

Supplement to Chapter 3 of *The Science of Digital Media* – Digital Image Processing

Programming Exercise – Digital Imaging > Blending Modes¹

Introduction:

In digital imaging processing programs, blending modes allow you to combine the pixels of a foreground and background layer. You can apply a blending more to a layer in an image or to a painting tool. Some common blending modes are defined as follows:

Given are two RGB image layers, foreground and background, with 100% opacity on each layer. Let a foreground pixel be given by $\mathbf{F} = (f_r, f_g, f_b)$ a background pixel be defined by $\mathbf{B} = (b_r, b_g, b_b)$ where $0 \leq f_r, f_g, f_b, b_r, b_g, b_b \leq 1$. Then for each foreground pixel \mathbf{F} and corresponding background pixel \mathbf{B} at the same location in the image, the resulting composite pixel color $\mathbf{C} = (c_r, c_g, c_b)$ is given for each blending mode in Table 1. Operations are done channel-by-channel, and results are clipped to a range of 0 to 1.

blending mode	equation
normal	$\mathbf{C} = \mathbf{F}$
multiply	$\mathbf{C} = \mathbf{F} * \mathbf{B}$
divide	$\mathbf{C} = \left(\frac{\mathbf{B}}{\mathbf{F} + \frac{1}{255}} \right) \left(\frac{256}{255} \right)$
screen	$\mathbf{C} = 1 - ((1 - \mathbf{F})(1 - \mathbf{B}))$
overlay	$\mathbf{C} = \mathbf{B}(\mathbf{B} + 2\mathbf{F}(1 - \mathbf{B}))$
dodge	$\mathbf{C} = \left(\frac{\mathbf{B}}{\frac{256}{255} - \mathbf{F}} \right) \left(\frac{256}{255} \right)$

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burn	$C = 1 - \left(\left(\frac{1 - B}{F + \frac{1}{255}} \right) \left(\frac{256}{255} \right) \right)$
hard light	If $F > 0.5$ then $C = 1 - 2(1 - B)(1 - F)$ If $F \leq 0.5$ then $C = 2(F * B)$
soft light	$C = 2(F * B) + B^2 - 2(F * B^2)$
grain extract	$C = B - F + 0.5$
grain merge	$C = B + F - 0.5$
difference	$C = B - F $
addition	$C = B + F$
subtraction	$C = B - F$
darken only	$C = \min(B, F)$
lighten only	$C = \max(B, F)$

Table 1

Instructions:**The Assignment**

Using the programming language of your choice, implement these blending modes. Allow the user to specify the input file names and the type of blending to be performed.

Your program should determine a new value for each pixel based on the values for the foreground and background images and the blending mode applied. Write the resulting file to a permanent file.

Before Writing the Program

To run your program, you will need some raw grayscale image files as input, so create these first or ask your instructor if he or she plans to create them for you. The image files should have one byte per pixel. Your program will need to know the width and height of the input images in order to be able to read the raw files. The input image files can be created by saving an image (BMP, JPG, etc.) in raw format in a standard image processing program.

Evaluating Your Results

Open your output files in an image processing program that can read raw files. Compare your results to the results obtained by applying these blending modes in GIMP, Photoshop, or some other image processing program.

Ideas for Further Experimentation and Analysis

- Try applying an alpha channel to the foreground and background image and look at how this is combined with blending modes in Photoshop, GIMP, or some other image processing program. See if you can implement this yourself.