


Introduction to Image Processing

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Introduction to Image Processing

- **Pixels: Grey Scale** 
- Pixels: Color
- Color Issues
- Image Manipulation
- Image Enhancement

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Introduction to Image Processing

Pixels: Grey Scale



24 Columns

106	89	87	108	122	118	123	131	137	136	132	135	135	136	136	129	132	126	110	104	89	86	82	99
107	98	95	107	118	121	129	138	133	128	127	119	118	122	123	126	126	134	128	117	99	86	94	101
112	110	115	110	121	129	124	123	117	111	103	96	93	96	97	101	111	123	120	114	118	109	116	111
110	118	118	118	118	118	120	116	106	90	105	106	103	117	106	88	106	100	119	120	123	122	116	102
115	120	123	123	120	121	119	106	101	78	58	63	42	63	62	58	75	87	99	116	130	125	122	126
118	118	124	121	123	117	103	102	82	47	42	36	37	41	39	52	76	86	94	112	120	121	121	125
118	130	124	127	124	103	91	68	46	38	38	75	137	98	32	37	51	89	96	106	116	120	117	115
117	120	129	130	116	108	86	53	46	30	40	185	213	194	84	121	68	87	88	116	116	114	121	119
113	122	123	126	115	110	100	68	44	45	51	175	210	195	90	199	129	84	99	123	123	127	129	114
122	125	129	133	117	108	101	65	42	39	43	95	141	98	32	59	44	66	92	96	116	124	121	115
119	115	126	109	96	107	101	66	28	20	28	56	117	40	35	38	46	86	86	96	115	124	126	118
105	119	116	119	109	101	100	78	36	25	24	34	35	42	37	46	89	85	108	117	126	127	129	119
113	115	123	132	122	125	117	96	85	55	49	52	43	47	64	86	95	113	121	127	131	127	125	122
117	122	124	118	123	121	107	108	104	103	92	82	100	99	90	95	119	121	125	129	120	117	117	112
104	113	116	117	121	120	117	119	118	109	112	115	115	116	108	116	123	126	126	122	127	125	125	118
76	105	111	116	124	131	128	127	131	120	126	124	130	130	126	129	136	131	125	125	122	117	121	118
115	117	117	113	112	117	123	128	125	135	130	123	127	129	118	130	134	133	127	126	125	123	117	123
128	129	118	116	112	108	117	118	121	130	132	126	128	125	116	129	126	130	128	123	122	116	121	117

18 Rows

Matrix: 24 Columns x 18 Rows = 432 numbers

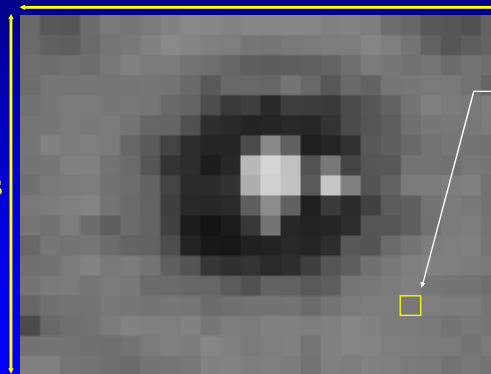
Each number is a picture element or "pixel"

Introduction to Image Processing

Pixels: Grey Scale



24 Columns



18 Rows

Each square is a picture element, or "pixel"

24 Columns x 18 Rows = 432 pixels

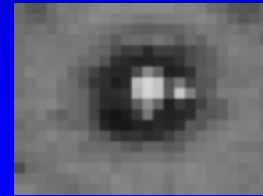
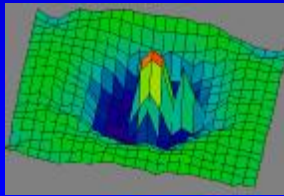
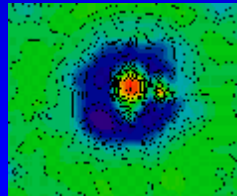
Not all display levels are perceivable on all devices

Introduction to Image Processing

Pixels: Grey Scale



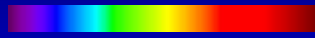
```
106 89 87 108 122 118 123 131 137 136 132 135 135 136 136 129 132 126 110 104 89 86 82 99
107 98 95 107 118 121 129 138 133 128 127 119 118 122 123 126 126 154 128 117 99 86 94 101
112 110 115 110 121 129 124 123 117 111 103 96 93 96 97 101 111 123 120 114 118 109 116 111
110 118 118 118 118 120 116 106 90 105 106 103 117 106 88 106 100 119 120 123 122 116 102
115 120 123 123 120 121 119 106 101 78 58 63 42 63 62 58 75 87 99 116 130 125 122 126
118 118 124 121 123 117 103 102 82 47 42 36 37 41 39 52 76 86 94 112 120 121 121 125
118 130 124 127 124 103 91 68 46 38 38 75 137 98 32 37 51 89 96 106 116 120 117 115
117 120 129 130 116 108 86 53 46 20 40 185 213 194 84 121 68 87 88 116 116 114 121 119
113 122 123 126 115 110 100 68 44 45 51 175 210 195 90 199 129 84 99 123 123 127 129 114
122 125 129 133 117 108 101 65 42 39 43 95 141 98 32 59 44 66 92 96 116 124 121 115
119 115 126 109 96 107 101 66 28 20 28 56 117 40 35 38 46 86 86 96 115 124 126 118
105 119 116 119 109 101 100 78 36 25 24 34 35 42 37 46 89 85 108 117 126 127 129 119
113 115 123 132 122 125 117 96 85 55 49 52 43 47 64 86 95 113 121 129 131 127 125 122
117 122 124 118 123 121 107 108 104 103 92 82 100 99 90 95 119 121 125 129 120 117 117 112
104 113 116 117 121 120 117 119 118 109 112 115 115 116 108 116 123 126 126 121 127 125 125 118
76 105 111 116 124 131 128 127 131 120 126 124 130 130 126 129 136 131 125 125 122 117 121 118
115 117 117 113 112 117 123 128 125 135 130 123 127 129 118 130 134 133 127 126 125 123 117 123
128 129 118 116 112 108 117 118 121 130 132 126 128 125 116 129 126 130 128 123 122 116 121 117
```



Contour / surface map created using MathCad

Introduction to Image Processing

- Pixels: Grey Scale
- **Pixels: Color**
- Color Issues
- Image Manipulation
- Image Enhancement



Introduction to Image Processing

Pixels: Color

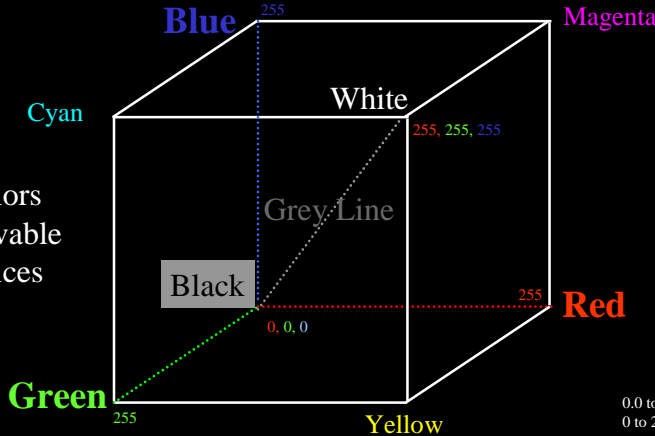


Red-Green-Blue Matrices

Introduction to Image Processing

Red-Green-Blue Color Cube

R = 0 to 255 G = 0 to 255 B = 0 to 255

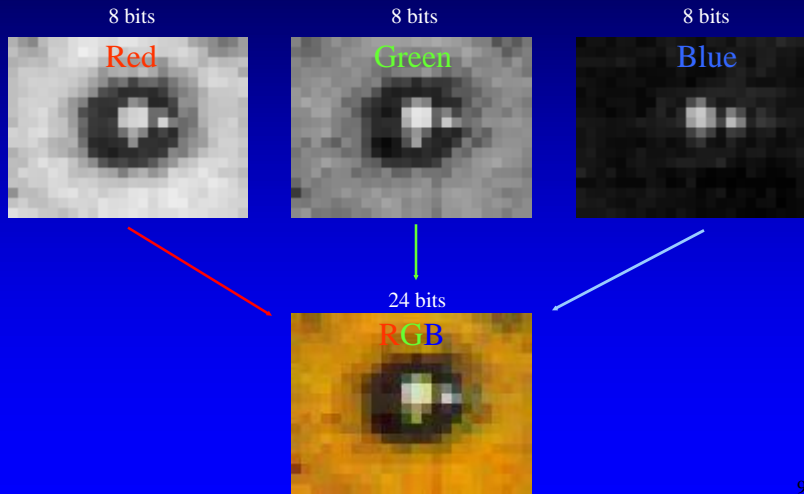


Not all colors are perceivable on all devices

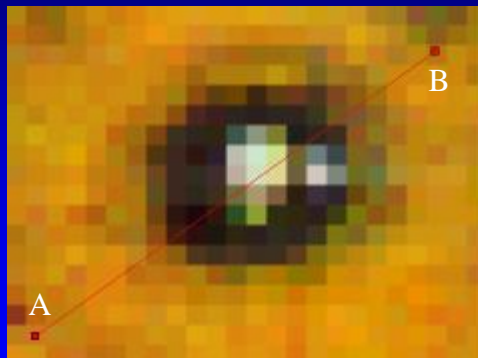
0.0 to 1.0
0 to 255 (8-bits)

24-bit graphics:
256 x 256 x 256 = 16,777,216 colors
256 shades of grey

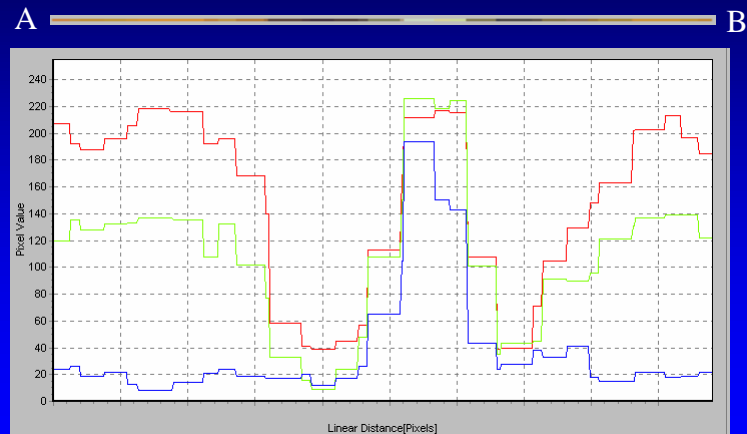
Pixels: Color



Pixel Profile of RGB Image



Pixel Profile of RGB Image



From www.efg2.com/Lab/ImageProcessing/PixelProfile.htm

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Introduction to Image Processing

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Color Issue: Too Many Bits

Pixels with Axon Scanner

16 bits Red (Cy5)

1111 0010 1101 0100 $\sqrt{}$



16 bits Green (Cy3)

1010 0101 1010 0101

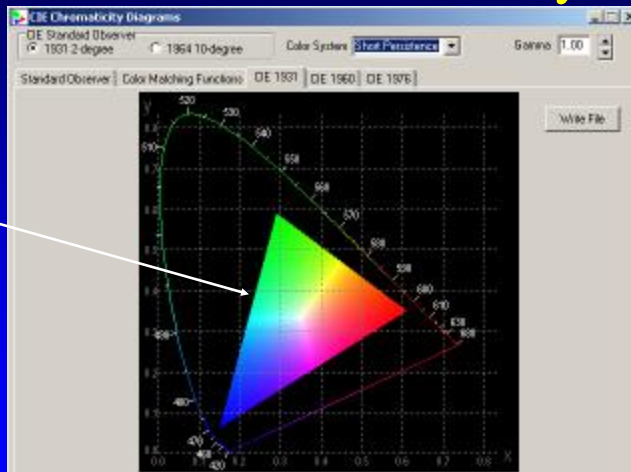
24-bit RGB Pixel: 1111 0010 1010 0101 0000 0000

Similar problem with 14-bit microscope images displayed in color.

Analysis of raw data may show details not seen on an image.

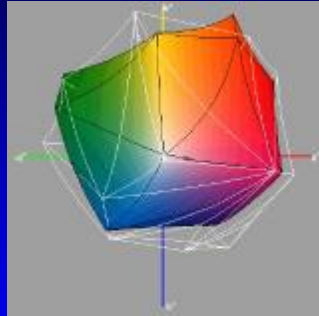
Color Issue: Fidelity

CRT
Gamut



Introduction to Image Processing

3D Color Gamut



From "Visualization of Expanded Printing Gamuts Using 3-Dimensional Convex Hulls"
by Karl Guyler, Hallmark Cards, Kansas City

Note: Color calibration can be used to minimize needless differences

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Introduction to Image Processing

- Pixels: Grey Scale
- Pixels: Color
- Color Issues
- **Image Manipulation**
 - Image Registration
 - Image Comparison
- Image Enhancement



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Introduction to Image Processing

Image Manipulation

Comparison without Registration

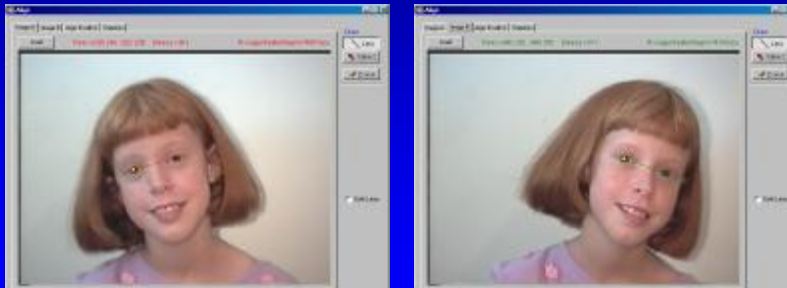


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Image Manipulation: Registration

Two registration points needed
if image has rotation



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Image Manipulation: Registration

Translation and Rotation:
Align second image with first



Image Manipulation: Comparison

Comparison with Alignment



Image Processing at CooperSurgical

Aceto-Positive Cervical Lesion Research

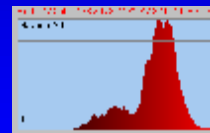


Original images from the web site of the
American Society for Colposcopy and Cervical Pathology
www.asccp.org

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Introduction to Image Processing

- Pixels: Grey Scale
- Pixels: Color
- Color Issues
- Image Manipulation
- Image Enhancement
 - Contrast Improvement
 - Spatial Filters



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Introduction to Image Processing

Image Enhancement: Contrast Improvement

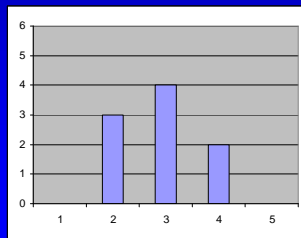
Original Image

2	3	3
3	2	4
2	4	3

Enhanced Image

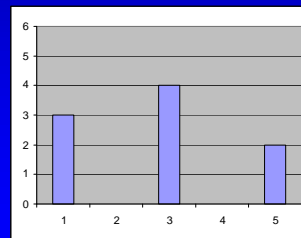
1	3	3
3	1	5
1	5	3

Original Histogram



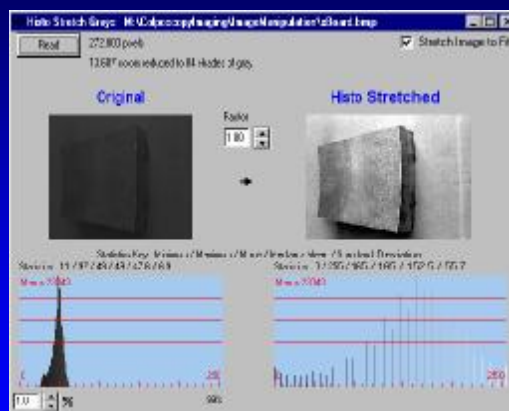
Stretch
→
to improve
contrast

Histostretched



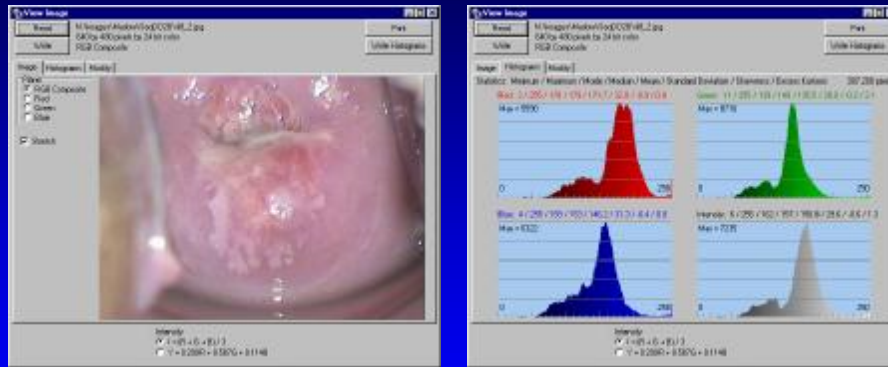
Introduction to Image Processing

Image Enhancement: Contrast Improvement



Introduction to Image Processing

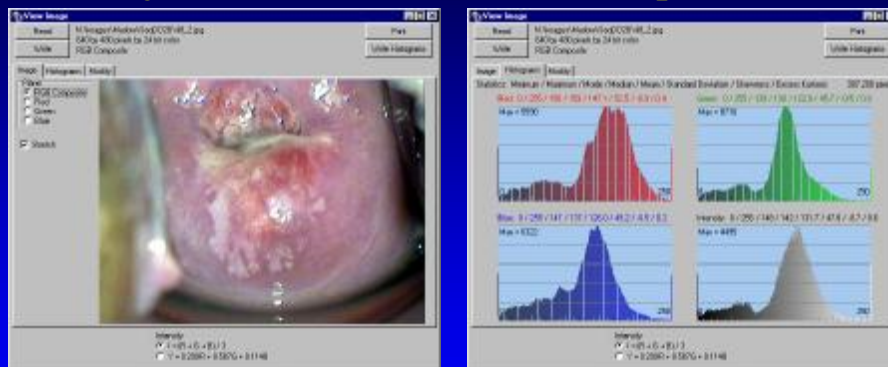
Image Enhancement: Contrast Improvement



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Image Enhancement: Contrast Improvement



Histogram stretching the color planes separately will yield an image with maximum contrast, but may introduce a color shift. The color shift here is negligible.

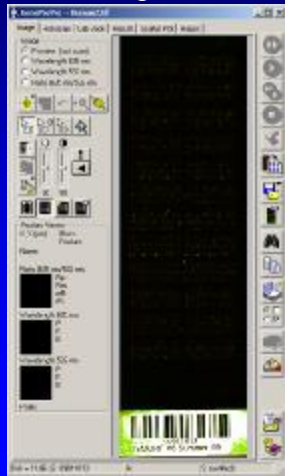
Usually, convert Red-Green-Blue (RGB) \rightarrow Hue-Saturation-Intensity (HSI), stretch I to yield I', and then convert HSI' \rightarrow R'G'B'

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Image Processing of Microarray Slides
Axon Sample: Human2 Preview

Original

Autoscale

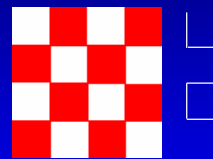
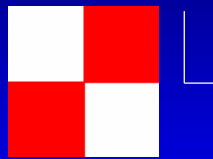


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Introduction to Image Processing
Spatial Frequency

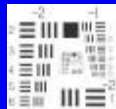
Frequency = 1

Frequency = 2



1 Cycle

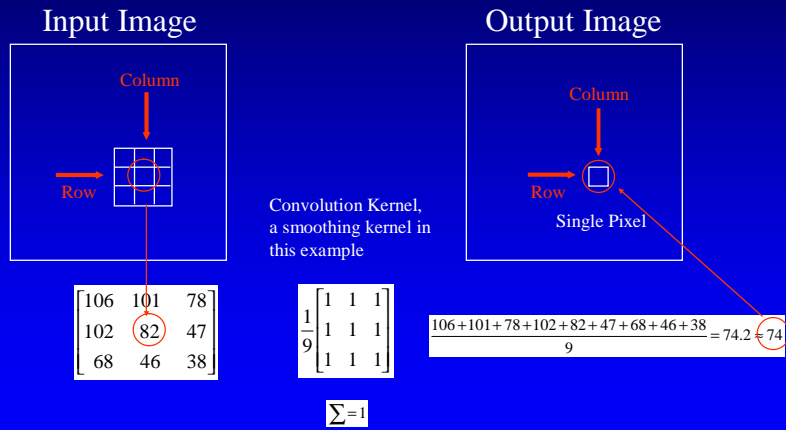
2 Cycles



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Spatial Filters: Convolution



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Introduction to Image Processing

Spatial Filters: Convolution

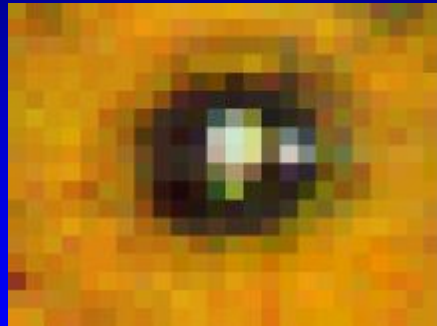
Type

Low-Pass Spatial Filter	Smooth	$\frac{1}{9} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	$\Sigma=1$
High-Boost Spatial Filter	Sharpen	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	$\Sigma=1$
Laplace Filter	Edge Enhance	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	$\Sigma=0$

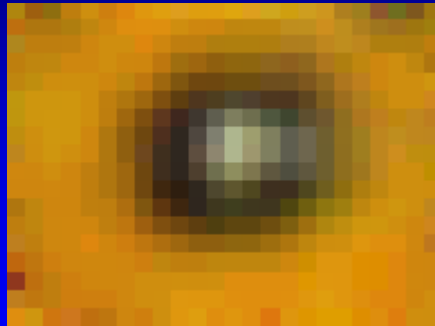
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Introduction to Image Processing
Spatial Filter: Smooth

Original



Enhanced



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Introduction to Image Processing
Spatial Filter: Sharpen (original)



Picture Copyright © Adaptec, Used with Permission

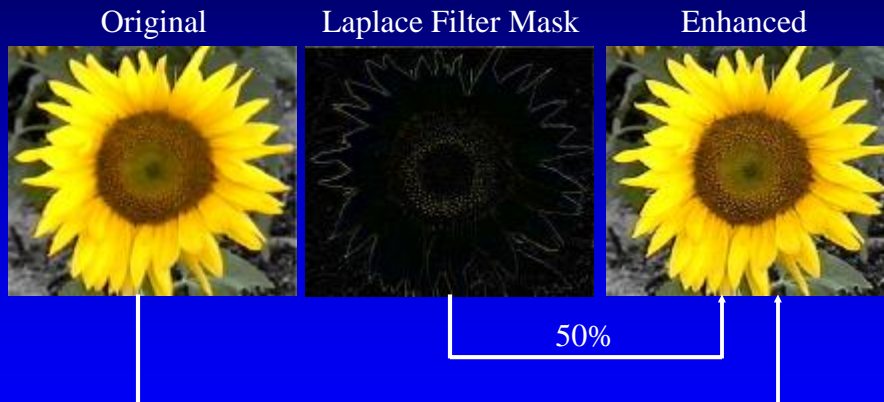
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Introduction to Image Processing
Spatial Filter: Sharpen (enhanced)



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Introduction to Image Processing
Spatial Filter: Edge Enhance



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Introduction to Image Processing

- Pixels: Grey Scale



- Pixels: Color



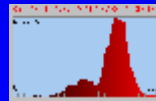
- Color Issues



- Image Manipulation



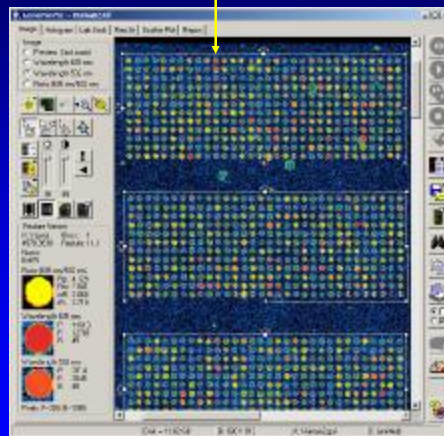
- Image Enhancement



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Image Processing of Microarray Slides

Axon Example: Single Feature



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