



VISÃO COMPUTACIONAL



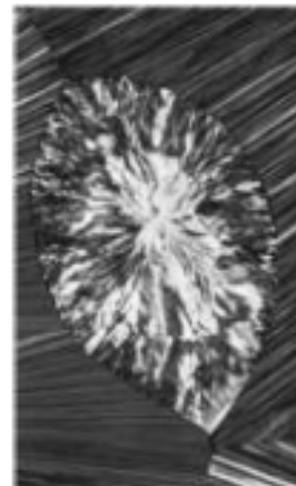
Fundamentos de Imagem

Aquisição de Imagens Digitais

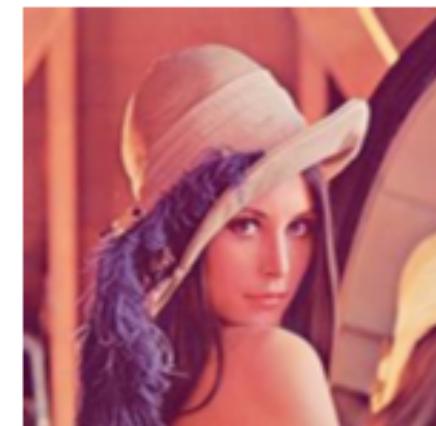
► Luz Visível



microscópio óptico



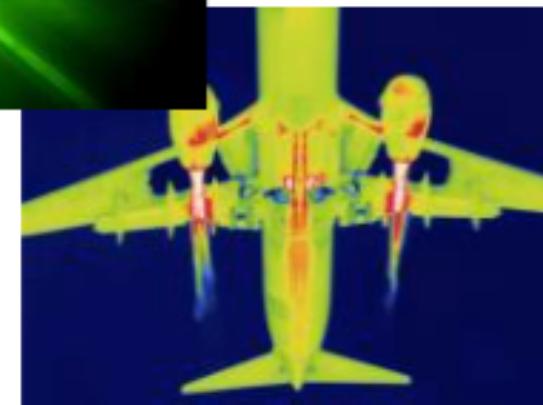
colesterol



Aquisição de Imagens Digitais

► Luz infravermelha

- Visão noturna: infravermelho curto (0.75-1.4um)
- Imagem termal: infravermelho longo (8-15um)

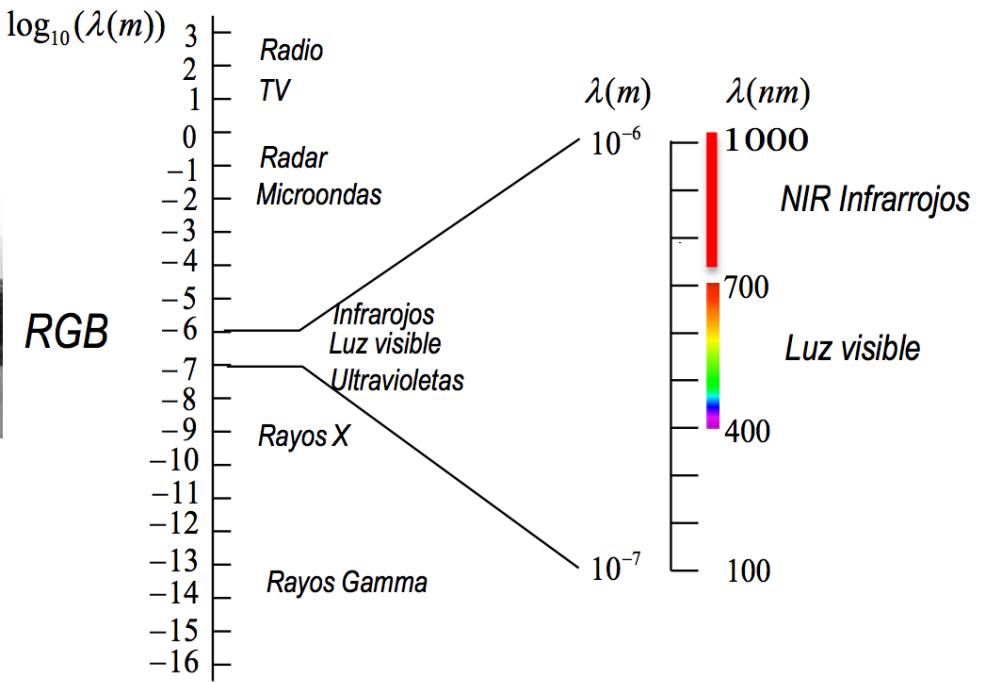


Aquisição de Imagens Digitais

▷ Luz Ultravioleta



NIR

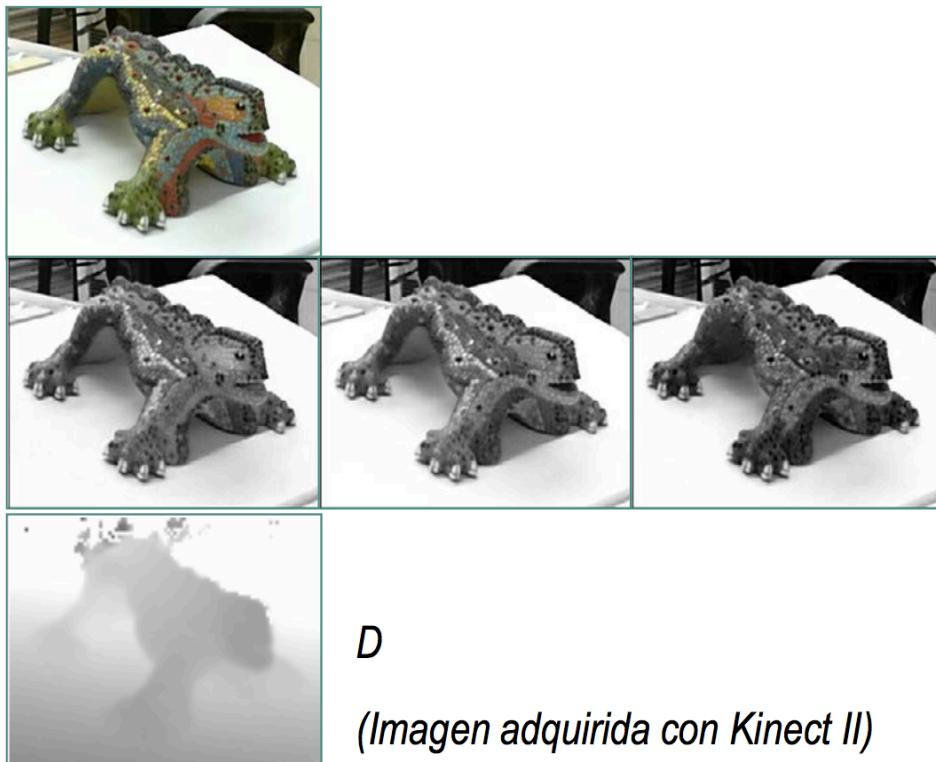


Credits: RGB-NIR Scene Dataset at ivrl.epfl.ch

Imagens Térmicas



Imagens de Profundidade (RGBD)



Aquisição de Imagens Digitais

▷ Raio X

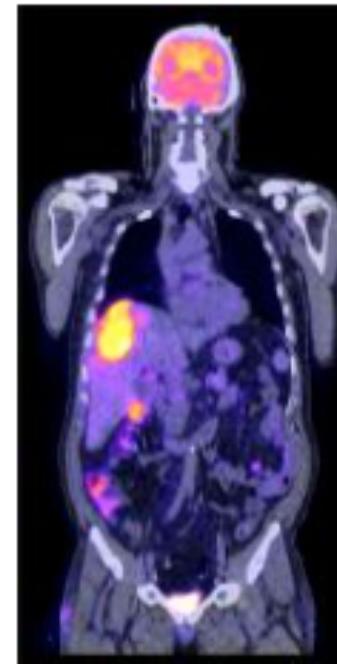


Aquisição de Imagens Digitais

▷ Raio Gama



PET scan



Aquisição de Imagens Digitais

▷ Micro-ondas



radar imageador

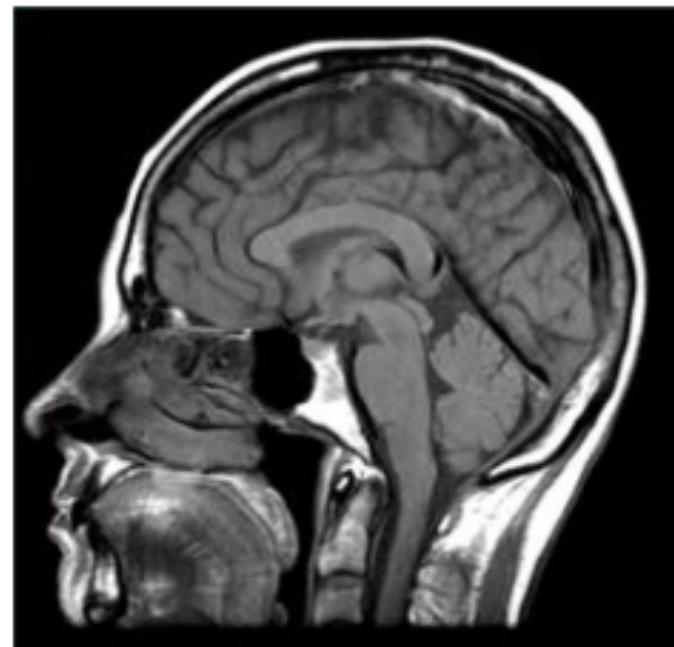


Aquisição de Imagens Digitais

▷ Ondas de rádio



ressonância magnética



Aquisição de Imagens Digitais

▷ Ultrassom

- Imageamento acústico



Aquisição de Imagens Digitais

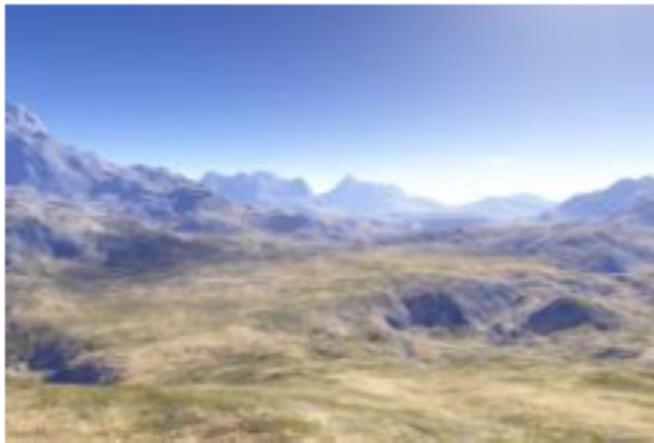
▷ Microscópio eletrônico



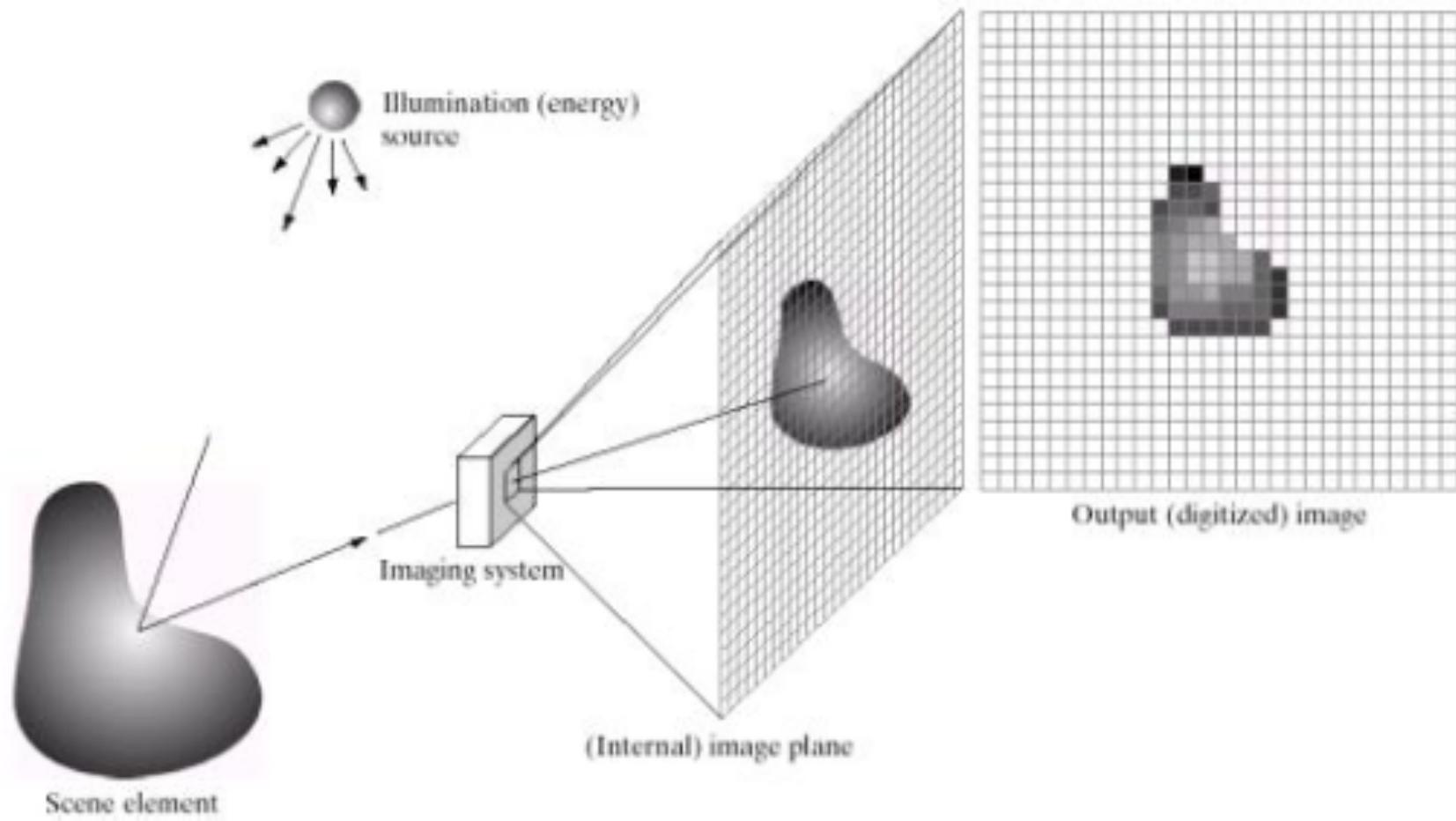
verme

Aquisição de Imagens Digitais

▷ Computação Gráfica

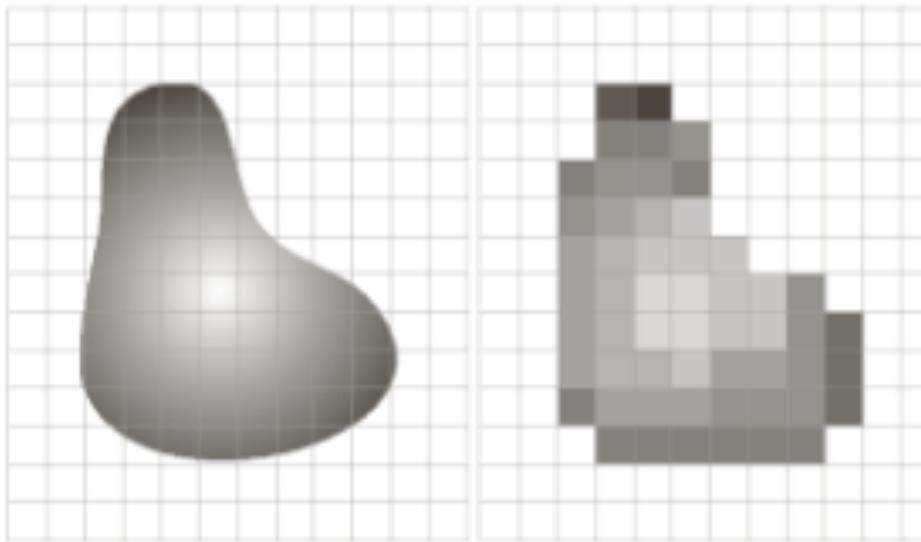


Aquisição de Imagens Digitais

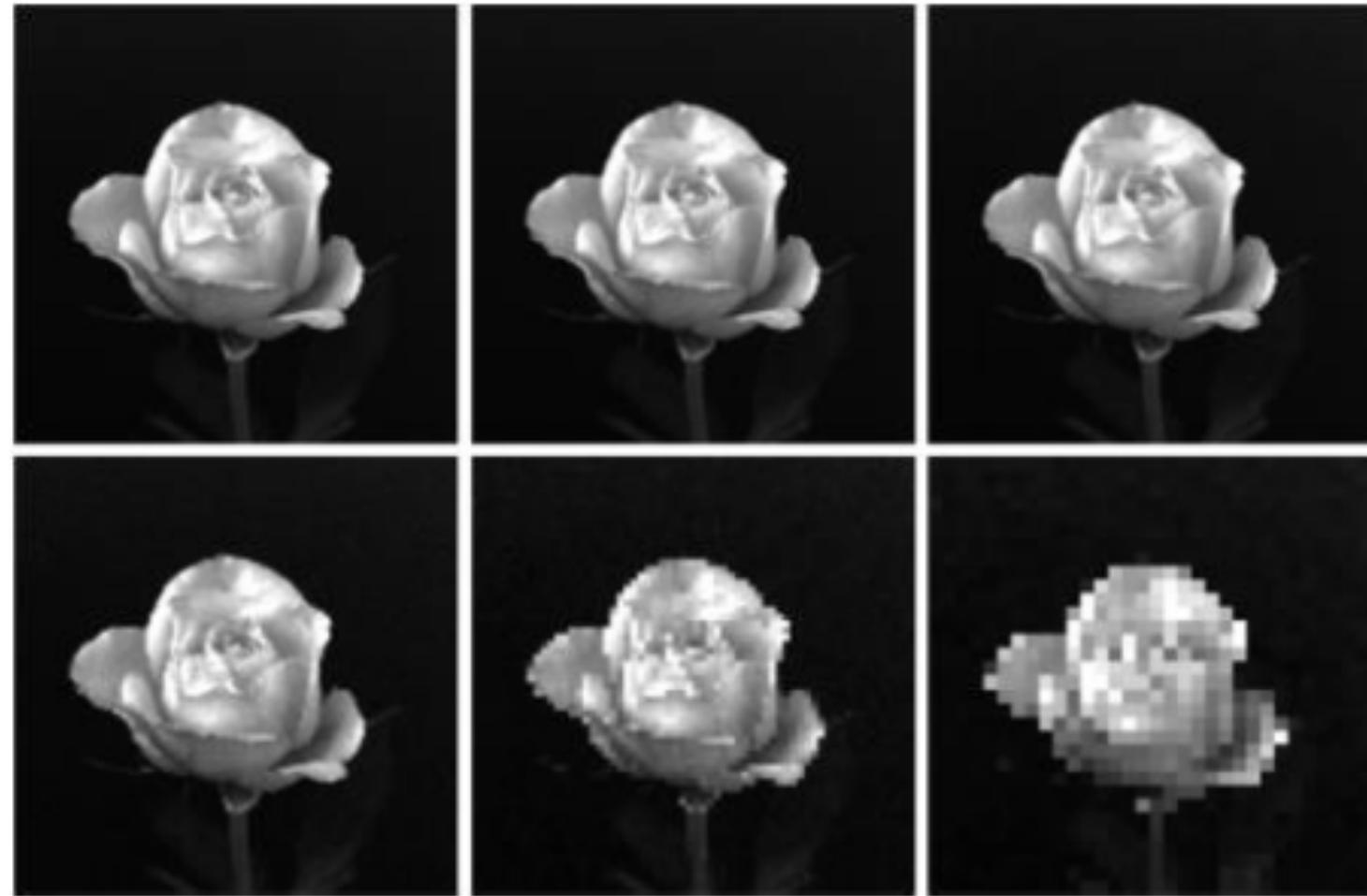


Amostragem e Quantização de Imagens

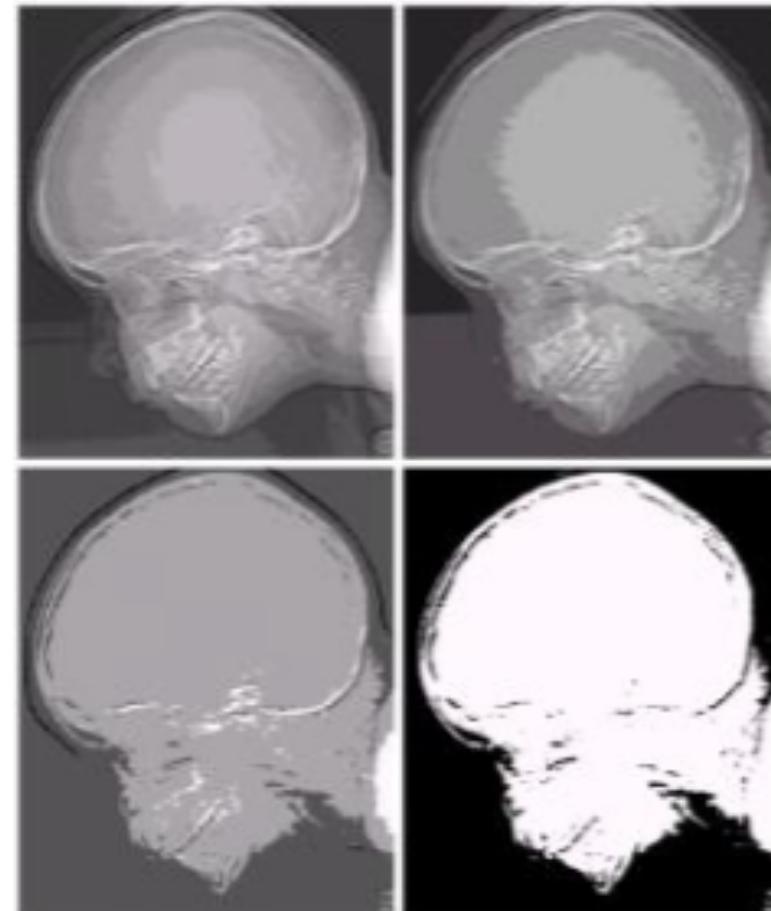
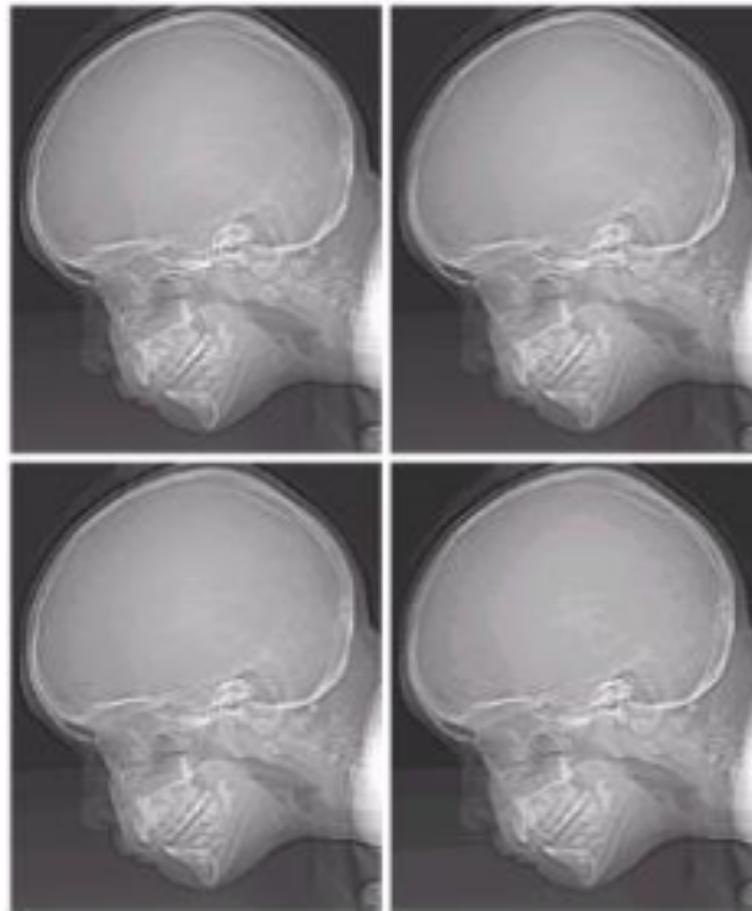
- ▷ Conversão de dados contínuos para formato digital:
- ▷ **Amostragem:** digitalização dos valores de coordenadas;
 - Diferentes coordenadas x e y
- ▷ **Quantização:** digitalização dos valores de amplitude;
 - Ex: diferentes níveis de cinza



Amostragem



Quantização



A wide-angle photograph of a coastal scene at sunset. The sky is filled with dramatic, billowing clouds, half in deep blue shadow and half bathed in the intense orange and yellow light of the setting sun. Below the horizon, a rocky cliff or headland is silhouetted against the bright water. The ocean waves are a mix of white foam and golden sunlight, crashing onto a sandy beach in the foreground. The overall atmosphere is one of natural beauty and tranquility.

O que é uma imagem?

Imagem é uma matriz de números



62	62	63	64	65	66	67	67	69	70	71	72	72	73	73	73	72	72	71	70	69	67	66	66	66	65	63	62	61	60	60		
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48	50	48	52	19	13	33	36	18	18	36	49	51	54	47	47	49	46	46	49	49	47	44	53	44	48	44	46	46	46	45		

Aqui são 256 tons de cinza!! (e não apenas 50)

Pixel

▷ Coordenada

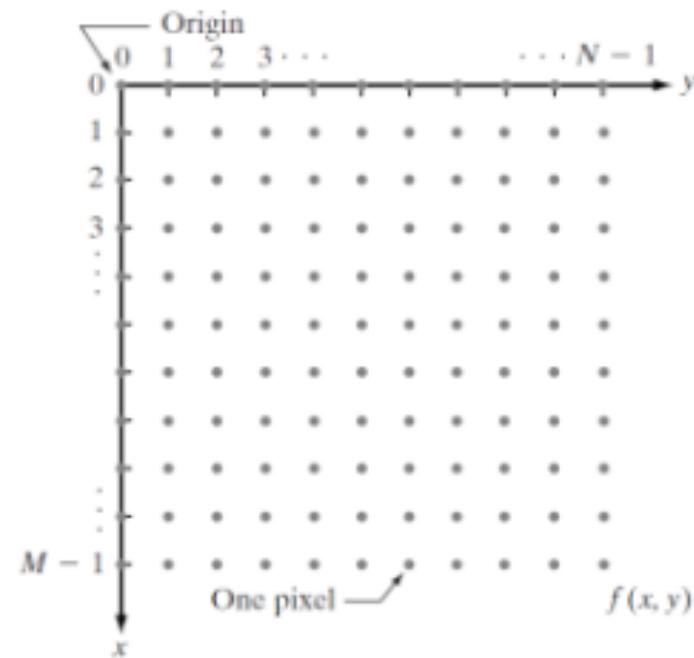
▷ Valor (Cor)



Representação de Imagens Digitais

▷ Matriz bidimensional

- Resolução: quantidade de linhas e colunas

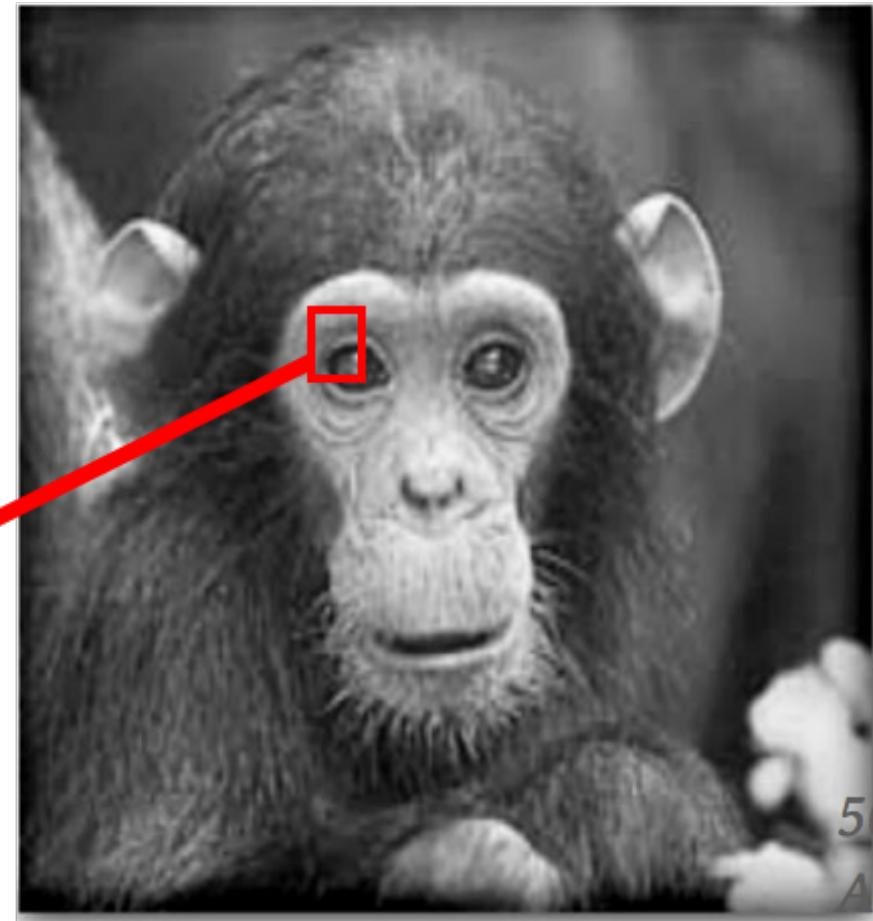


Largura

520

$j=1$

$i=1$



Itensidade: [0,255]



$im[176][201]$ tem valor
164

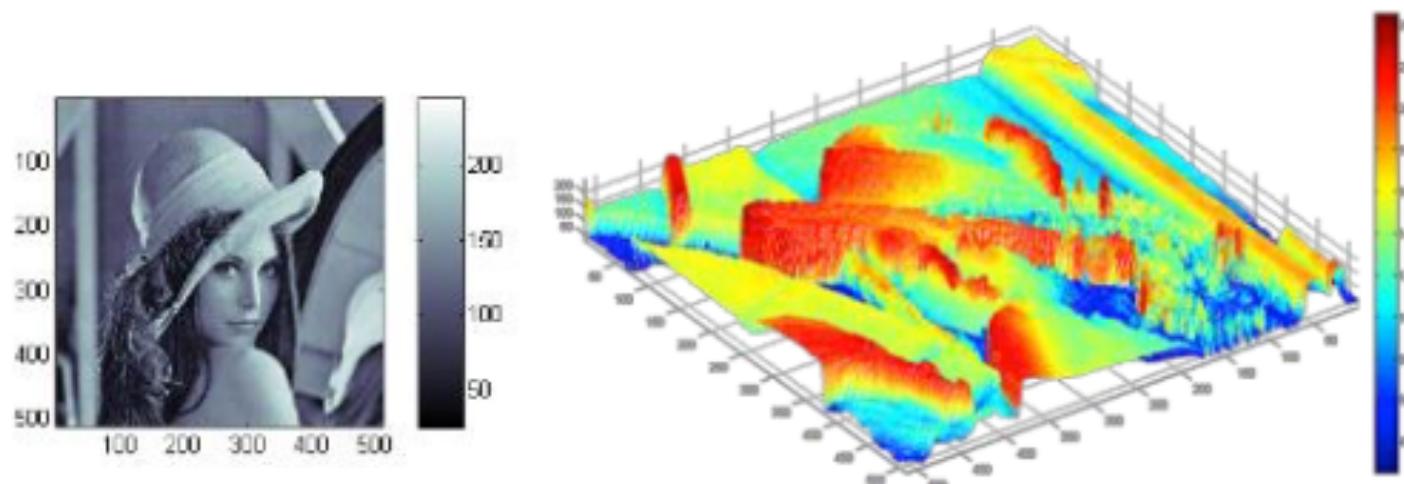
$im[194][203]$ temo valor 37

Altura

Imagen Digital

► Função discreta bidimensional $f(x,y)$

- x e y : coordenadas espaciais
- Amplitude de f em cada ponto (x,y) : intensidade ou nível de cinza



Fundamentos de Cor

- ▷ Cor é nossa percepção de diferentes comprimentos de onda de luz;
- ▷ A luz é um fenômeno físico, mas a cor depende da interação da luz com o sistema visual.

Sistema Computacional de Cores

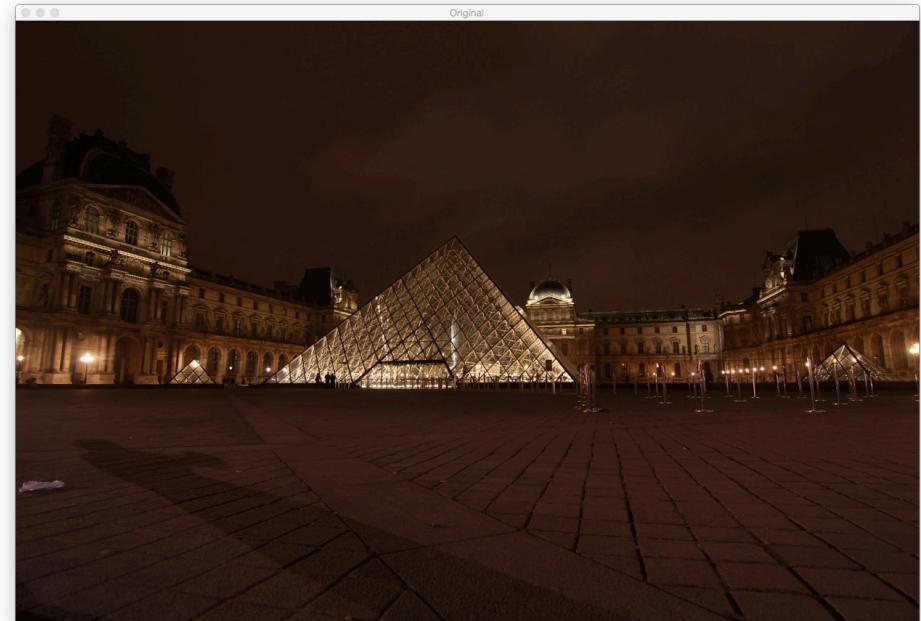
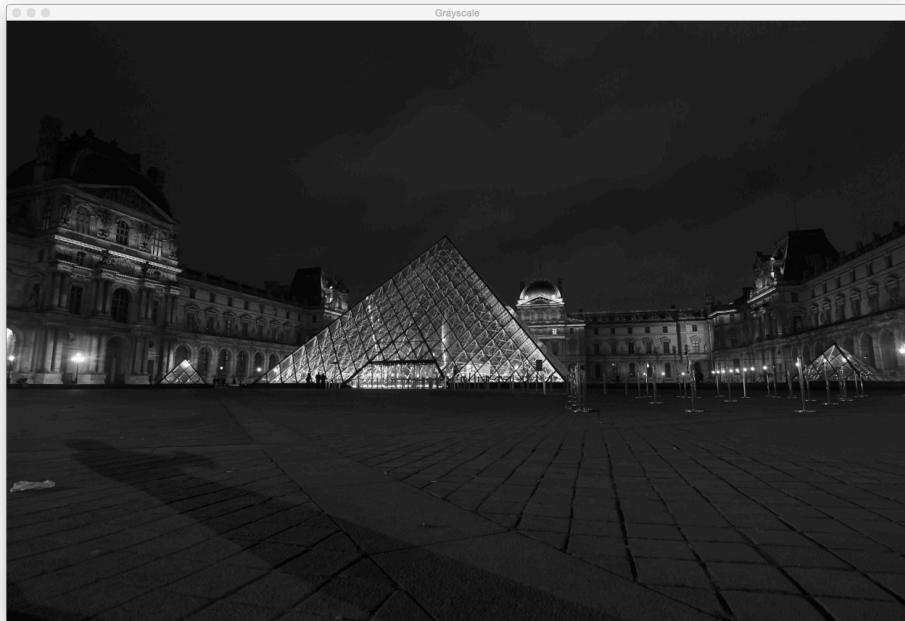
► Cada tom (R, G e B) é armazenado em 1B

► Resolução de cor:

- 2 cores (1 bit)
- 16 cores (4 bits)
- 256 cores (8bits = 1 byte)
- 16 milhões de cores (24 bits = 3bytes)

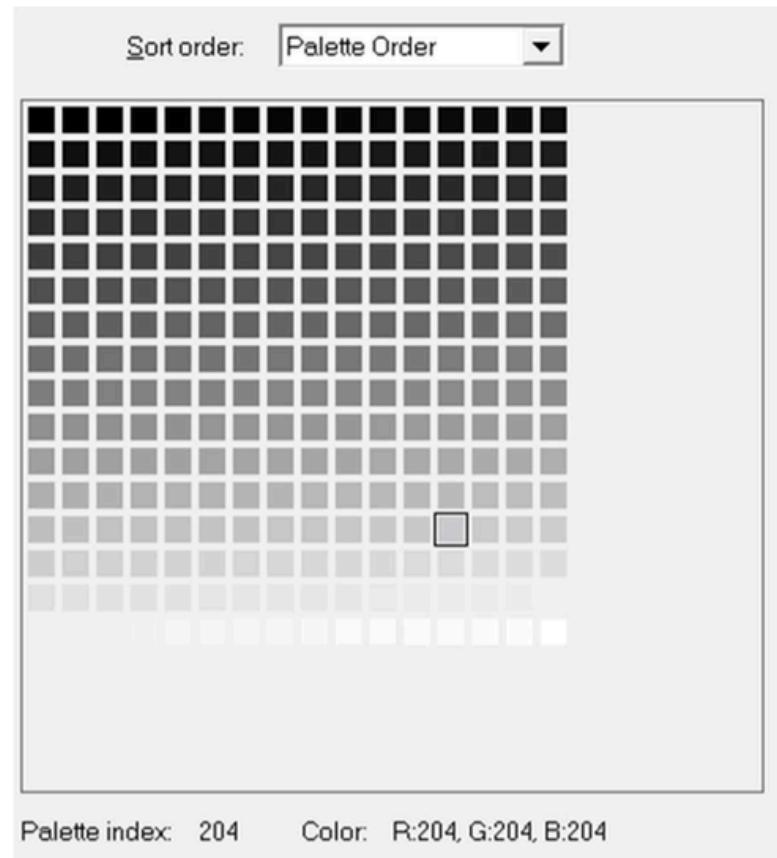
Paleta de
Cores

Tons de Cinza x Cores



Cor é importante para quais problemas?

Tons de cinza



Tons de Cinza



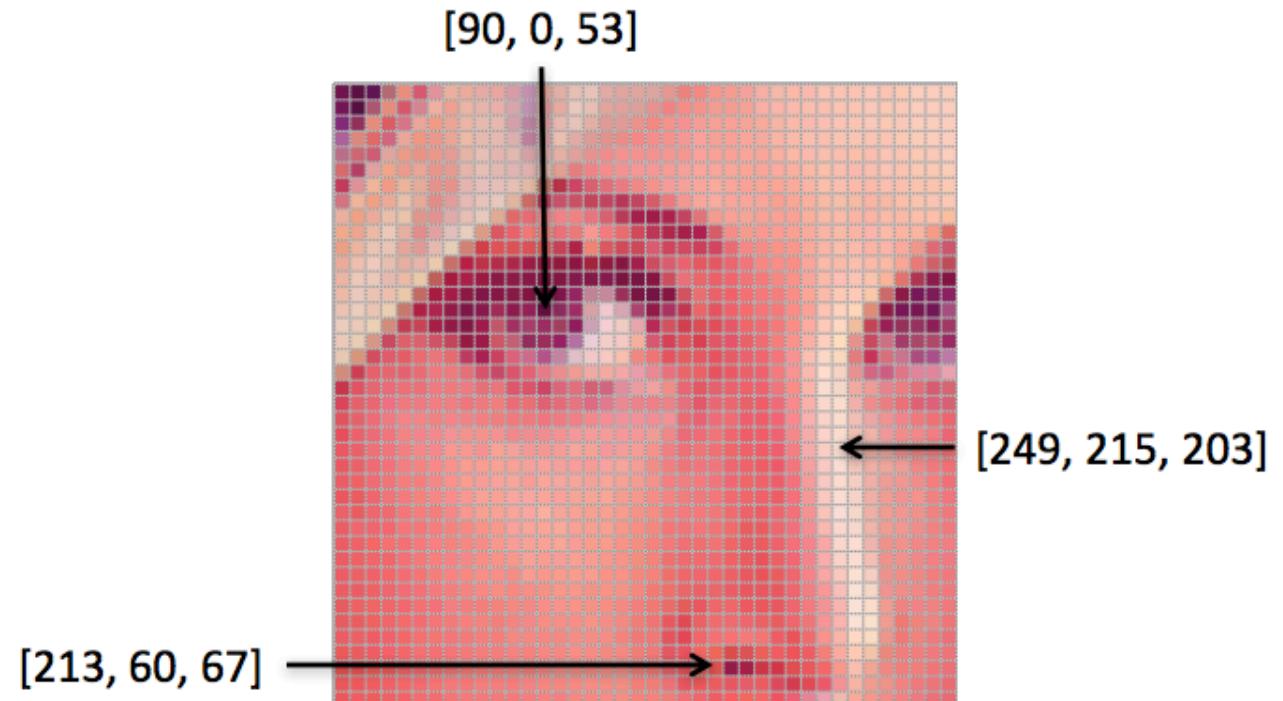
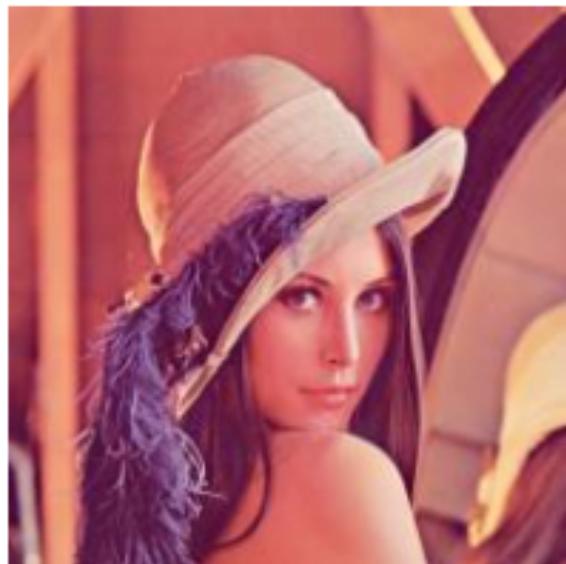
62 62 63 64 65 66 67 67 69 70 71 72 72 73 73 73 72 72 71 70 69 67 66 66 66 65 63 62 61 60 60
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61 62 63 64 66 66 68 68 69 70 71 72 73 73 73 72 72 71 71 69 68 67 66 66 65 65 64 63 62 61 61
61 63 64 64 66 67 68 68 68 69 70 71 71 73 73 74 73 73 73 71 70 69 68 66 66 65 64 63 62 61 61 60
61 63 64 65 67 68 69 69 70 70 71 71 72 55 53 69 72 72 71 71 70 69 68 67 66 65 64 63 62 60 60 60
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63 65 66 66 68 68 69 70 71 71 72 18 4 4 7 8 66 71 70 69 68 68 67 66 65 64 63 61 59 59 58
63 65 67 67 68 69 69 70 71 71 72 64 4 27 24 54 33 29 52 64 68 68 67 66 65 64 63 62 61 59 58 58
64 65 66 66 68 69 70 71 71 24 24 12 17 24 48 60 37 43 36 52 66 68 67 66 65 64 63 61 60 59 58 57
65 66 67 67 68 69 71 59 6 6 6 5 34 36 12 47 34 17 29 54 43 63 67 66 65 64 63 62 60 59 58 57
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0

255

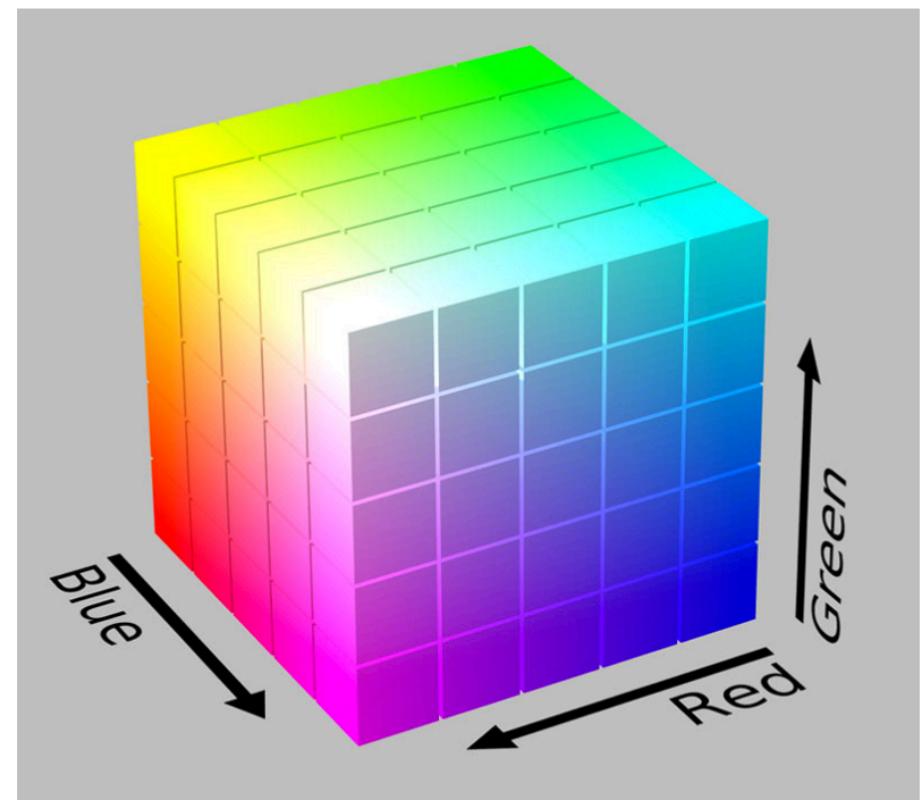
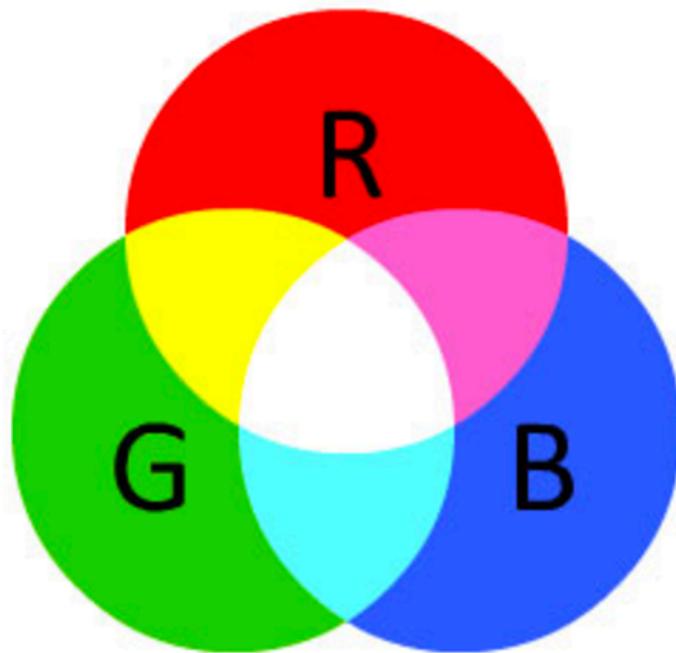
Imagen em Cores

- ▷ Diferentes modelos
- ▷ RGB, LAB, CMY, HSV: três canais por pixel
- ▷ CMYK: quatro canais por pixel



Espaços de Cores - RGB

- ▷ No openCV é definido como BGR
- ▷ Espaço de cor aditivo
- ▷ Canais: R,G,B



RGB

- ▷ Cor preta: (0,0,0)
 - Ausência de luz
- ▷ Cor Branca: (255, 255, 255)
 - Quantidade máxima das três cores
- ▷ Tons de Cinza: (Diagonal entre (0,0,0) e (255,255,255))



RGB



Red



Green



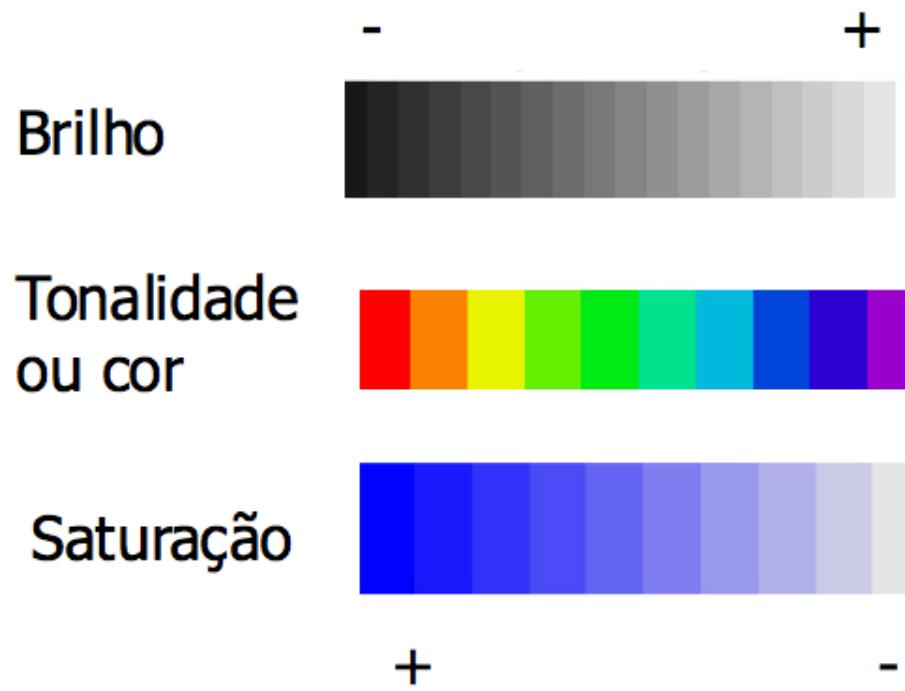
Blue

Espaço de Cores - HSV

▷HSV

- Hue (Matiz) – Valor de Cor (0 – 179)
- Saturation (Saturação) – "vibração" da cor(0-255)
 - O quanto pura é a cor
- Value (Brilho) –(0-255)
 - O quanto branca é a cor

▷Útil para detectar cores em visão computacional



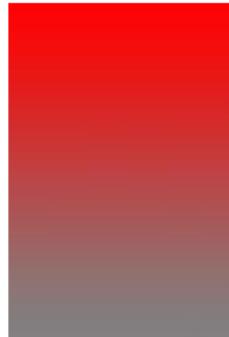
Matiz (Hue)

- ▷ Propriedade que permite classificar e distinguir uma cor
- ▷ Cor pura



Saturação

▷ Grau de pureza da cor

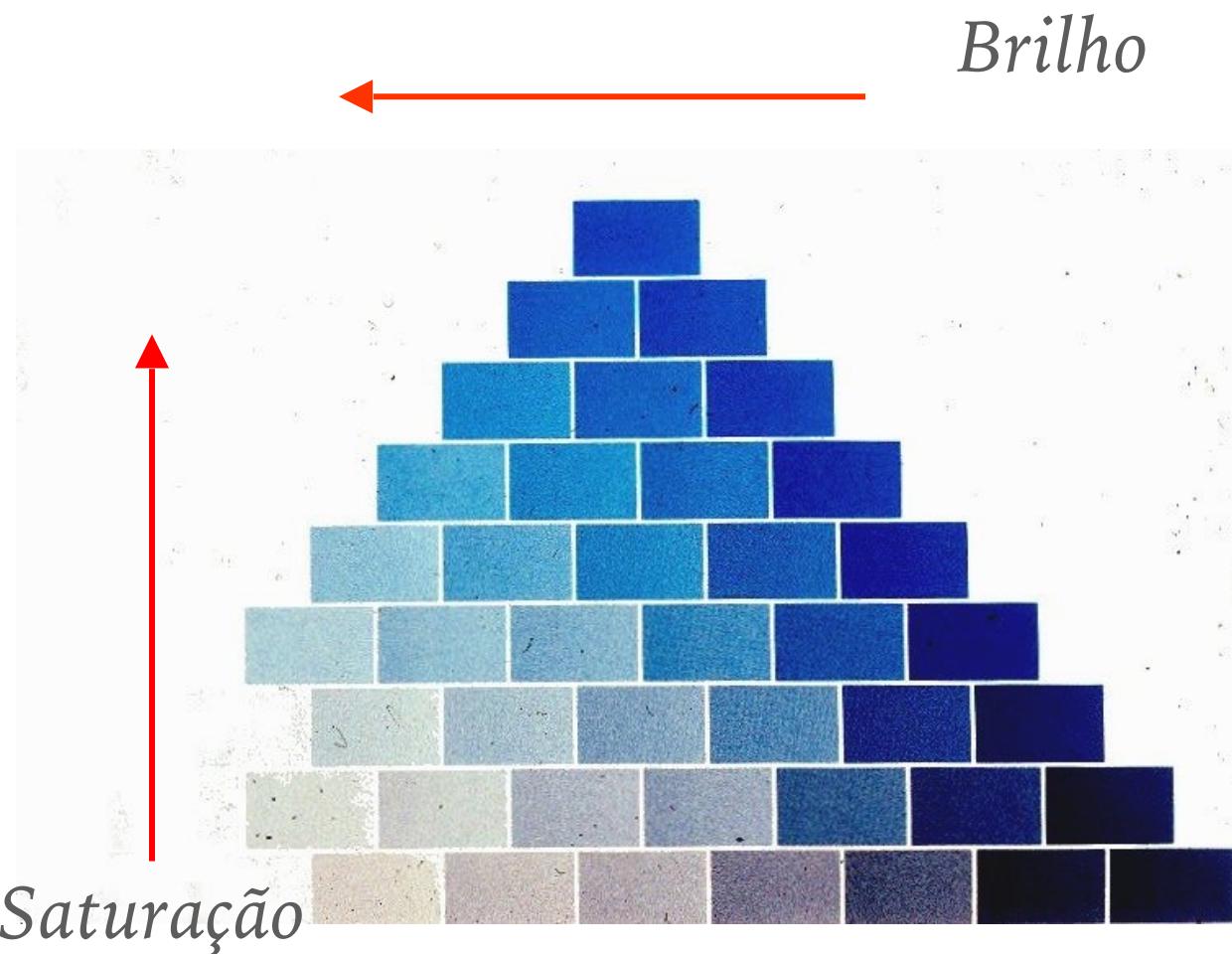


Value (Brilho)

► Canal acromático referente à quantidade de luz emitida ou refletida

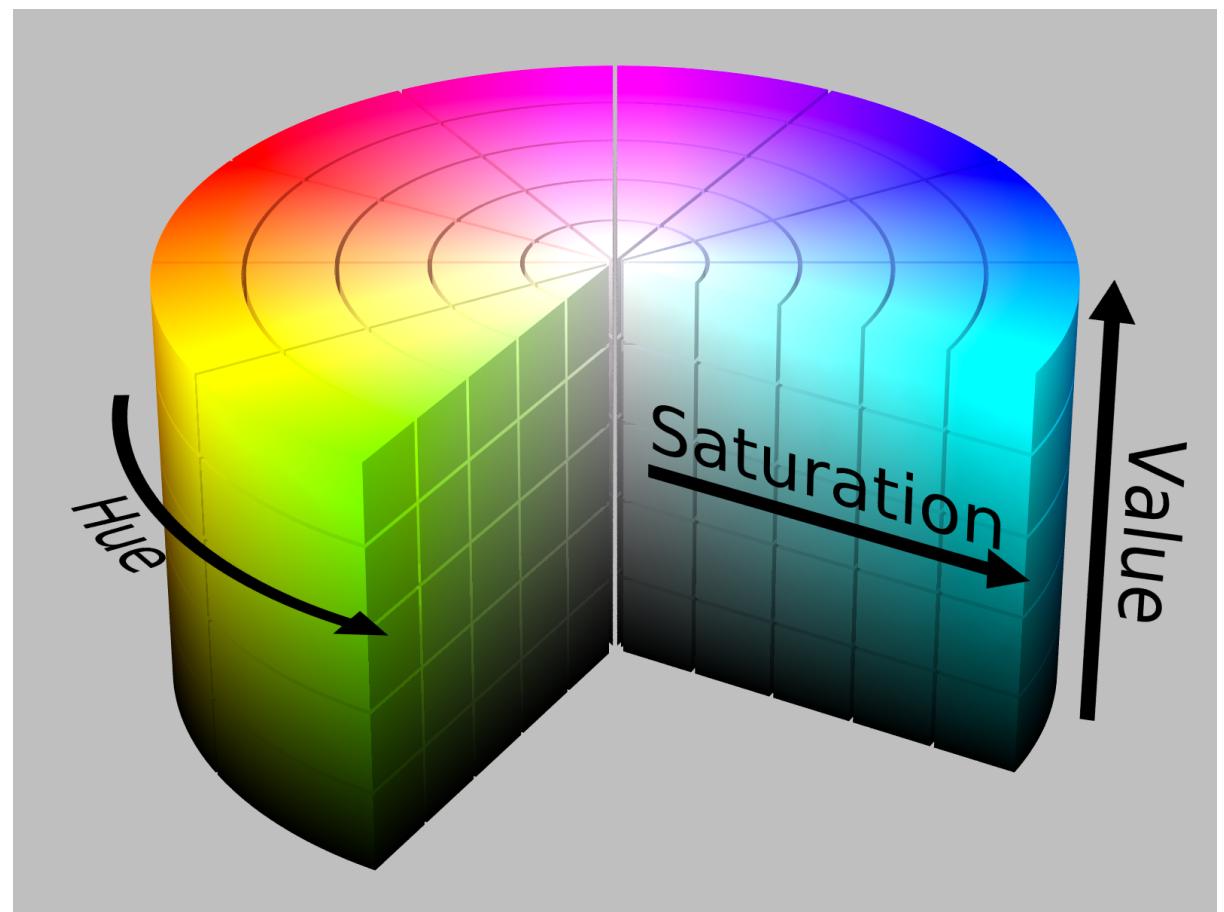
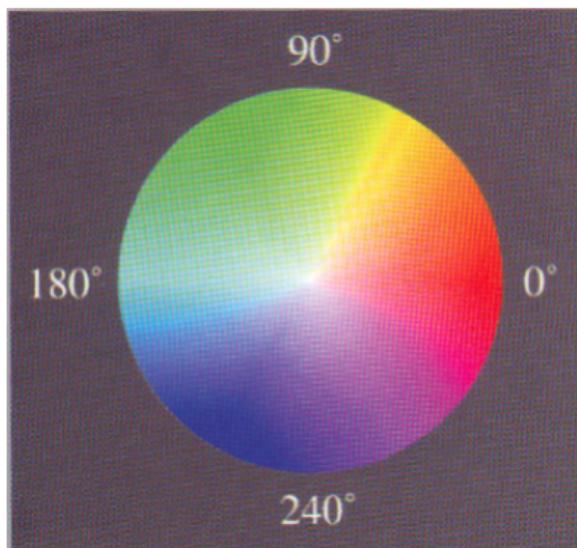


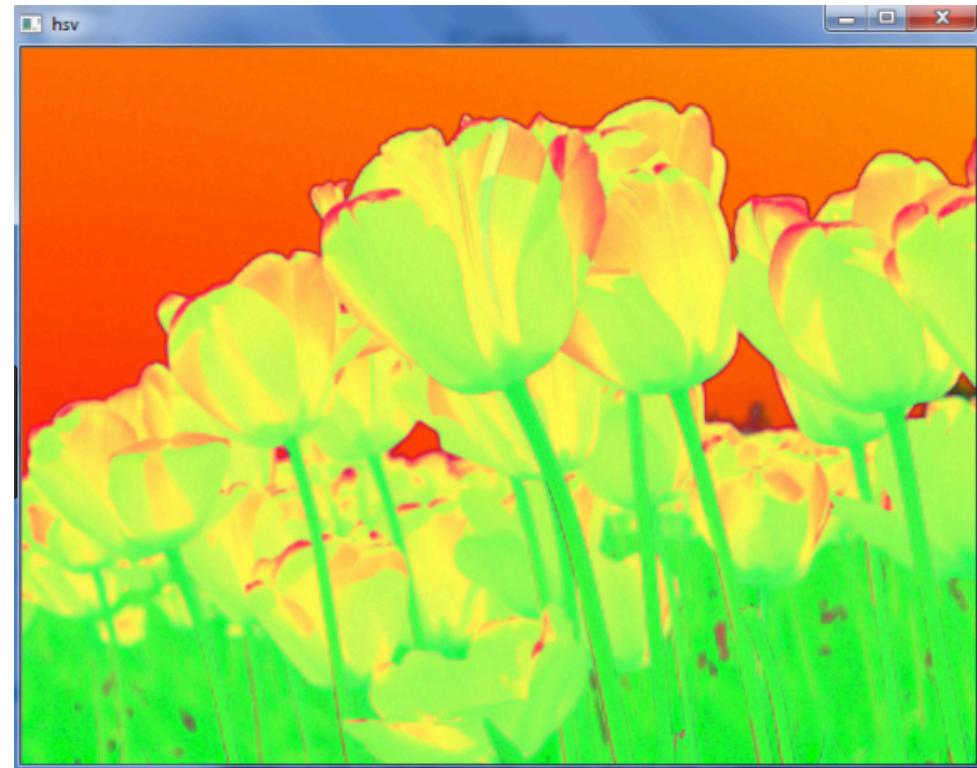
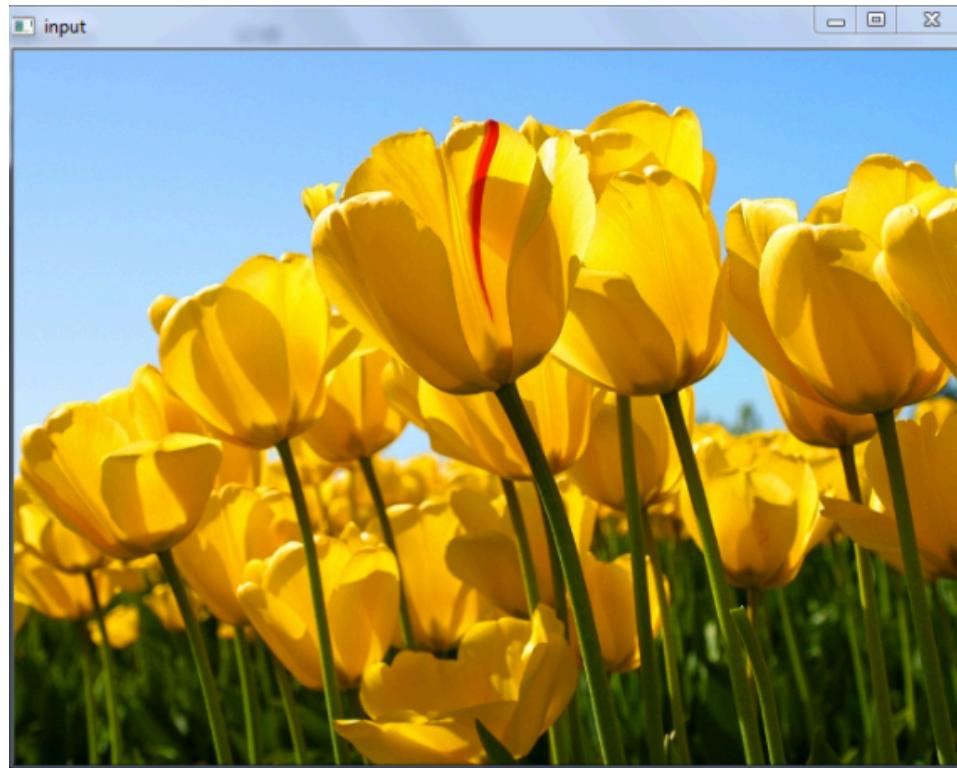
BRILHO VERSUS SATURAÇÃO



Representação

- ▷ Sólido de representação do HSV

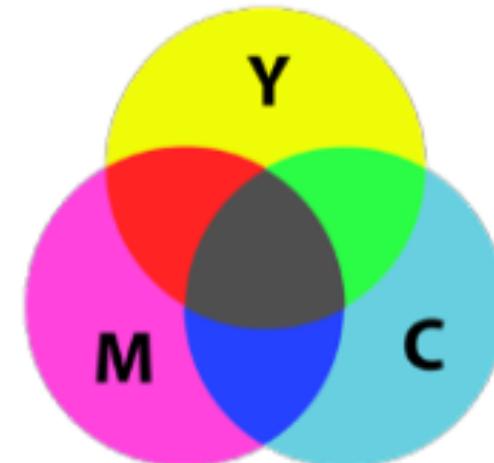






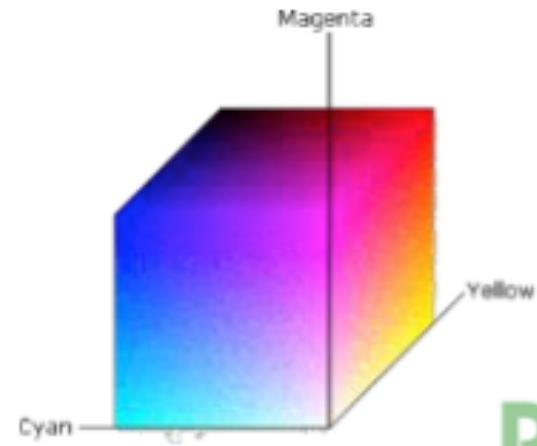
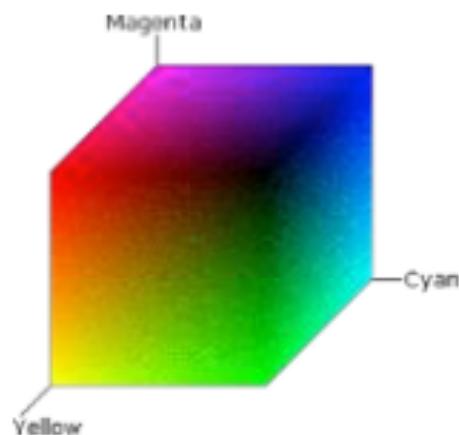
CMY

- ▷ Modelo subtrativo
- ▷ Mistura de pigmentos de diferentes cores
- ▷ Pigmentos subtraem um determinado espectro de luz e refletem um outro espectro, o que determina a sua cor
- ▷ Cores primárias de pigmento
 - Ciano (cyan, C)
 - Magenta (magenta, M)
 - Amarelo (yellow, Y)



CMY

- ▷ Complementar ao RGB
 - $(C, M, Y) = (255 - R, 255 - G, 255 - B)$
- ▷ Cor preta: (255, 255, 255)
 - Mistura da quantidade máxima dos três pigmentos
- ▷ Cor branca: (0,0,0)
 - Ausência de pigmento



CMYK

▷ Canal específico para a cor preta (K)

▷ Conversão CMY -> CMYK

▷ $K = \min(C, M, Y)$

▷ $C' = C - K$

▷ $M' = M - K$

▷ $Y' = Y - K$

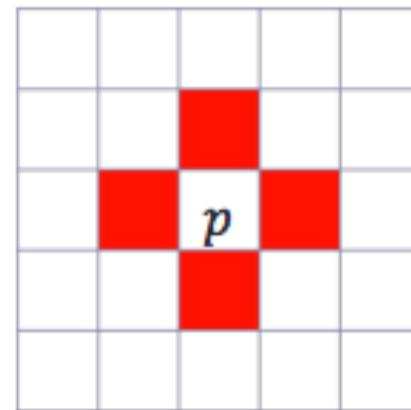


Relacionamento entre Pixels



Relacionamento entre Pixels

- ▷ Dado um pixel p com coordenadas (x,y)
- ▷ 4-vizinhança de p : vizinhos verticais e horizontais
- ▷ $N_4(p) = \{(x+1,y), (x-1,y), (x,y+1), (x,y-1)\}$

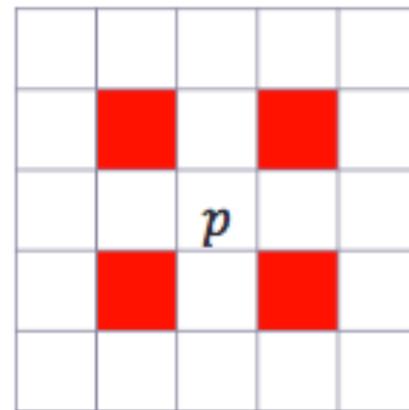


Relacionamento entre Pixels

▷ Dado um pixel p com coordenadas (x, y)

▷ $N_d(p)$: vizinhos diagonais de p

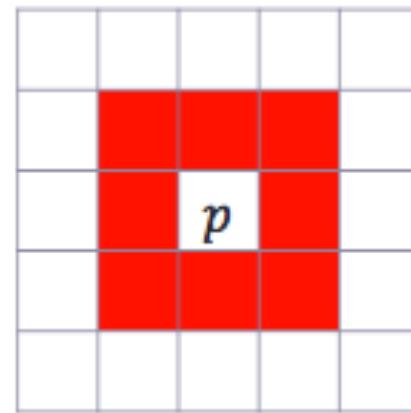
$$N_d(p) = \{(x+1, y+1), (x+1, y-1),\}$$
$$\{(x-1, y+1), (x-1, y-1)\}$$



Relacionamento entre Pixels

- ▷ Dado um pixel p com coordenadas (x,y)
- ▷ 8-vizinhança de p : vizinhos verticais, horizontais e diagonais

$$N_8(p) = N_4(p) \cup N_D(p)$$



Relacionamento entre Pixels

▷ Dado um conjunto V de níveis de cinza

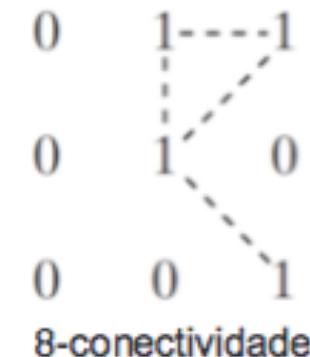
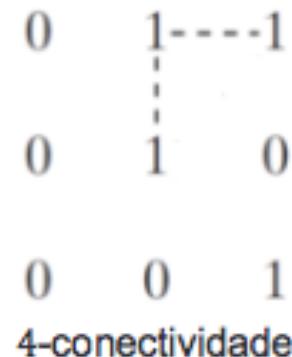
- Ex:

- Em uma imagem binária, $V = \{1\}$
- Em uma imagem em tons de cinza, $V = \{32, 33, \dots, 63, 64\}$

p e q com valores de V são 4-conectados se $q \in N_4(p)$

p e q com valores de V são 8-conectados se $q \in N_8(p)$

0	1	1
0	1	0
0	0	1



Relacionamento entre Pixels

- ▷ Distância euclidiana entre p e q:

$$D_e(p, q) = \sqrt{(x - s)^2 + (y - t)^2}$$

Relacionamento entre Pixels

- ▷ Distância quarteirão (city-block) entre p e q:

$$D_4(p, q) = |x - s| + |y - t|$$

$$\begin{array}{ccccc} & & 2 & & \\ & 2 & 1 & 2 & \\ 2 & 1 & 0 & 1 & 2 \\ & 2 & 1 & 2 & \\ & & 2 & & \end{array}$$

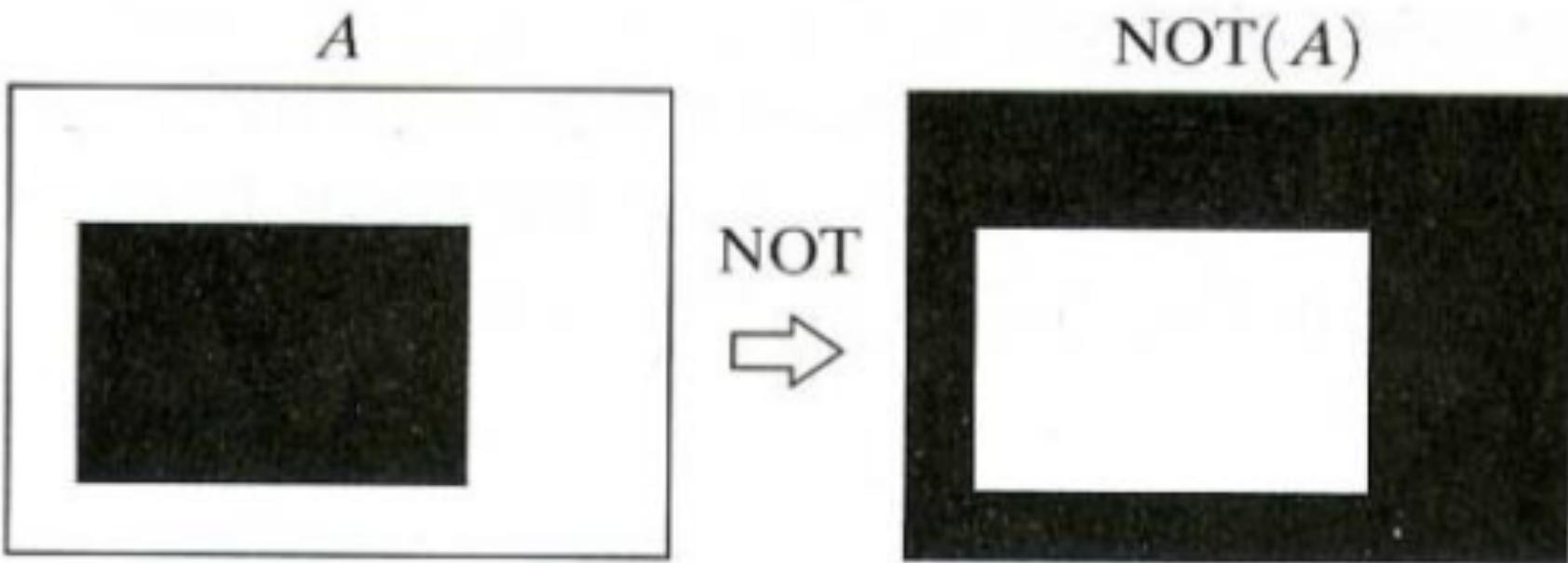
Relacionamentos entre Pixels

- ▷ Distância xadrez entre p e q:

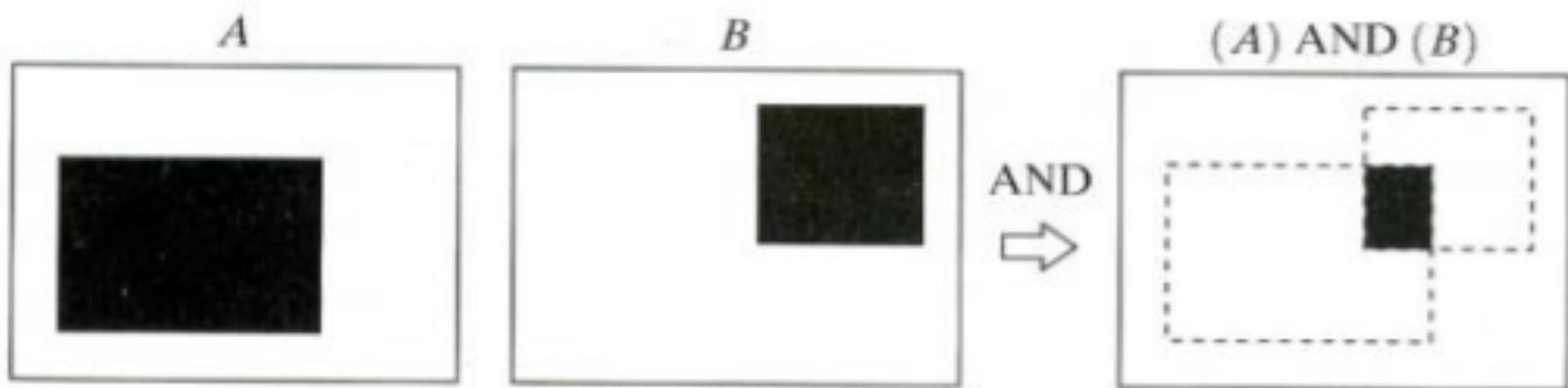
$$D_8(p, q) = \max(|x - s|, |y - t|)$$

2	2	2	2	2
2	1	1	1	2
2	1	0	1	2
2	1	1	1	2
2	2	2	2	2

Operações Lógicas pixel a pixel



Operações Lógicas pixel a pixel



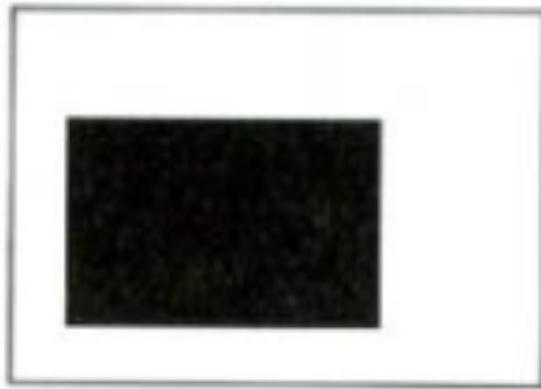
Operações Lógicas pixel a pixel



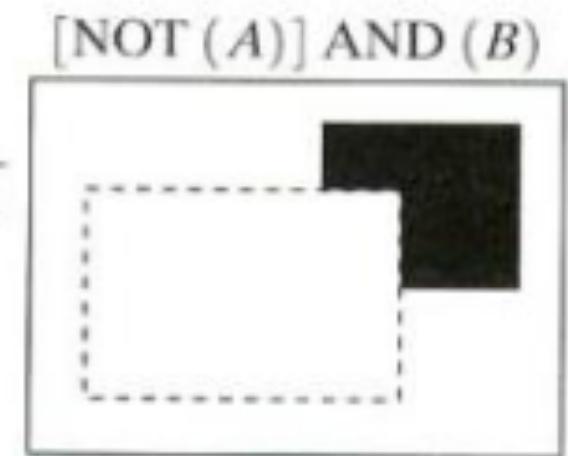
Operações Lógicas pixel a pixel



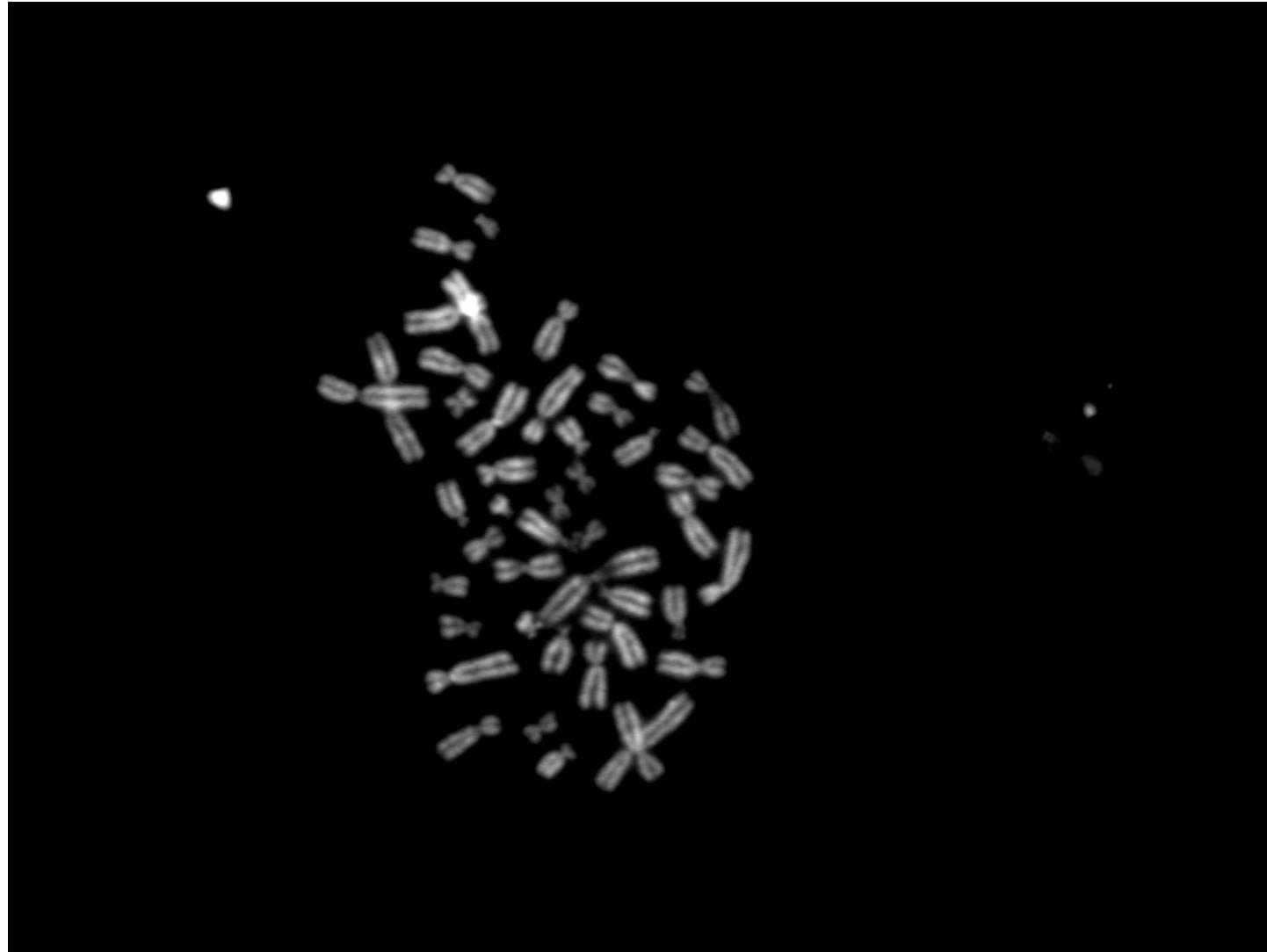
Operações Lógicas pixel a pixel



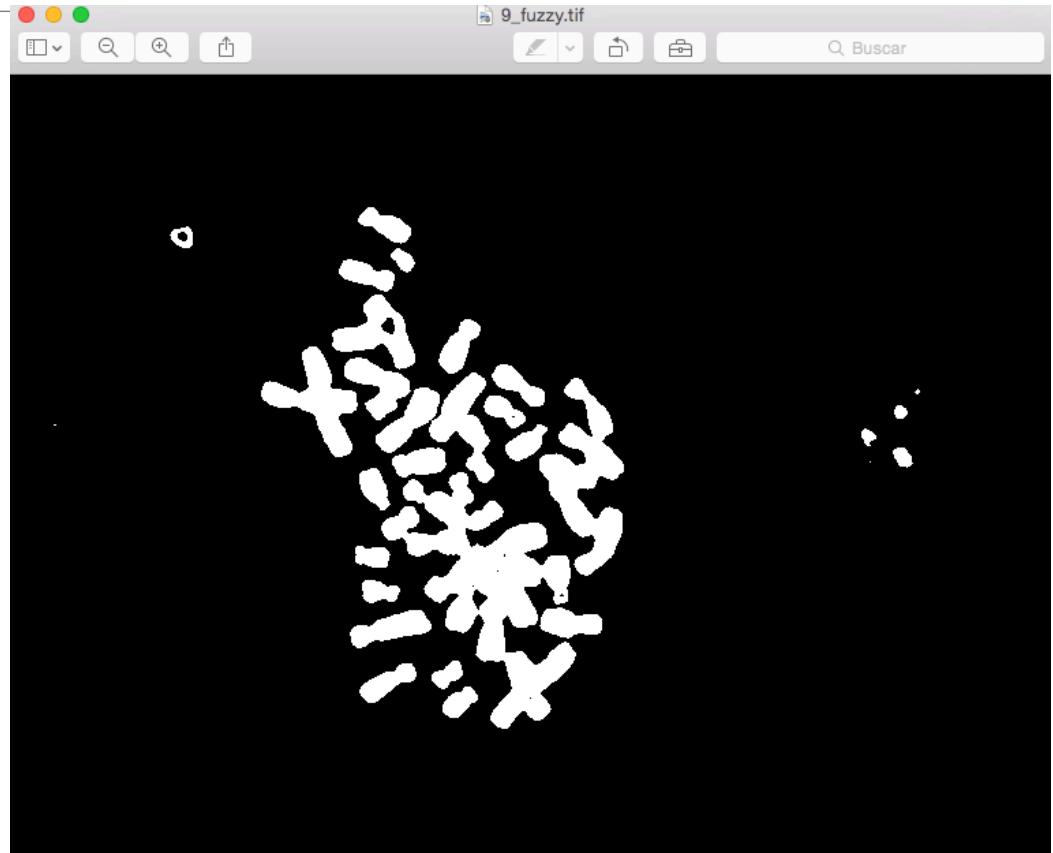
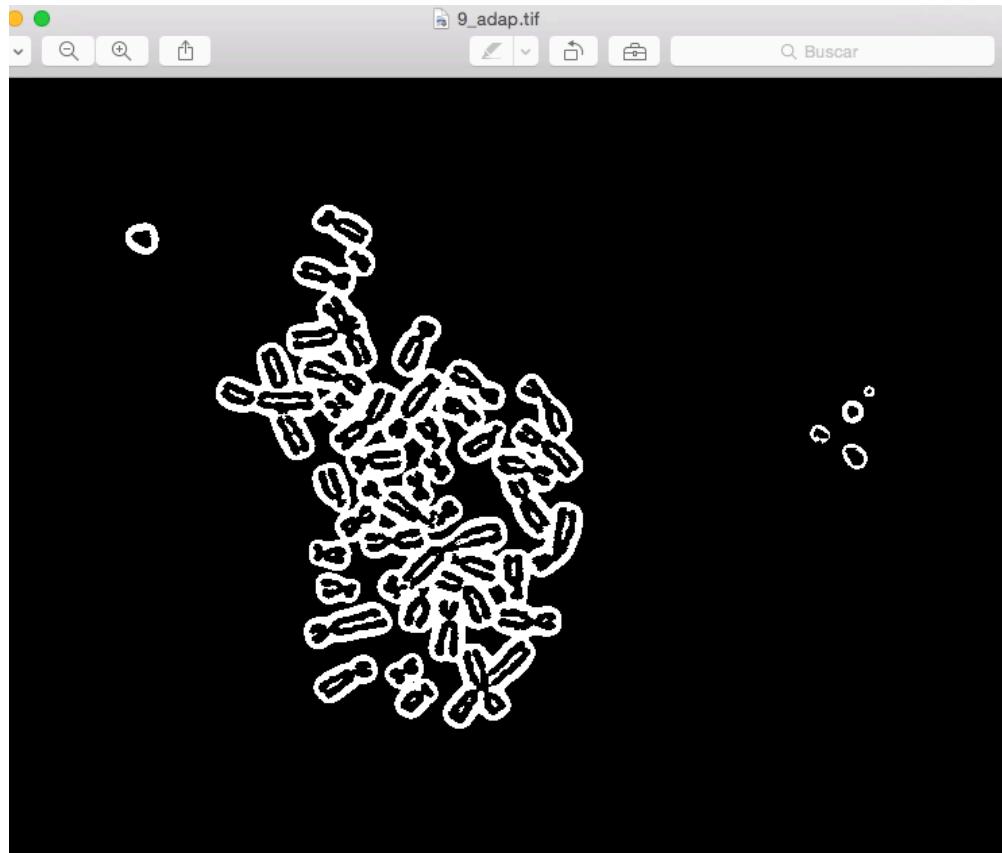
NOT-
AND
→



Exemplo



Exemplo



Exemplo



Desafio Chroma Key

Relacionamentos entre Pixels

- ▷ Operações aritméticas pixel a pixel
 - Ex: soma



Transformações de Imagem



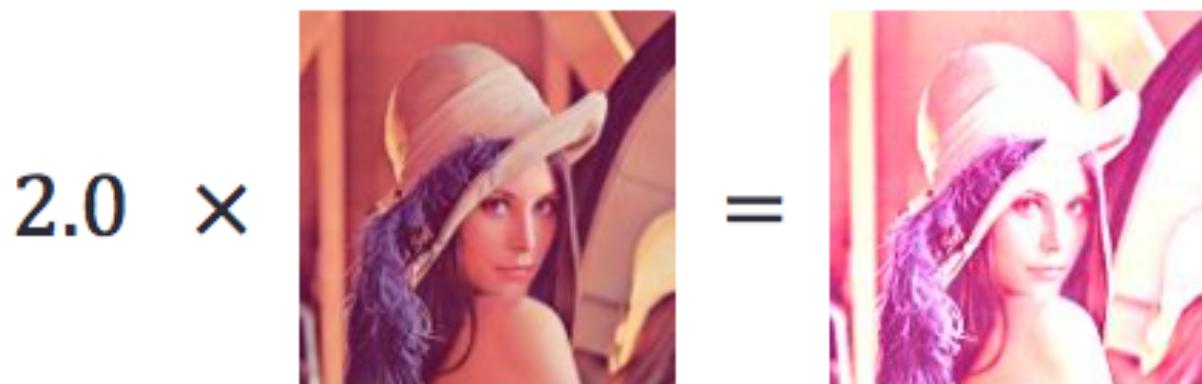
$$g(x,y) = f(x,y) + 20$$



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

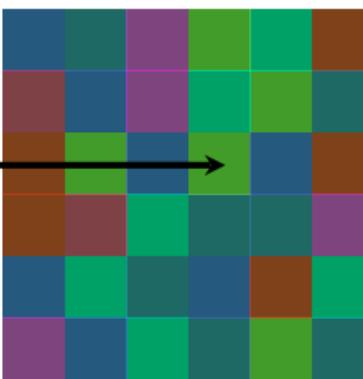
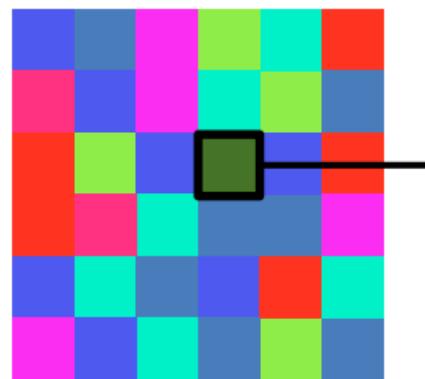
Relacionamento entre Pixels

- ▷ Operações aritméticas pixel a pixel
 - Ex: multiplicação por escalar



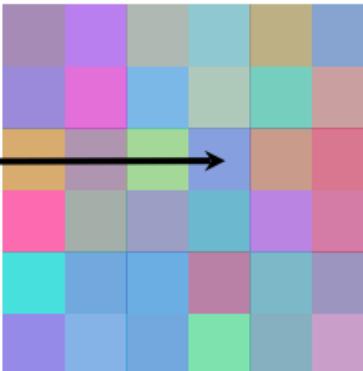
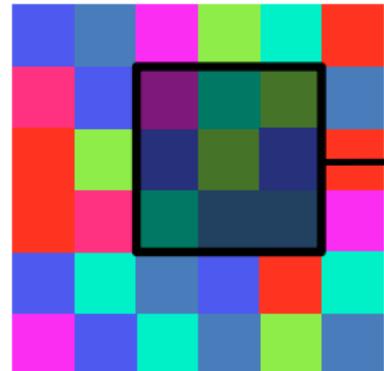
Tipos de Operações

Point Operation



point processing

Neighborhood Operation



filtering

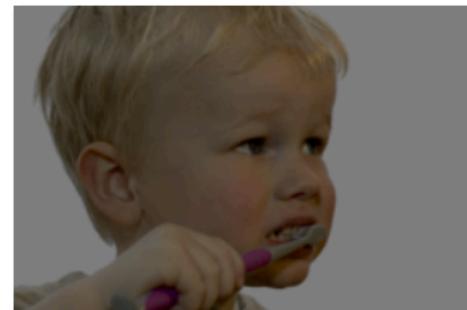
Exemplos de Operação de Ponto



Original



Darken



Lower Contrast



Nonlinear Lower Contrast



Invert



Lighten



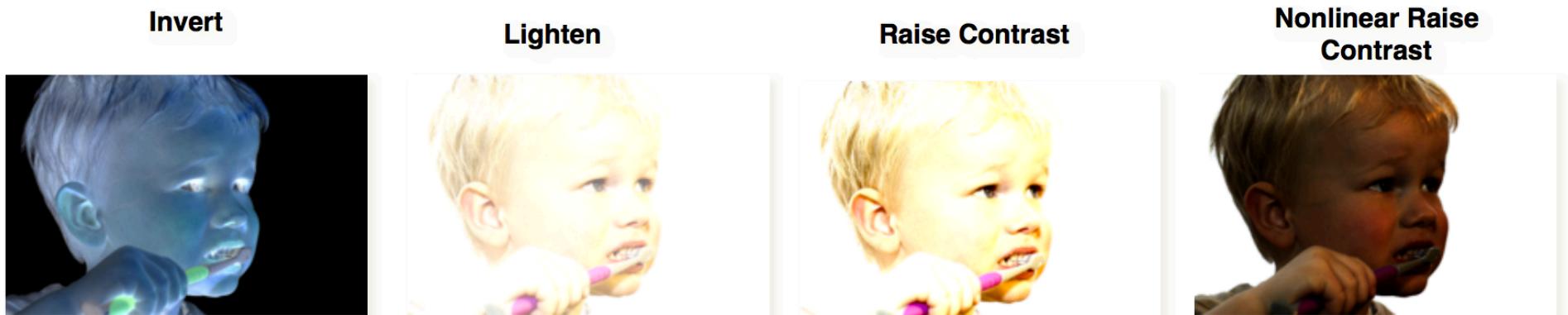
Raise Contrast



Nonlinear Raise Contrast



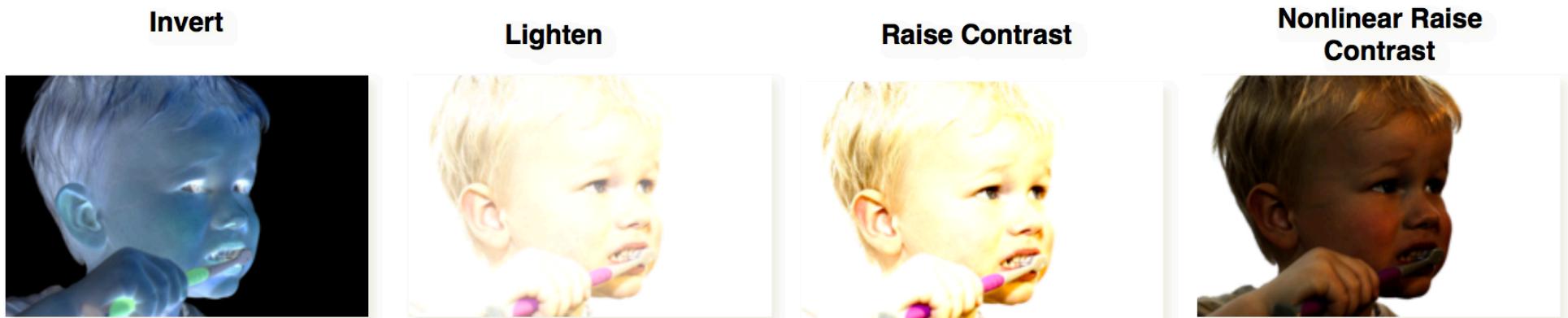
x
pixel value

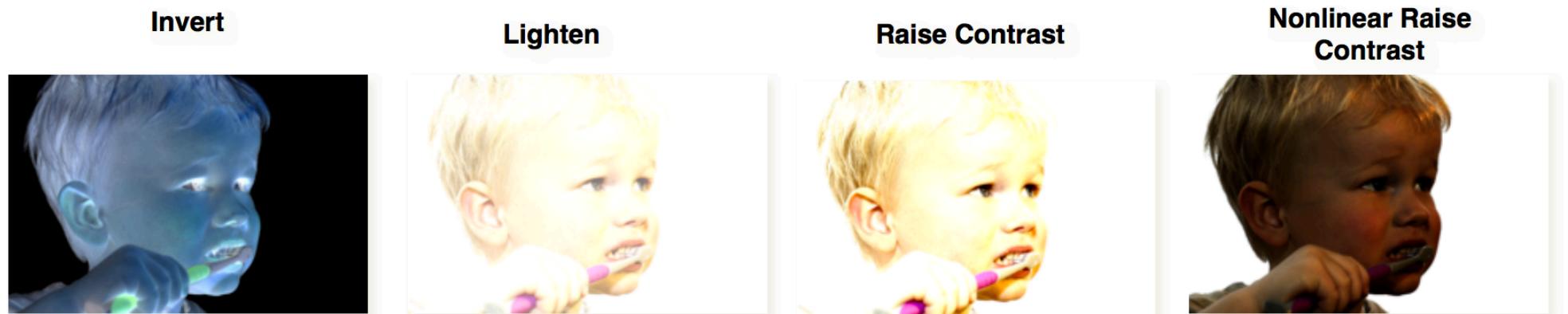


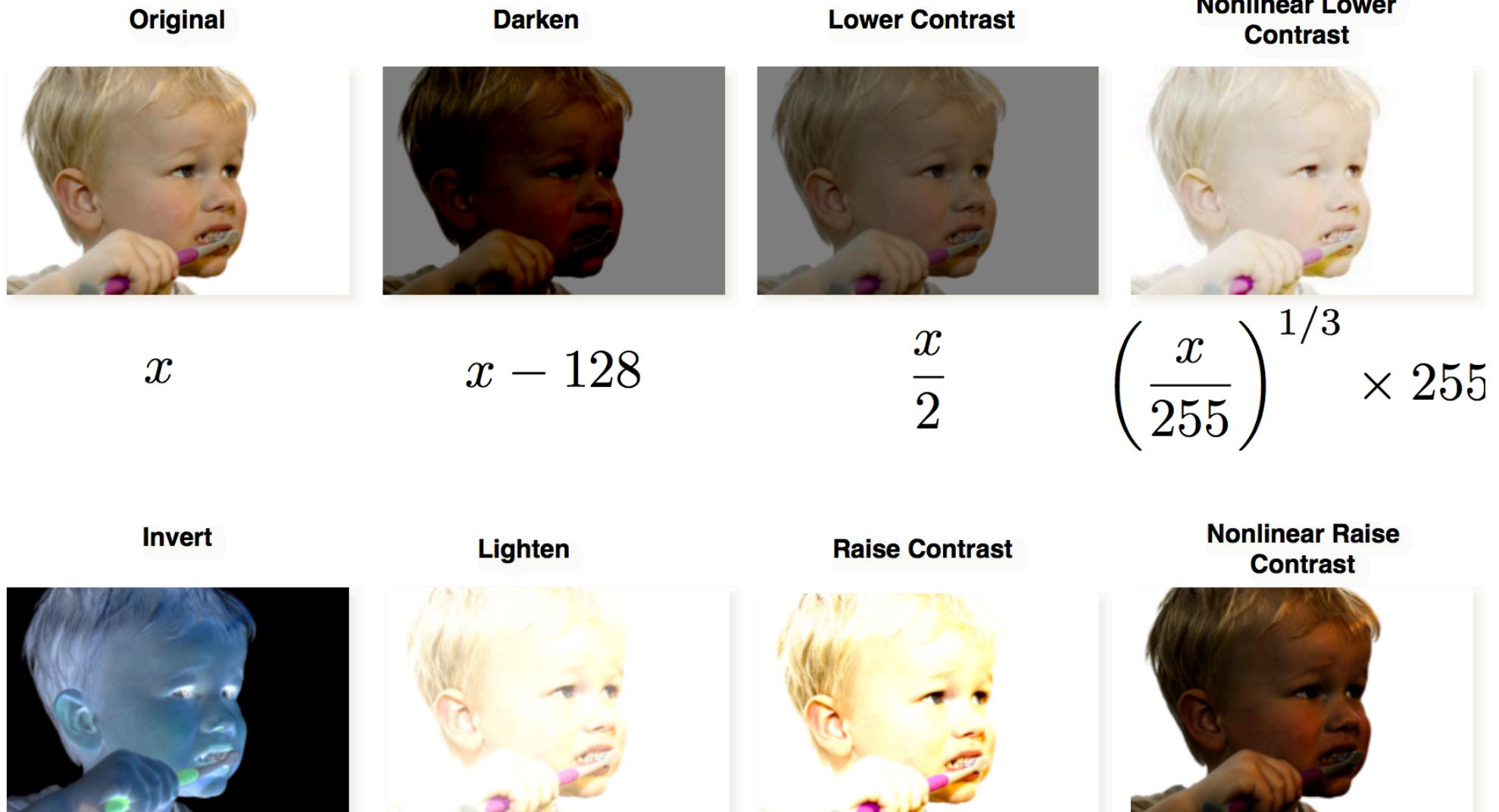


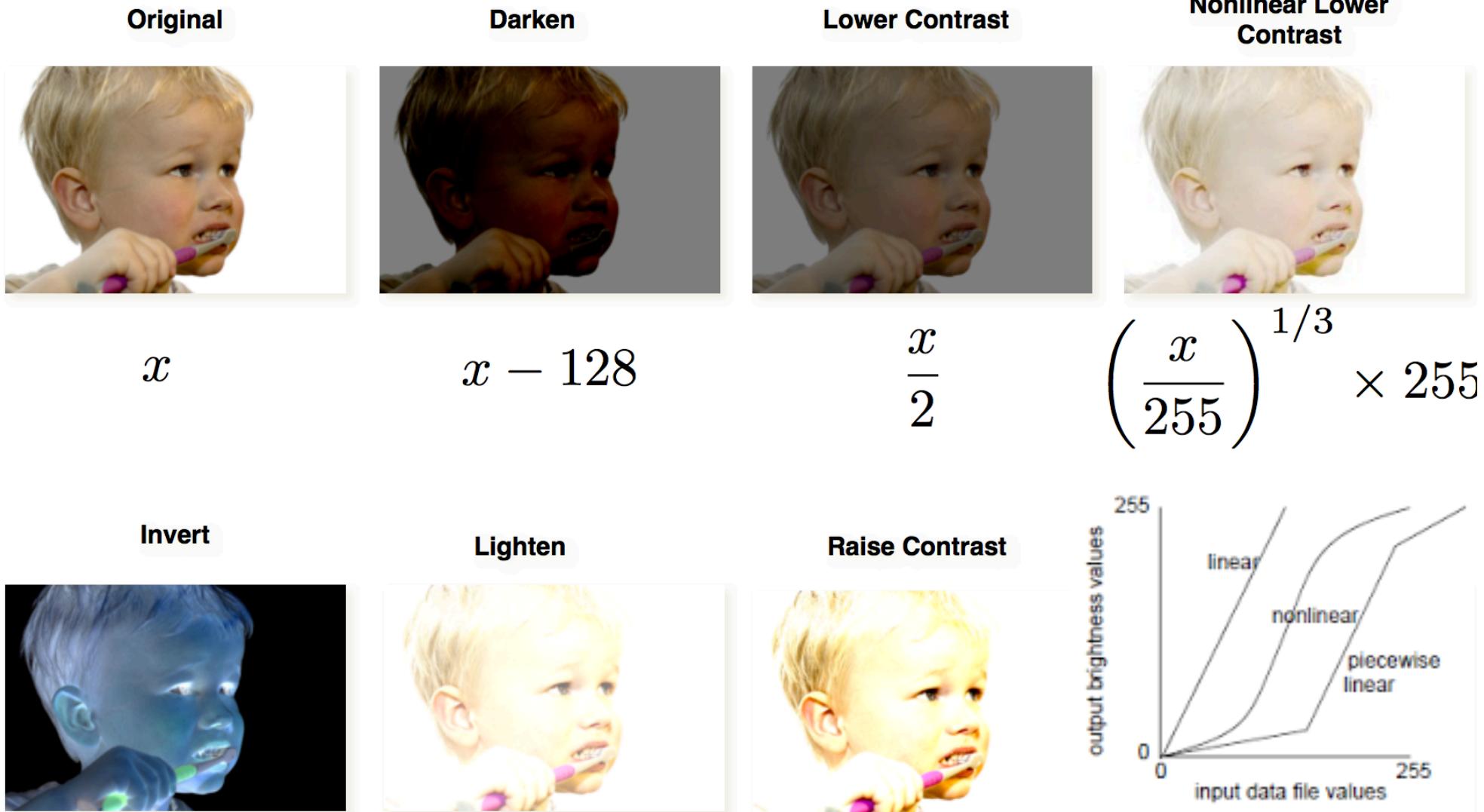
x

$x - 128$



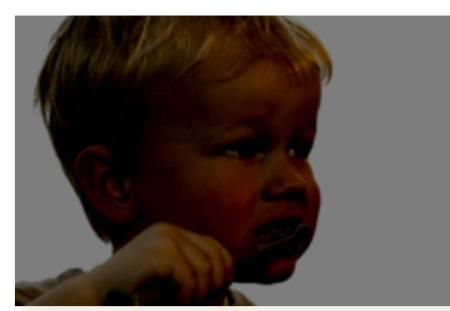
 x $x - 128$ $\frac{x}{2}$ 







x



$x - 128$



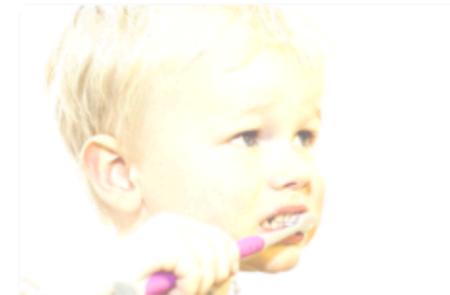
$\frac{x}{2}$



$\left(\frac{x}{255}\right)^{1/3} \times 255$



$255 - x$



Original



Darken



Lower Contrast



Nonlinear Lower Contrast

 x $x - 128$ $\frac{x}{2}$
$$\left(\frac{x}{255}\right)^{1/3} \times 255$$

Invert



Lighten



Raise Contrast



Nonlinear Raise Contrast

 $255 - x$ $x + 128$

Original



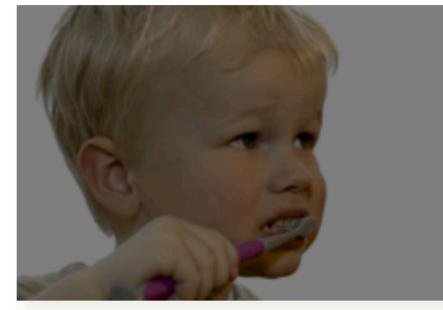
$$x$$

Darken



$$x - 128$$

Lower Contrast



$$\frac{x}{2}$$

Nonlinear Lower Contrast



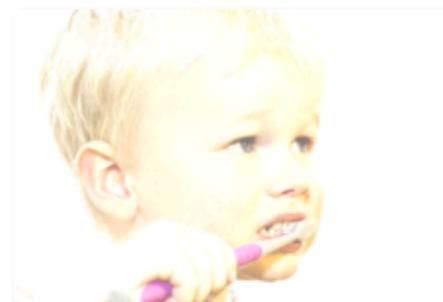
$$\left(\frac{x}{255}\right)^{1/3} \times 255$$

Invert



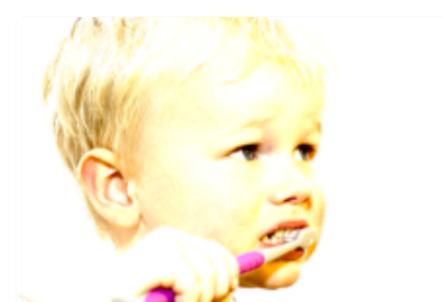
$$255 - x$$

Lighten



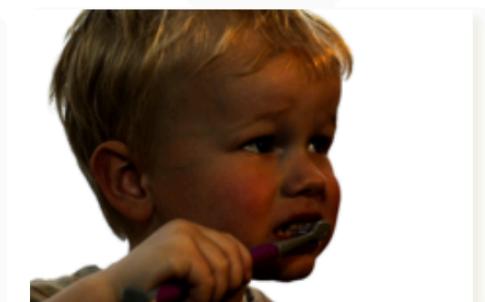
$$x + 128$$

Raise Contrast



$$x \times 2$$

Nonlinear Raise Contrast



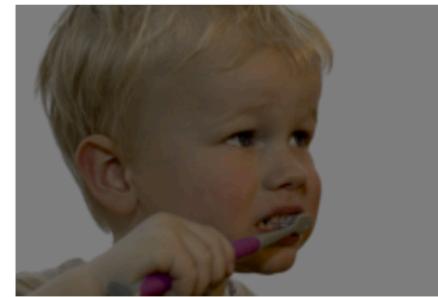
Original



Darken



Lower Contrast



Nonlinear Lower Contrast

 x $x - 128$ $\frac{x}{2}$
$$\left(\frac{x}{255}\right)^{1/3} \times 255$$

Invert



Lighten



Raise Contrast



Nonlinear Raise Contrast

 $255 - x$ $x + 128$ $x \times 2$
$$\left(\frac{x}{255}\right)^2 \times 255$$

Exemplos de Operação de Filtro



Original



Gradient Magnitude



Gaussian Blur



Median



Adaptive Thresholding



Bilateral