Цвет

URL: http://www.school30.spb.ru/cgsg/cgc/
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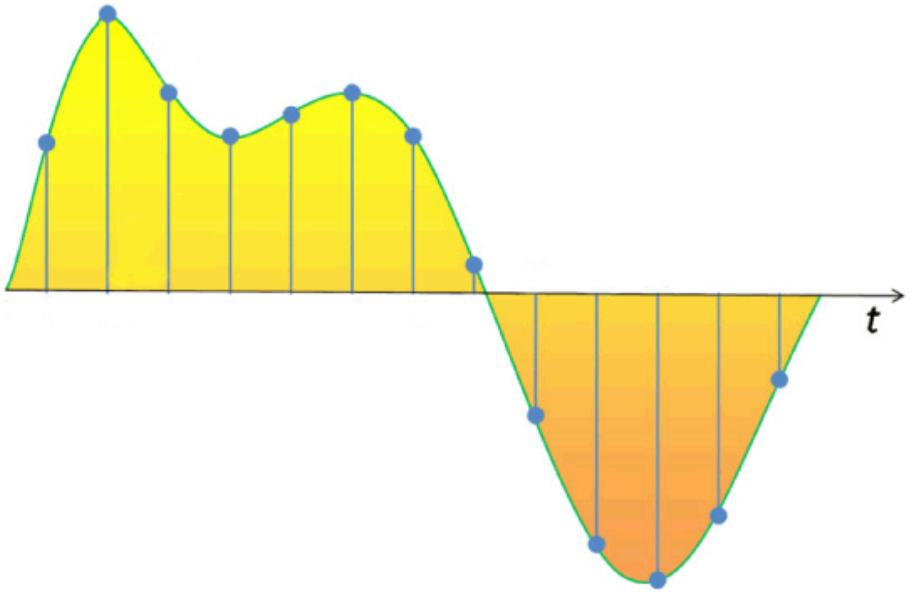
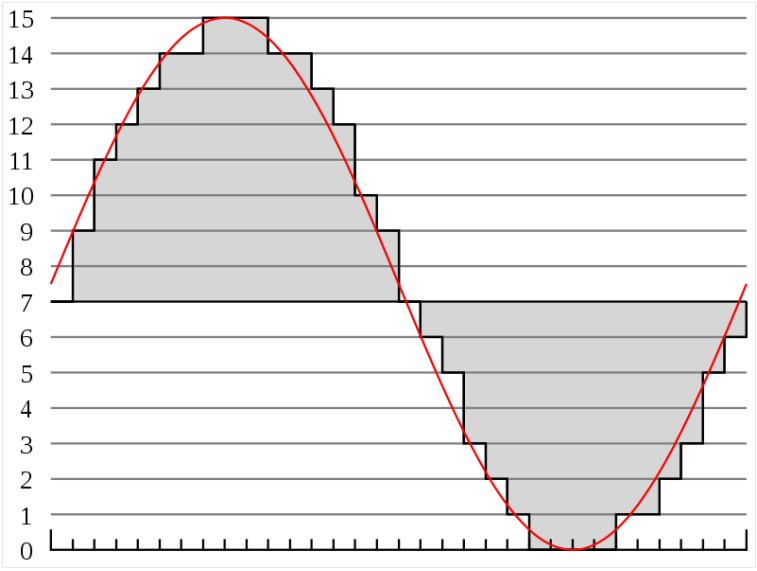
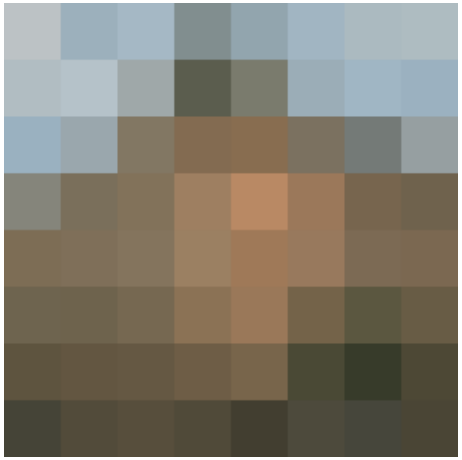
Sampling & Quantization

- *Дискретизация сигнала – разбиение непрерывного сигнала на «выборки» (**sampling**, sampling rate)*
- *Квантование выборки – кодирование аналогового сигнала в дискретные величины (**quantization**)*





Sampling (разрешение)



8x8

16x16

32x32

64x64

128x128

256x256

Quantization (глубина цвета)

2 цвета

3 цвета

4 цвета

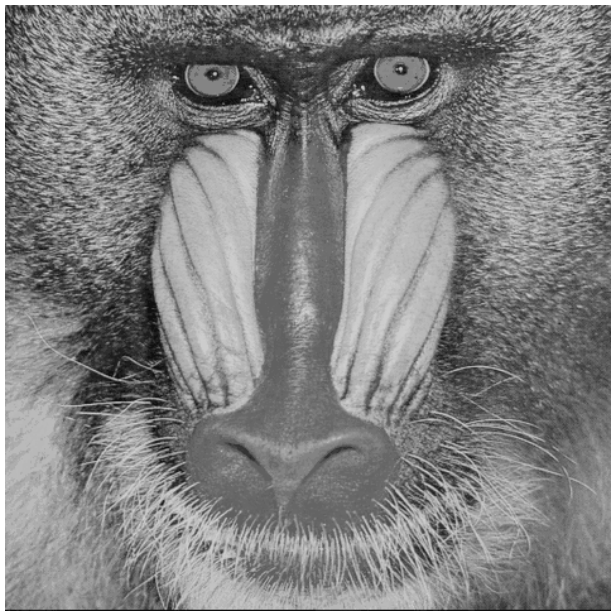
8 цветов

16 цветов

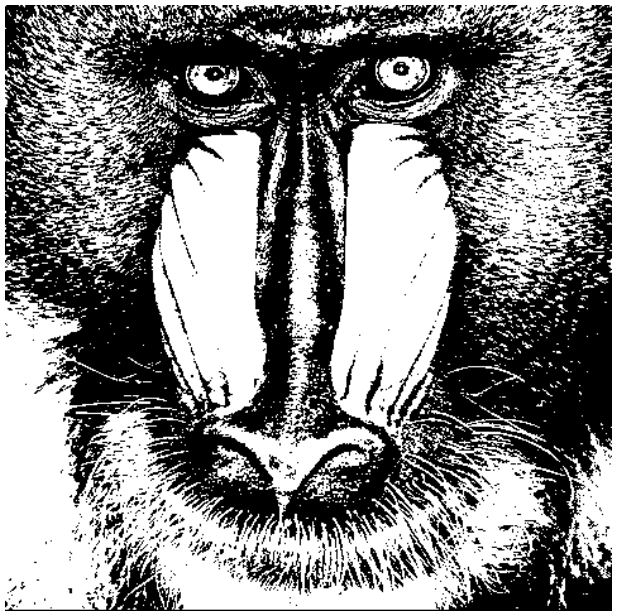
256 цветов

Fixed Thresholding

```
if (Img(x, y) > Threshold)
  color = 1;
else
  color = 0;
```



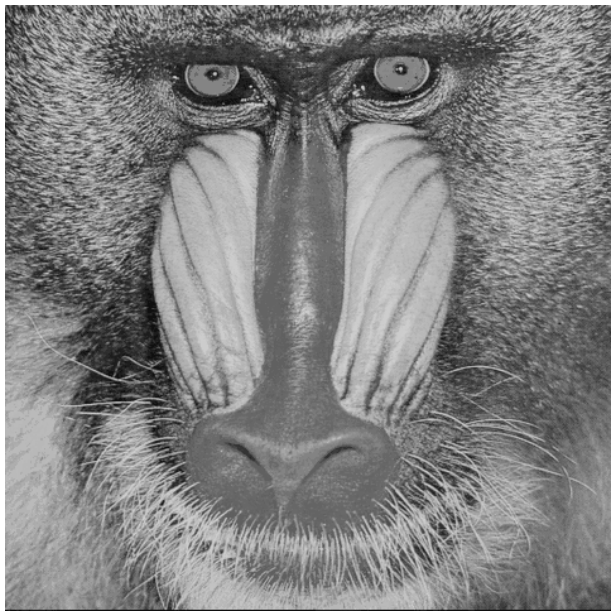
оригинал



порог = 128

Random Thresholding

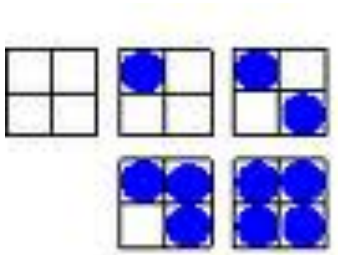

```
if (Img(x, y) > rand() % 255)
  color = 1;
else
  color = 0;
```



оригинал

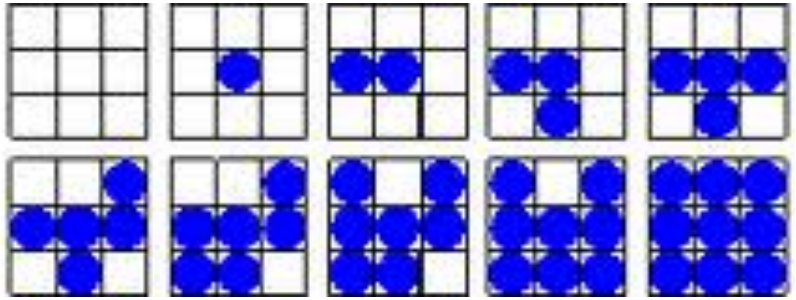
«случайный» порог

Patterning



5 уровней

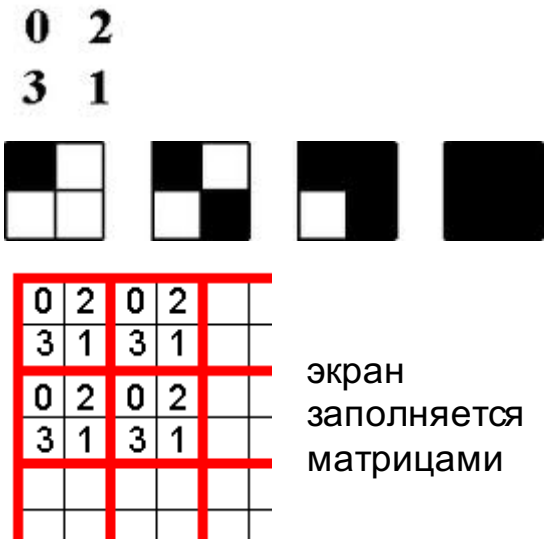
(2x2)



10 уровней

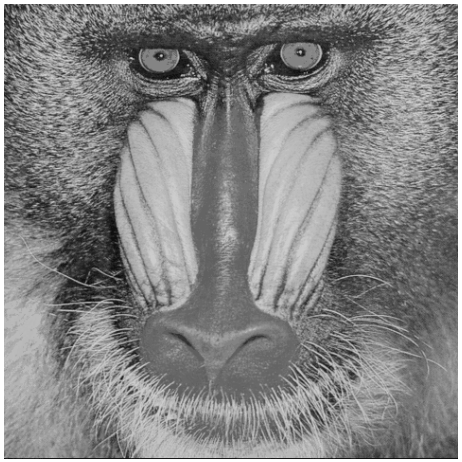
(3x3)

Ordered Dither

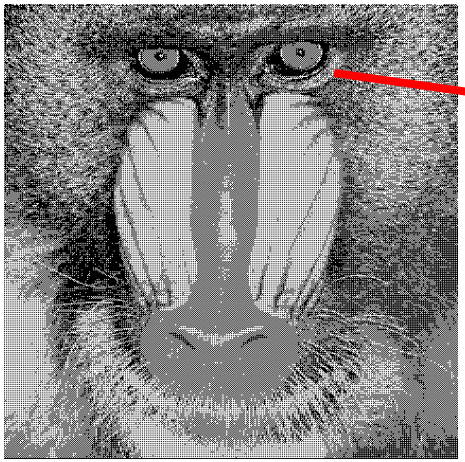


экран заполняется матрицами

```
int M_2x2[2][2] =
{
   {0, 2},
   {3, 1}
};

if (Img(x, y) * 5 / 256 > M_2x2[y % 2][x % 2])
   color = 1;
else
   color = 0;
```



оригинал



матрица 2x2

увеличенный фрагмент

Метод Байера получения матриц смешивания

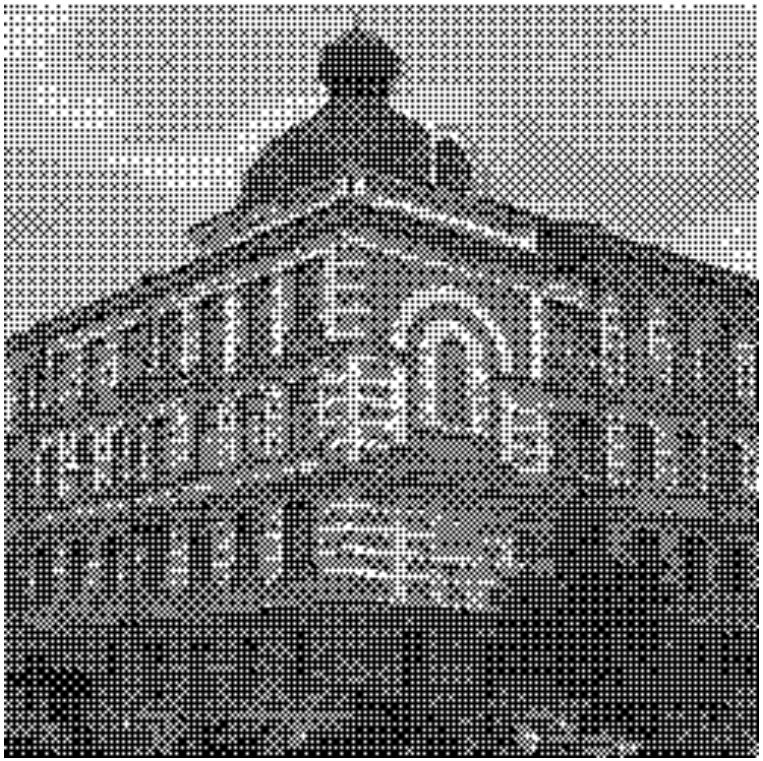

```
int M2[2][2] =
{
  {0, 2},
  {3, 1}
};
```

```
int M4[4][4] =
{
  { 0,  8,  2, 10},
  {12,  4, 14,  6},
  { 3, 11,  1,  9},
  {15,  7, 13,  5},
};
```

```
for (i = 0; i < 4; i++)
  for (j = 0; j < 4; j++)
  {
    M2n[0 + i][0 + j] = Mn[i][j] * 4 + 0;
    M2n[0 + i][4 + j] = Mn[i][j] * 4 + 2;
    M2n[4 + i][0 + j] = Mn[i][j] * 4 + 3;
    M2n[4 + i][4 + j] = Mn[i][j] * 4 + 1;
  }
```

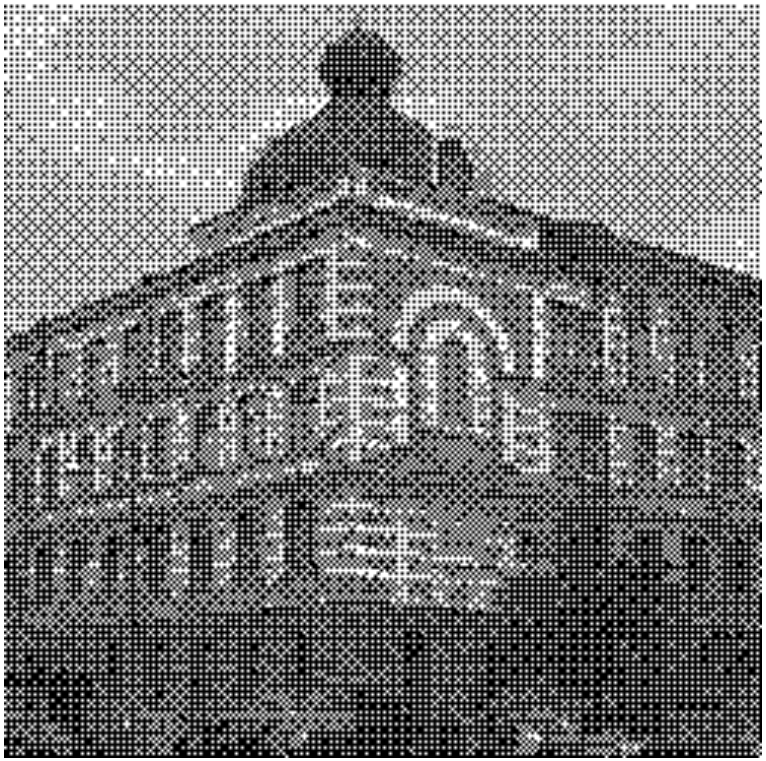
Примеры матриц Байера

2x2

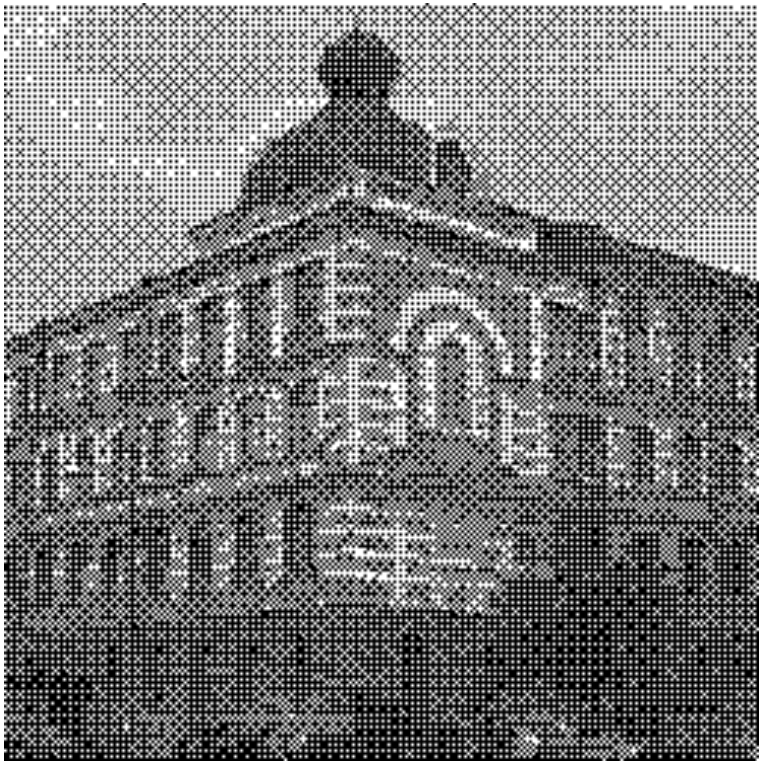


4x4

Примеры матриц Байера

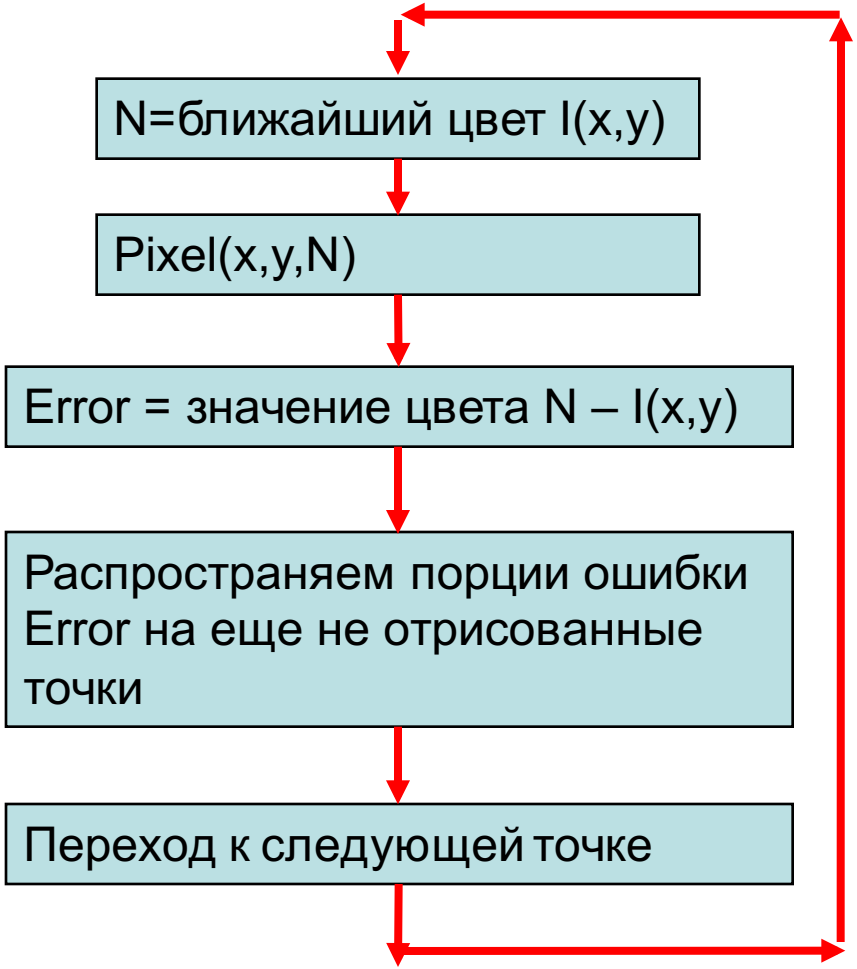


8x8



16x16

Error Diffusion: алгоритм Флойда-Стейнберга



	*	7
3	5	1

1/16

Error Diffusion: примеры фильтров

*	3
3	2

1/8

False Floyd-Steinberg

		*	7	5
3	5	7	5	3
1	3	5	3	1

1/48

Jarvice, Judice, Ninke

		*	8	4
2	4	8	4	2
1	2	4	2	1

1/42

Stucki

		*	8	4
2	4	8	4	2

1/32

Burkes

Frankie Sierra

		*	5	3
2	4	5	4	2
	2	3	2	

1/32

		*	4	3
1	2	3	2	1

1/16

	*	2
1	1	

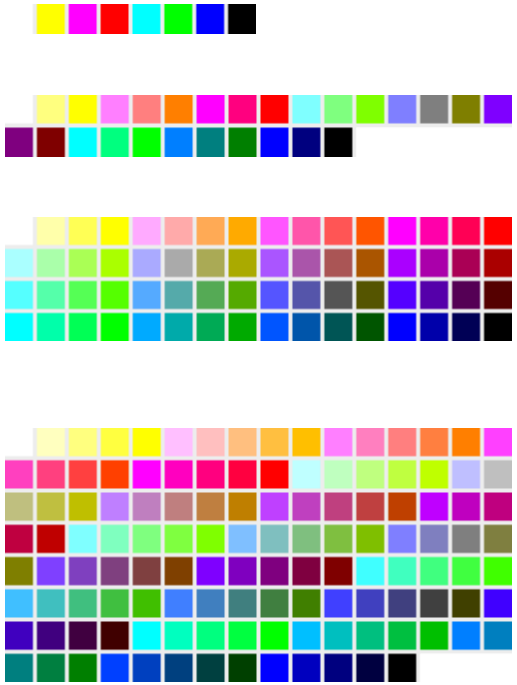
1/4

Подбор цвета: uniform palette

Универсальная палитра для любых изображений:

цвет задается по RGB каналам:

$$ColorNo = B + SizeB * (G + SizeG * R)$$



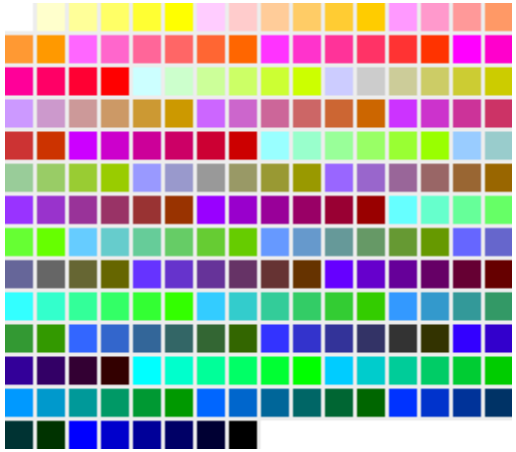
8

27

64

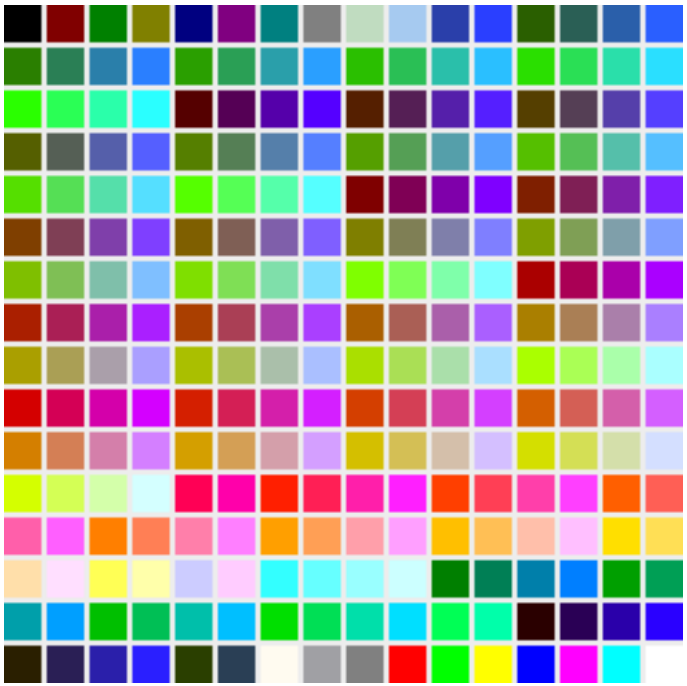
125

216

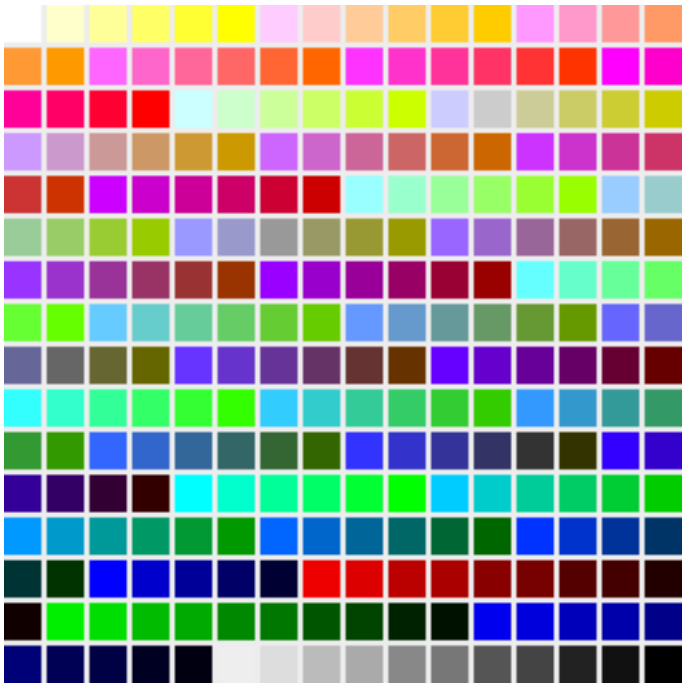


Подбор цвета: OS palette

Используются в индексированных графических режимах

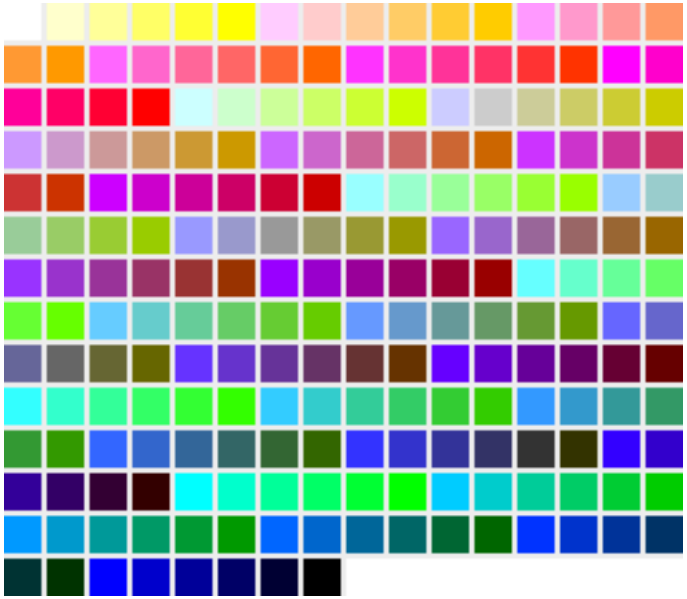


MS Windows



Mac OS

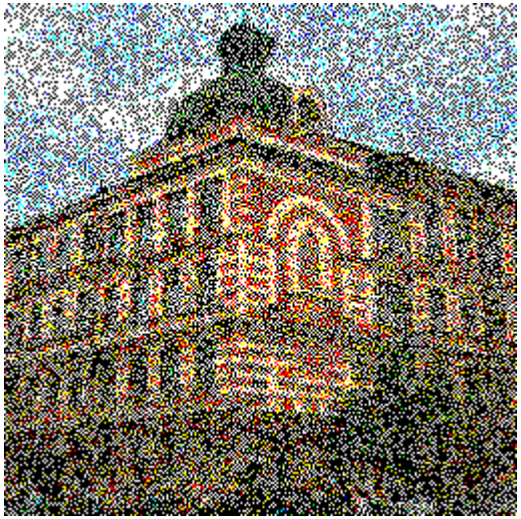
Подбор цвета: WEB & safe palette



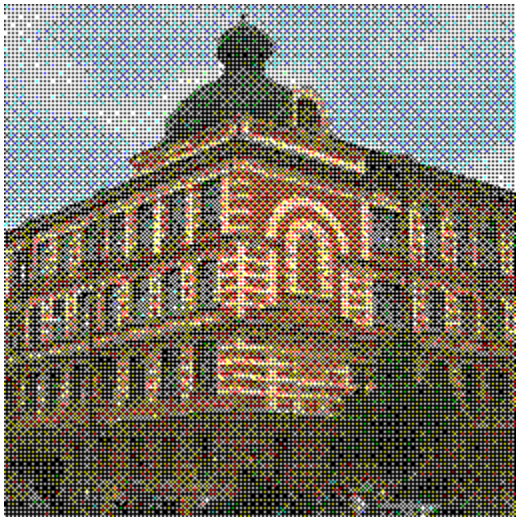
WEB палитра

оттенки по каналам
шаг: 0-51-102-163-204-255

Пример разных методов



random threshold

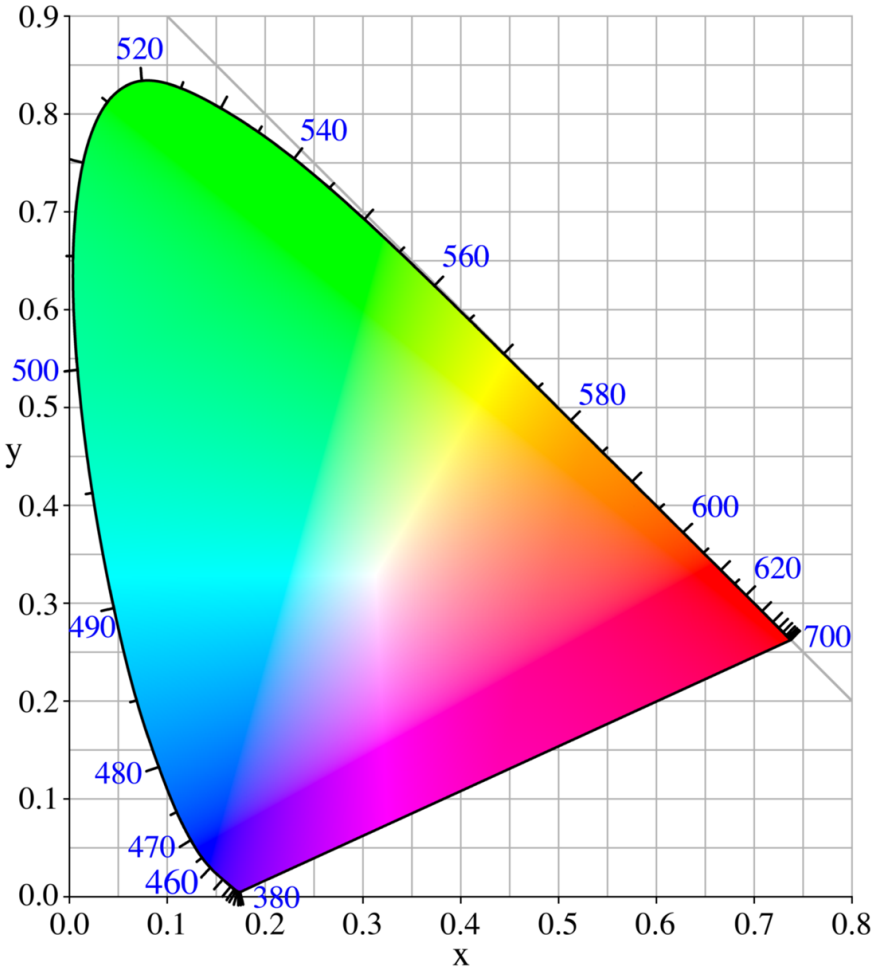


ordered dither

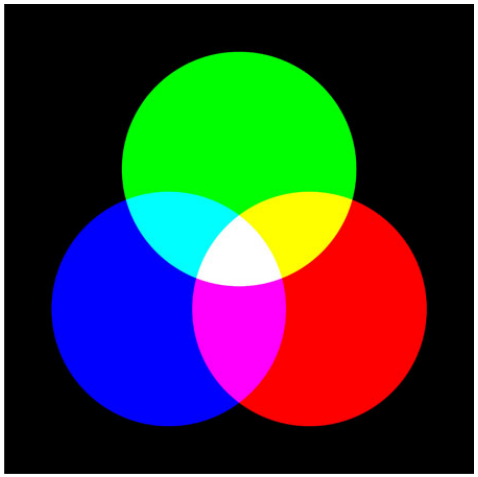
error diffusion

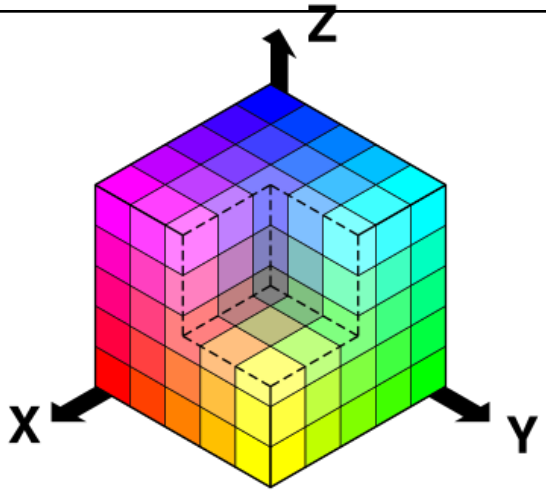
График МКО

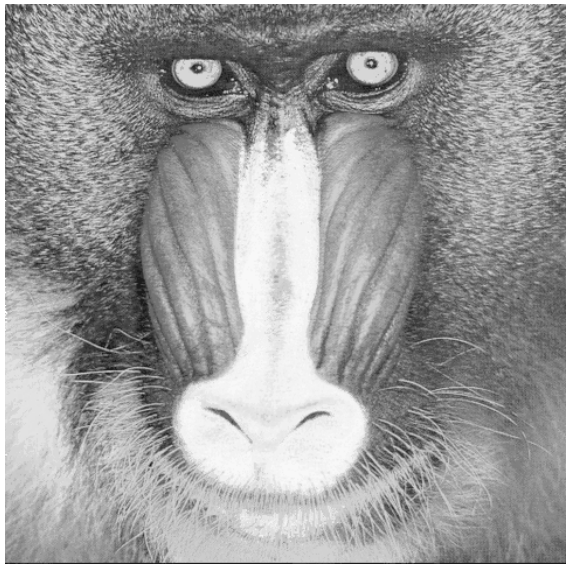
Международная Комиссия по Освещенности (Commission internationale de l'éclairage - CIE)



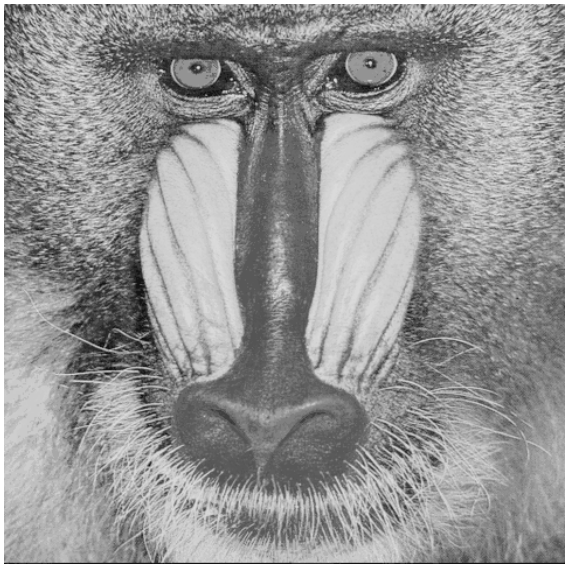
RGB



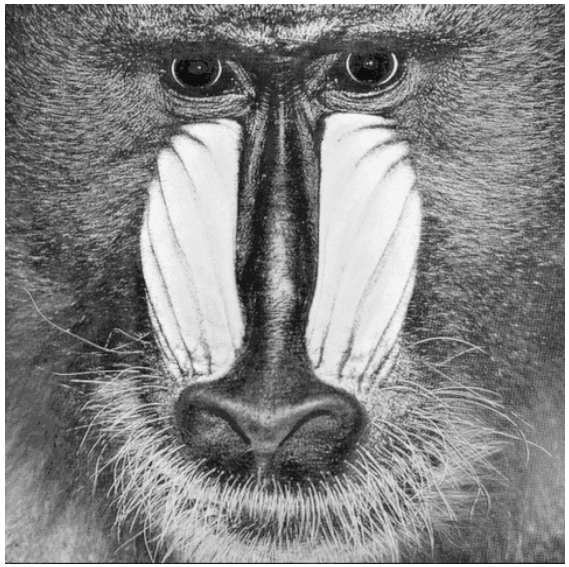




red

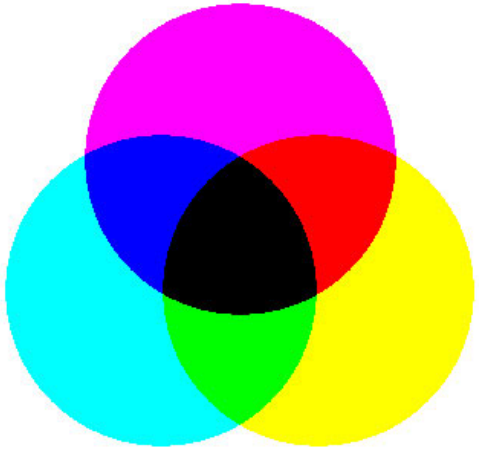


green

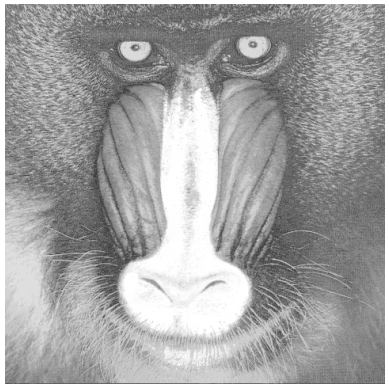


blue

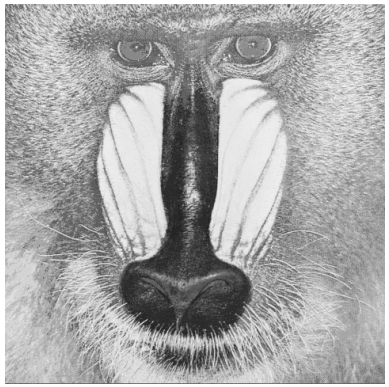
CMYK



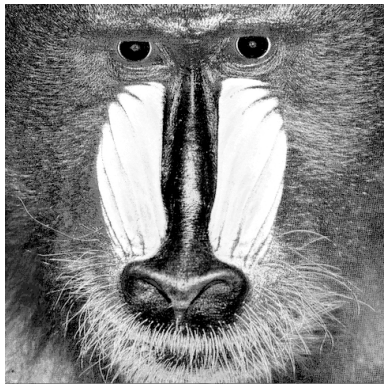
```
RGB2CMYK:
  C = 1.0 - R;
  M = 1.0 - G;
  Y = 1.0 - B;
  K = min(C, M, Y);
  C = C - K;
  M = M - K;
  Y = Y - K;

CMYK2RGB:
  R = 1.0 - min(1.0, C + K);
  G = 1.0 - min(1.0, M + K);
  B = 1.0 - min(1.0, Y + K);
```



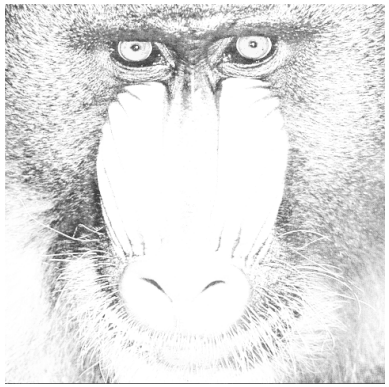
cyan



magenta

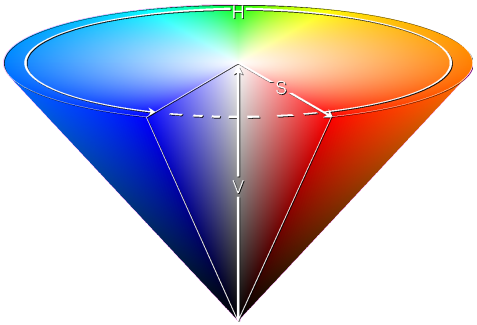


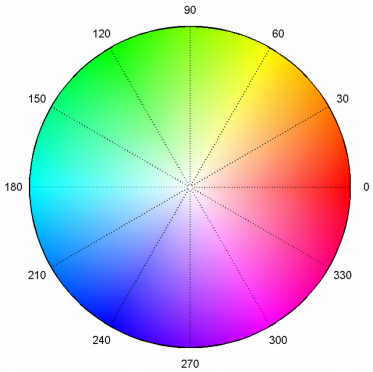
yellow

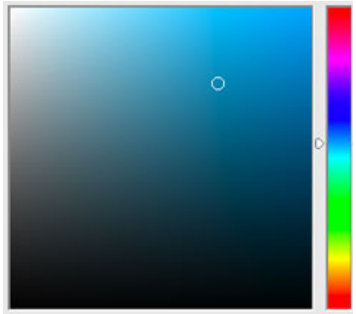


black

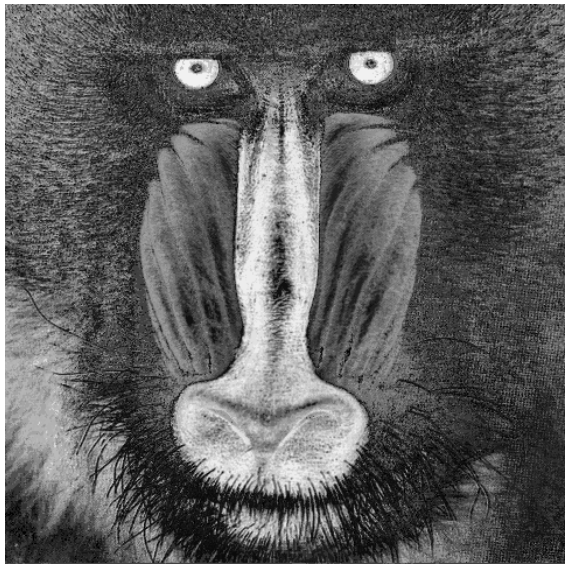
HSV



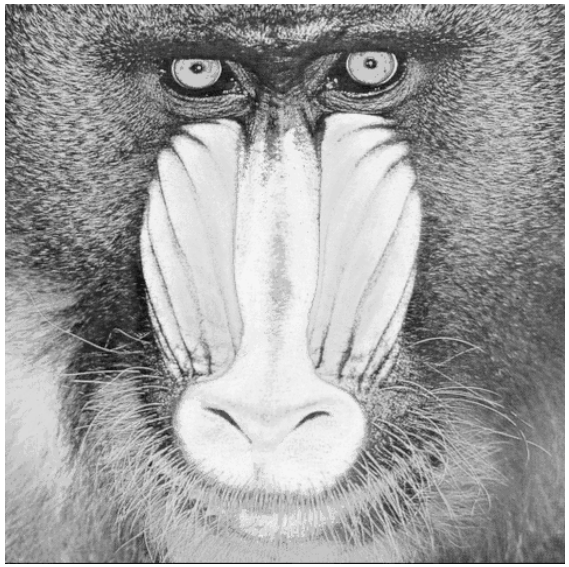




hue



saturation



value

HSV conversion

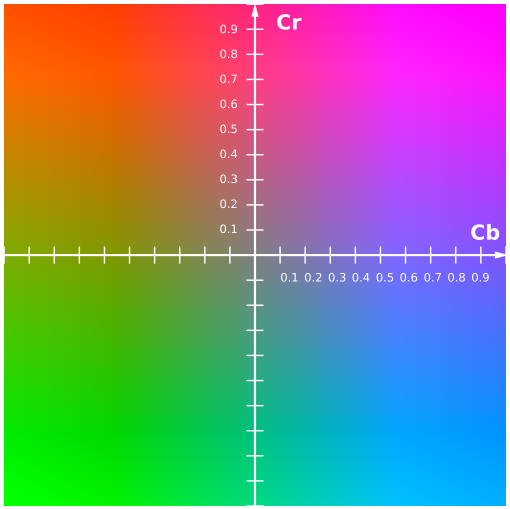
```
HSV2RGB:
  if (S == 0)
    return <V, V, V>;
  else
  {
    H = H / 60.0;
    n = (int)H;
    frac = H - n;
    c1 = V * (1.0 - S);
    c2 = V * (1.0 - S * frac);
    c3 = V * (1.0 - S * (1.0 - frac));
    if (n == 0)
      return <V, c3, c1>;
    if (n == 1)
      return <c2, V, c1>;
    if (n == 2)
      return <c1, V, c3>;
    if (n == 3)
      return <c1, c2, V>;
    if (n == 4)
      return <c3, c1, V>;
    if (n == 5)
      return <V, c1, c2>;
  }
```

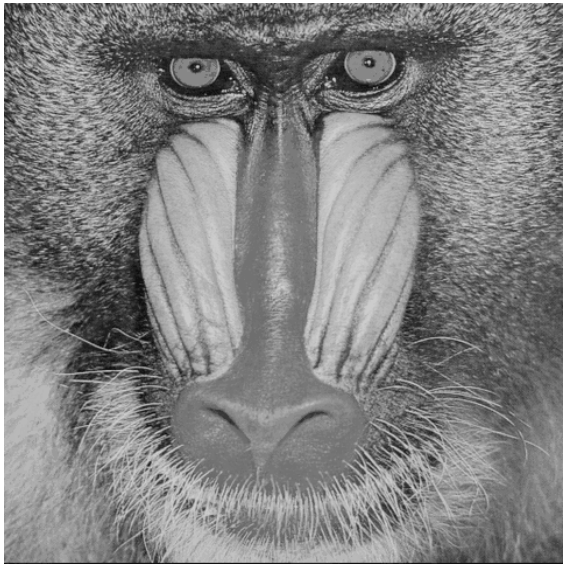
```
RGB2HSV
  maxc = max(R, G, B);
  minc = min(R, G, B);
  delta = maxc - minc;

  S = 0;
  if (maxc > 0)
    S = delta / maxc;
  V = maxc;
  if (S == 0)
    H = 0; /* неопределено */
  else
  {
    rc = (maxc - R) / delta;
    gc = (maxc - G) / delta;
    bc = (maxc - B) / delta;
    if (R == maxc)
      H = bc - gc;       /* Y-M */
    else if (G == maxc)
      H = 2 + rc - bc; /* C-Y */
    else
      H = 4 + gc - rc; /* M-C */
    H = H * 60.0;
  }
```

YCrCb

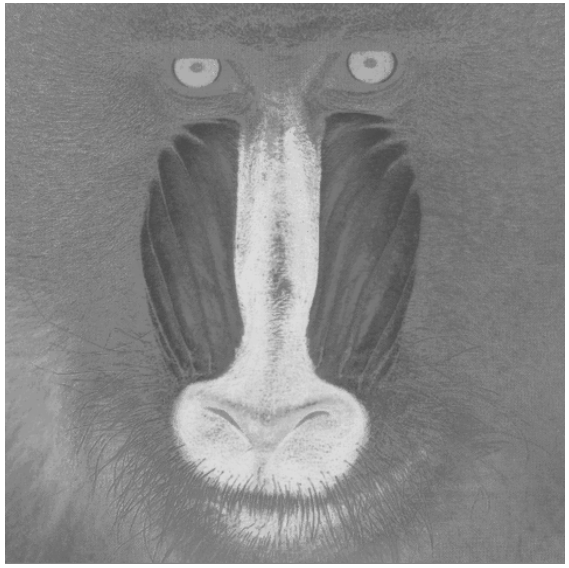
$$\begin{vmatrix} Y \\ Cb \\ Cr \end{vmatrix} = \begin{vmatrix} 0.299 & 0.587 & 0.114 \\ 0.5 & -0.4187 & -0.0813 \\ 0.1687 & -0.3313 & 0.5 \end{vmatrix} * \begin{vmatrix} R \\ G \\ B \end{vmatrix} + \begin{vmatrix} 0 \\ 128 \\ 128 \end{vmatrix}$$

$$\begin{vmatrix} R \\ G \\ B \end{vmatrix} = \begin{vmatrix} 1 & 0 & 1.402 \\ 1 & -0.34414 & -0.71414 \\ 1 & 1.772 & 0 \end{vmatrix} * \left(\begin{vmatrix} Y \\ Cb \\ Cr \end{vmatrix} - \begin{vmatrix} 0 \\ 128 \\ 128 \end{vmatrix} \right)$$

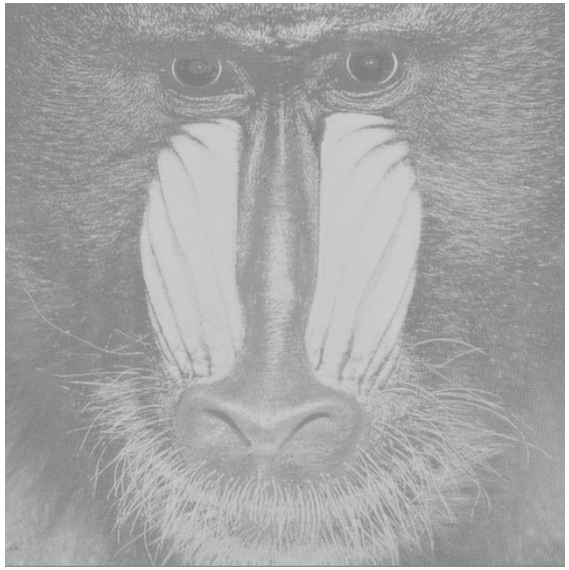




Y



Cr

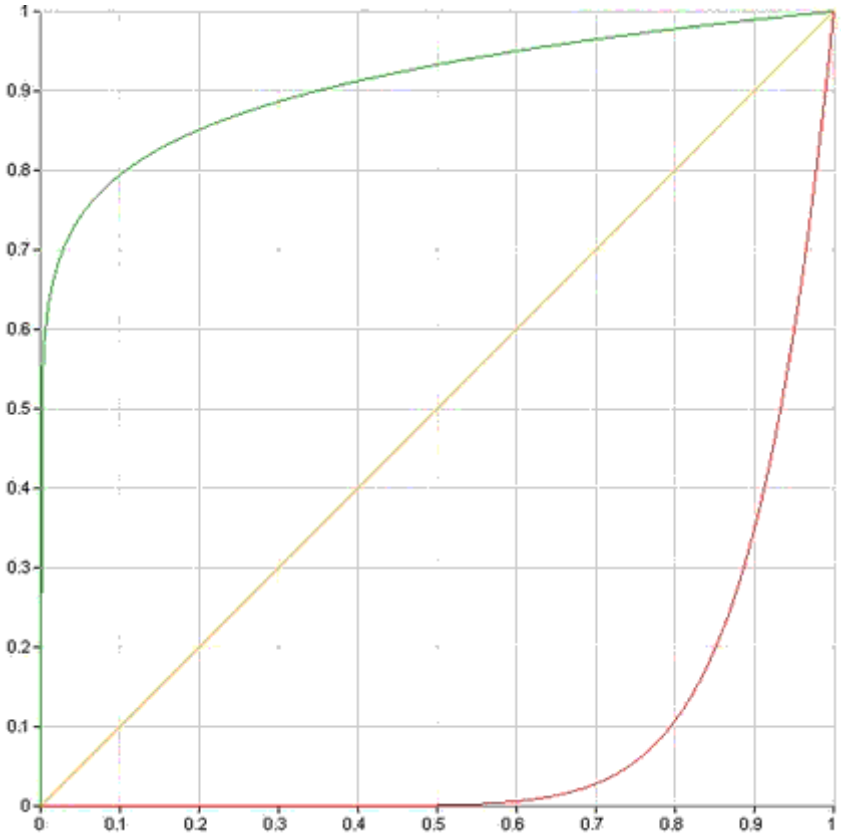


Cb

Коррекция цвета

- LUT: `Color = LUT[Color];`
- Гамма коррекция, контрастность, яркость

$$I_{вых} = I_{вх}^{\frac{1}{\gamma}}$$



- Практические задания
  - Реализовать полутонирование (dither/error diffusion) для монохромных изображений (результат выводить на экран или в файл)
  - Реализовать программу, выполняющую коррекцию цвета в полноцветном изображении путем изменения цветов в разных моделях (рассмотреть RGB и HSV). Результат демонстрировать на примере любого растрового изображения.
  - Реализовать сохранение растрового изображения в собственный формат, использующий цветовую модель YCrCb и разные коэффициенты квантования для компонент.

Ссылки

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