

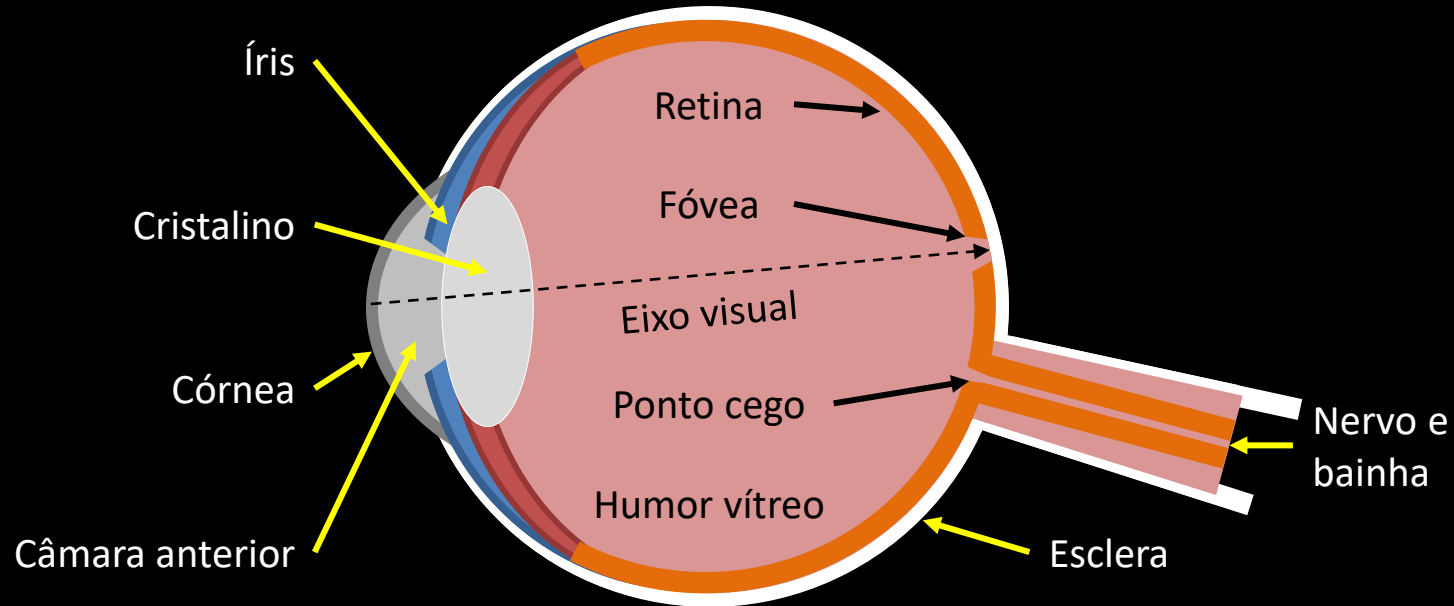
Aula 02 – Fundamentos da imagem digital I

Prof. João Fernando Mari

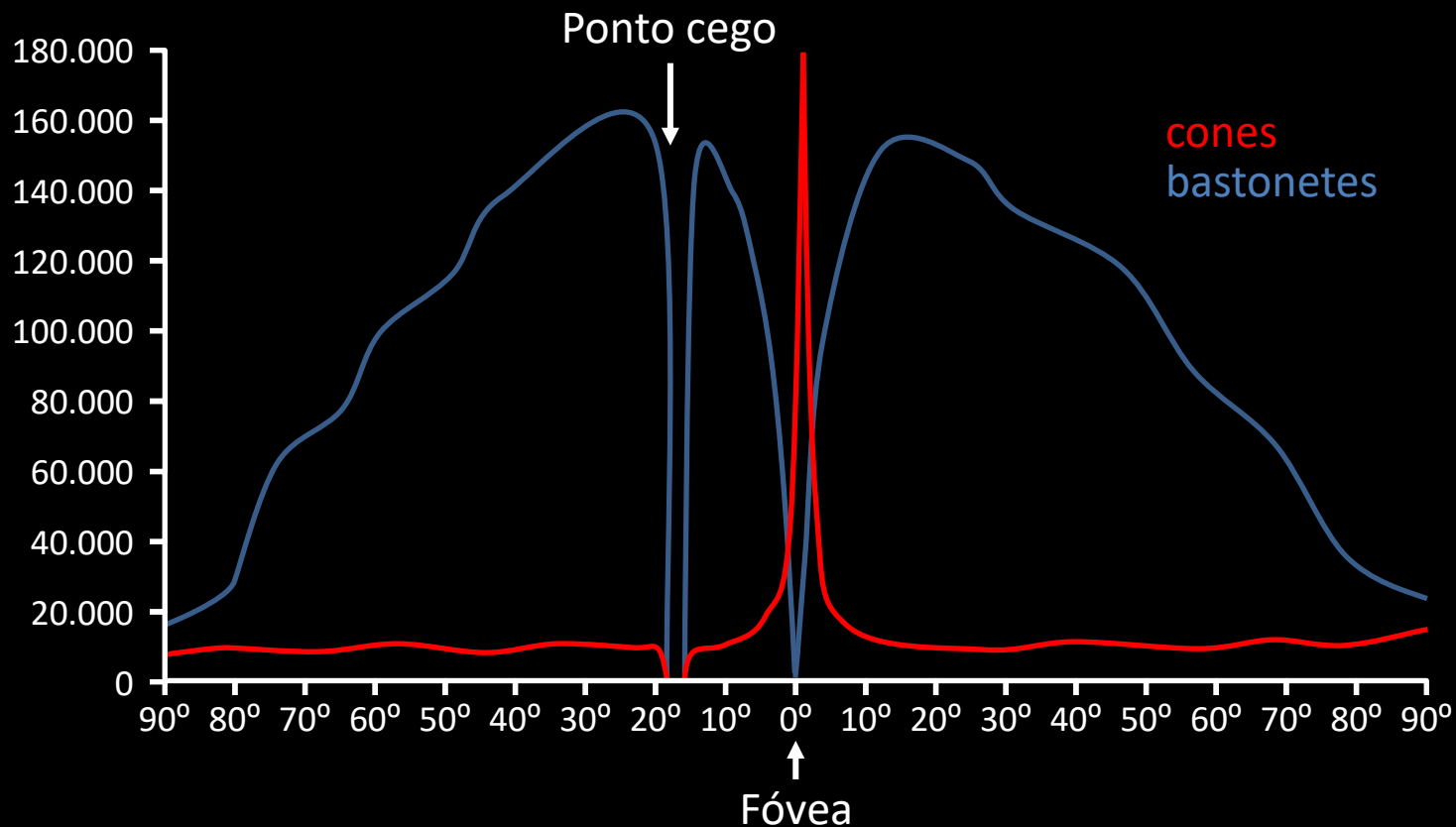
joaofmari.github.io

joaof.mari@ufv.br

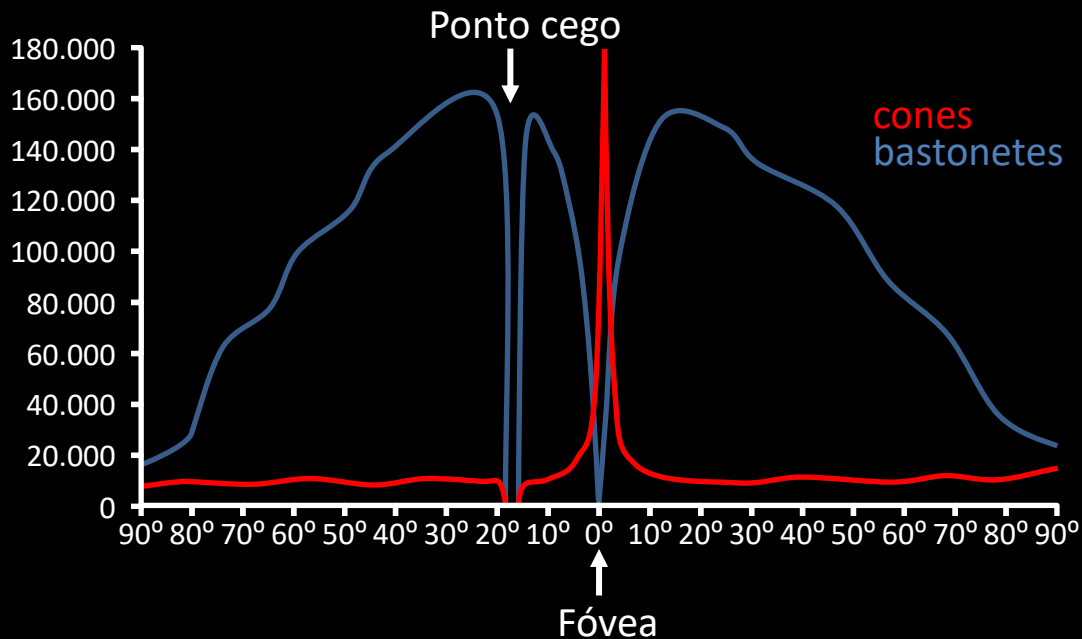
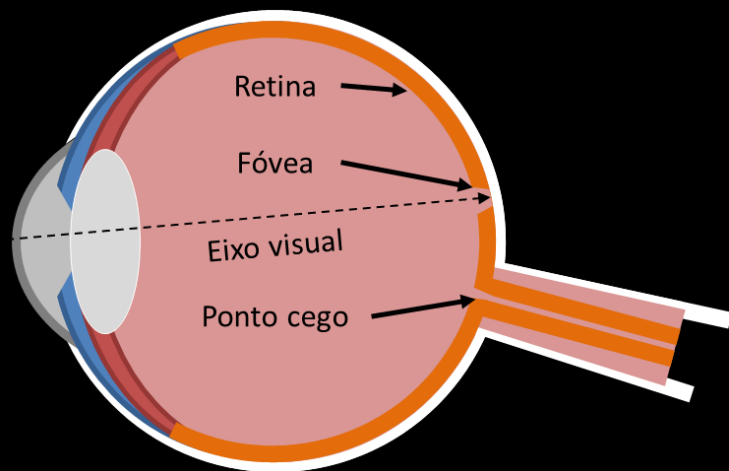
- O olho humano
- Câmera fotográfica
- A imagem digital
- Imagens coloridas – RGB
- O espaço de cores RGB
- Aquisição de imagens
- Sensores CCD e padrão de Bayer
- Amostragem
- Efeitos da resolução espacial
- Resolução de intensidade
- Efeitos da resolução de intensidade

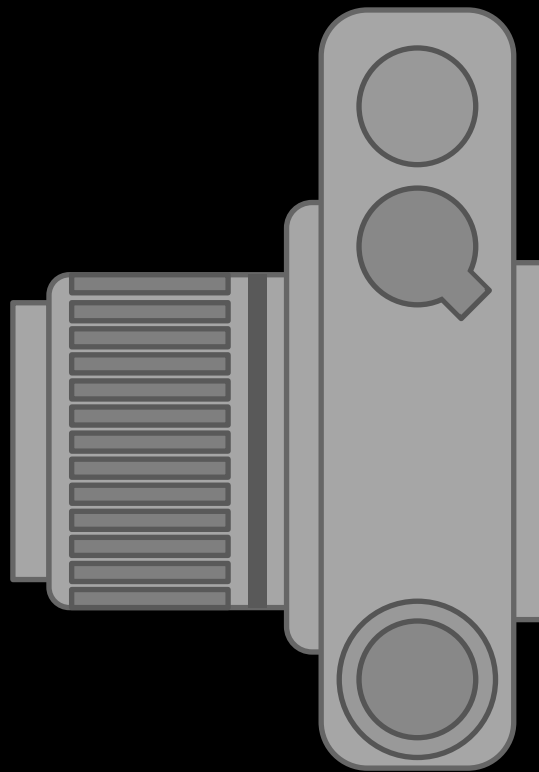


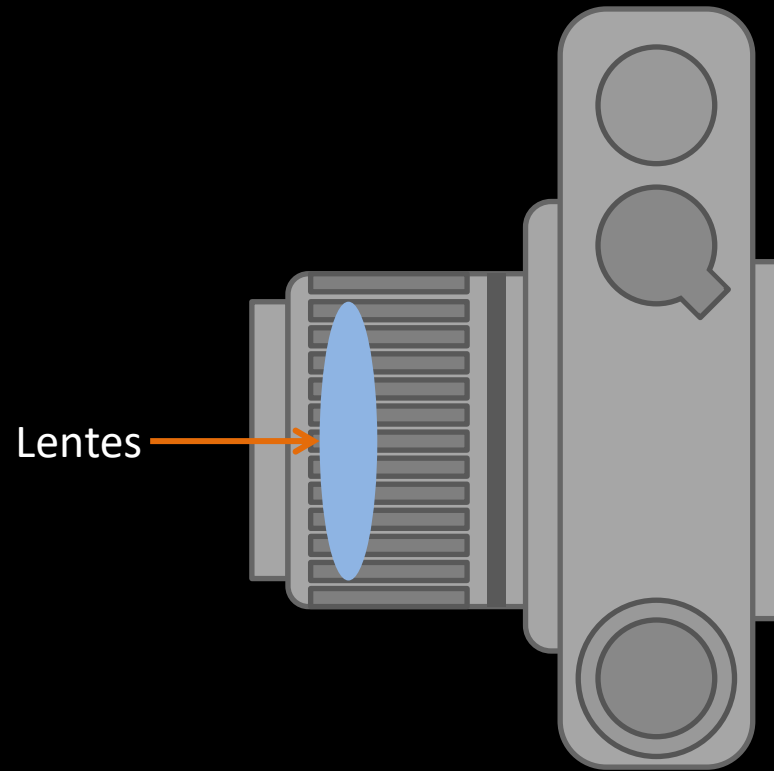
O olho humano



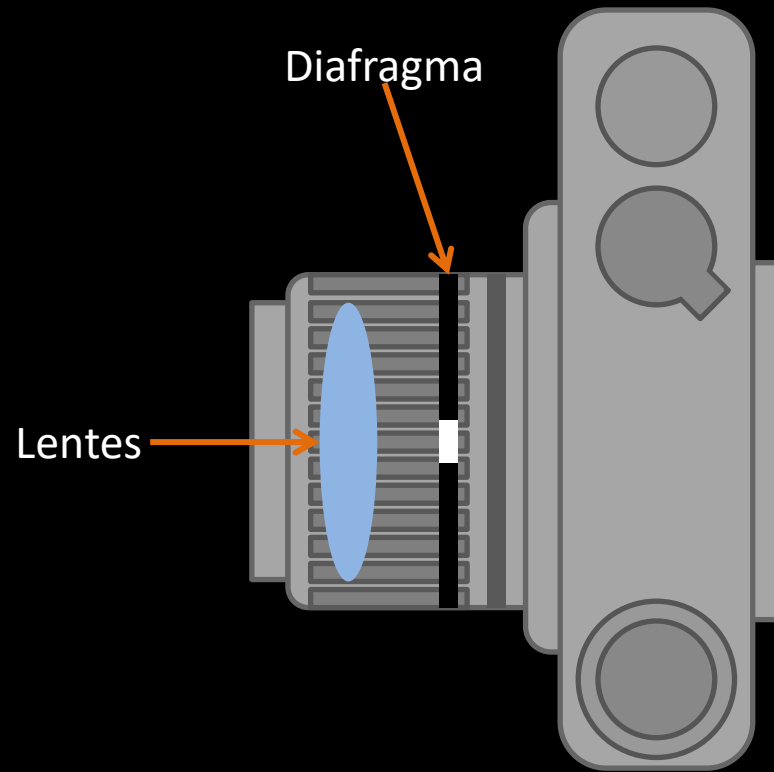
O olho humano

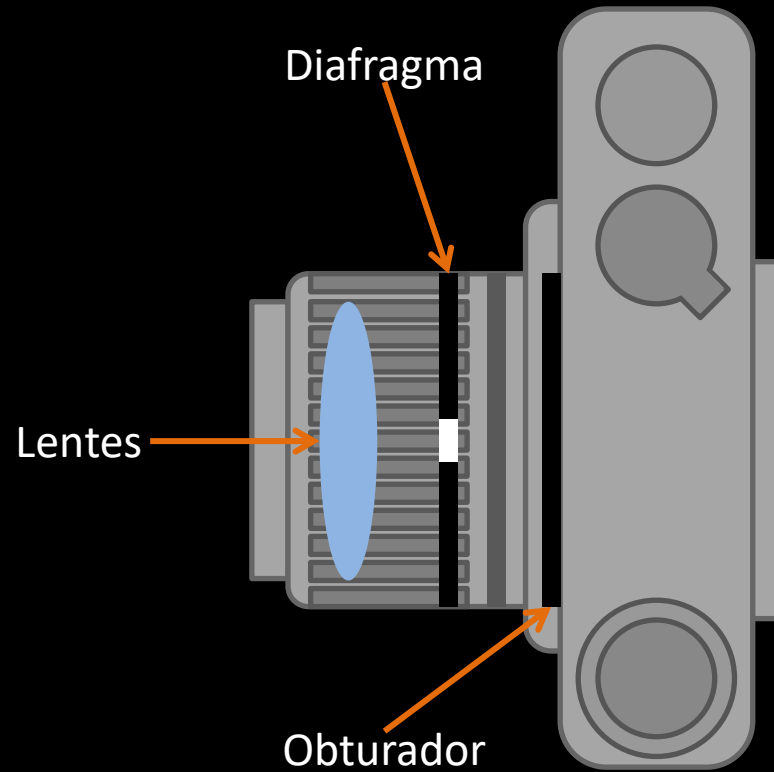


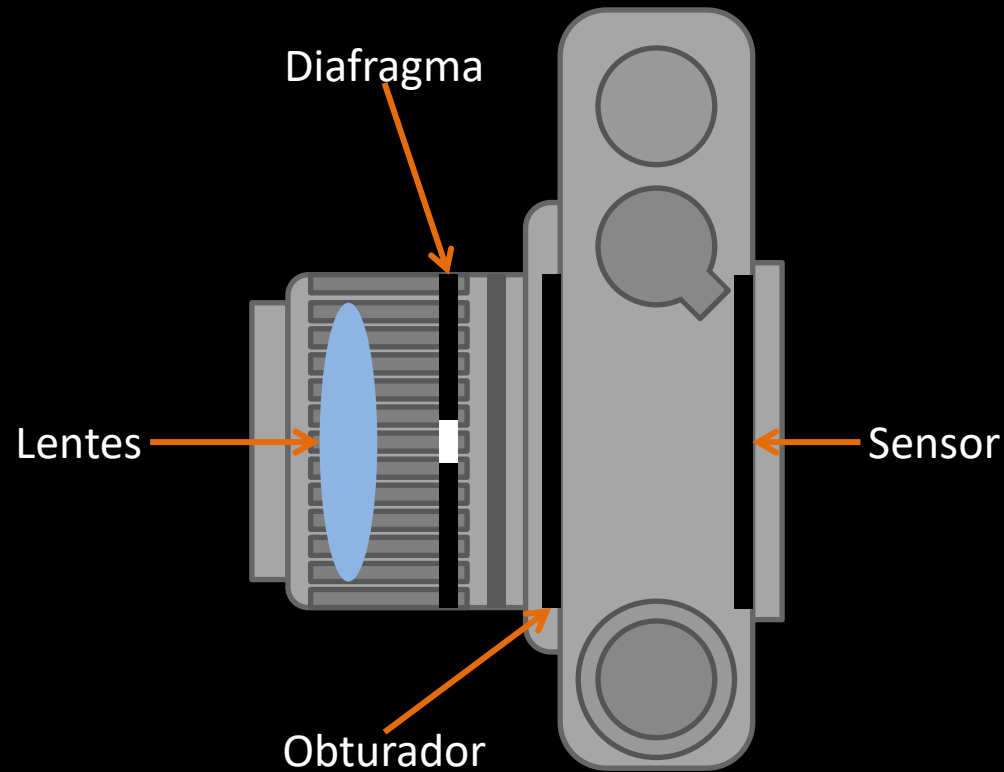


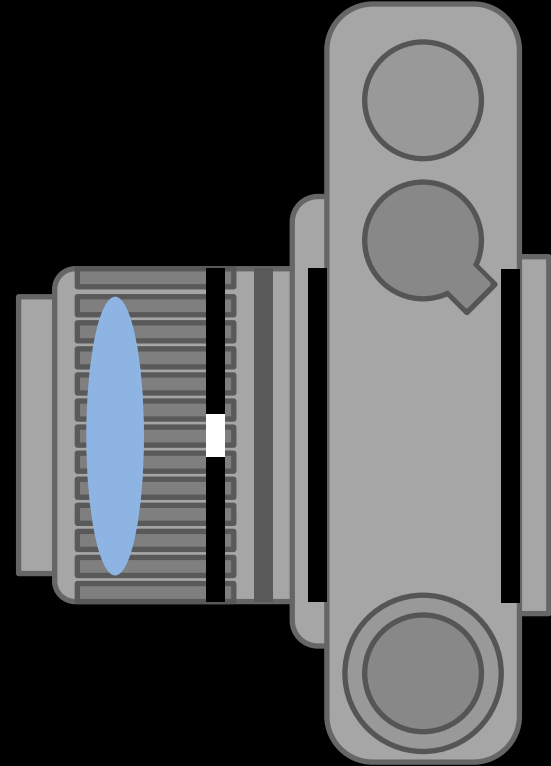


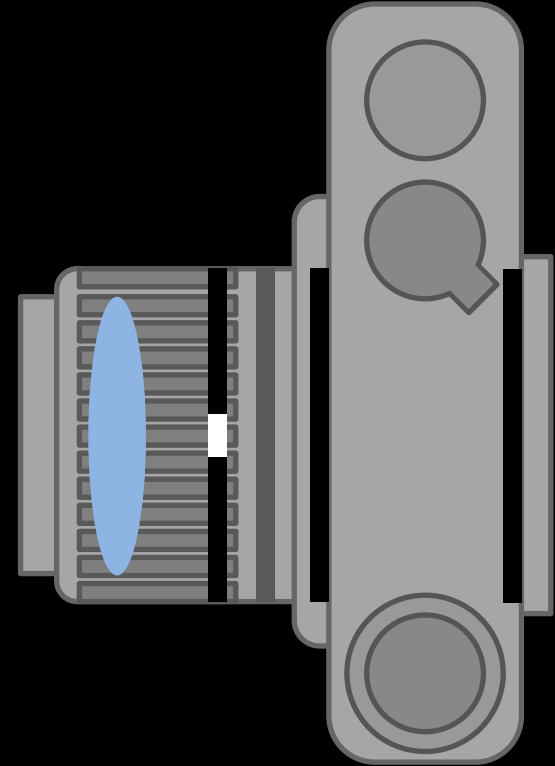
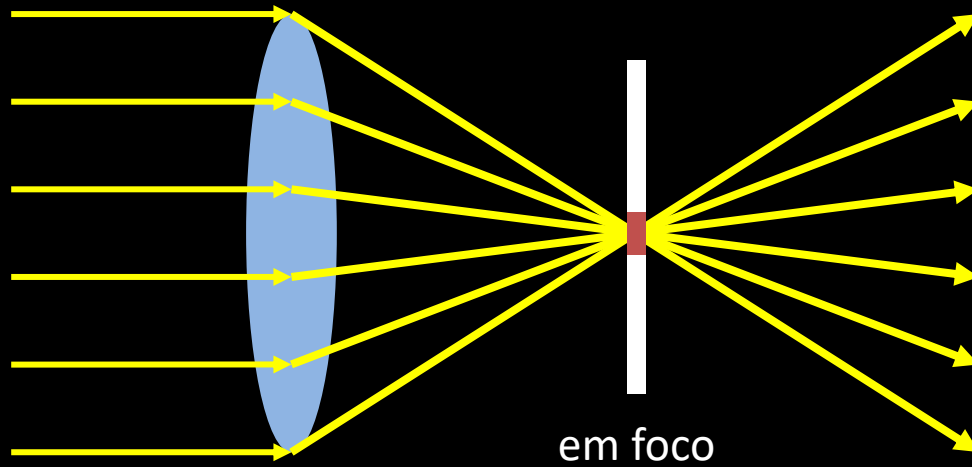
Lentes

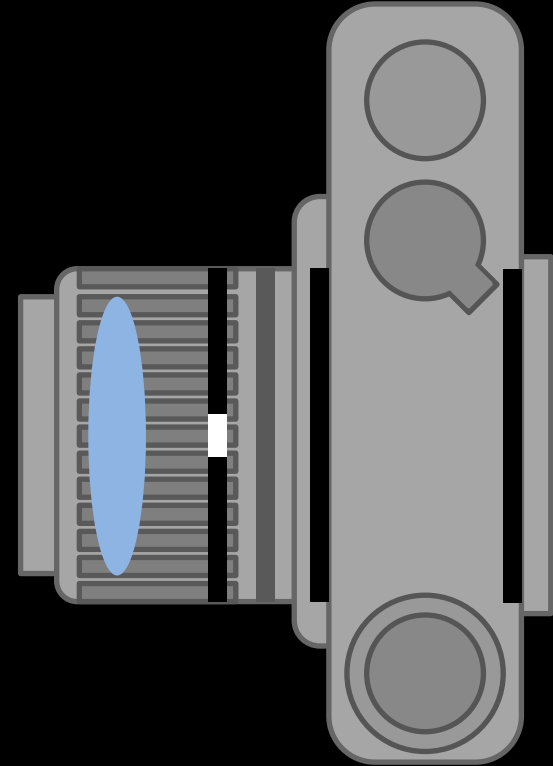
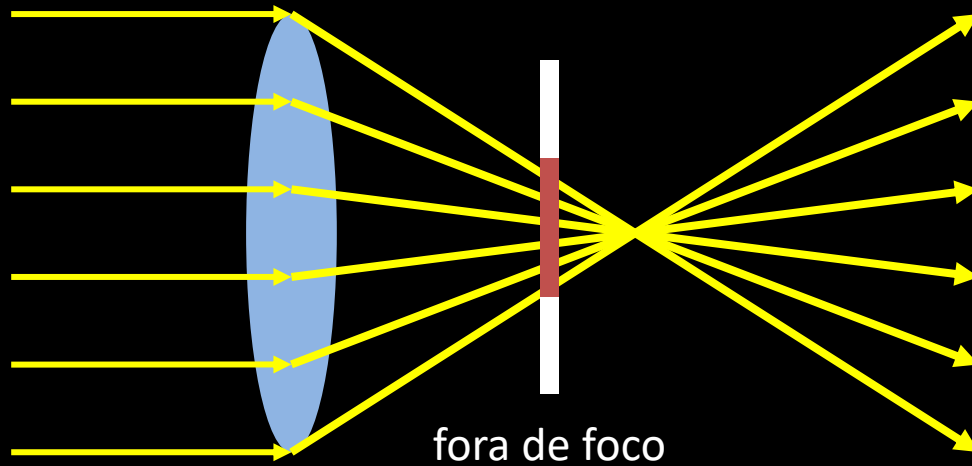


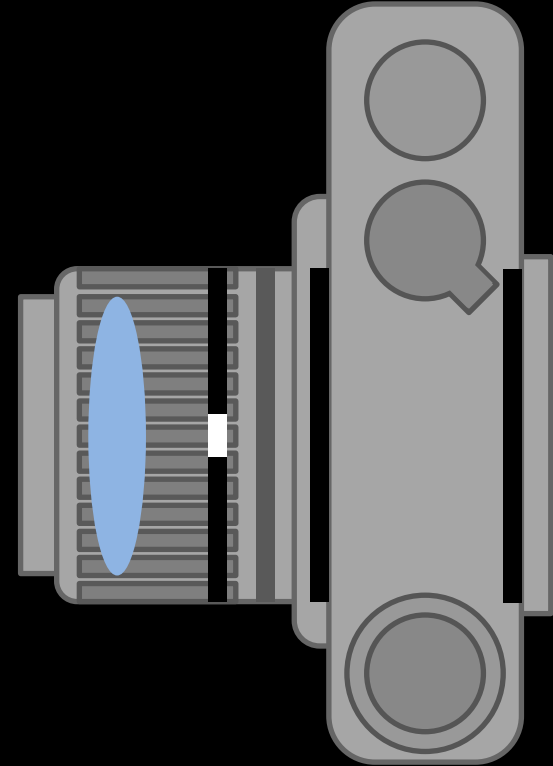
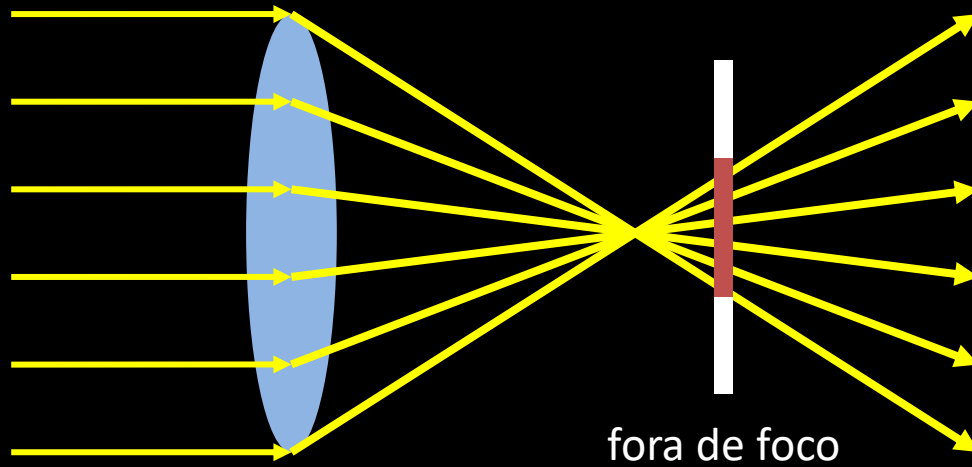


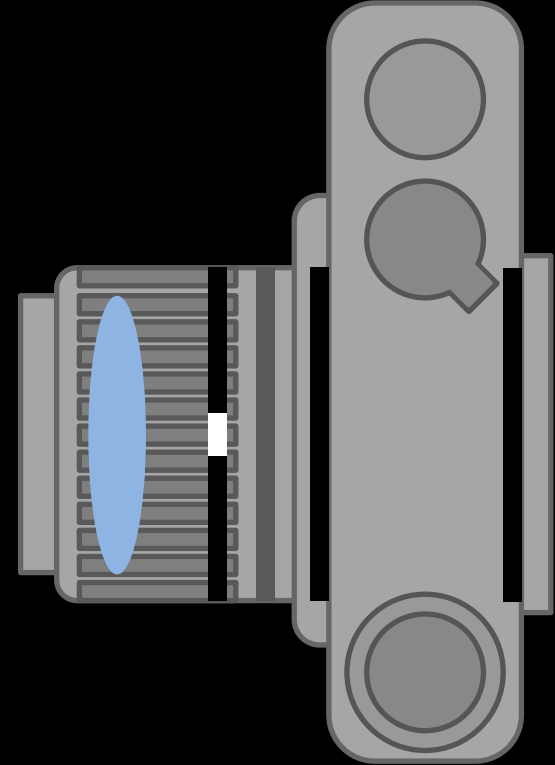


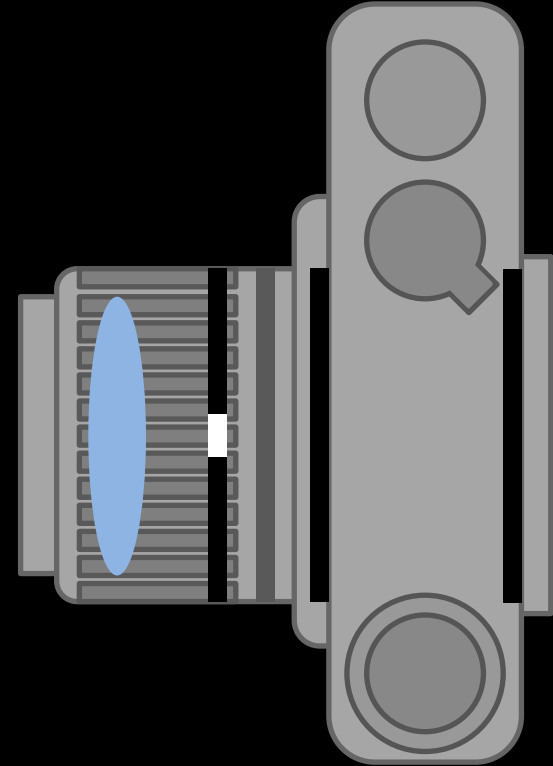


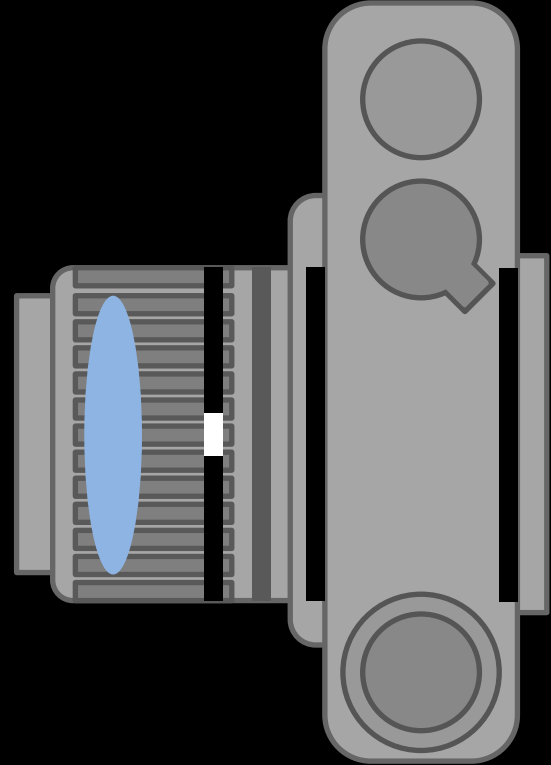


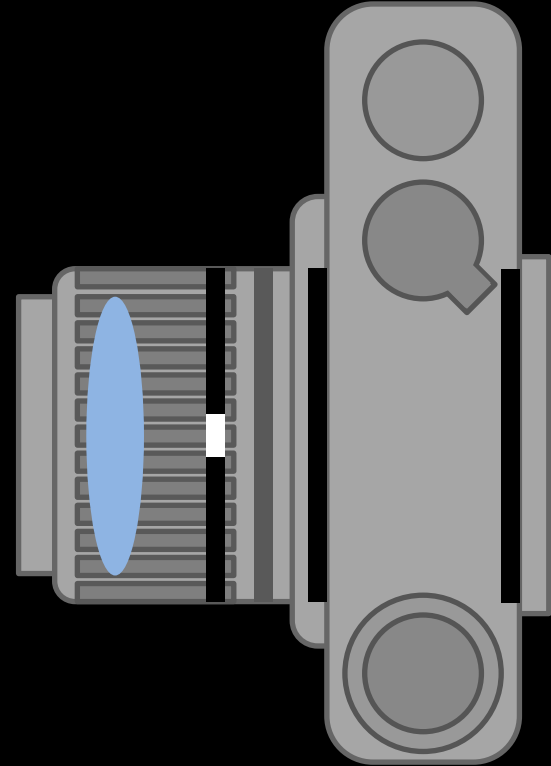
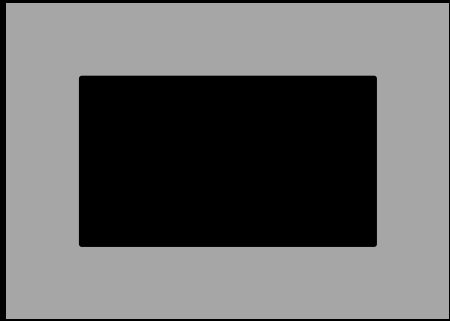


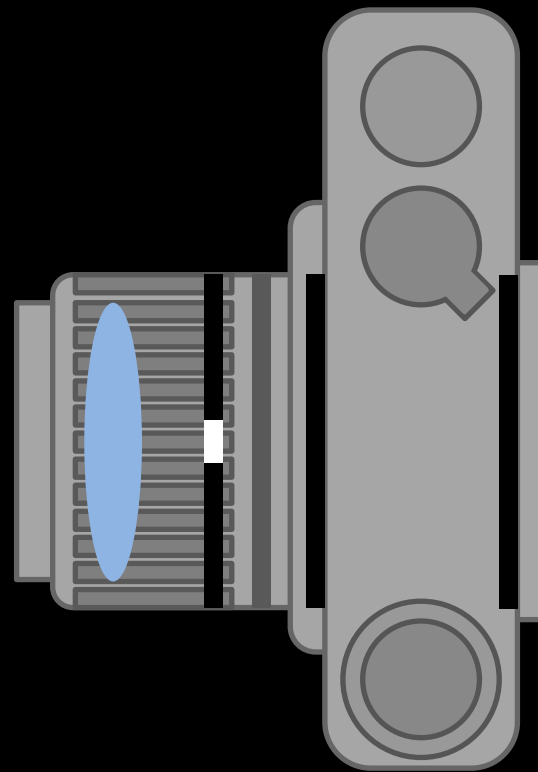
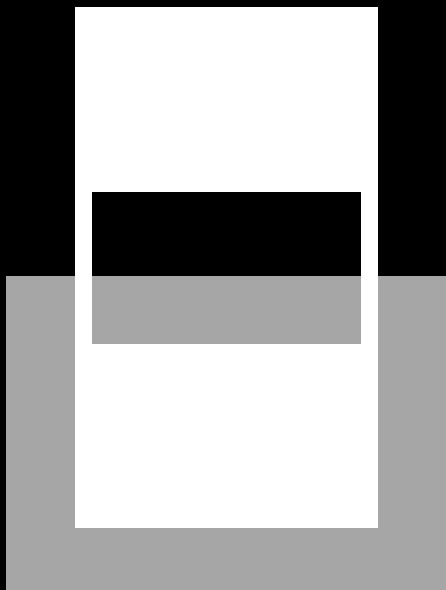


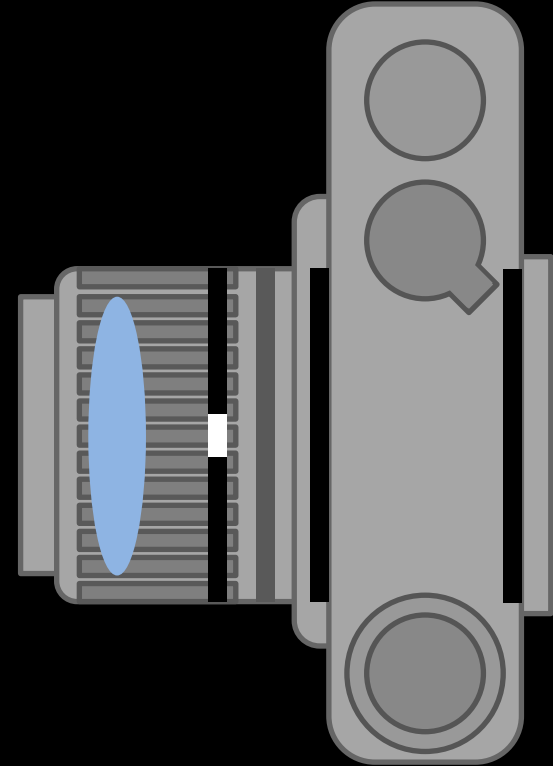
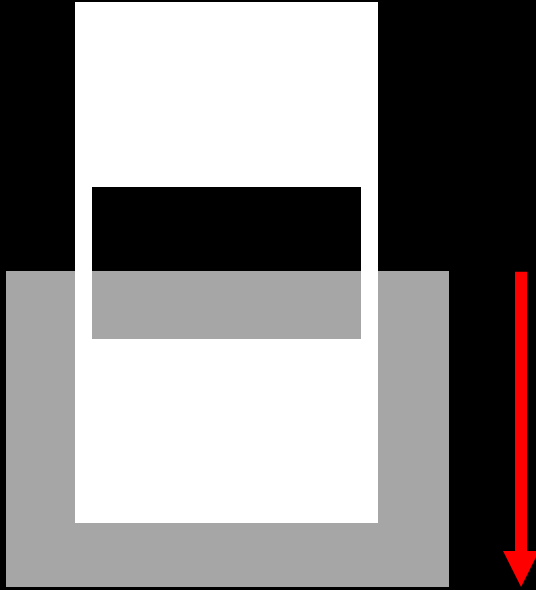


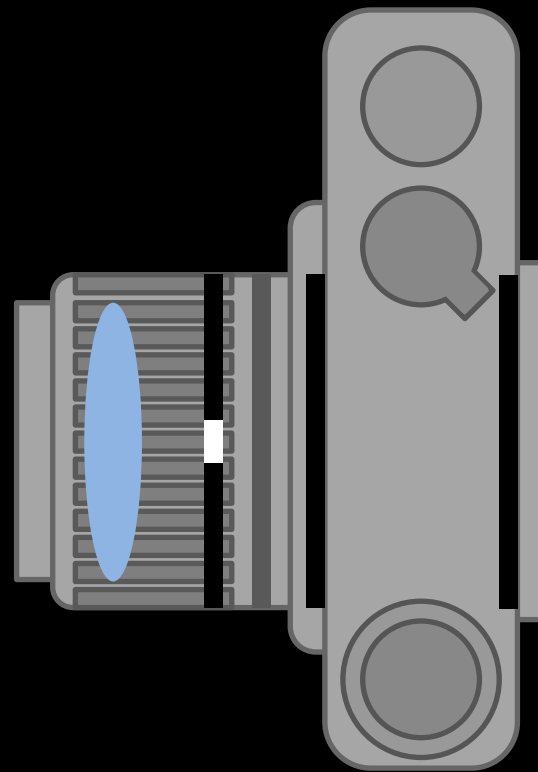
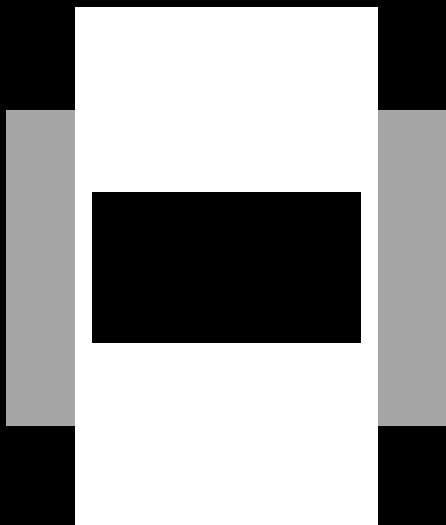


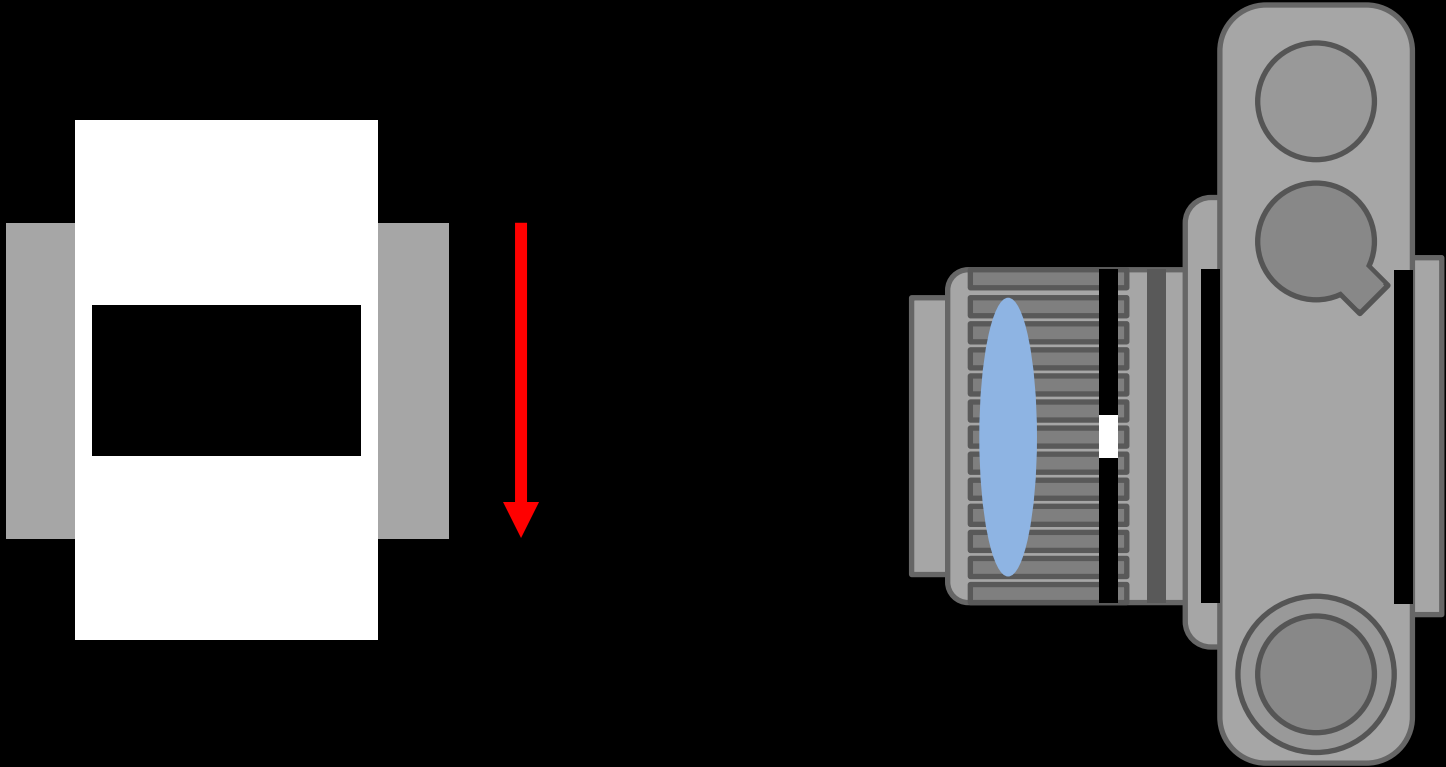


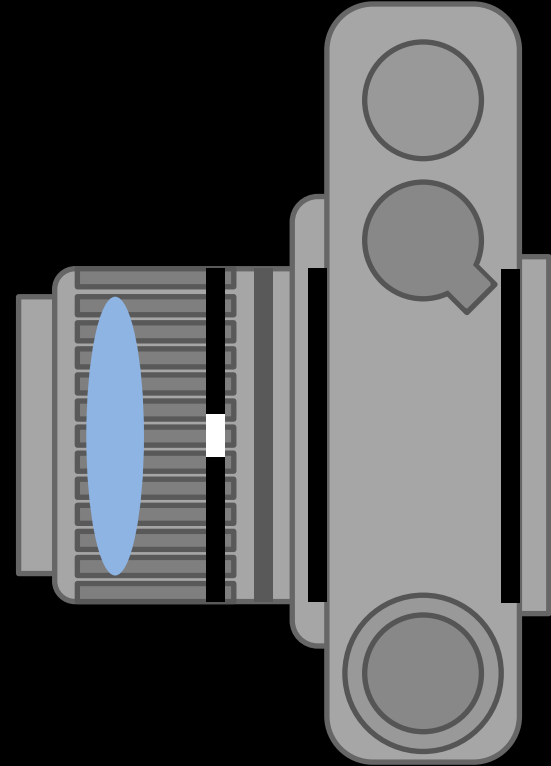
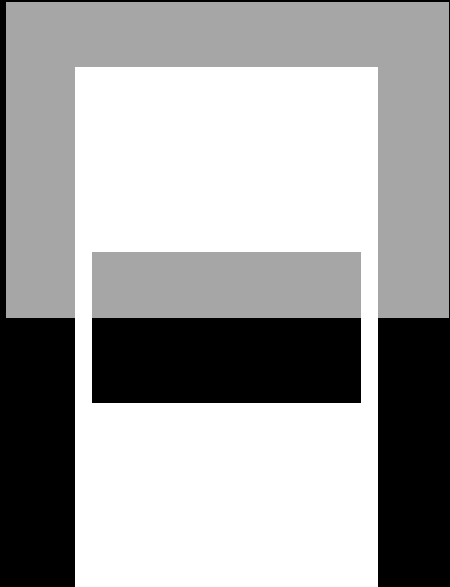


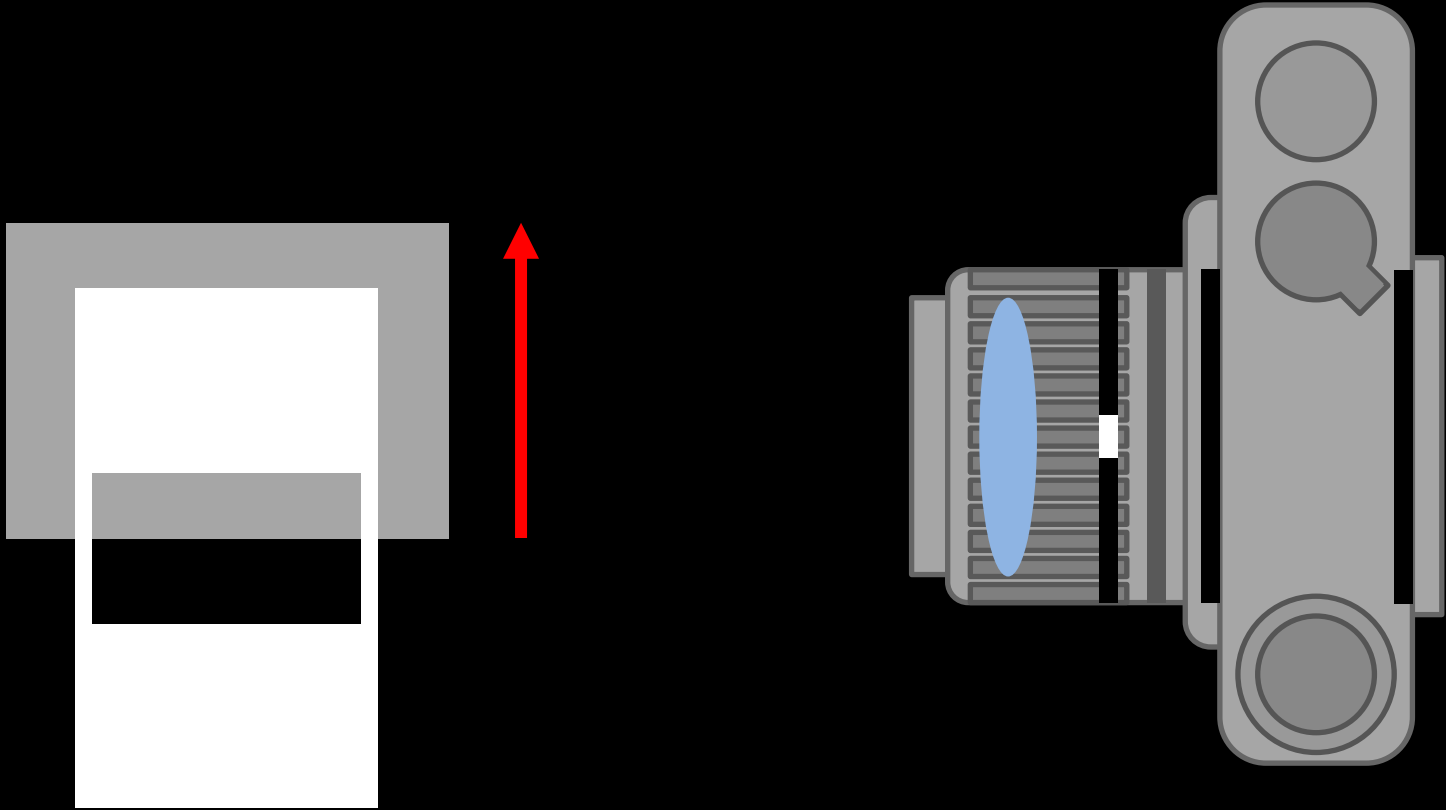


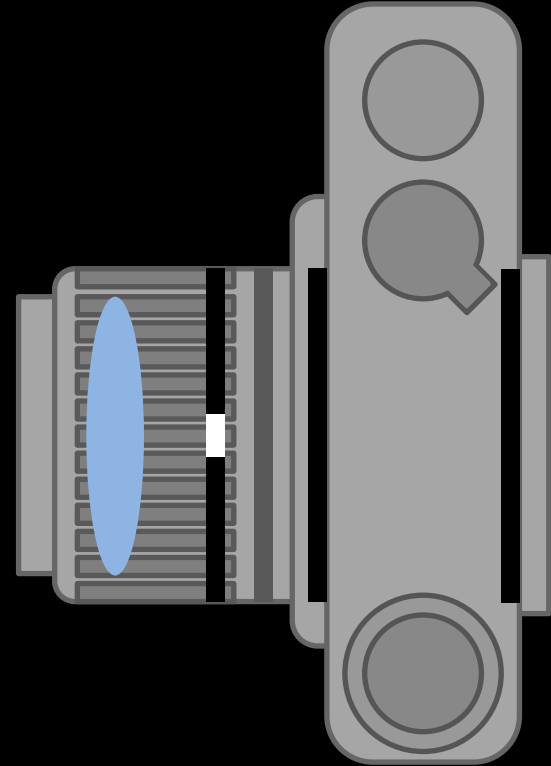
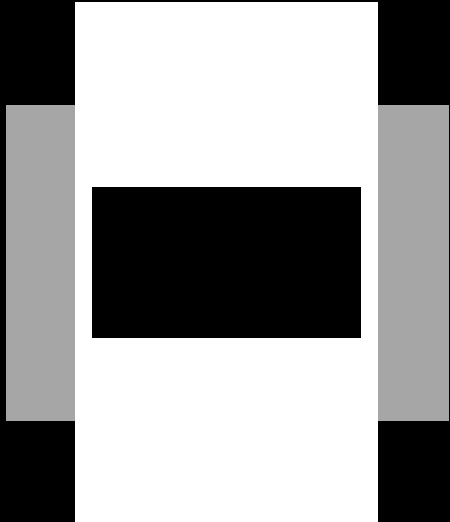


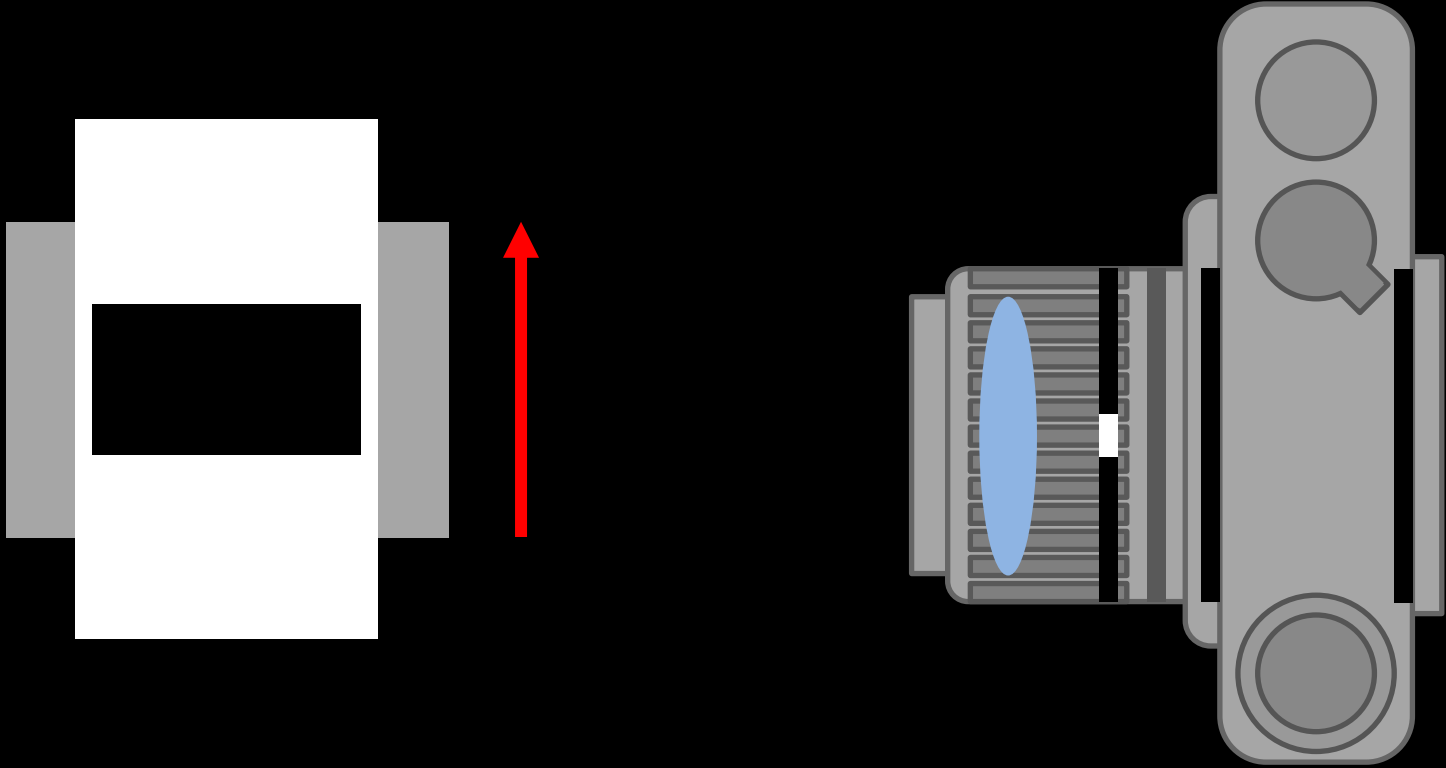












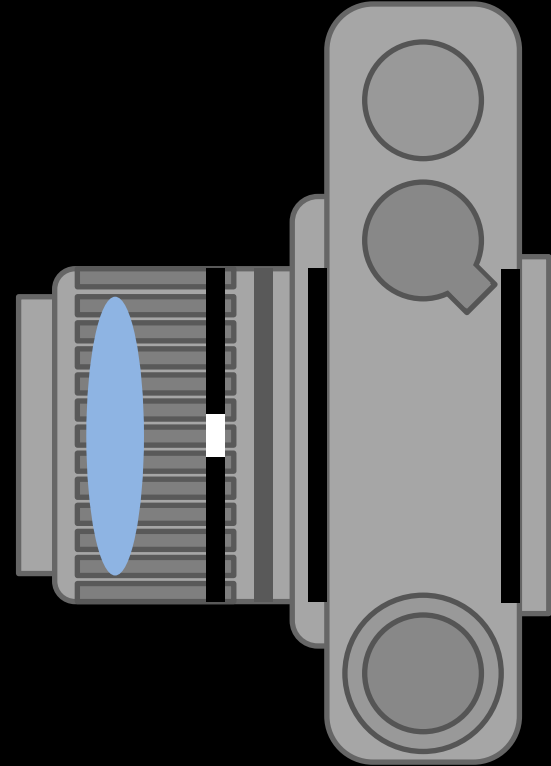
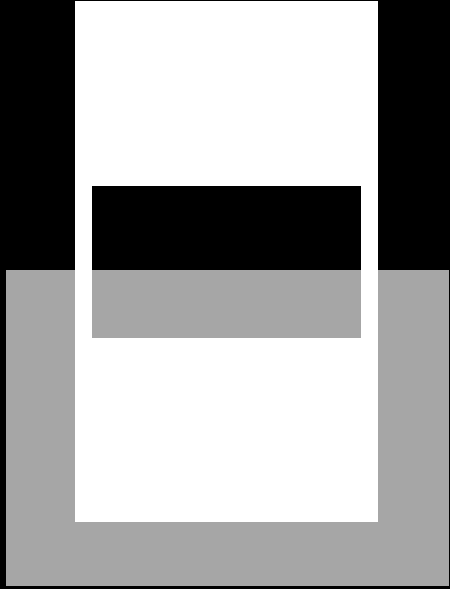


Imagem de intensidades (níveis de cinza):



Imagem colorida (RGB):



Imagem de intensidades (níveis de cinza):



Imagem colorida (RGB):

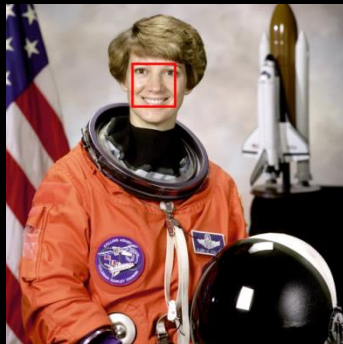


Imagem de intensidades (níveis de cinza):

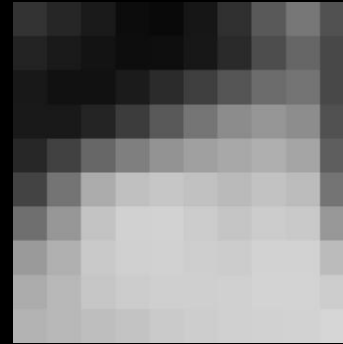


Imagem colorida (RGB):

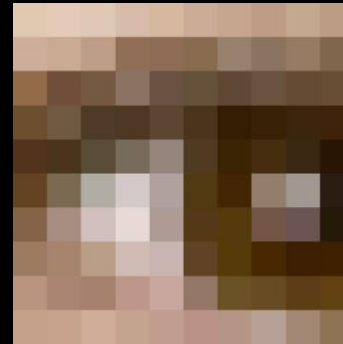
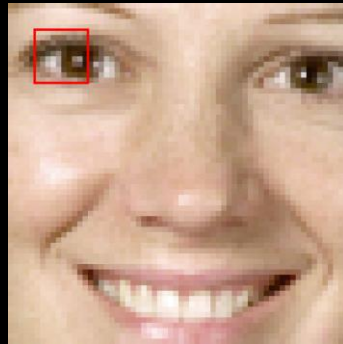
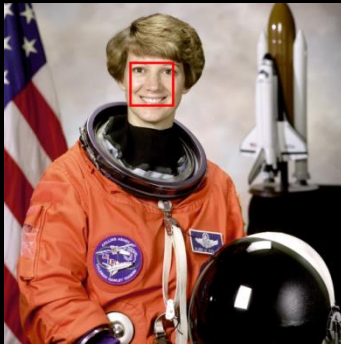


Imagem de intensidades (níveis de cinza):

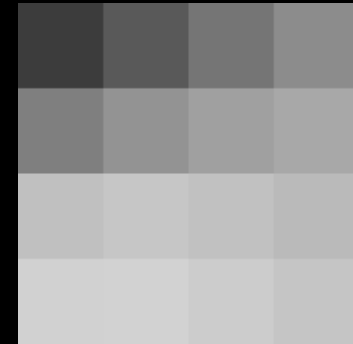
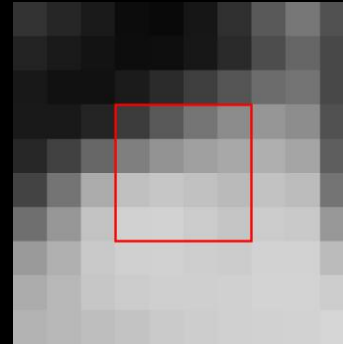
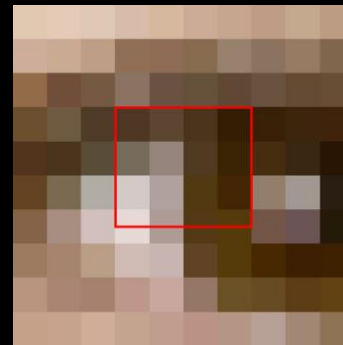
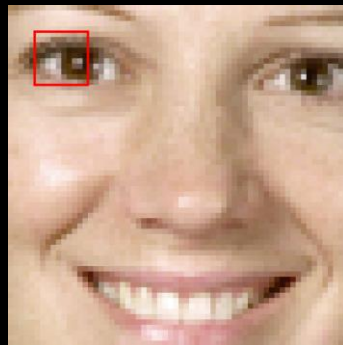
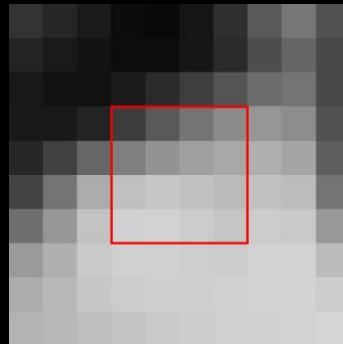


Imagem colorida (RGB):



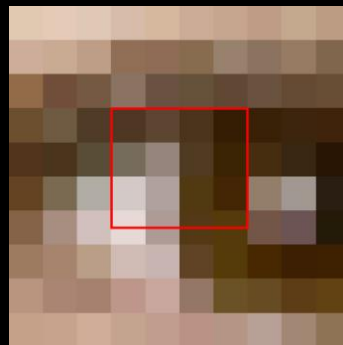
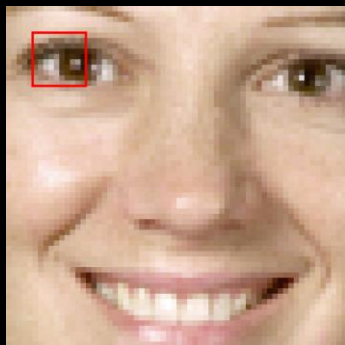
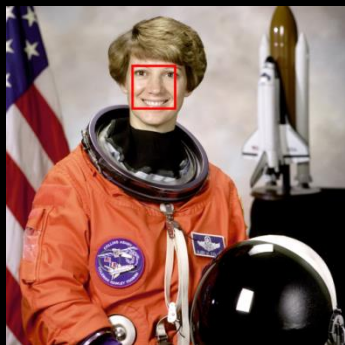
A imagem digital

Imagem de intensidades (níveis de cinza):



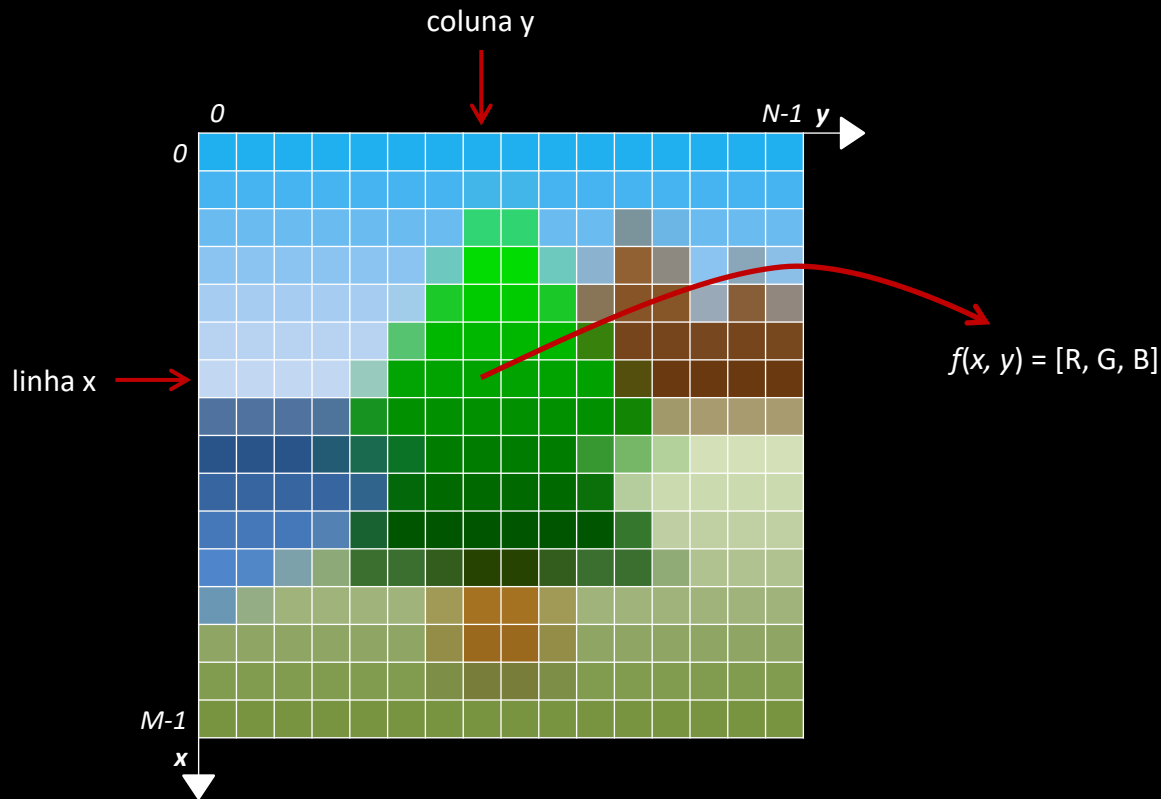
60	89	117	140
127	147	160	168
192	198	193	186
209	210	204	197

Imagem colorida (RGB):



78	92	75	51
56	70	52	30
36	49	28	3
118	149	80	59
108	133	58	36
91	124	33	3
211	176	81	69
202	161	57	38
200	158	17	4
231	174	83	85
218	155	57	58
214	150	21	11

A imagem digital



M linhas
N colunas
 $M \times N$ pixels





vermelho – R (red)



Imagens coloridas - RGB



vermelho – R (red)



verde – G (green)





vermelho – R (red)



verde – G (green)



azul – B (blue)





vermelho – R (red)



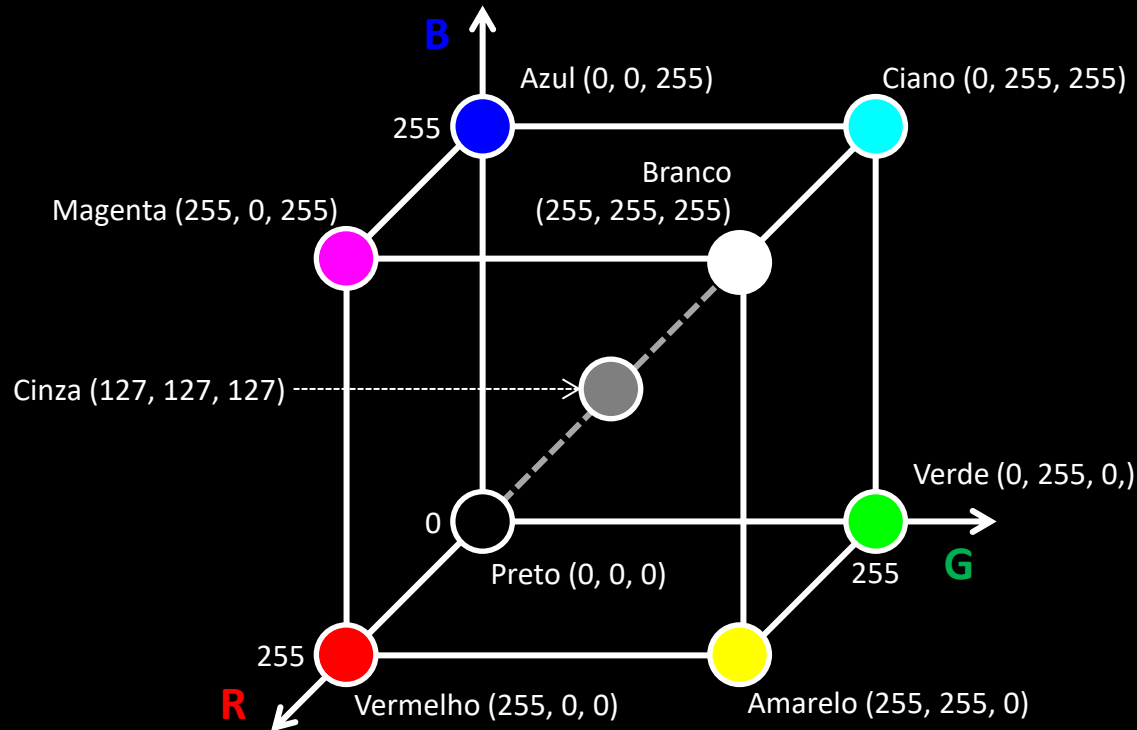
verde – G (green)



azul – B (blue)

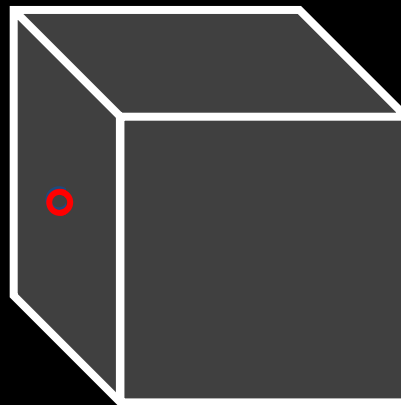


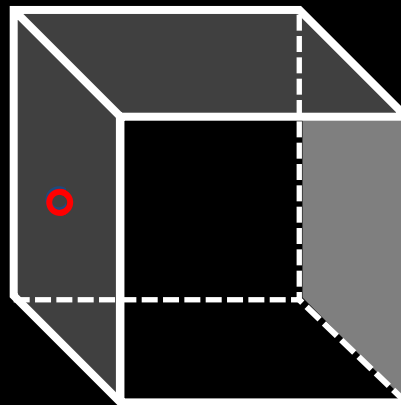
O espaço de cores RGB

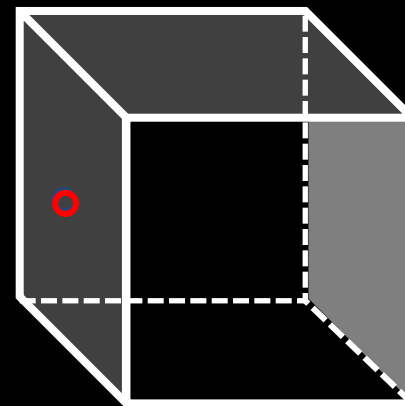
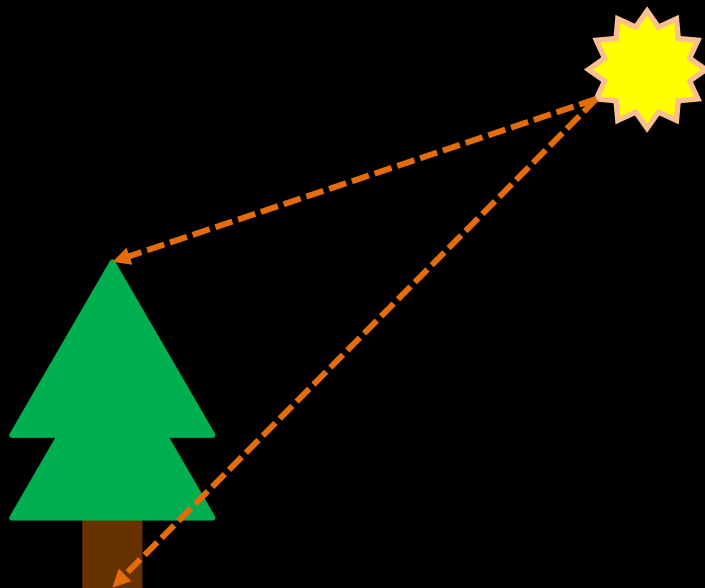


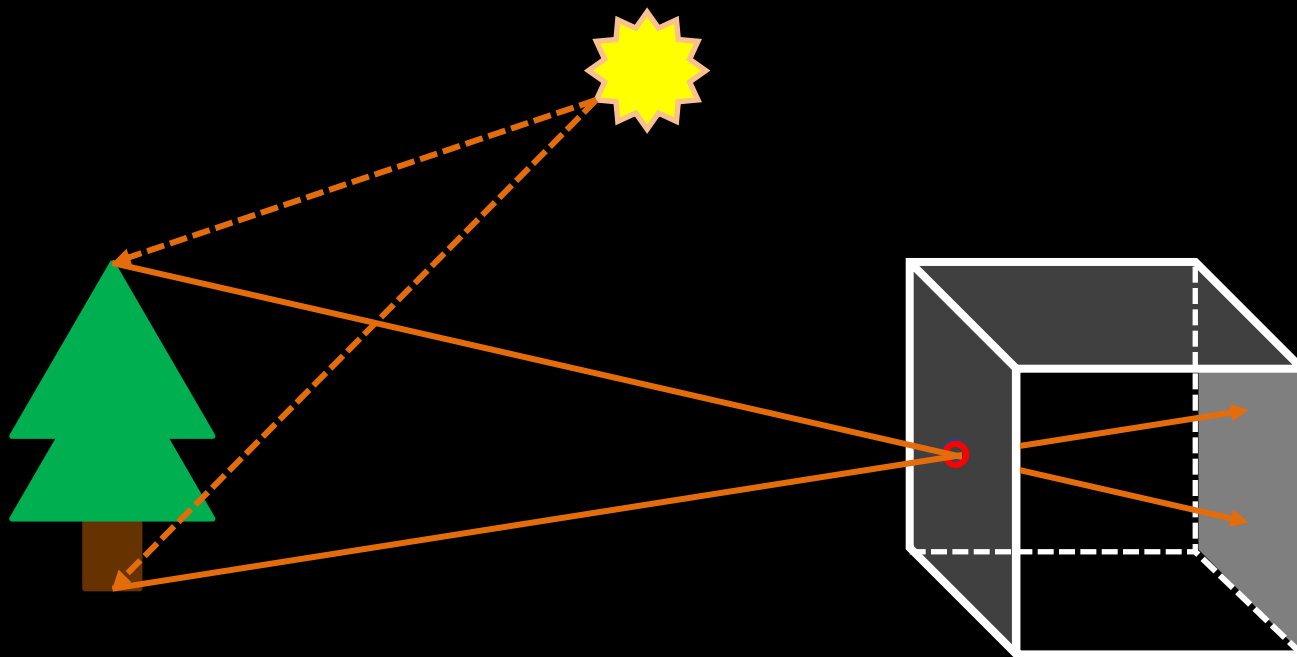


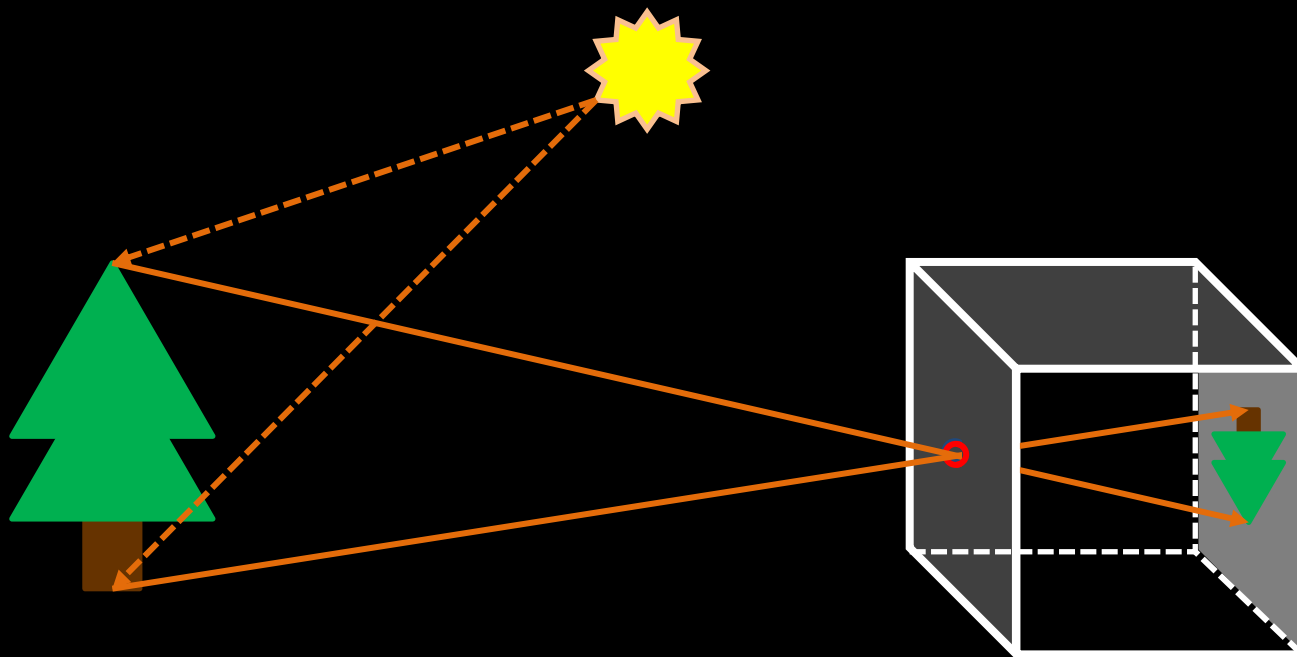


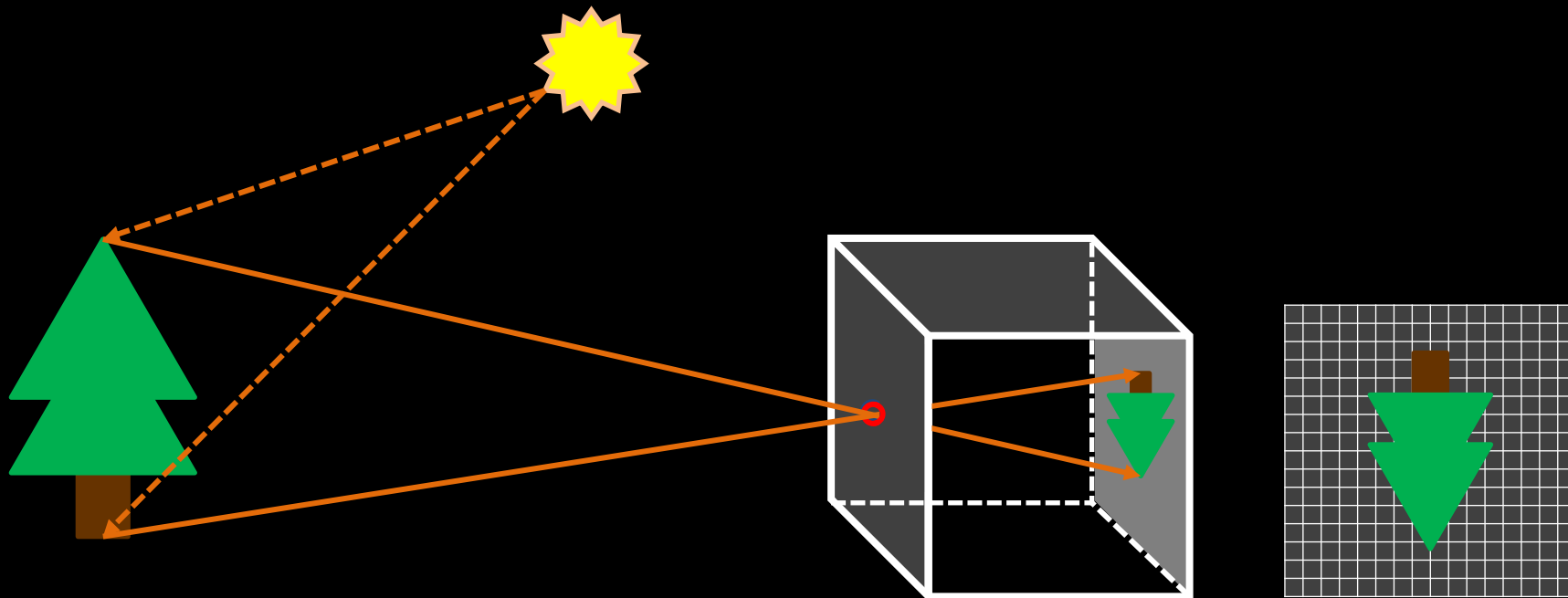




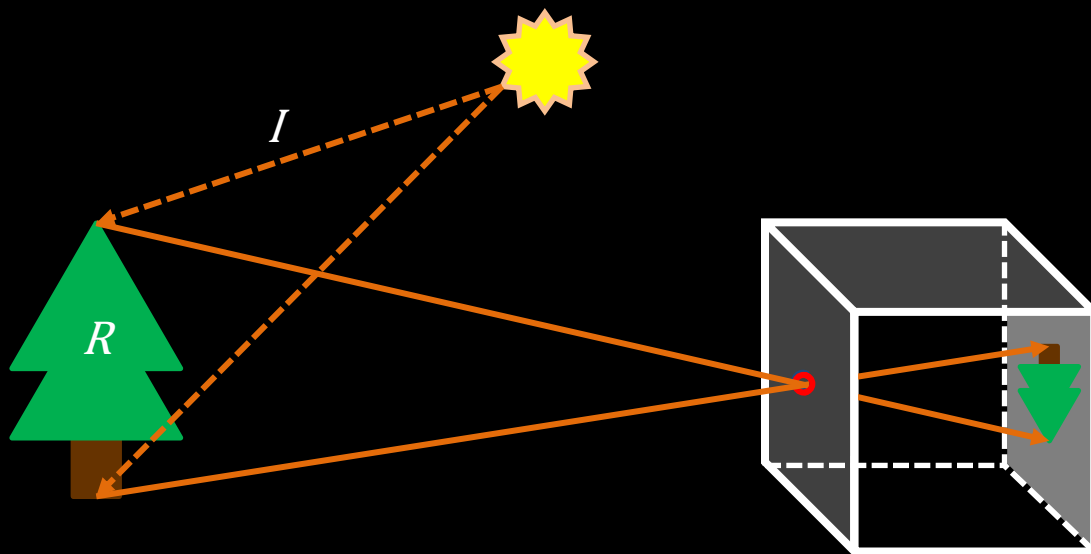








Aquisição de imagens



I : iluminância
 $0 < i(x,y) < \infty$

R : refletância
 $0 < r(x,y) < 1$

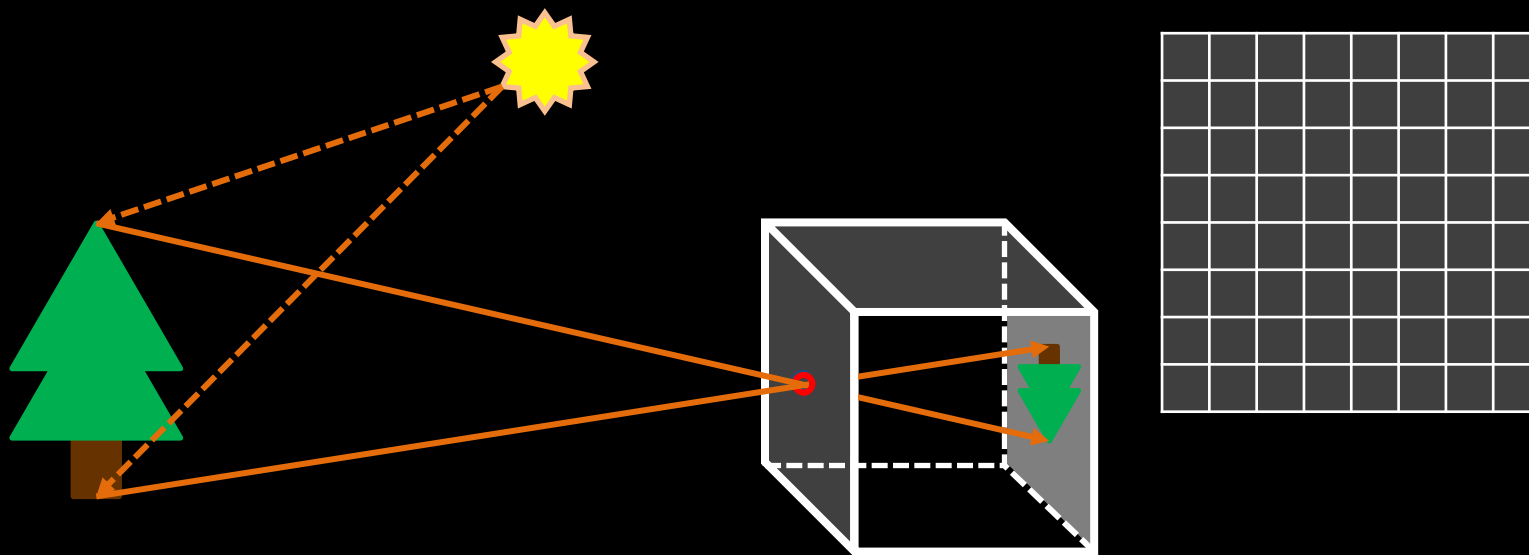
$$f(x, y) = i(x, y) \times r(x, y)$$

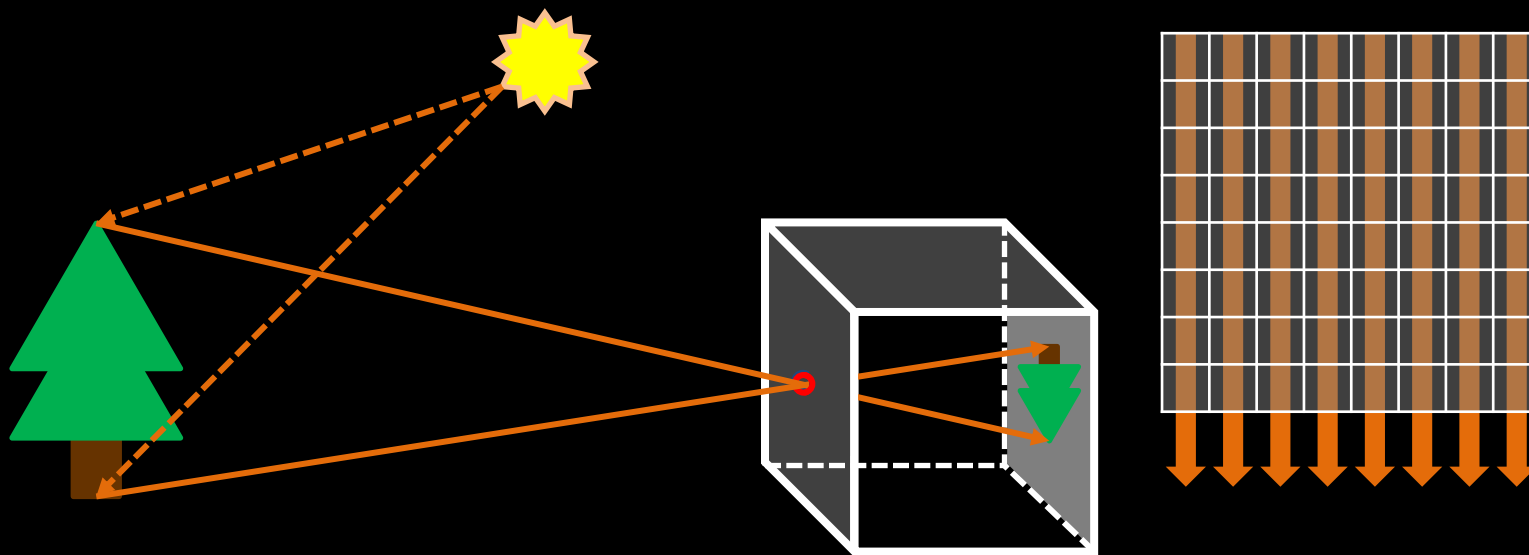
$i(x, y)$ (em lux ou lúmen/m²)

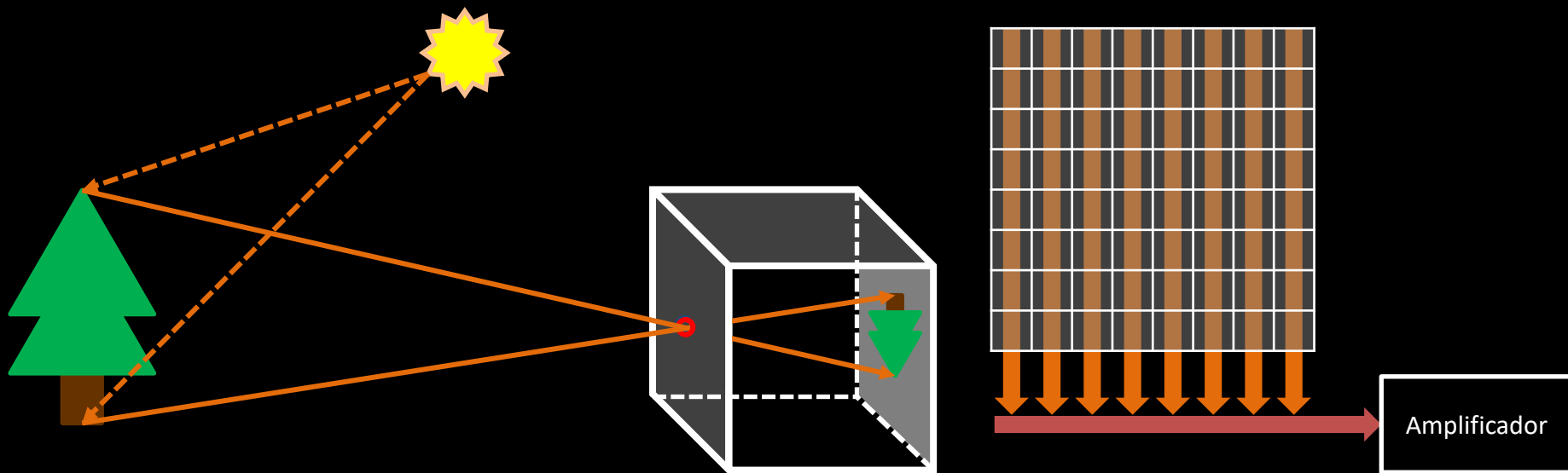
900	Dia ensolarado
100	Dia nublado
10	Escritório
0,001	Noite clara

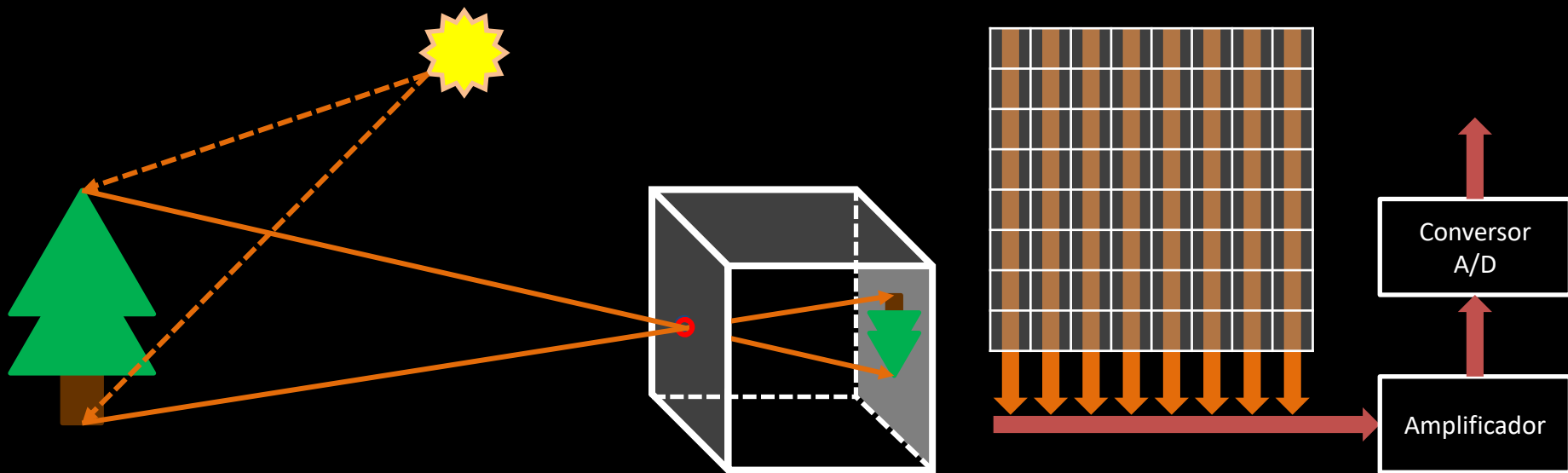
$r(x, y)$

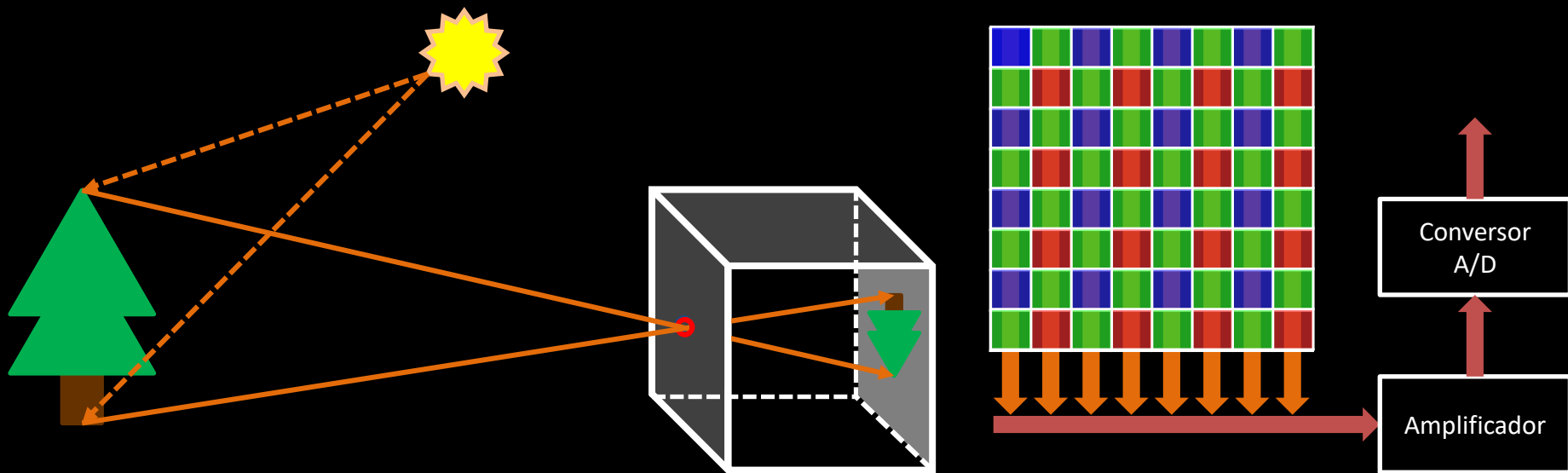
0,93	Neve
0,80	Parede branca
0,65	Aço inoxidável
0,01	Veludo preto











	0	1	2	3	4	5	6	7
0	Blue	Green	Blue	Green	Blue	Green	Blue	Green
1	Green	Red	Green	Red	Green	Red	Green	Red
2	Blue	Green	Blue	Green	Blue	Green	Blue	Green
3	Green	Red	Green	Red	Green	Red	Green	Red
4	Blue	Green	Blue	Green	Blue	Green	Blue	Green
5	Green	Red	Green	Red	Green	Red	Green	Red
6	Blue	Green	Blue	Green	Blue	Green	Blue	Green
7	Green	Red	Green	Red	Green	Red	Green	Red

Sensores CCD e padrão de Bayer

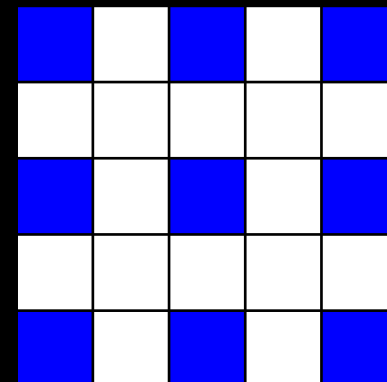
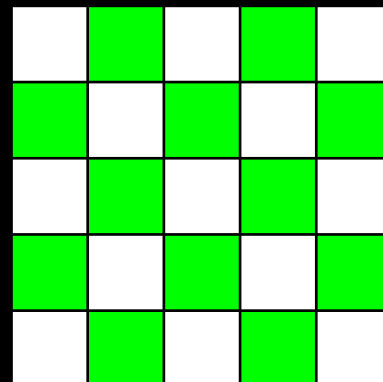
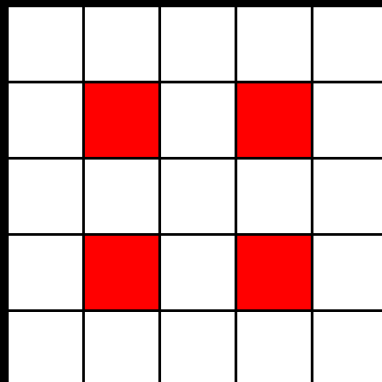
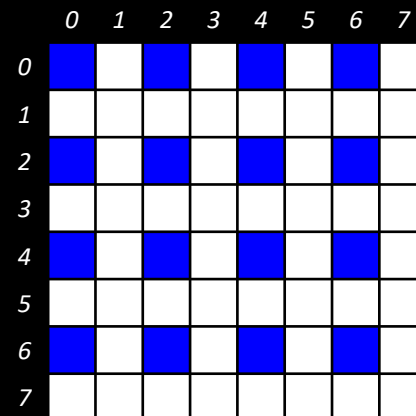
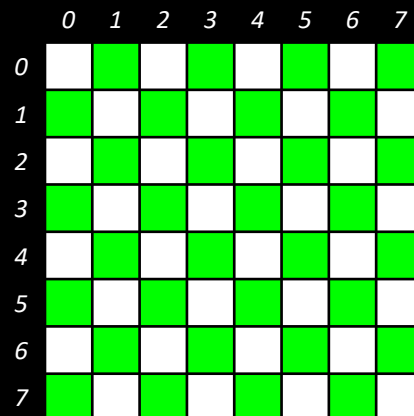
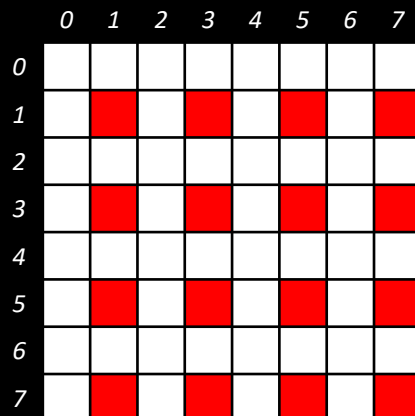
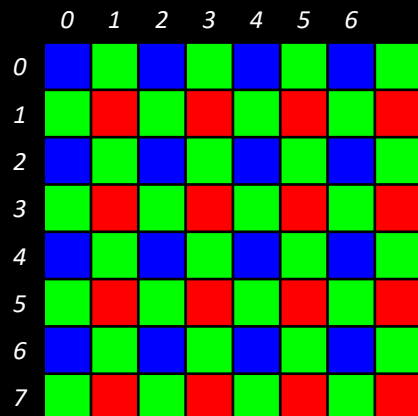
	0	1	2	3	4	5	6
0	Blue	Green	Blue	Green	Blue	Green	Blue
1	Green	Red	Green	Red	Green	Red	Green
2	Blue	Green	Blue	Green	Blue	Green	Blue
3	Green	Red	Green	Red	Green	Red	Green
4	Blue	Green	Blue	Green	Blue	Green	Blue
5	Green	Red	Green	Red	Green	Red	Green
6	Blue	Green	Blue	Green	Blue	Green	Blue
7	Green	Red	Green	Red	Green	Red	Green

	0	1	2	3	4	5	6	7
0								
1		Red		Red		Red		Red
2								
3		Red		Red		Red		Red
4								
5		Red		Red		Red		Red
6								
7		Red		Red		Red		Red

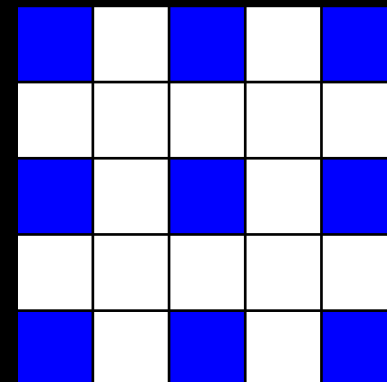
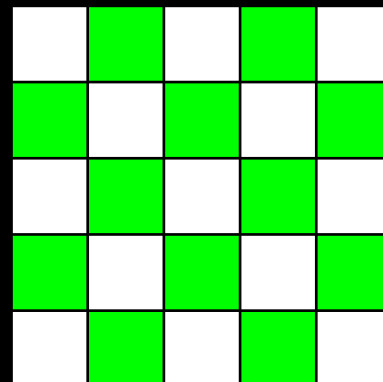
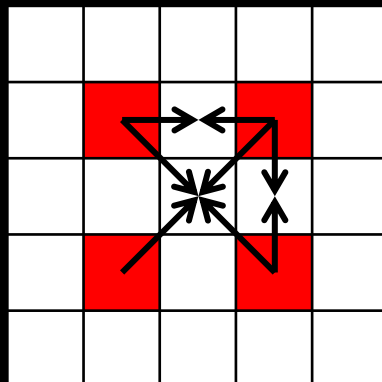
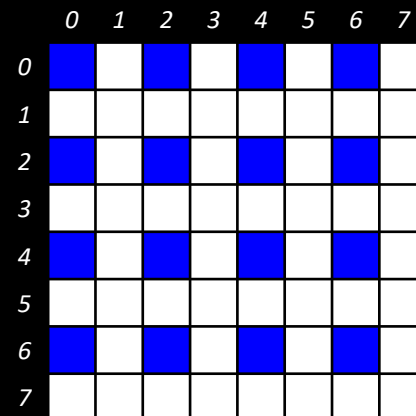
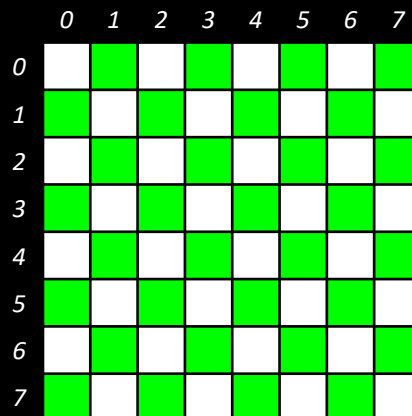
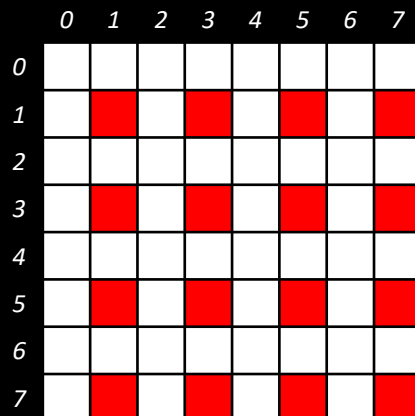
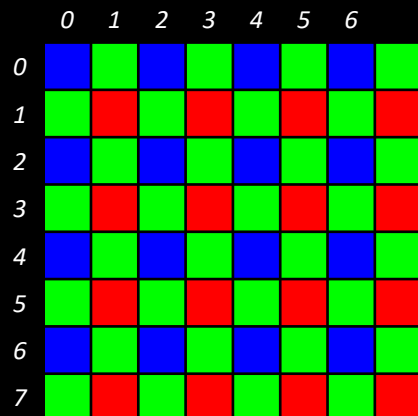
	0	1	2	3	4	5	6	7
0		Green		Green		Green		Green
1	Green		Green		Green		Green	
2		Green		Green		Green		Green
3	Green		Green		Green		Green	
4		Green		Green		Green		Green
5	Green		Green		Green		Green	
6		Green		Green		Green		Green
7	Green		Green		Green		Green	

	0	1	2	3	4	5	6	7
0	Blue		Blue		Blue		Blue	
1								
2	Blue		Blue		Blue		Blue	
3								
4	Blue		Blue		Blue		Blue	
5								
6	Blue		Blue		Blue		Blue	
7								

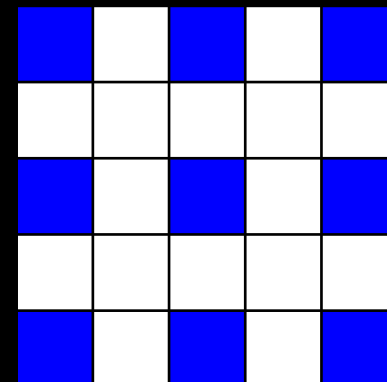
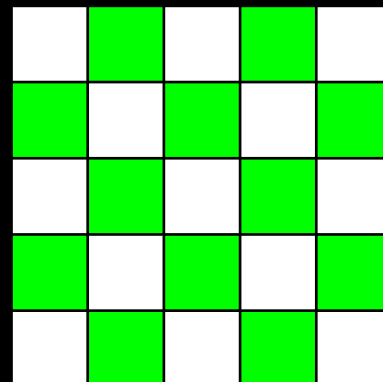
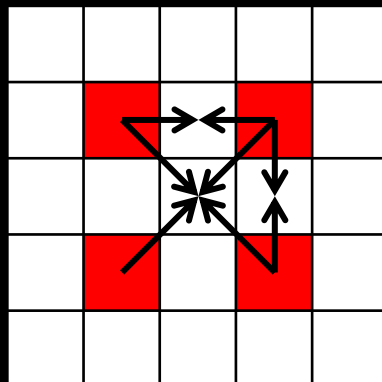
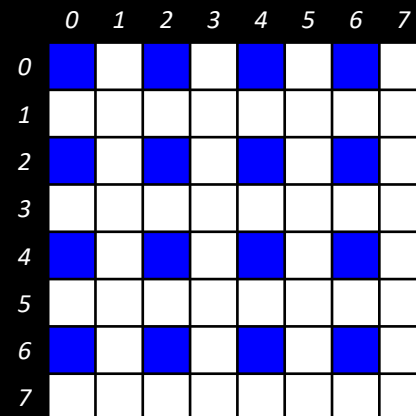
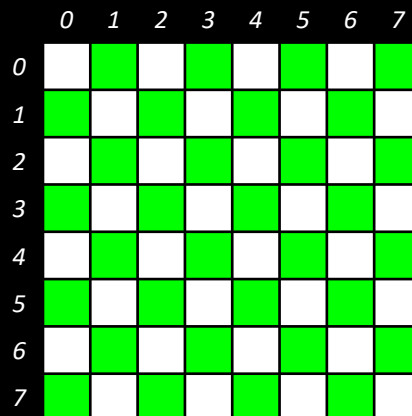
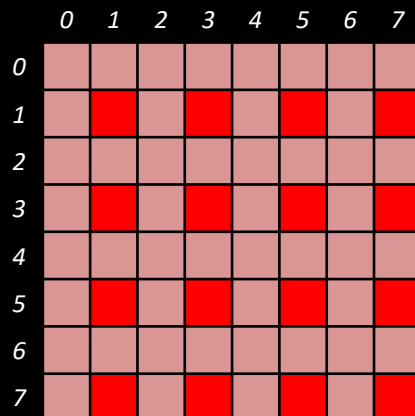
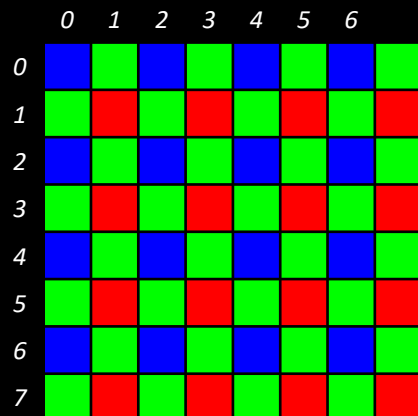
Sensores CCD e padrão de Bayer



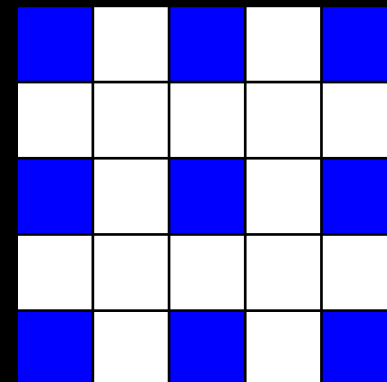
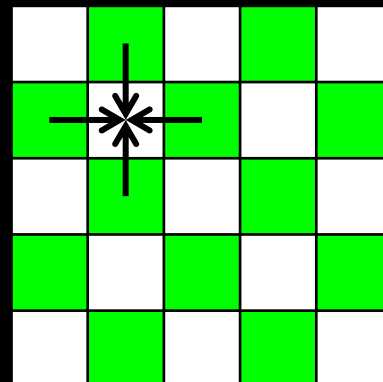
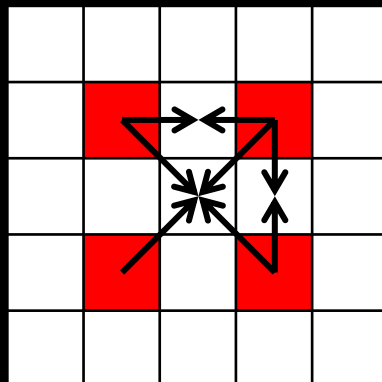
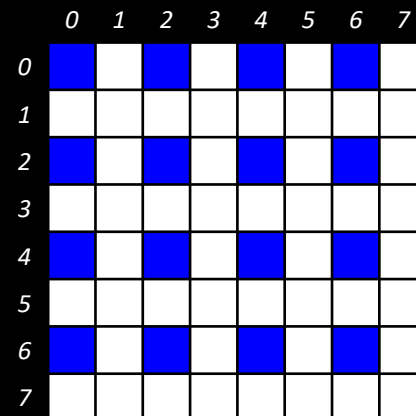
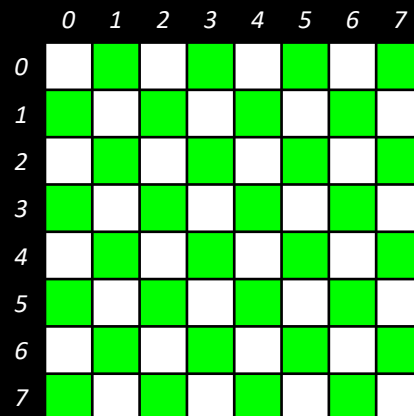
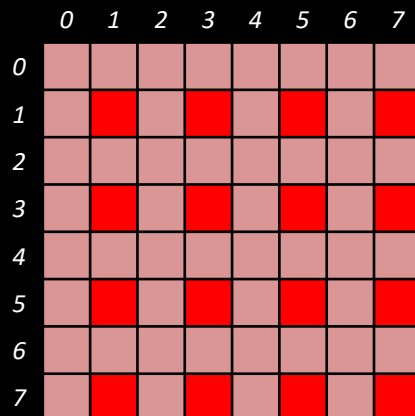
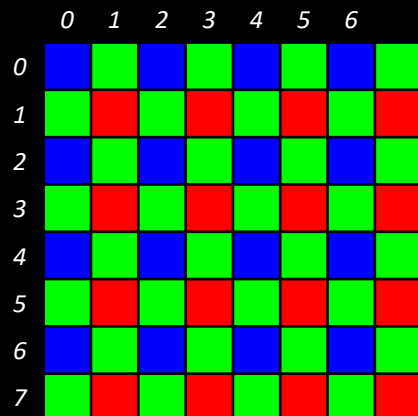
Sensores CCD e padrão de Bayer



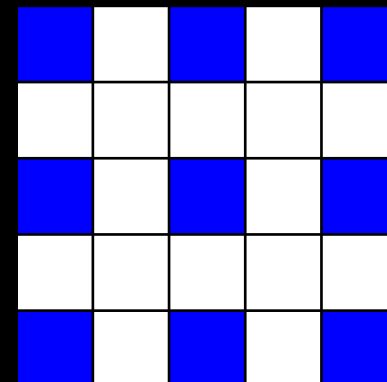
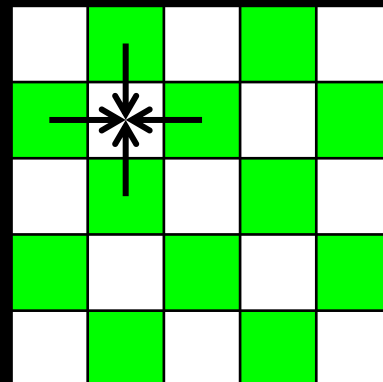
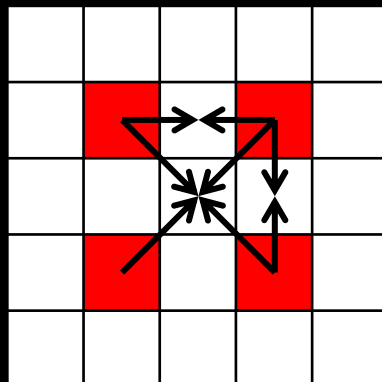
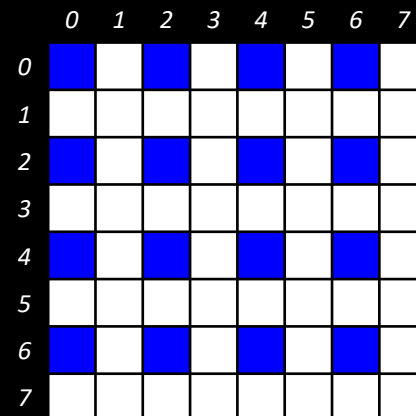
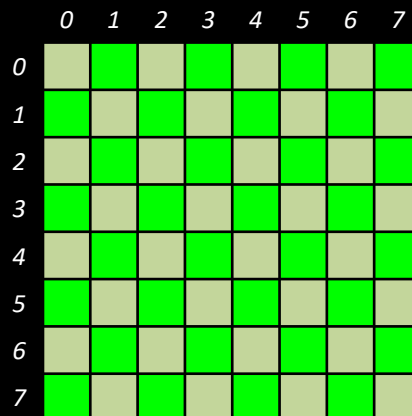
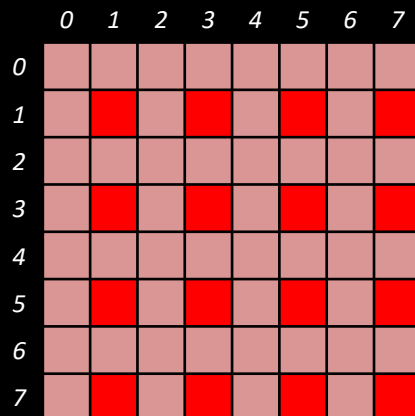
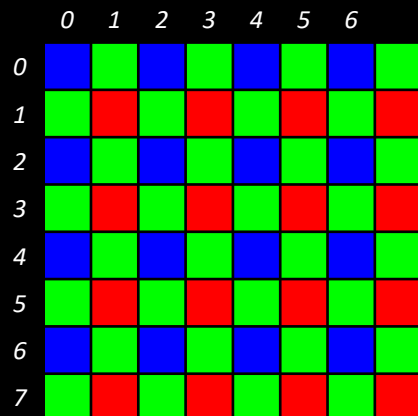
Sensores CCD e padrão de Bayer



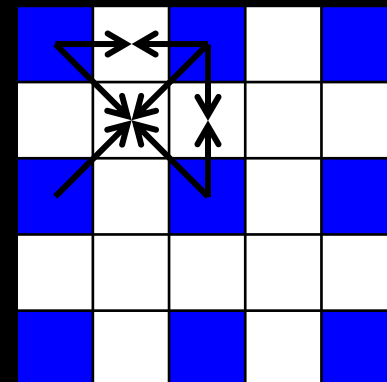
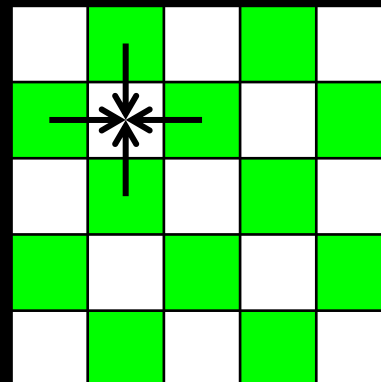
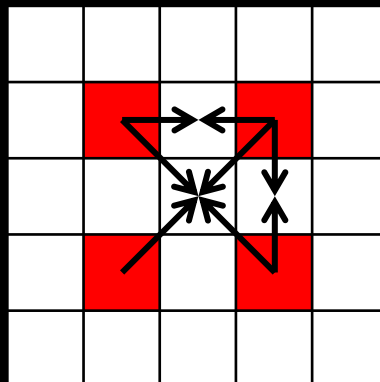
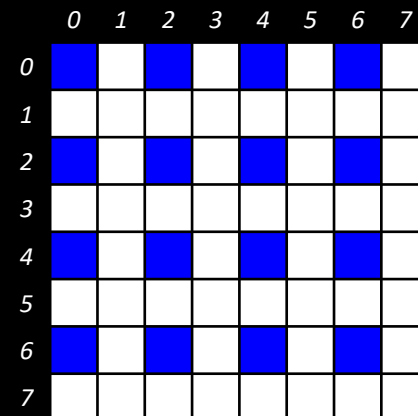
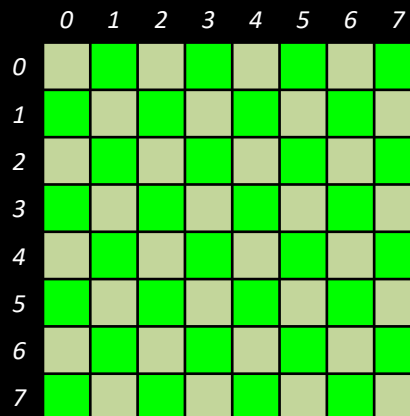
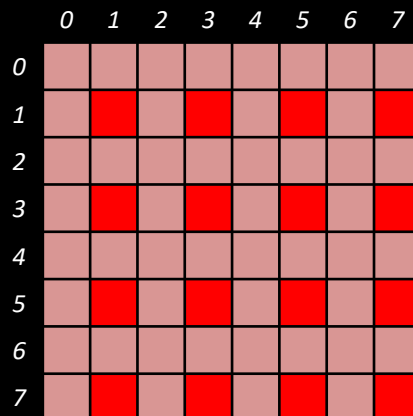
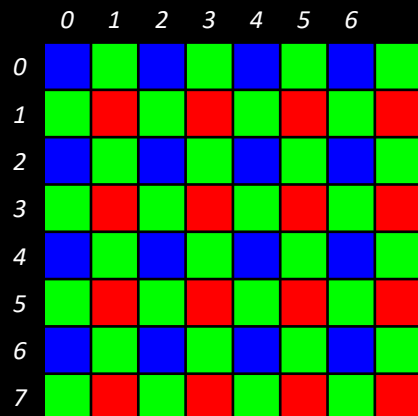
Sensores CCD e padrão de Bayer



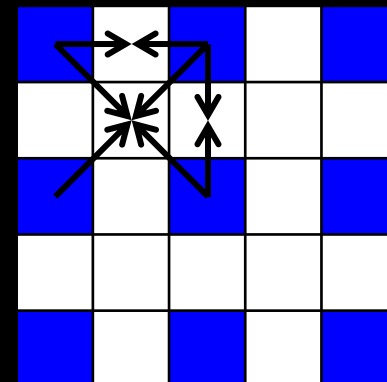
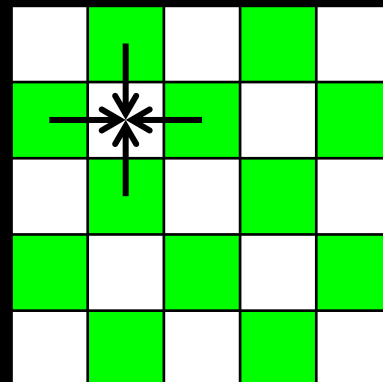
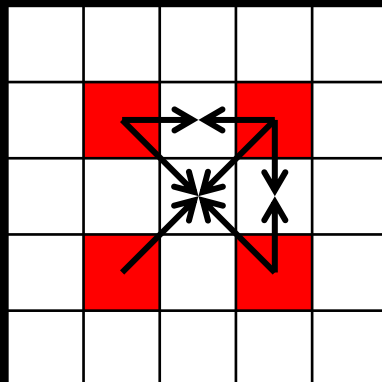
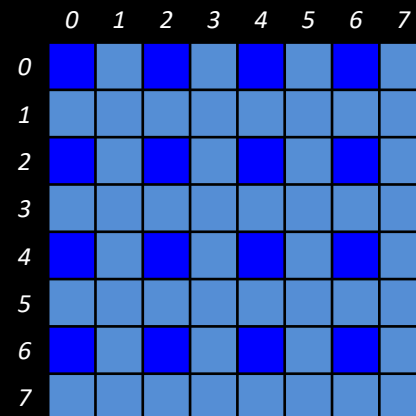
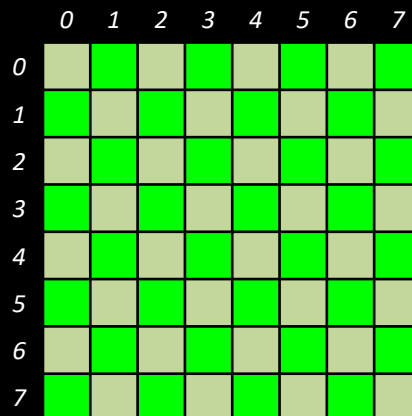
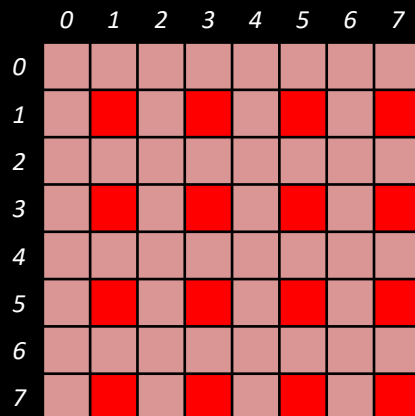
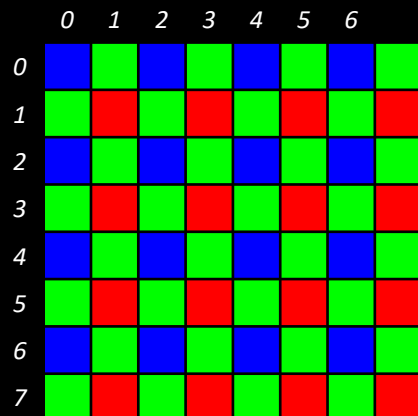
Sensores CCD e padrão de Bayer



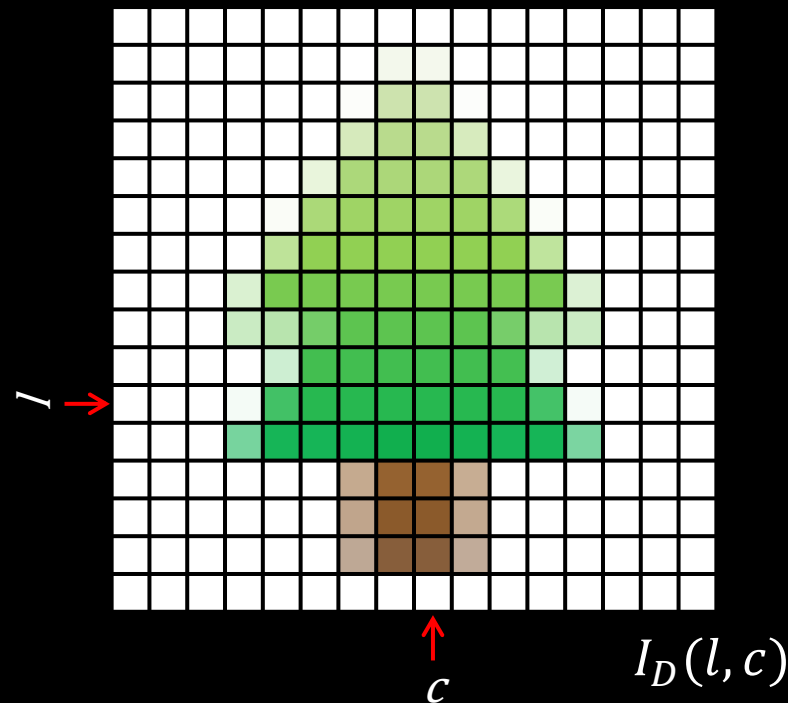
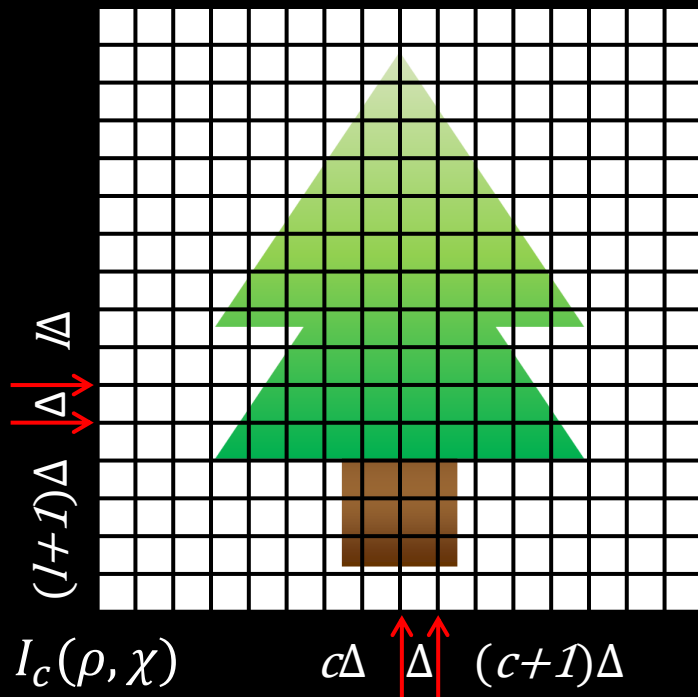
Sensores CCD e padrão de Bayer



Sensores CCD e padrão de Bayer



Amostragem



$$I_D = \frac{1}{\Delta^2} \int_{l\Delta}^{(l+1)\Delta} \int_{c\Delta}^{(c+1)\Delta} I_c(\rho, \chi) \delta\rho \delta\chi$$

Baseado em: Alan Peters, 2019

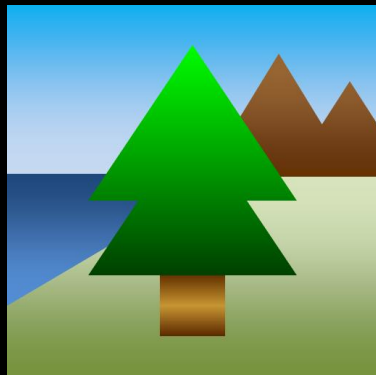


Imagem RGB contínua

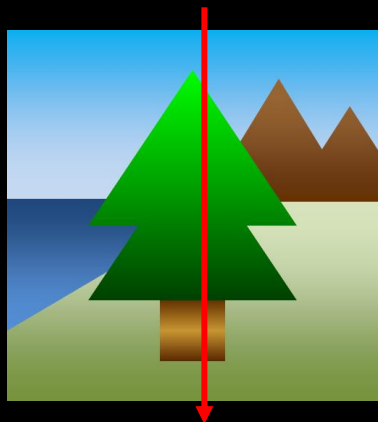


Imagem RGB contínua

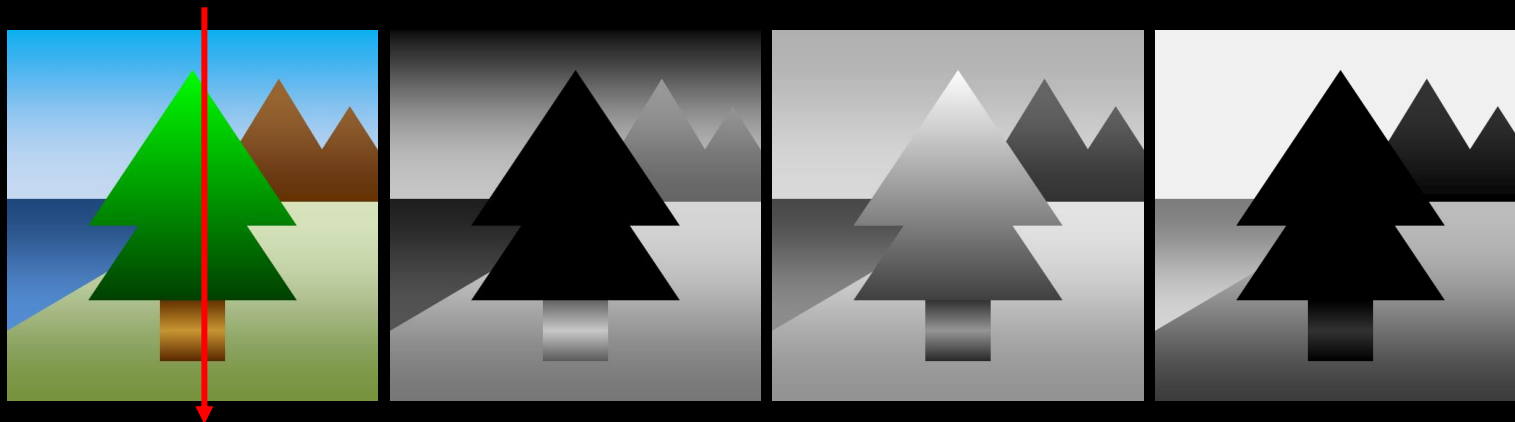


Imagem RGB contínua

Imagem R contínua

Imagem G contínua

Imagem B contínua

Amostragem

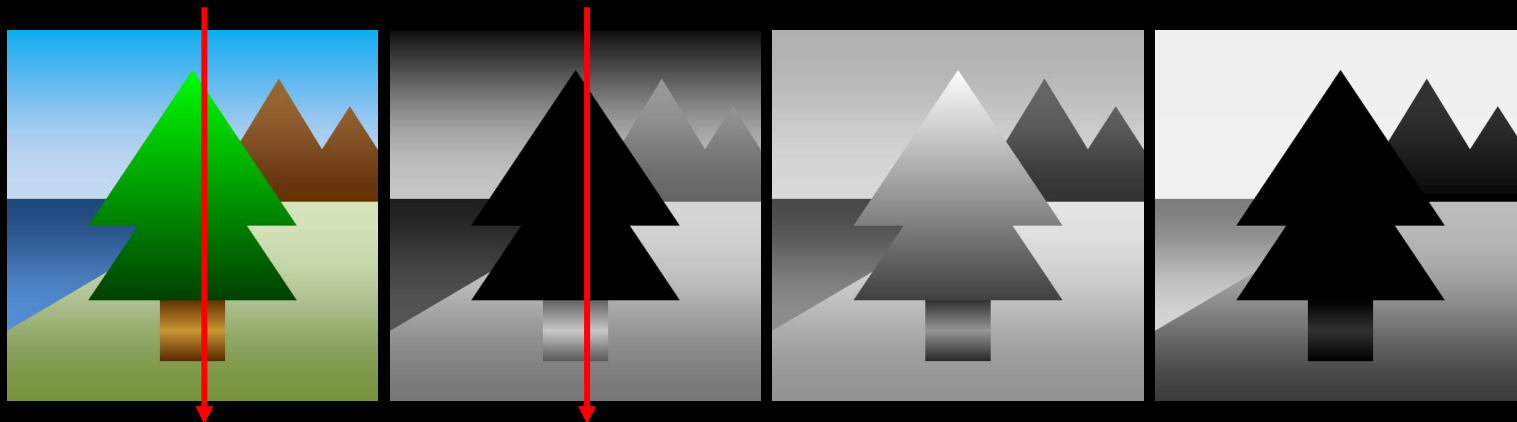


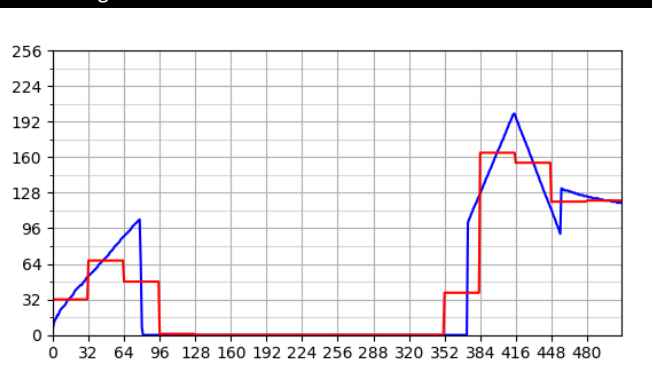
Imagem RGB contínua

Imagem R contínua

Imagem G contínua

Imagem B contínua

Amostragem do canal R



Amostragem

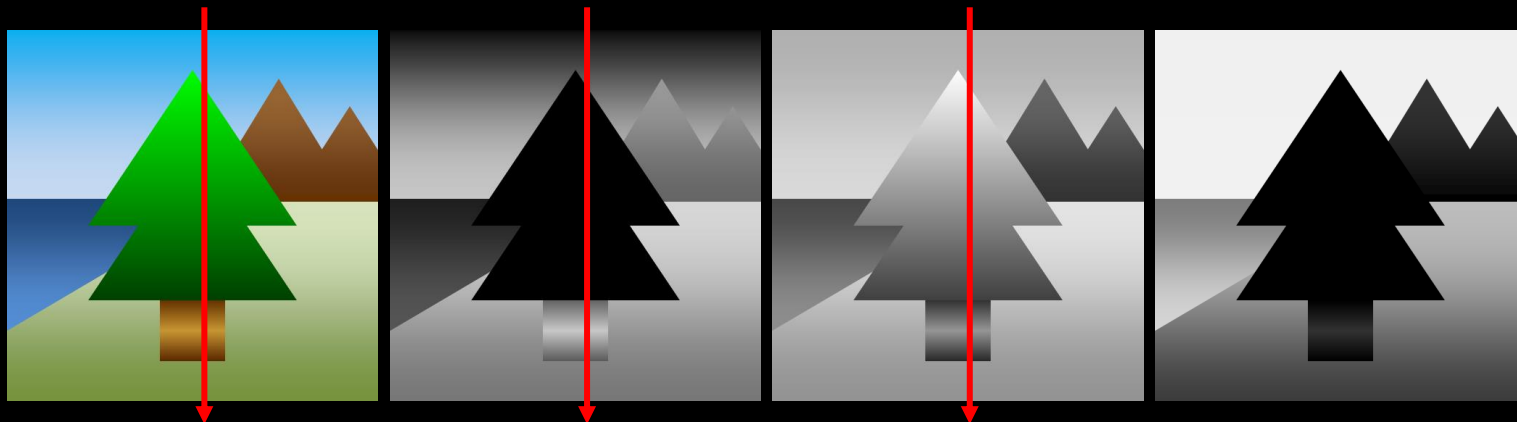


Imagem RGB contínua

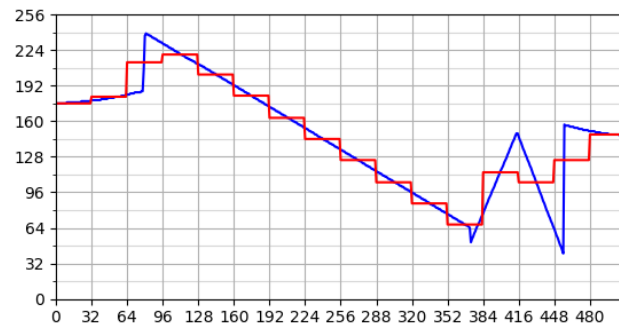
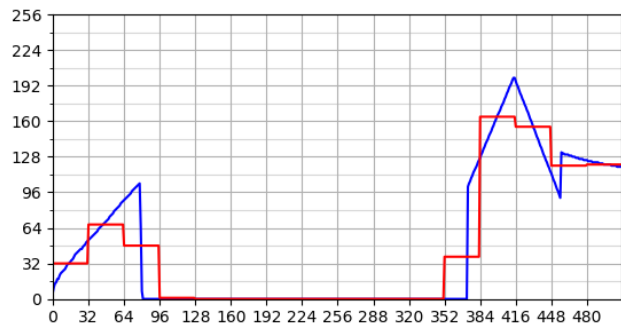
Imagem R contínua

Imagem G contínua

Imagem B contínua

Amostragem do canal R

Amostragem do canal G



Amostragem

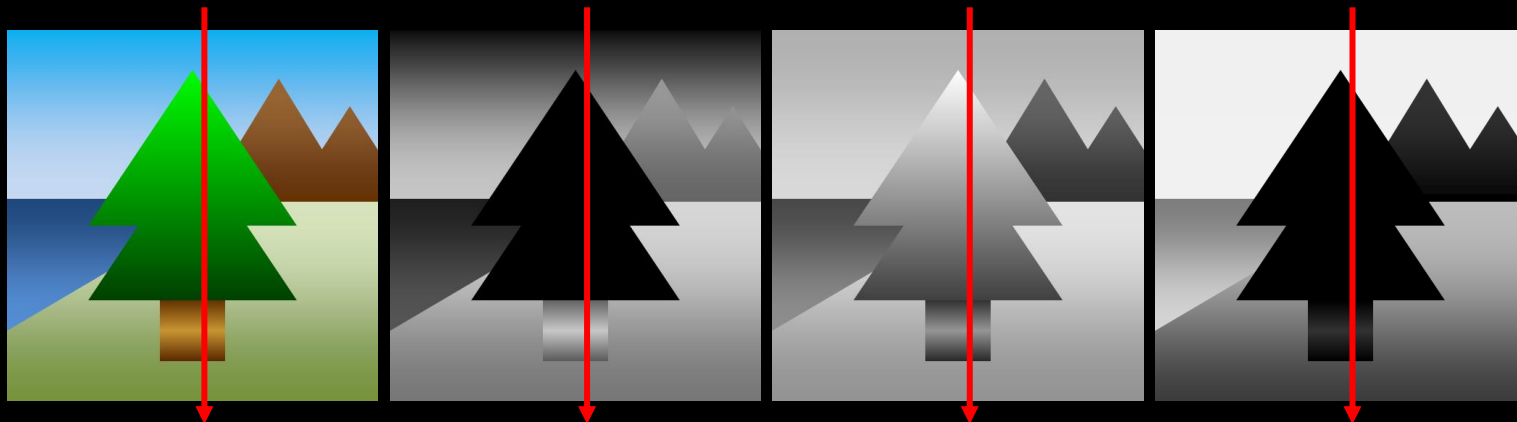


Imagem RGB contínua

Imagem R contínua

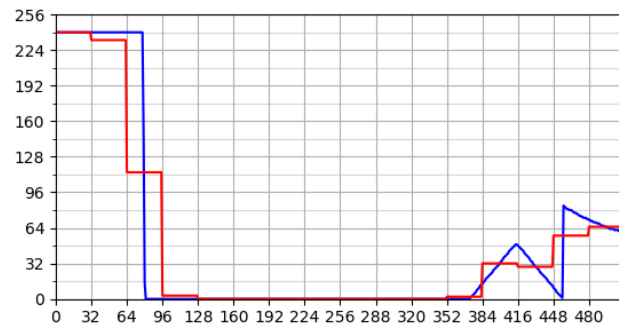
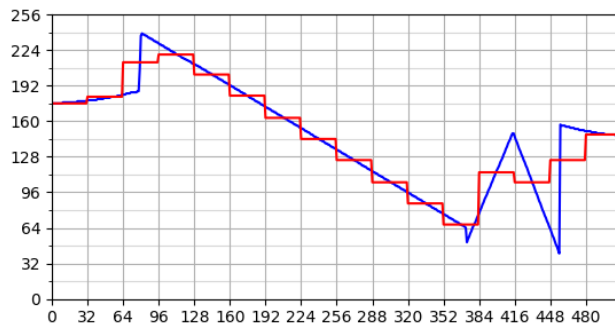
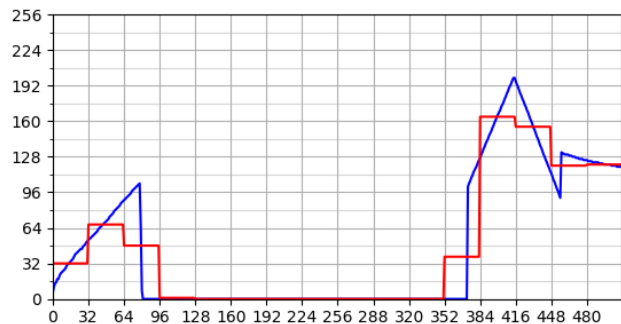
Imagem G contínua

Imagem B contínua

Amostragem do canal R

Amostragem do canal G

Amostragem do canal B



Amostragem

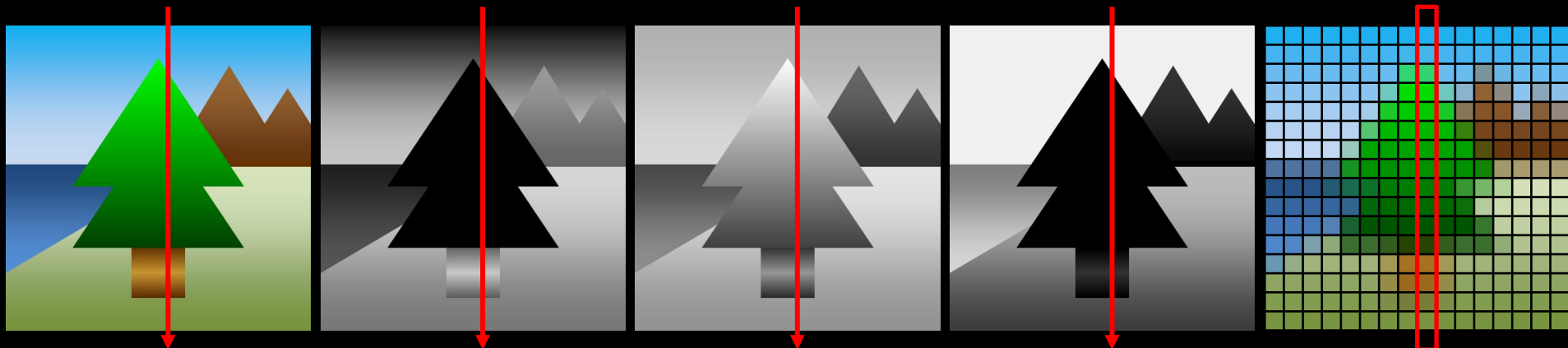


Imagem RGB contínua

Imagem R contínua

Imagem G contínua

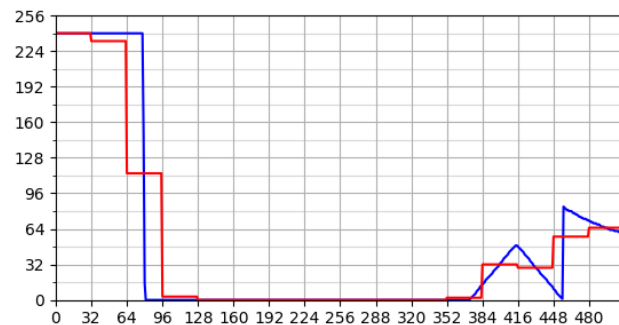
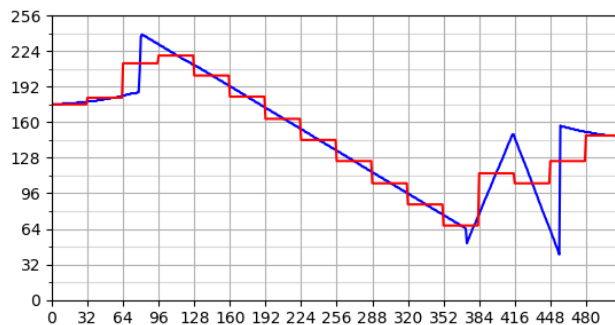
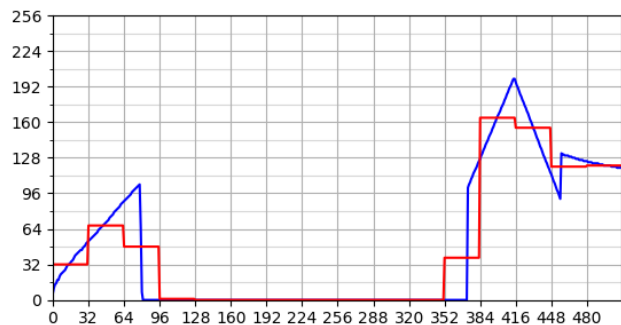
Imagem B contínua

Imagem RGB discreta (amostrada)

Amostragem do canal R

Amostragem do canal G

Amostragem do canal B



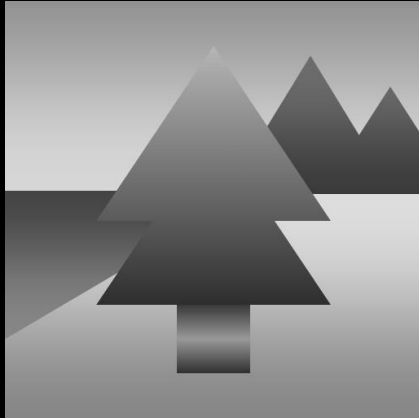


Imagem em níveis de cinza continua

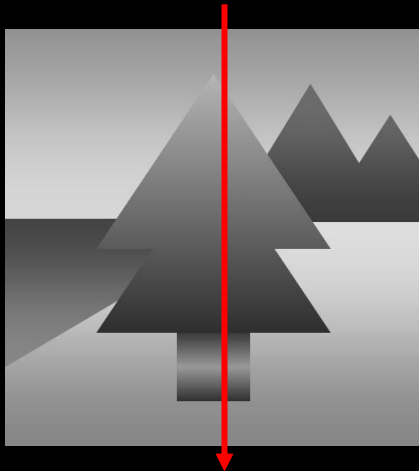
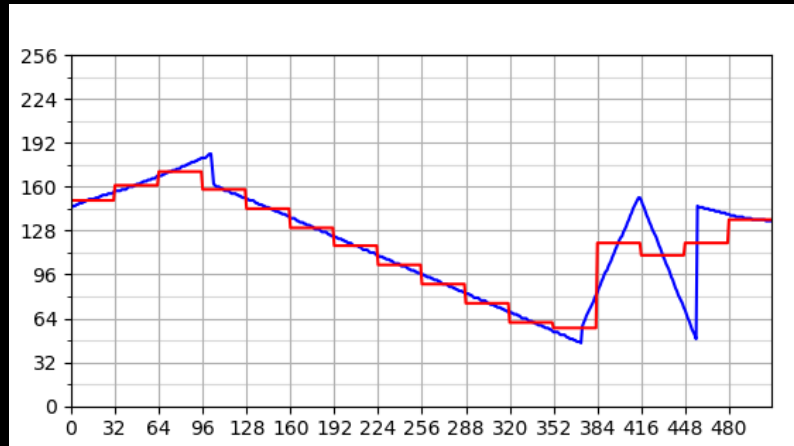


Imagem em níveis de cinza continua



Amostragem da imagem em níveis de cinza

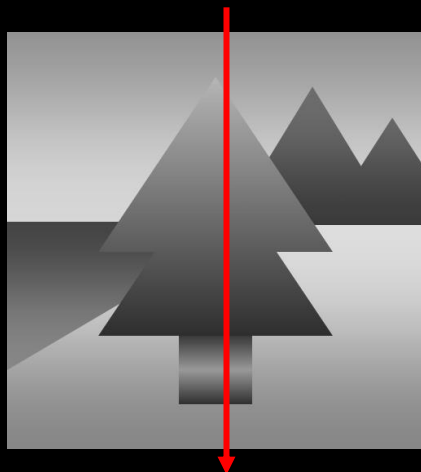
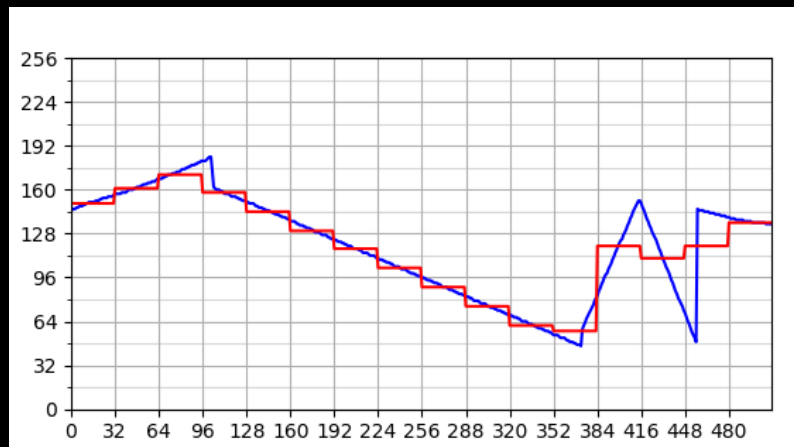


Imagem em níveis de cinza continua



Amostragem da imagem em níveis de cinza

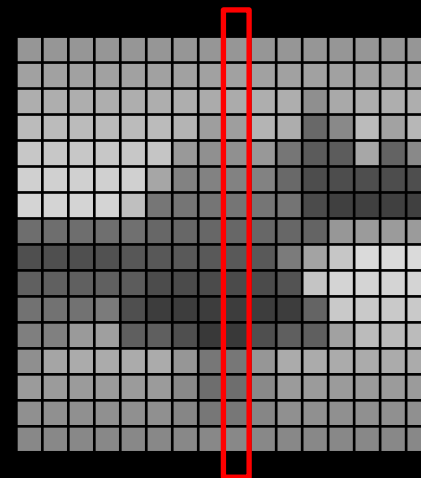


Imagem em níveis de cinza discreta
(amostrada)

Efeitos da resolução espacial

1,7 pol



300 ppi – 512 x 512



1,7 pol. a 150 ppi – 256 x 256



1,7 pol. a 75 ppi – 128 x 128



1,7 pol. a ~38 ppi – 64 x 64



1,7 pol. a 19 ppi – 32 x 32

Efeitos da resolução espacial

1,7 pol.
512 x 512 pixels
300 ppi



0,85 pol.
256 x 256 pixels
300 ppi



0,43 pol.
128 x 128 pixels
300 ppi



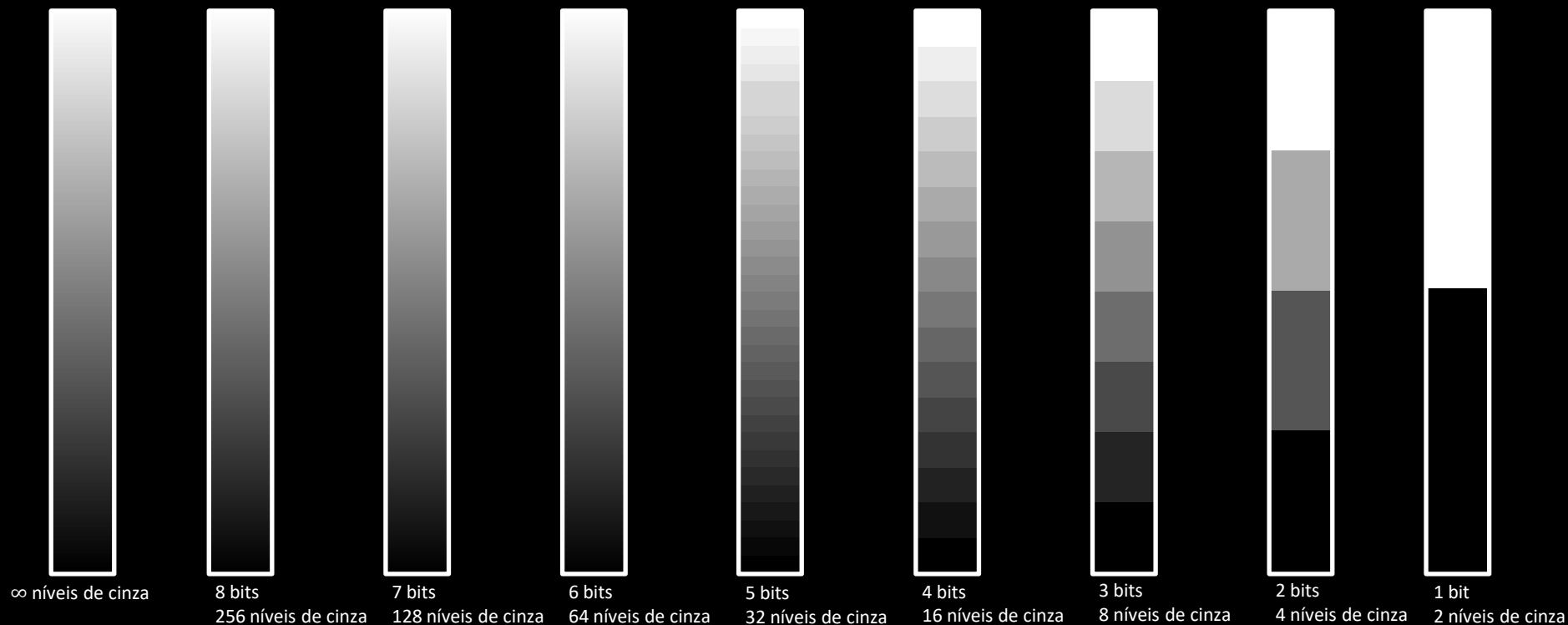
0,21 pol.
64 x 64 pixels
300 ppi



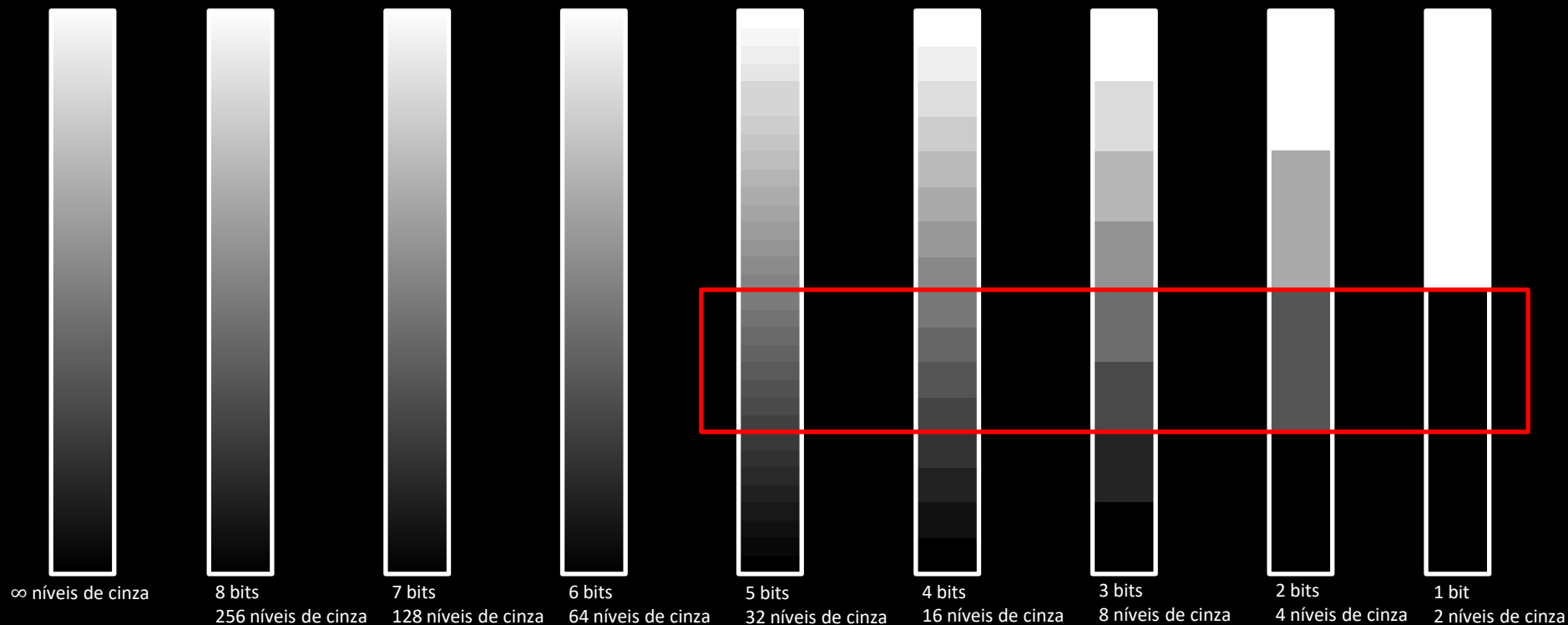
0,11 pol.
32 x 32 pixels
300 ppi



Resolução de intensidade



Resolução de intensidade



Efeitos da resolução de intensidade



8 bits. $2^8 = 256$ níveis de cinza



7 bits. $2^7 = 128$ níveis de cinza



6 bits. $2^6 = 64$ níveis de cinza



5 bits. $2^5 = 32$ níveis de cinza



4 bits. $2^4 = 16$ níveis de cinza



3 bits. $2^3 = 8$ níveis de cinza



1 bit. $2^1 = 2$ níveis de cinza

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