

## Three algorithms for converting color to grayscale

□ 24 August 2009 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/>) □ John (<http://www.johndcook.com/blog/author/john/>) □ Graphics (<http://www.johndcook.com/blog/category/graphics/>)

How do you convert a color image to grayscale? If each color pixel is described by a triple (R, G, B) of intensities for red, green, and blue, how do you map that to a single number giving a grayscale value? The GIMP (<http://www.gimp.org/>) image software has three algorithms.

The **lightness** method averages the most prominent and least prominent colors:  $(\max(R, G, B) + \min(R, G, B)) / 2$ .

The **average** method simply averages the values:  $(R + G + B) / 3$ .

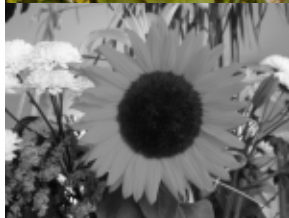
The **luminosity** method is a more sophisticated version of the average method. It also averages the values, but it forms a weighted average to account for human perception. We're more sensitive to green than other colors, so green is weighted most heavily. The formula for luminosity is  $0.21 R + 0.72 G + 0.07 B$ .

The example sunflower images below come from the GIMP documentation (<http://docs.gimp.org/2.6/en/gimp-tool-desaturate.html>).

Original image



Lightness



Average



### Luminosity



The lightness method tends to reduce contrast. The luminosity method works best overall and is the default method used if you ask GIMP to change an image from RGB to grayscale from the Image -> Mode menu. However, some images look better using one of the other algorithms. And sometimes the three methods produce very similar results.

**Update:** See More on colors and grayscale (<http://www.johndcook.com/blog/2009/08/24/more-on-colors-and-grayscale/>) for more details and more examples.

Graphics (<http://www.johndcook.com/blog/tag/graphics/>)



**JOHN** ([HTTP://WWW.JOHNDCOOK.COM/BLOG/AUTHOR/JOHN/](http://www.johndcook.com/blog/author/john/))

## 21 thoughts on “Three algorithms for converting color to grayscale”



**COLIN HOWE** ([HTTP://COLINHOWE.WORDPRESS.COM](http://colinhowe.wordpress.com))

24 August 2009 at 09:19 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12160>)

Always worth just seeing if each channel on it's own produces good results too!  
Can also get some really interesting shots when just looking at one channel 😊



**ADAMJTP** ([HTTP://TWITTER.COM/ADAMJTP](http://twitter.com/adamjtp))

24 August 2009 at 09:30 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12161>)

And if  $(0.21 R + 0.71 G + 0.07 B)$  seem like magic numbers then here are some

more magic numbers:

<http://jscience.org/experimental/javadoc/org/jsience/computing/ai/vision/GreyscaleFilter.html> (<http://jscience.org/experimental/javadoc/org/jsience/computing/ai/vision/GreyscaleFilter.html>)

I've heard that some portrait photographers use orange filters with black and white film (to remove freckles and spots).

**KEITH**

24 August 2009 at 20:15 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12162>)

Perhaps this is obvious to others, but what algorithm does actual film “use” to convert colors? An old-school analog (i.e. not digital) camera changes real world colors into b&w photographs, but using which of these methods, if any? I'm guessing it may vary with camera and film settings, and likely has changed over time, but is there one method it tends to favor over the others?



**JOHN**

24 August 2009 at 20:20 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12163>)

@Keith: That's a good question. I'd like to know the answer.

**POSSIBLYKEVIN**

25 August 2009 at 02:29 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12164>)

the answer is none of the above methods are used for film. in film or any system sensitive to the electromagnetic spectrum, can be considered as a reduction of an infinite number of frequencies (well infinite depending on your quantum view of the world I guess), into a smaller number, in a similar manner to a weighted sum histogram.

In film or a digital sensor there is a spectral sensitivity function that determine which frequencies of light get absorbed/sensitise the emulsion based upon the chemical structure. Through various means this gets converted to either silver halide crystals or in colour film different dye's are formed (eventually).

You then shine a light through the resultant film and bounce it off a screen, your eyes then view the result, In mathematical terms this is a highly non-linear transformation from scene-to-screen and is a function of many reductions from spectral to n-dimensional 'records' all of whose intensity functions are non-linear.

In film the actual 'colours' vary mostly due to the stocks used, but there are some effects that vary with intensity of exposure so the camera settings can effect the results though this is minor compared to the stock and development.

Re: the magic numbers, well they are based upon a mixing assumption. They are saying what linear combination of R, G and B would you perceive as being without colour, i.e. neutral. Depending on the exact colours of R, G and B you will get different proportions. The mixing also assumes that the individual colour channels are linear, else your not really that close to how our eyes behave. What you consider neutral is also heavily effected by the surroundings in which you view, your eyes are able to adjust their own gain functions to compensate for a certain amount of change, thus a piece of paper can look white to you even if the colour of the light shining on it is changed, although with highly coloured light you will still see it as being coloured.

Pingback: [igorbrejc.net](http://igorbrejc.net) » Fresh Catch For August 29th (<http://igorbrejc.net/freshcatch/fresh-catch-for-august-29th>)

Pingback: [ant.simianzombie.com](http://ant.simianzombie.com) » Scrollbars and Greyscale Algorithms (<http://ant.simianzombie.com/?p=1134>)

Pingback: Paweł Głowacki : Boian's TBitmap Visualizer and converting to grayscale (<http://blogs.embarcadero.com/pawelglowacki/2010/03/29/39019>)

Pingback: Paweł Głowacki : Converting to grayscale with TBitmap.ScanLine property (<http://blogs.embarcadero.com/pawelglowacki/2010/04/15/39051>)



**CREATIVENOTICE (HTTP://CREATIVENOTICE.COM)**

7 October 2010 at 15:04 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12169>)

Thanks for the post. Was exactly what I was looking for.



**MARK RANSOM**

29 October 2010 at 11:37 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12170>)

The "magic numbers" for luminosity are slightly rounded versions of the ones in

BT.709 for HDTV: [http://en.wikipedia.org/wiki/YUV#BT.709\\_and\\_BT.601](http://en.wikipedia.org/wiki/YUV#BT.709_and_BT.601)  
([http://en.wikipedia.org/wiki/YUV#BT.709\\_and\\_BT.601](http://en.wikipedia.org/wiki/YUV#BT.709_and_BT.601))

There appears to be a bug, the weights should add up to 1.0. I think the multiplier for G should be 0.72 rather than 0.71.

As for how B/W film converts to gray, it appears to depend on the exact film chemistry: [http://en.wikipedia.org/wiki/Photographic\\_film#Spectral\\_sensitivity](http://en.wikipedia.org/wiki/Photographic_film#Spectral_sensitivity)  
([http://en.wikipedia.org/wiki/Photographic\\_film#Spectral\\_sensitivity](http://en.wikipedia.org/wiki/Photographic_film#Spectral_sensitivity))

**MATEJ (HTTP://WWW.MATEJUKMAR.COM)**

21 April 2011 at 02:55 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12171>)

I did some testing with all three mentioned methods and discovered that Luminosity method is best if picture is not too blue. So I tried this:

1. for every pixel I first check if blue component is greater than green and red
2. if it IS I use Lightness method (or Average - both are good) ... if NOT I use Luminosity method for current pixel.

This algorithm gives very good results. It comes very close to Photoshop's convert to Grayscale "mystic" algorithm 😊



**DON STEWART (HTTP://DONSBOT.WORDPRESS.COM)**

16 May 2011 at 13:52 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12172>)

I converted this nice example to Haskell as part of an multidimensional array programming tutorial. The result is pleasingly concise (and parallel).

[http://www.haskell.org/haskellwiki/Numeric\\_Haskell:\\_A\\_Repa\\_Tutorial#Example:\\_parallel\\_image\\_desaturation](http://www.haskell.org/haskellwiki/Numeric_Haskell:_A_Repa_Tutorial#Example:_parallel_image_desaturation)  
([http://www.haskell.org/haskellwiki/Numeric\\_Haskell:\\_A\\_Repa\\_Tutorial#Example:\\_parallel\\_image\\_desaturation](http://www.haskell.org/haskellwiki/Numeric_Haskell:_A_Repa_Tutorial#Example:_parallel_image_desaturation))

**WEIGHT CONVERSION (HTTP://WEIGHTCONVERSION.ORG.UK)**

1 July 2011 at 23:21 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12173>)

n film or a digital sensor there is a spectral sensitivity function that determine which frequencies of light get absorbed.

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Allen

**SHAM**

17 October 2011 at 08:27 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12174>)

sir, thanks a lot.wish u all the beat for your future work and hope u will always help us by providing such data.

Pingback: Wineapp - creating a high-tech hash: gray scaling « Mobile apps

(<http://chrisjager.wordpress.com/2011/12/07/wineapp-creating-a-high-tech-hash-gray-scaling/>)

Pingback: » Java color image to grayscale conversion algorithm(s) ZeroCool (<http://zerocool.is-a-geek.net/?p=329>)

Pingback: gattr (<http://gattr.com/174/>)

**TAREK (HTTP://SEUDOLAB.COM/)**

18 June 2012 at 19:16 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12178>)

thank you. nice thing on image. love it!

**JSDING (HTTP://WWW.DBFACE.COM)**

18 February 2013 at 19:04 (<http://www.johndcook.com/blog/2009/08/24/algorithms-convert-color-grayscale/comment-page-1/#comment-12179>)

I just use the average method to grayscale a button (disable status) in a HTML5 canvas project

```
var context = canvasEl.getContext('2d'),  
    imageData = context.getImageData(0, 0, canvasEl.width, canvasEl.height),  
    data = imageData.data,  
    iLen = imageData.width,  
    jLen = imageData.height,  
    index, average, i, j;
```

```
for (i = 0; i < iLen; i++) {  
  for (j = 0; j < jLen; j++) {  
  
    index = (i * 4) * jLen + (j * 4);  
    average = (data[index] + data[index + 1] + data[index + 2]) / 3;  
  
    data[index] = average;  
    data[index + 1] = average;  
    data[index + 2] = average;  
  }  
}  
  
context.putImageData(imageData, 0, 0);
```

Thanks for the post.

Pingback: First steps in Freemat | Uskerine's blog (<http://uskerine.wordpress.com/2013/06/02/first-steps-in-freemat/>)

Comments are closed.

☐ [Back to school \(http://www.johndcook.com/blog/2009/08/24/back-to-school/\)](http://www.johndcook.com/blog/2009/08/24/back-to-school/)

More on colors and grayscale ☐ (<http://www.johndcook.com/blog/2009/08/24/more-on-colors-and-grayscale/>)

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