

## RGB to Grayscale Conversions

Consider a color image, given by its red, green, blue components  $R$ ,  $G$ ,  $B$ . We present some methods for converting the color image to grayscale.

(<http://www.tannerhelland.com/3643/grayscale-image-algorithm-vb6/>)

### 1. Simple averaging

$$Gray = (R + G + B) / 3 .$$

### 2. Weighted average

$$Gray = 0.3R + 0.59G + 0.11B$$

or

$$Gray = 0.2126R + 0.7152G + 0.0722B$$

or

$$Gray = 0.299R + 0.587G + 0.114B$$

### 3. Desaturation

In the HSI color model the  $S$  is the saturation component of the color. Saturation describes the intensity (purity) of that hue. When colour is fully saturated, the colour is considered in purest (truest) version. Primary colours red, blue or yellow are considered truest version colour as they are fully saturated.

Desaturating an image means setting the  $S$  component to 0. This can be done by averaging the minimum and the maximum values of  $R$ ,  $G$ , and  $B$ :

$$Gray = (\min(R, G, B) + \max(R, G, B)) / 2 .$$

### 4. Decomposition

- Maximum  $Gray = \max(R, G, B)$
- Minimum  $Gray = \min(R, G, B)$

### 5. Single colour channel

$$Gray = R$$

or

$$Gray = G$$

or

$$Gray = B$$

### 6. Custom number of grey shades

Usually a grayscale image has intensities that range between 0 to 255. If one wants to reduce the number of shades, one can divide the interval  $[0, 255]$  in a number of subintervals equal with the number of grey shades that we want to use. Let  $p < 256$  be the number of shades we want to use. We consider the intervals:

$$[a_0 = 0, a_1), [a_1, a_2), \dots, [a_{p-1}, a_p = 255], \quad a_i - a_{i-1} = 255 / p .$$

All the pixels with intensities in interval  $[a_{i-1}, a_i)$  will be set to a common value (the middle point of the interval, for example). If we have a colour image, first compute one of the weighted average of the colour components (see 2.) and then apply the above described algorithm.

7. Custom number of grey shades with error-diffusion dithering

Image dithering: <http://www.tannerhelland.com/4660/dithering-eleven-algorithms-source-code/>

We explain error diffusion using an example. Consider the case of transforming a grayscale image into a binary one. The first pixel in the image is dark grey, assume it has 65 intensity, being closer to 0 (black) than to 255 (pure white) the pixel will be assigned to 0. Error diffusion works by spreading the error of each calculation to neighboring unvisited pixels. If it finds a pixel of 85 gray, it too determines that 85 is closer to 0 than to 255 and so it would make the pixel black. The error diffusion algorithm makes note of the “error” in its conversion, specifically, that the first gray pixel we have forced to black was actually 65 steps away from black. When it moves to the next pixel, the error diffusion algorithm adds the error of the previous pixel to the current pixel. If the next pixel is 85 gray, instead of simply forcing that to black as well, the algorithm adds the error of 65 from the previous pixel. This results in a value of 150, which is actually closer to 255, and thus closer to white.

The Floyd-Steinberg Dithering algorithm is using the following diffusion mask:

$$\begin{bmatrix} \# & * & \frac{7}{16} \\ \frac{3}{16} & \frac{5}{16} & \frac{1}{16} \end{bmatrix}$$

The \* marks the position of the currently processed. The error is diffused only on pixels that were not already visited (the pixel marked # is left unchanged, because it was already processed).

*Basic Floyd-Steinberg dithering algorithm*

***I = Input Image***

***OutputImage = 0;***

***for i = 1 to m***

***for j = 1 to n***

***OutputImage[i,j] = NearestColor(I[i,j]);***

***err = I[i,j] - OutputImage[i,j];***

***I[i,j+1] += err\*(7/16);***

***I[i+1,j-1] += err\*(3/16);***

***I[i+1,j] += err\*(5/16);***

***I[i+1,j+1] += err\*(1/16);***

***end for j***

***end for i***

**What about the “inverse” problem: grayscale to RGB?** Try to find a method that transforms a grayscale image in a color one.