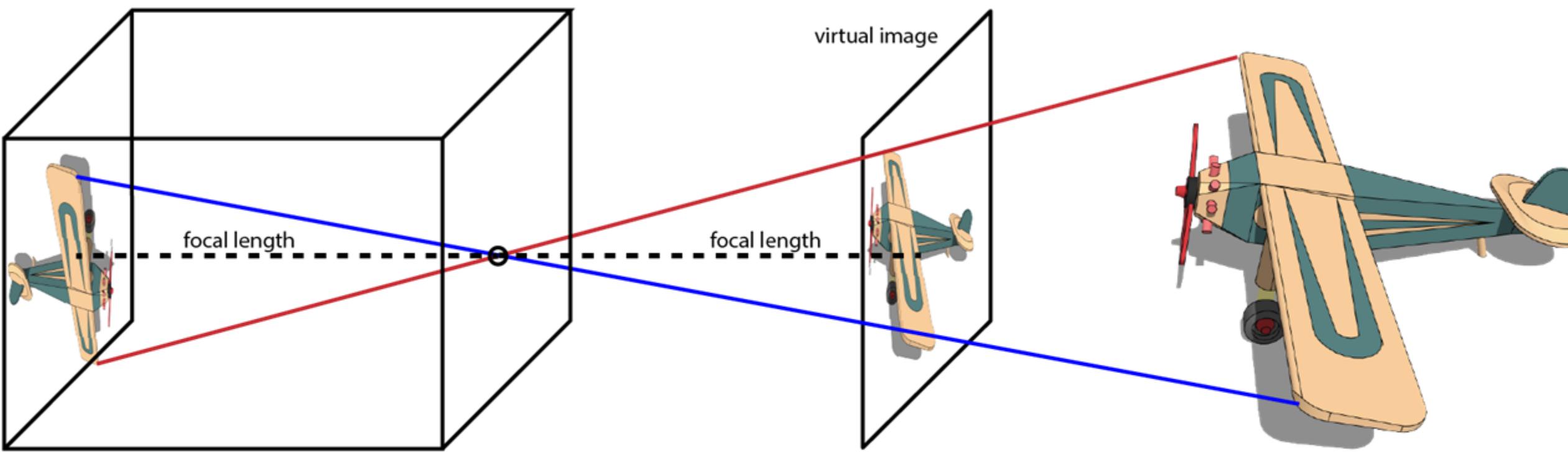
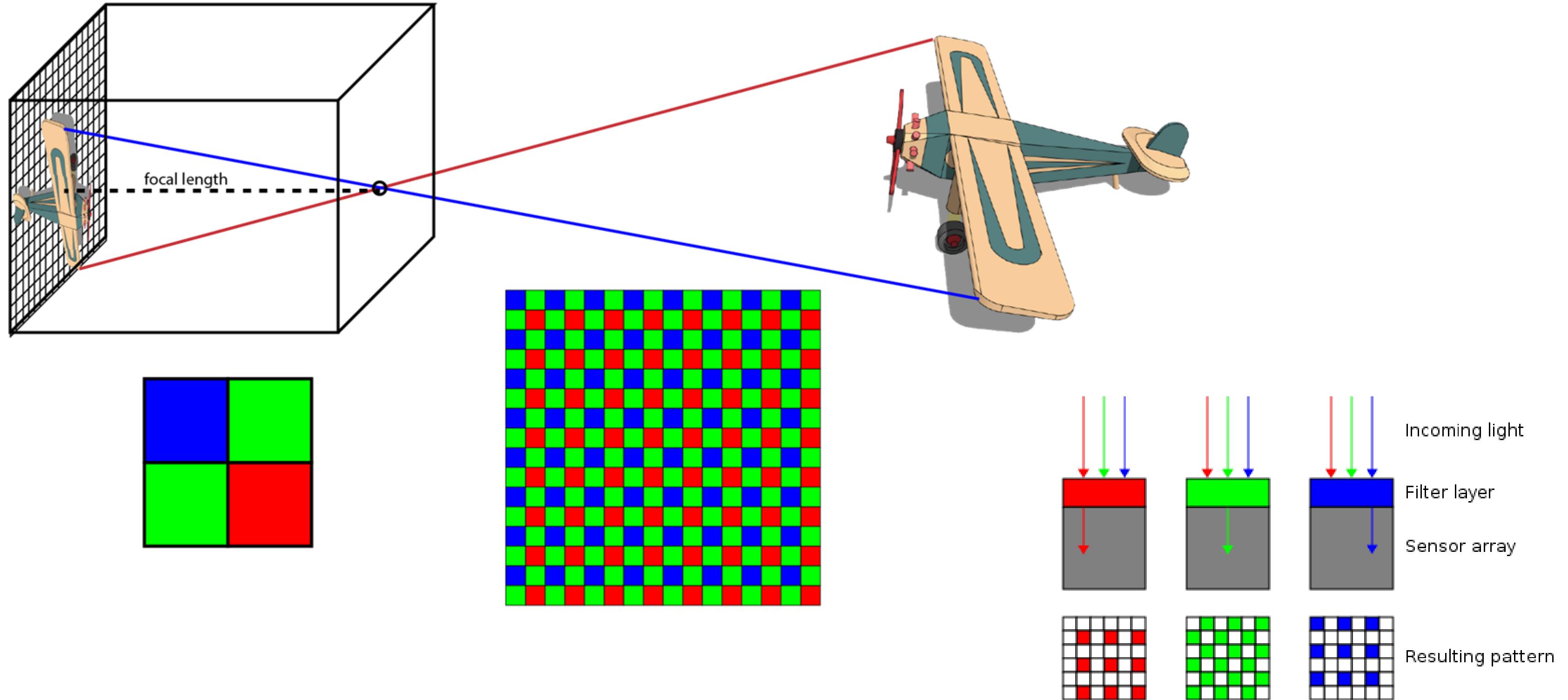


Вспомогательные материалы

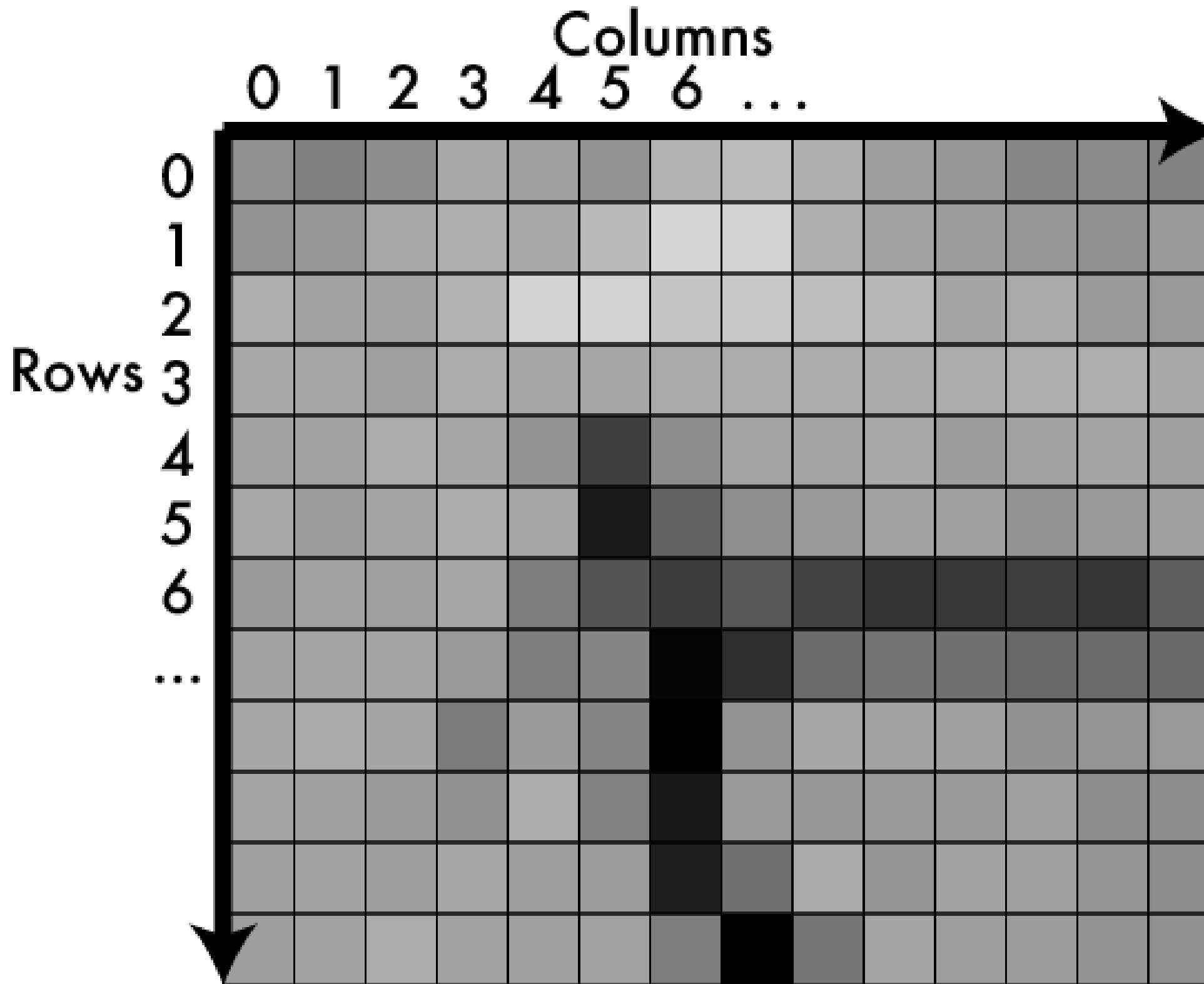
Model: pinhole camera



CMOS sensors

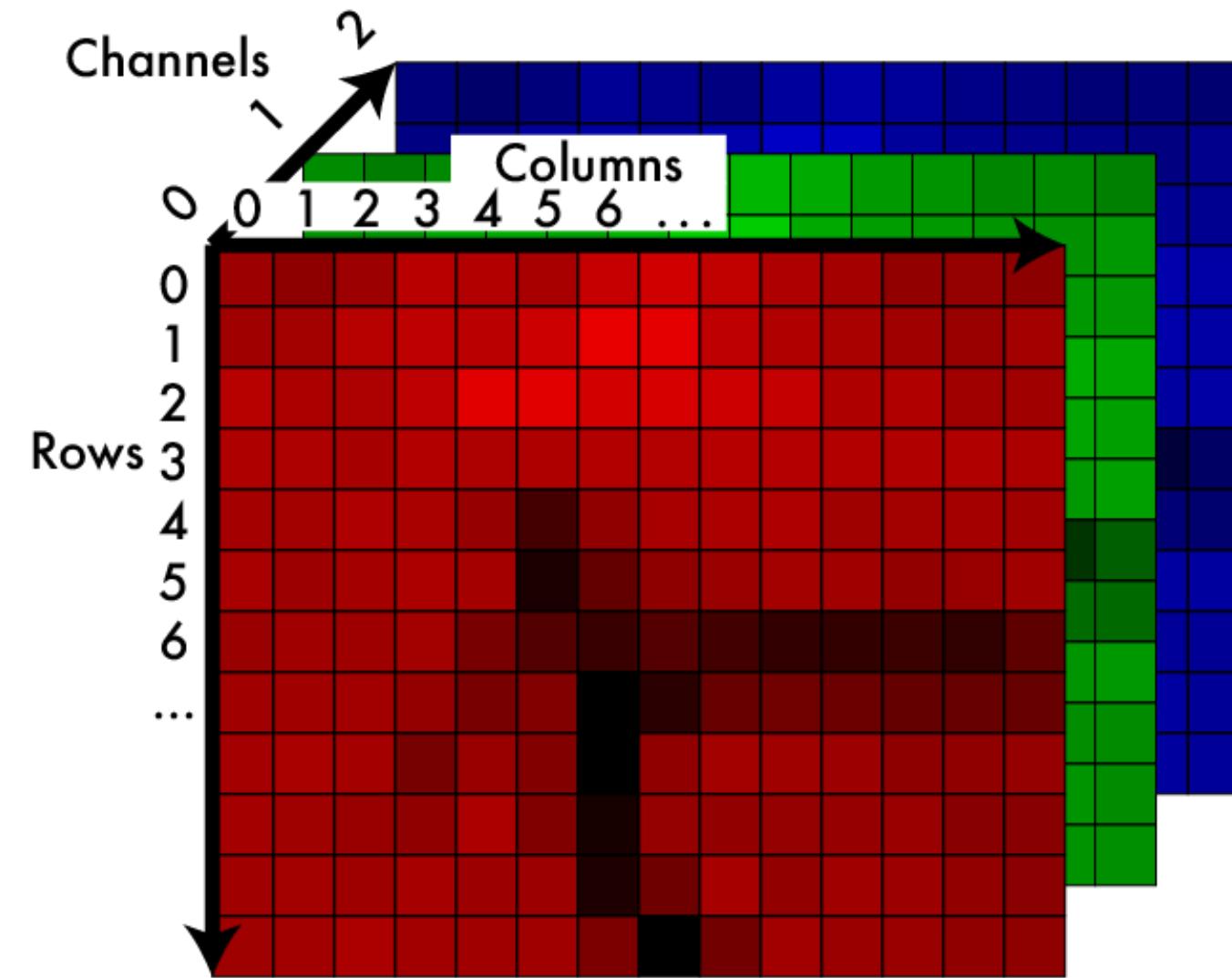


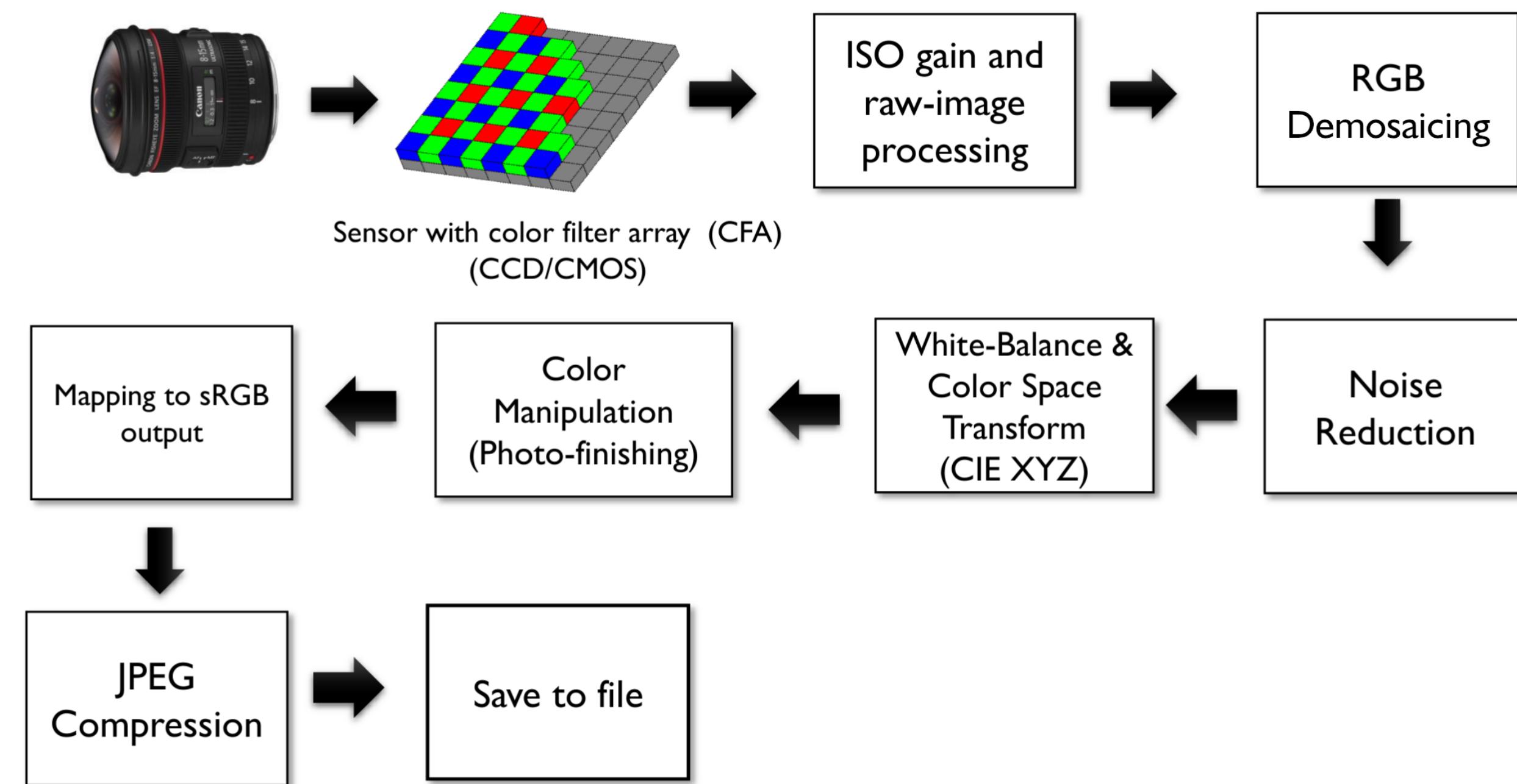
An image is a matrix of light



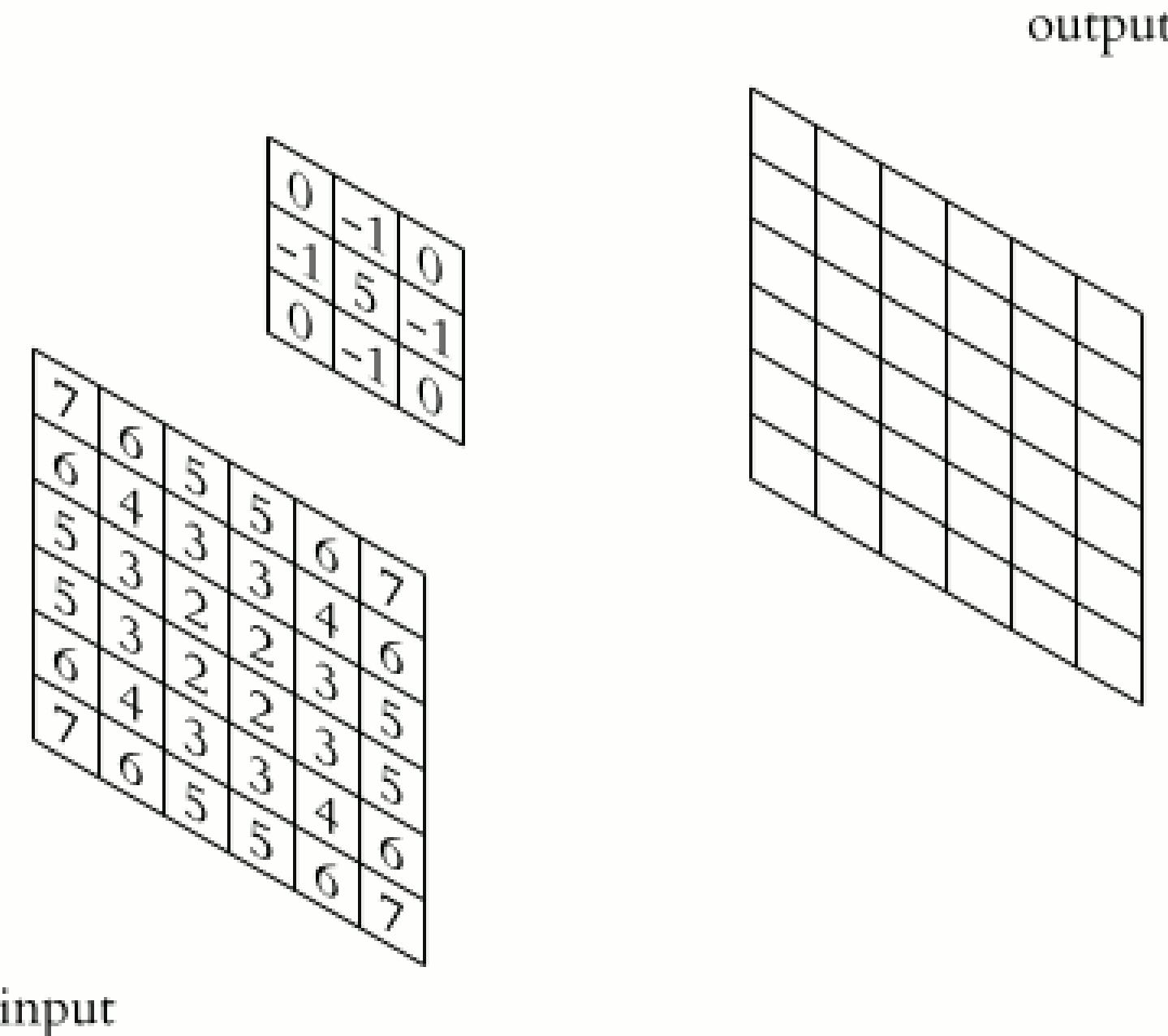
Values in matrix = how much light

		Columns													
		0	1	2	3	4	5	6	...						
Rows	0	100	102	107	102	132	146	136	156	148	122	115	104	105	103
	1	100	102	107	102	132	146	136	156	148	122	115	104	105	103
	2	100	102	107	102	132	146	136	156	148	122	115	104	105	103
	3	100	102	107	102	132	146	136	156	148	122	115	104	105	103
	4	100	102	107	102	132	146	136	156	148	122	115	104	105	103
	5	100	102	107	102	132	30	60	156	148	122	115	104	105	103
	6	100	102	107	102	132	40	20	50	32	20	20	24	30	62
	...	100	102	107	102	132	71	14	156	51	57	57	58	62	58
	0	100	102	107	102	132	69		156	148	122	115	104	105	103
	1	100	102	107	102	132	89	12	156	148	122	115	104	105	103
	2	100	102	107	102	132	146	13	45	148	122	115	104	105	103
	3	100	102	107	102	132	146	46		42	122	115	104	105	103





Свертка



https://upload.wikimedia.org/wikipedia/commons/1/19/2D_Convolution_Animation.gif

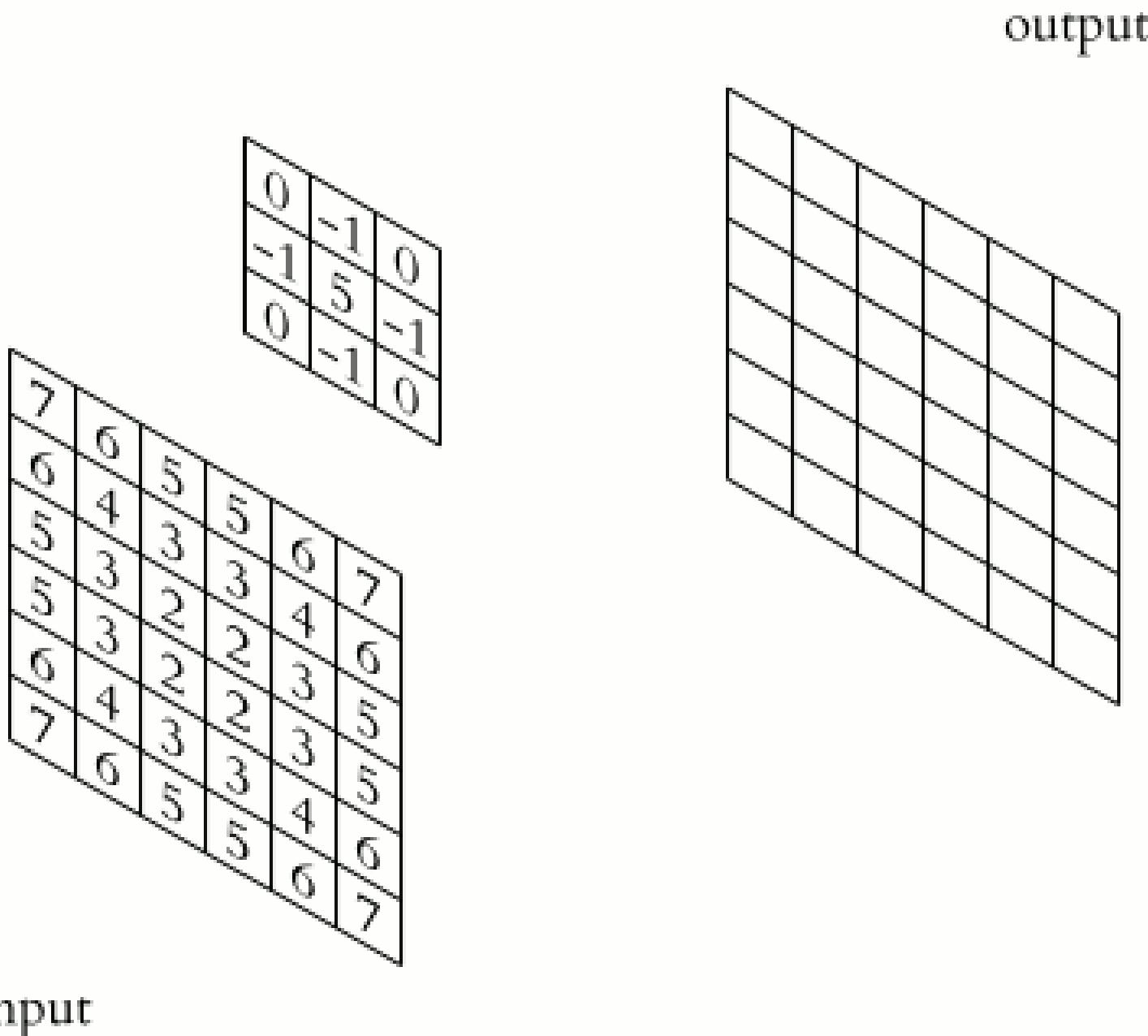
Свертка

input

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

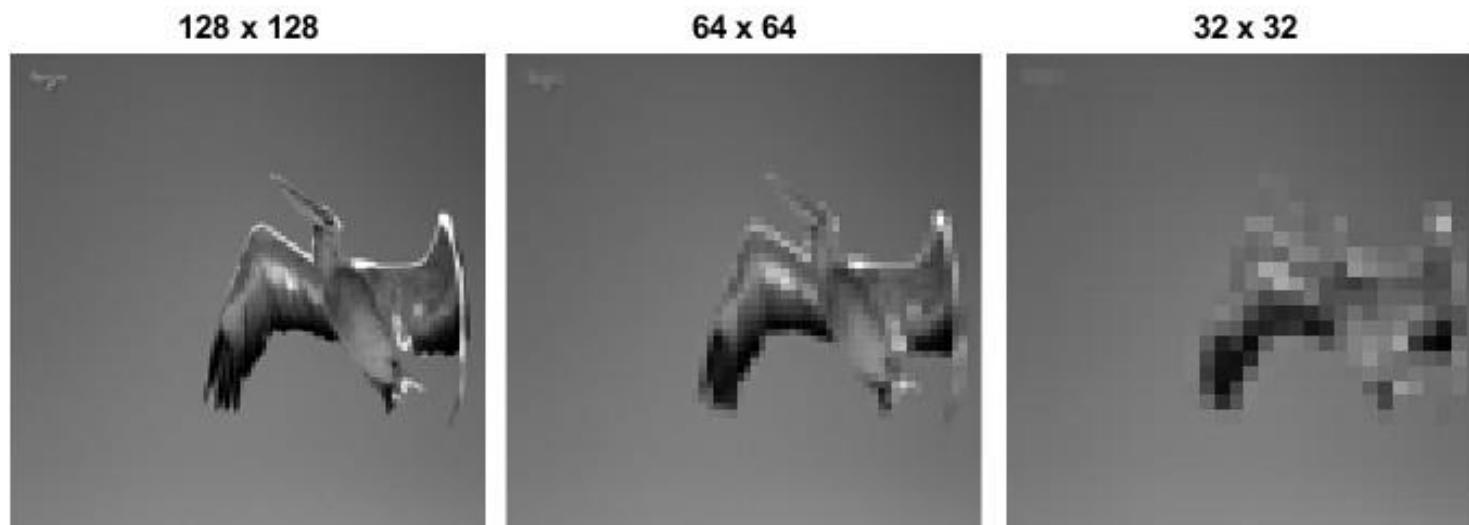
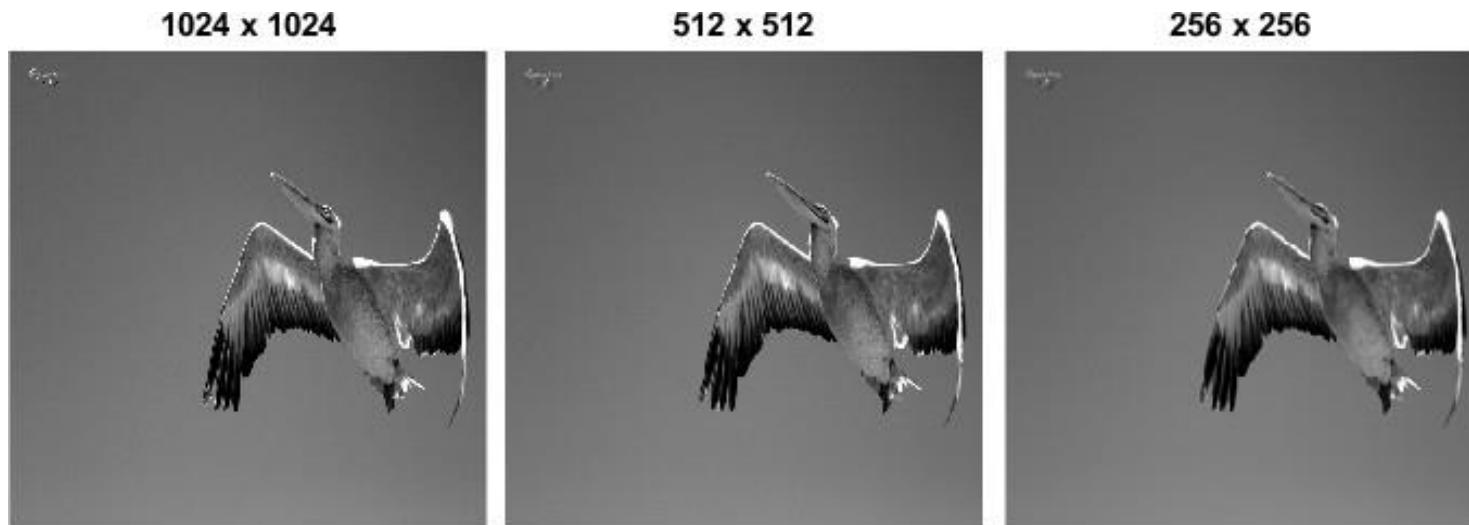
output

Свертка

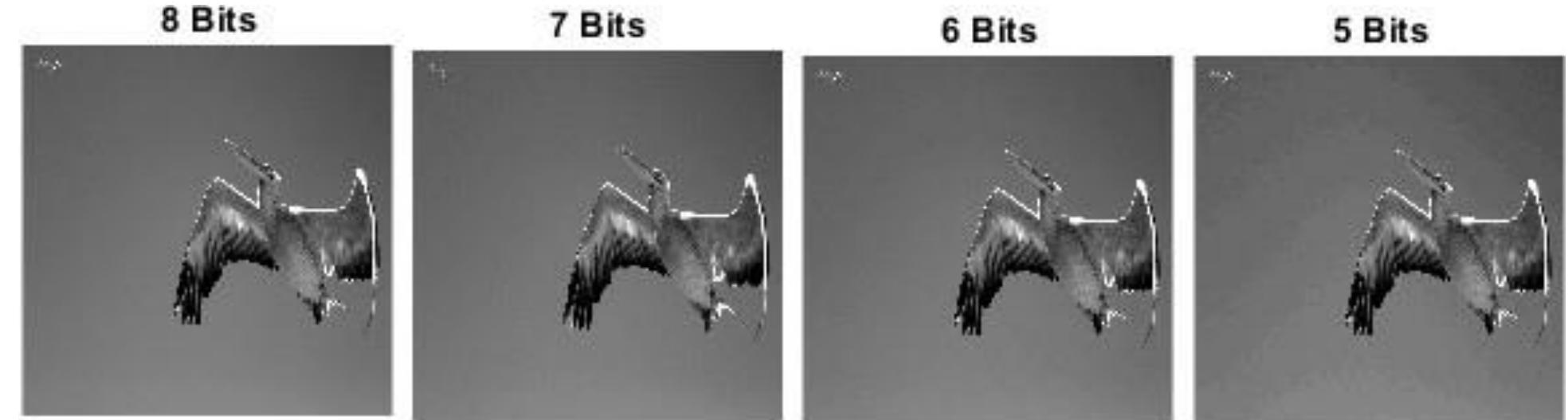


Дискретизация и квантование

Дискретизация



Квантование



Эквализация гистограммы

1	2	1	1	1
2	5	3	5	2
2	5	5	5	2
2	5	3	5	2
1	1	1	2	1

Input Image

Gray Level (rk) input Image (see ref image)	Frequency (nk)	nk/n (PDF=Probability Density Function)	CDF (Cumm Distributive Function)	Equalized level	Equalized level (round off)
0	0	0	0	0	0
1	8	0.32	0.32	2.24	2
2	8	0.32	0.64	4.48	4
3	2	0.08	0.72	5.04	5
4	0	0	0.72	5.04	5
5	7	0.28	1	7	7
6	0	0	1	7	7
7	0	0	1	7	7

1	2	1	1	1
2	5	3	5	2
2	5	5	5	2
2	5	3	5	2
1	1	1	2	1

Input Image

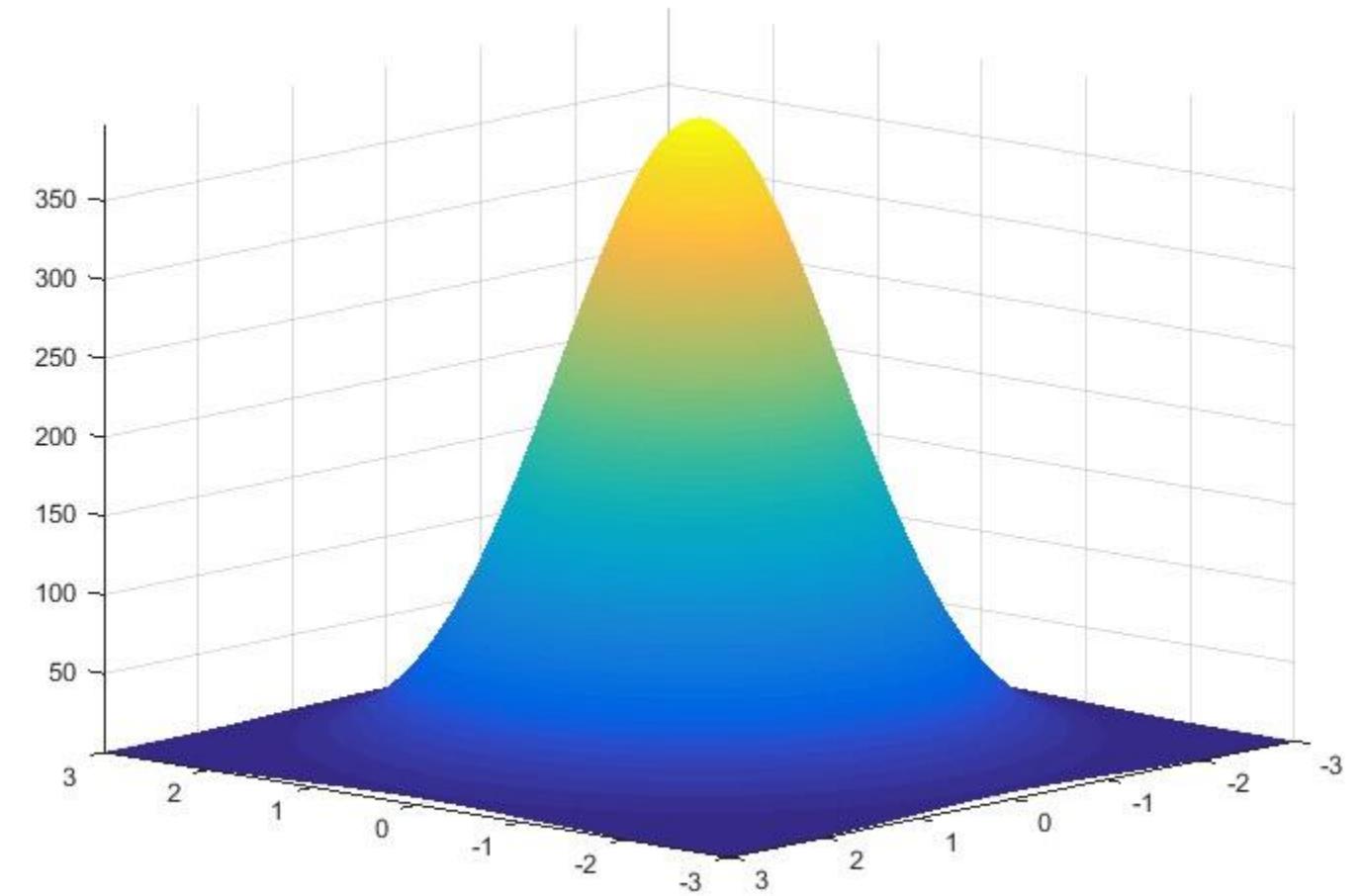


2	4	2	2	2
4	7	5	7	4
4	7	7	7	4
4	7	5	7	4
2	2	2	4	2

Output Image

Фильтр Гаусса

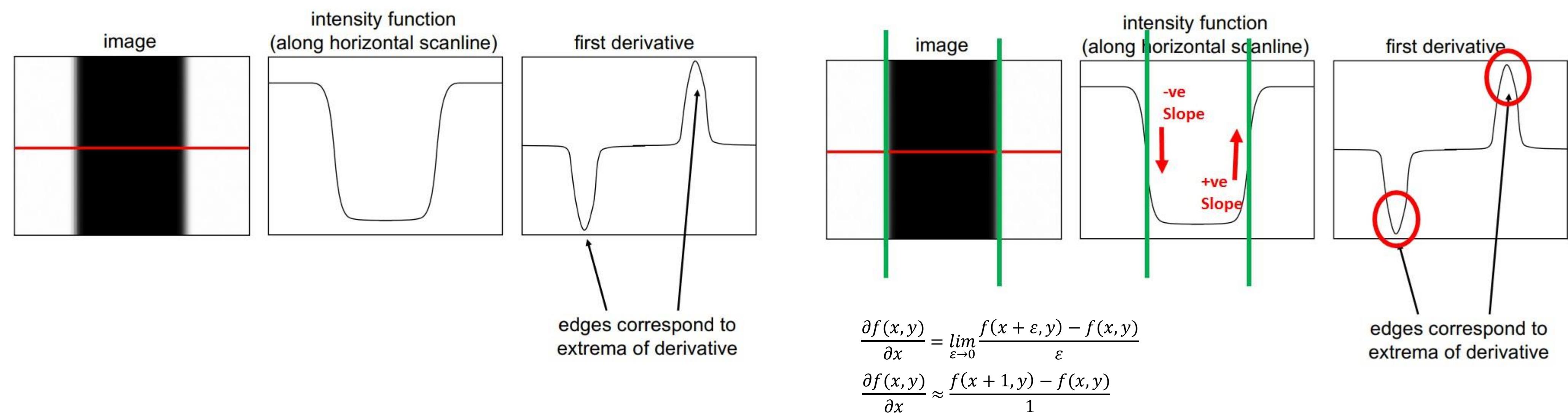
$$h(u, v) = \frac{1}{2\pi\sigma^2} e^{-\frac{u^2+v^2}{2\sigma^2}}$$



1 / 16

1	2	1
2	4	2
1	2	1

Детекция границ



Исходное изображение



Градиент в направлении x



Градиент в направлении у

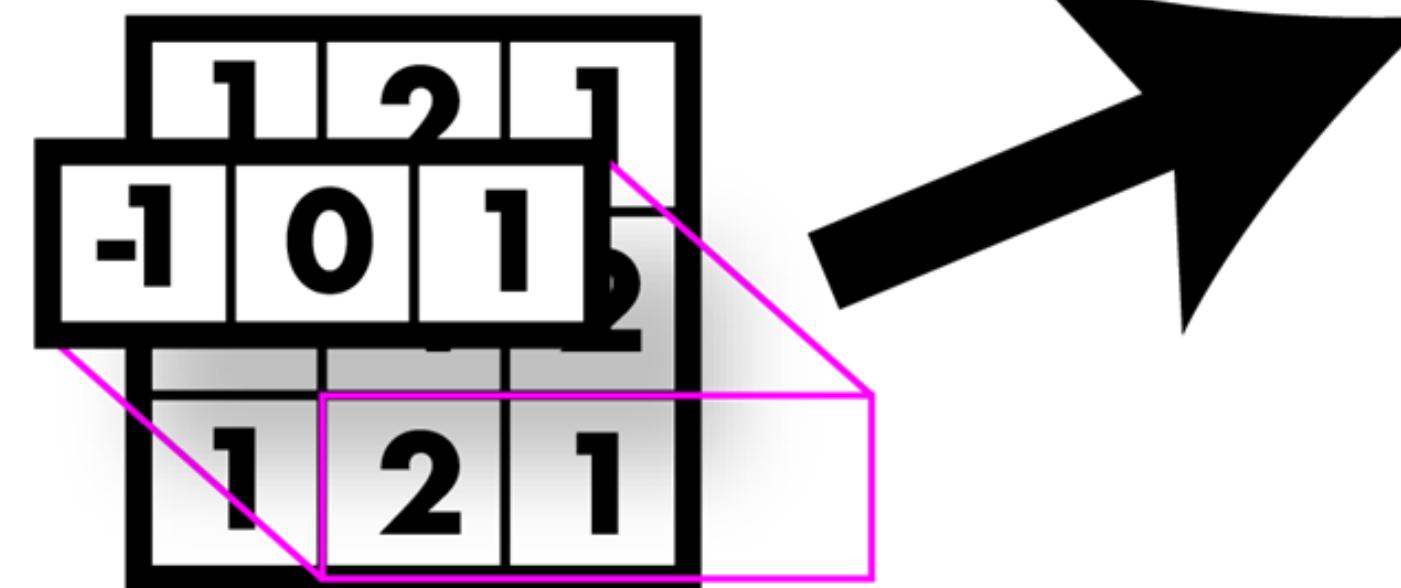
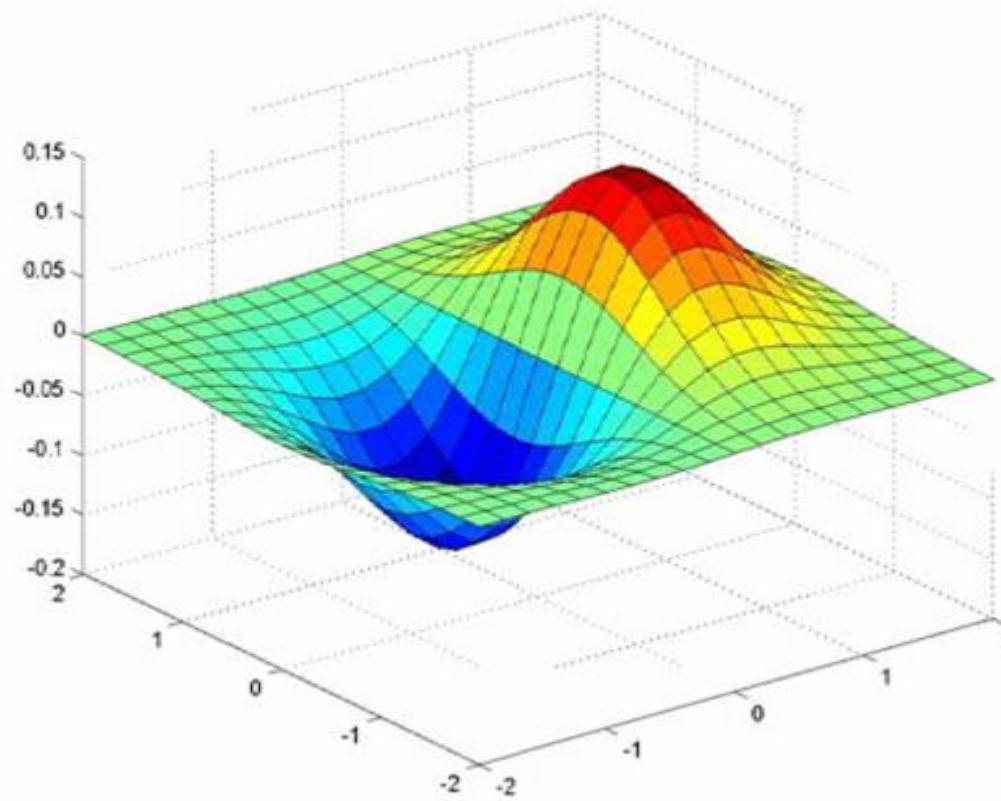


Амплитуда градиента



Фильтр Собеля (сглаживание и производная)

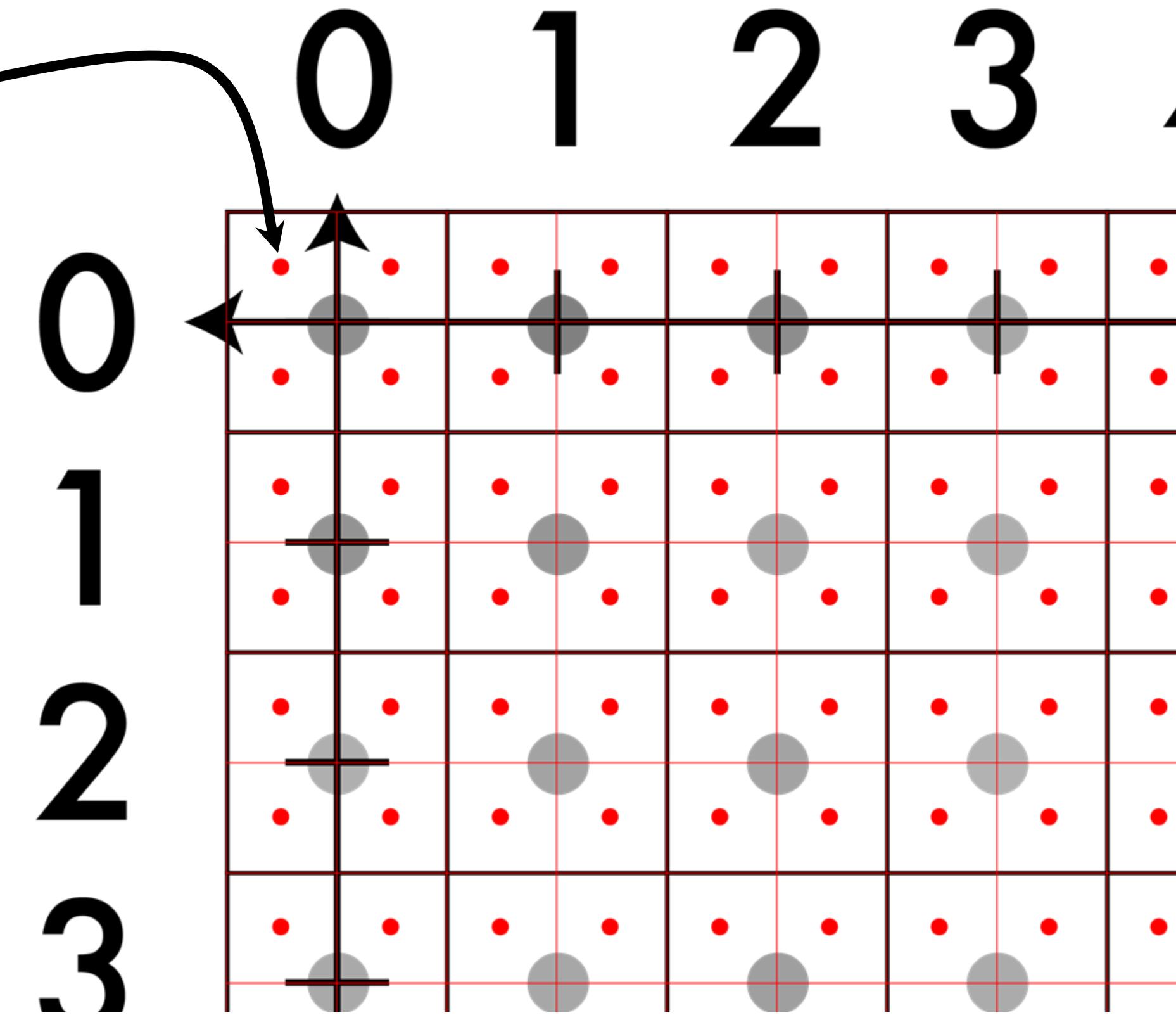
$$\frac{1}{2} \times \left(\begin{bmatrix} -1 & 0 & 1 \end{bmatrix} * \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix} \right)$$



$$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$$

Проблема интерполяции

This point is:
 $(-.25, -.25)$



Интерполяция по ближайшему соседу



Билинейная интерполяция

$$q_1 = V_1 \cdot d_2 + V_2 \cdot d_1$$

$$q_2 = V_3 \cdot d_2 + V_4 \cdot d_1$$

$$q = q_1 \cdot d_4 + q_2 \cdot d_3$$

Equivalent:

$$q = q_1 \cdot d_4 + q_2 \cdot d_3$$

$$q = (V_1 \cdot d_2 + V_2 \cdot d_1) \cdot d_4 + (V_3 \cdot d_2 + V_4 \cdot d_1) \cdot d_3$$

(subst)

$$q = V_1 \cdot d_2 \cdot d_4 + V_2 \cdot d_1 \cdot d_4 + V_3 \cdot d_2 \cdot d_3 + V_4 \cdot d_1 \cdot d_3$$

(distribution)

Recall:

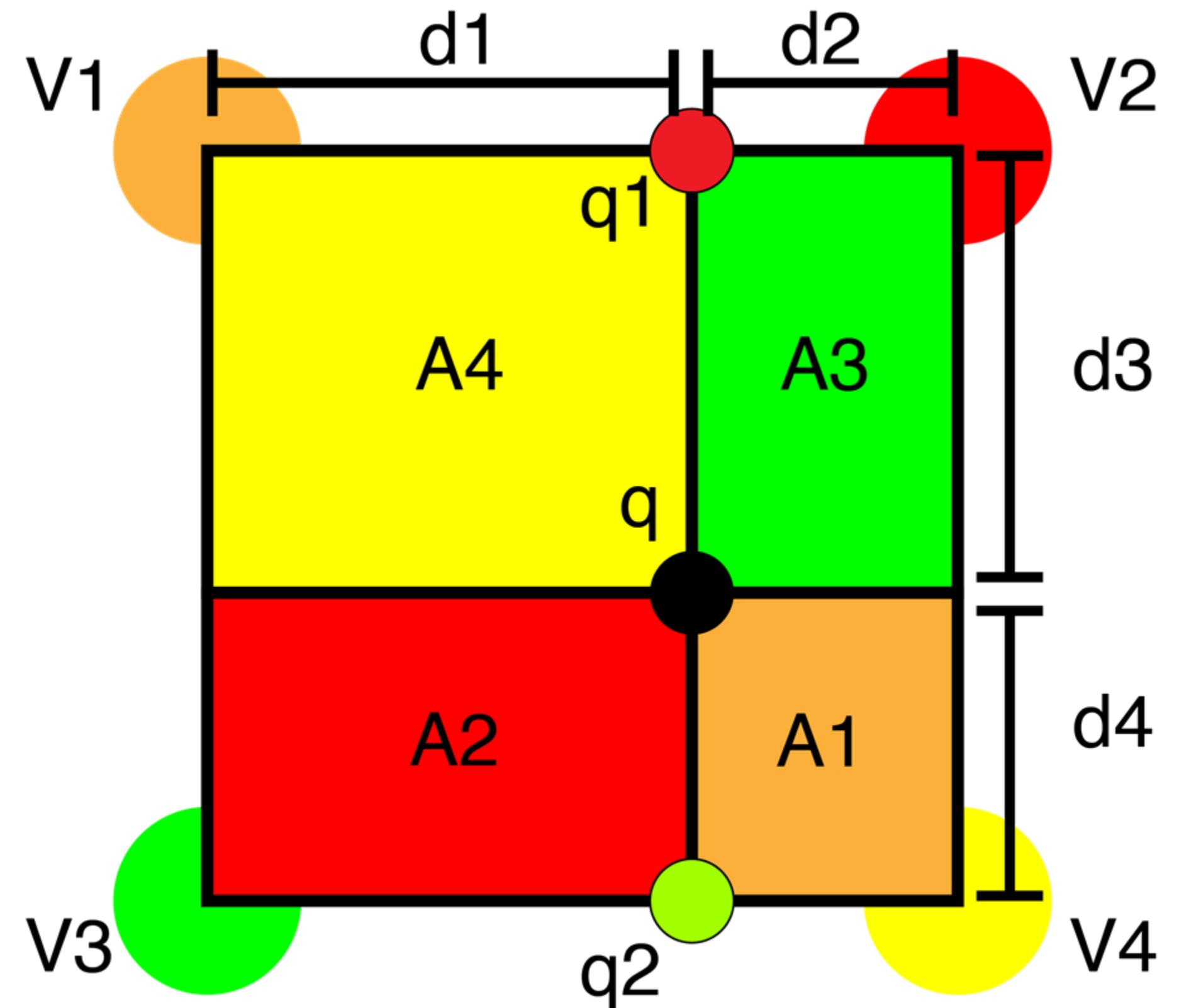
$$A_1 = d_2 \cdot d_4$$

$$A_2 = d_1 \cdot d_4$$

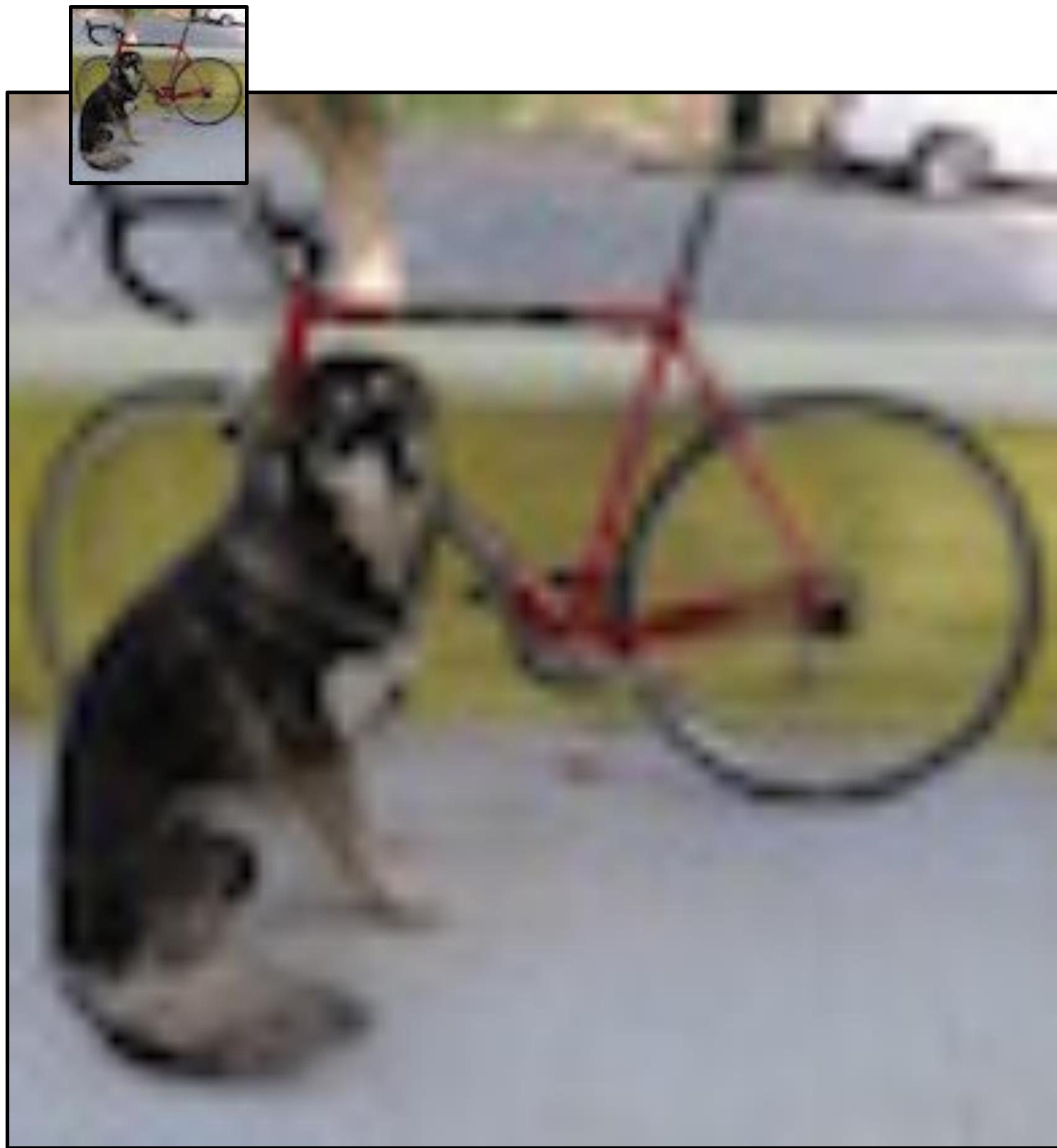
$$A_3 = d_2 \cdot d_3$$

$$A_4 = d_1 \cdot d_3$$

$$q = V_1 \cdot A_1 + V_2 \cdot A_2 + V_3 \cdot A_3 + V_4 \cdot A_4$$

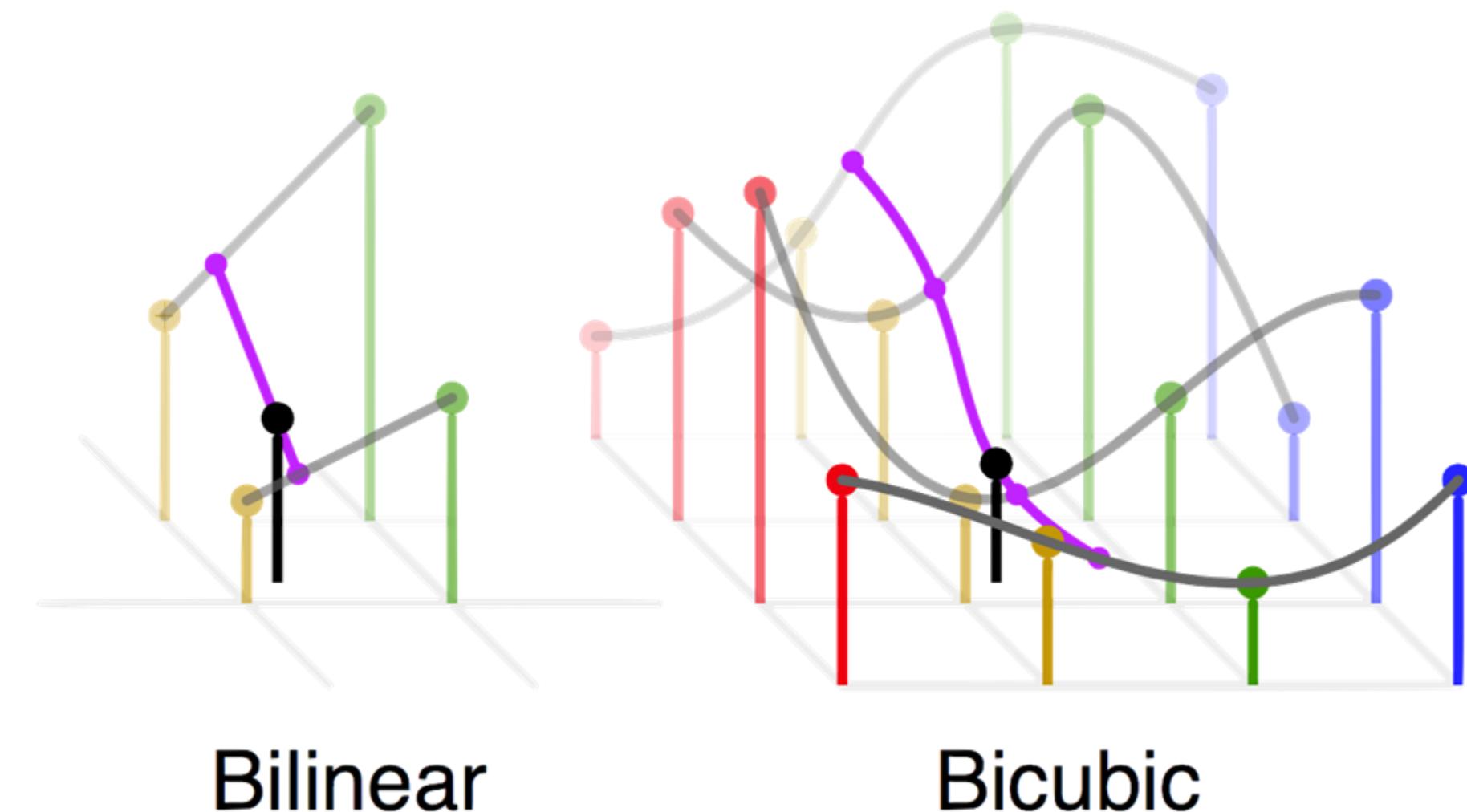


Билинейная интерполяция

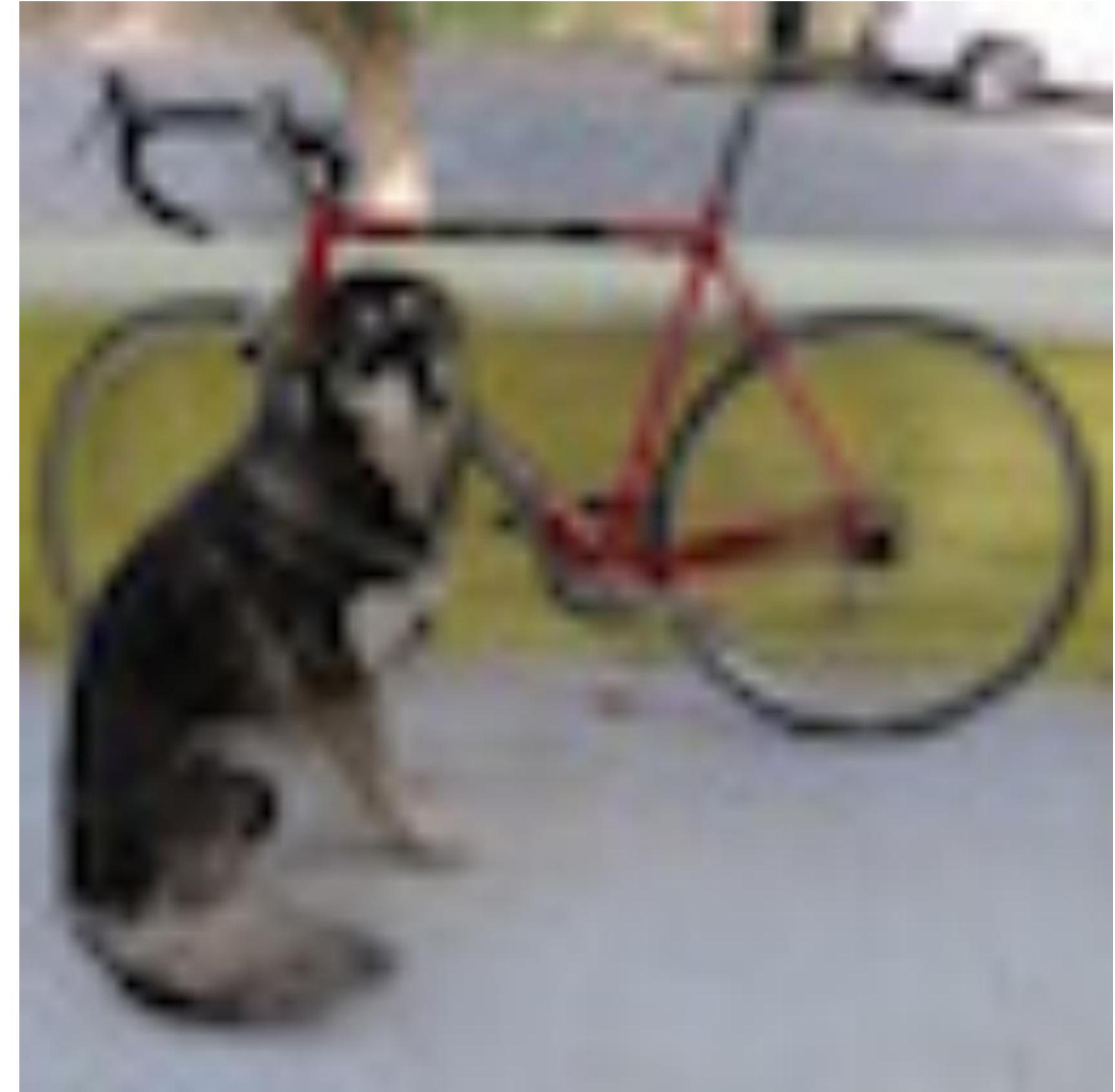
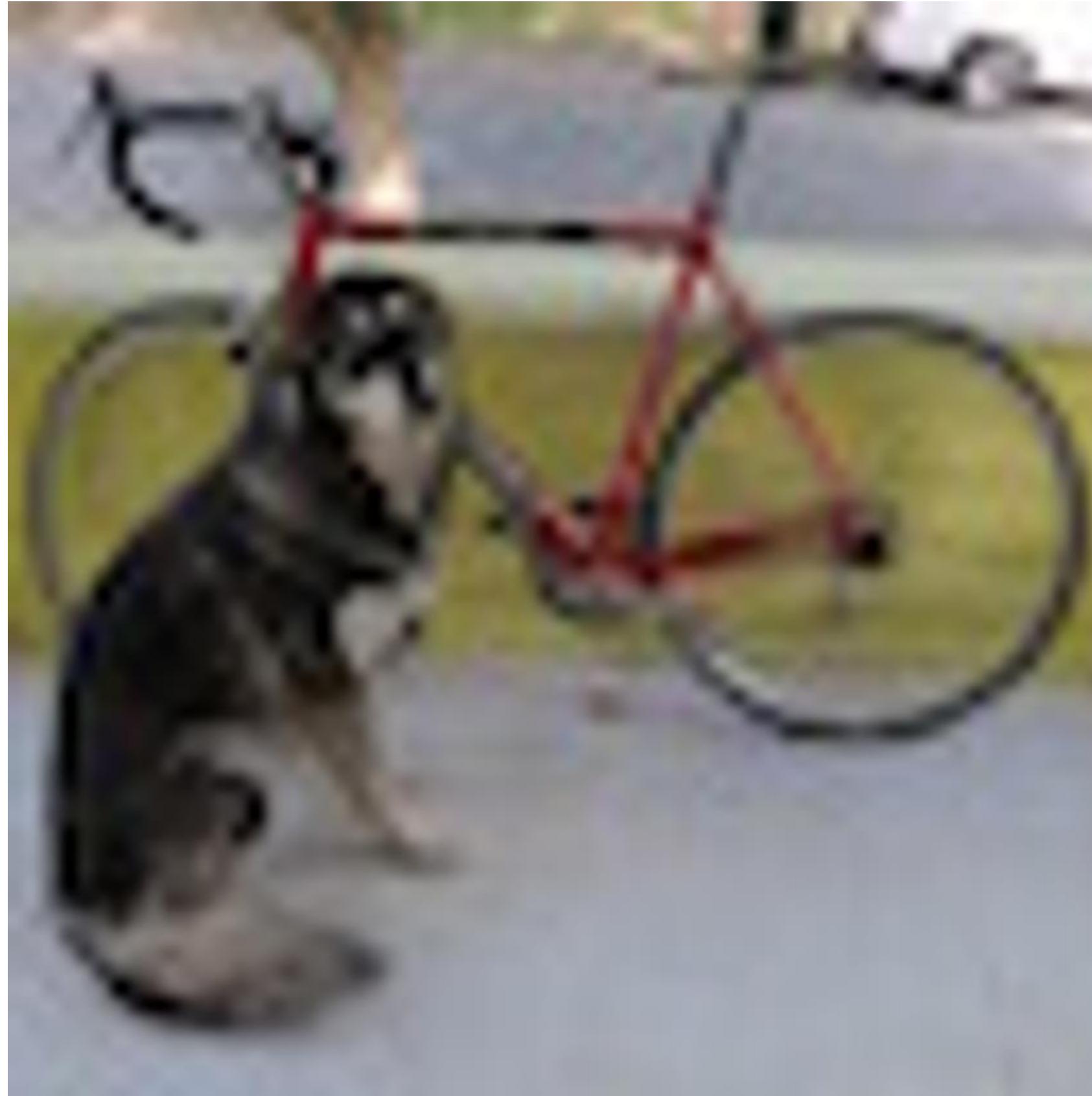


Бикубическая интерполяция

- A cubic interpolation of 4 cubic interpolations
- Smoother than bilinear, no “star”
- 16 nearest neighbors
- Fit 3rd order poly:
$$f(x) = a + bx + cx^2 + dx^3$$
- Interpolate along axis
- Fit another poly to interpolated values



Бикубическая vs Билинейная



Полезные ресурсы

- <https://pjreddie.com/courses/computer-vision/>
- <https://sites.google.com/site/drkhanrizwan17/computer-vision-course>
- https://github.com/ml-dafe/cv_mipt_major
- <https://code.mipt.ru/courses-public/cv/public/-/blob/fall-2023/README.md>