

Examples of image processing applications:

3. first digital image - sent by transatlantic cable
4. space program - big funder of image processing
5. intelligence and reconnaisance - multi-spectral display, map overlays
6. measurement and inspection - three-dimensional measurements
7. industrial surveilance and inspection in manufacturing
8. robotics
9. medical - tomography reconstruction
10. graphics - colorization of "It's A Wonderful Life"
11. typical image processing tasks - rendering detail more visible, deblurring.
12. typical image processor (schematic)
13. typical image processor (photo)
14. modern small image processor
15. how humans form images (eyeball as an imaging system)
16. eyeball imaging
17. physical imaging
18. camera model
19. simpler camera model
20. why do we need a camera model?
21. homogeneous coordinates
22. What does T matrix mean?
23. What does T matrix mean (detailed)
24. gray scale images versus range images
25. types of lighting - MOST IMPORTANT

tubes are subject to drift

26. image orthicon tube (complex)
27. vidicon tube (most used in cheap cameras)
28. CCD technology
29. organization (line transfer)
30. solid state sensors come in many forms
31. most people will use CCD cameras
32. camera and sensor technology
33. camera complexity (typically two parts)
34. a lot will use television output (lowers resolution and increases complexity)
35. convert analog in to digital for image processing
36. more complexity
37. don't build your own camera interface
38. film recording
39. non-linear film characteristics: density=transparancy, exposure=light incident
40.
41. example of digitized image

42. image axis convention
43. represent image as an array of numbers (matches CCD cameras)
ISSUES IN QUANTIZATION,ETC.
44. spatial number of samples - constant number of gray scales
45. same thing
46. constant resolution, varying number of gray scales
47.
48.
49. some classic test images
50. histogram distribution (mention bins)
51. re-distribute grey levels
52. detailed example of histogram equalization
53. same thing
54. before and after histograms
55. LUTs (look up tables)
56. example of non-linear histogram transforms
57. same
58. X
59. Fourier transform definition
60. example of the Fourier transform of a pulse
61. photo of the Fourier transform of a pulse
62. two-dimensional calculated transform
63. examples of transforms
64. examples of transforms
65. for digital images must be digitized
66. discrete signals
67. discrete Fourier transform definition
68. DFT example
69. example of DFT - image compression and display
70. how to implement a 2-D FFT using 1-D FFTs
71. periodicity because of algorithm
72. shifting because of periodicity
73. DFT shows orientation
74. how to calculate graphically
75. examples of FFT analysis: (a) original; (b) low pass filtered and rotated; (c) low pass filtered; (d), (e), and (f) power spectra of (a), (b), and (c)
76. definition of neighborhoods (usually 3x3 but often larger)
77. sliding mask
78. definition of operator
79. formally defined as a spatial convolution
80. computationally complex
81. but easy to code - most image processing is programmed in C
82. image transformations
83. examples of linear image processing (based upon FFTs, etc. originally) (original photo)
84. define kernel [edge operator, horizontal, derivatives, gradients, etc.

85. vertical NOT horizontal
86. Lalacian (second derivative)
87. edge detection and thresholding
88. example photo
89. Laplacian - processed and thresholded
90. Laplacian - processed, gray scale
    non-linear filters
91. sample photo (original)
92. median filtered (note wood grain, glint, etc. smoothed)
93. original noisy image
94. median filter
95. original stamp photo
96. (a) original; (b) Sobel (edge) operator, (c) and (d) unsharp masking, i.e. put edges on original image
97. X
98. edge operators: direction and strength of x&y differences
99. have many possible orientations (done on Amiga)
100. edge operation
101. can have edge operators in many directions and orders
102. results depend on your image
103. gradient operators (mention Sobel differences here)
104. industrial part processing (mention thinning, image morphology is fast and simple)
105. image morphology on a binary image (structuring element with orientation, slides along)
106. erosion - if element matches keep pixel, else delete
107. same original as 105
108. dilation - expand at origin using template
109. rolling ball analogy of erosion
110. result
111. rolling ball analogy of dilation
112. result
113. call dilation "closing"
114. closing - original gives ineterior edge detail
115. call erosion "opening"
116. original - opening gives exterior detail
117. X
118. X
119. binary image - recognize geometry, simpler for industrial applications
120. connectivity analysis - what is pixel connected to?
121. define connectivity in many ways
122. "blob coloring"
123. run length encoding - record only start and end of binary object
124. example of run length coding
125. binary images are easy to get
126. X

127. code in color
128. GM CONSIGHT system - stress simplicity
129. same
130. same
131. use knowledge to look for more objects, etc.
132. color sensitivity of eye (tri-stimulus values)
133. define chromaticity coordinates
134. chromaticity diagram (only need two coordinates, usually r and g, to define any color - nothing with a negative value is allowed)
135. color chromaticity diagram
136. intensity = total sensor input
137. saturation is defined as a measure of how much "white" is "NOT" present
138. many other color systems such as Y,I,Q (TV) where Y=luminance, I and Q are color signals
139. X
140. typical problems in image processing

1.
2. small, stand alone image processing system
3. lots of specialized hardware (lots of disk)
4. usually have very nice graphics
5. X
6. new IBM-PC based processors, use hard disk a lot
7. configure for what you need, true color in and out
8. non-standard sources
9. real-time processing
10. lots of flexibility: frame store, convolution processors, systolic array processor
11. convolver: up to 63x63 kernel, fast (real-time)
12. digital signal processor with C interface
13. ITEX software functions (not too sophisticated): can it be called from a user program? can you insert your own routines?
14. example of Image Action 1.0
15. types of edge operators
16. filters
17. get images
18. arithmetic processing of multiple images
19. X
20. dynamic image analysis - motion detection
21. difference picture analysis
22. how do you find a moving object in a picture
23. dendrite growth of crystals
24. shuttle experiment: record growth on film and bring back to ground
25. how crystals grow
26. optical experiment: cameras record only 250 frames
27. use collimated back lighting (NO laser) which makes crystals look dark on a black background
28. sample photo - lots of detail
29. how to detect when dendrite starts growing
30. constrained to on-board IBM-PC clone which is space qualified. Use difference pictures since they are memory efficient
31. advanced processing
32. do differences, originally with respect to reference frame, then frame to frame
33. histogram analysis, then convert to binary
34. adaptive thresholding
35. get rid of small noise
36. digitized detailed photo (tip radius is also important)
37. do difference in gray, then digitize
38. difference processing
39. binary images
40. picture dependent thresholding
41. segmentation, blob coloring

42. example
43.
44. X
45. X
46. X
47. fabric to be studied (slide #19)
48. noisy original
49. first erosion (right-oriented); image morphology of pin stripes
50. second erosion (left-oriented)
51. AND two erosions
52. X
53. done on IBM-PC, thresholded color difference (slide #1)
54. thresholded horizontal color gradient (slide #3)
55. eroded horizontal color gradient (slide #4)
56. dilated horizontal color gradient (slide #5)
57. thresholded vertical color gradient (slide #6)
58. eroded vertical color gradient (slide #7)
59. dilated vertical color gradient (slide #8)
60. eroded vertical color gradient (slide #9)
61. dilated vertical color gradient (slide #10)
62. logical OR of final results (slide #11)
63. logical AND of final results (slide #12)
64. X
65. same as above using chromaticity gradient (slide #13)
66. same as above using chromaticity gradient (slide #14)
67. same as above using chromaticity gradient (slide #15)
68. same as above using chromaticity gradient (slide #16)
69. same as above using chromaticity gradient (slide #17)
70. same as above using chromaticity gradient (slide #18)
71. same as above using chromaticity gradient (slide #19)
72. same as above using chromaticity gradient (slide #20)
73. same as above using chromaticity gradient (slide #21)
74. same as above using chromaticity gradient (slide #22)
75. X
76. entropy results (slide #2)
77. X
78. textured pattern (slide #22)
79. X
80. new pattern, blue pin stripes on a glen plaid (slide #20)
81.
82. color difference results (slide #7)
83.
84. horizontal color gradient (slide #8) NO GOOD
85. vertical color gradient (slide #11) NO GOOD
86. entropy (slide #12)
87.

88. dark pin stripes (slide #23)
89. color gradient, 4 pin stripes (slide #23)
90. color difference, pin stripes (slide #24)
91. X
92. chromaticity gradient, 3 pin stripes (slide #3)
93. X (slide #4)
94. entropy results, different thresholding
95. entropy results, different thresholding (slide #5)
96. X
97. another fabric, red and blue pin stripes (slide #26)
98. X
99. color difference results (slide #13)
100. X
101. entropy results (slide #11)
102.
103. horizontal color gradient (slide #15)
104. vertical color gradient (slide #16)
105. horizontal chromaticity gradient (slide #17)
106. vertical chromaticity gradient (slide #18)