Digital Image Processing Homework 1

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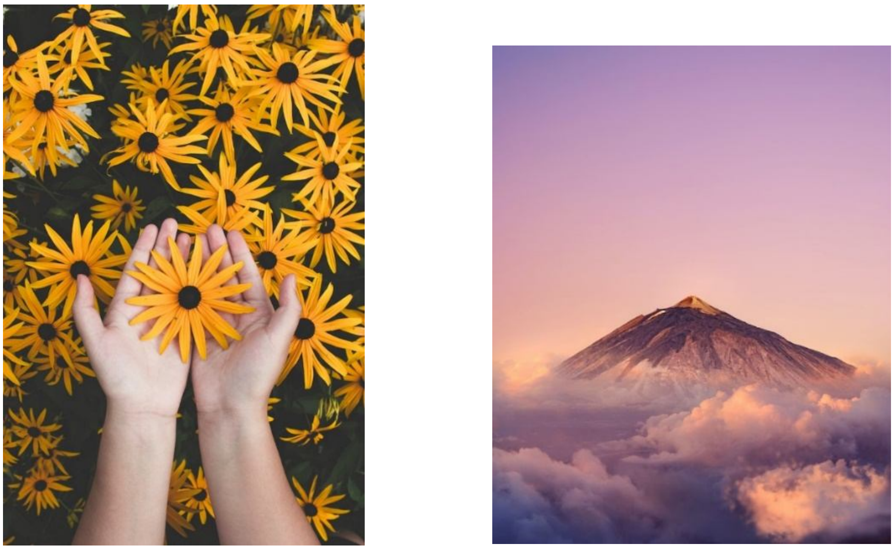
1 Image input/flip/output

1.1 BMP format

The BMP format is a raster graphics image file format used to store bitmap digital images. It primarily consists of three sections: the "File Header," the "Info Header," and the "Bitmap Data." The first two sections, "File Header" and "Info Header," contain information about the bitmap, such as its width and height in pixels, pixel depth, compression details, and more. The third section stores the actual bitmap data. The following table provides a detailed overview of the file structure within a BMP file.

	Name	Size	Description
File Header (14 bytes)	Signature	2 bytes	‘BM’
	FileSize	4 bytes	File size in bytes
	Reserved 1	2 bytes	unused (=0)
	Reserved 2	2 bytes	unused (=0)
	DataOffset	4 bytes	Offset from beginning of file to the beginning of the bitmap data
Info Header (40 bytes)	Size	4 bytes	Size of Info Header
	Width	4 bytes	Horizontal width of bitmap in pixels
	Height	4 bytes	Vertical height of bitmap in pixels
	Planes	2 bytes	Number of Planes
	Bits Per Pixel	2 bytes	Bits per pixel
	Compression	4 bytes	Type of compression
	ImageSize	4 bytes	(compressed) Size of image
	XpixelsPerM	4 bytes	Horizontal resolution: Pixels/meter
	YpixelsPerM	4 bytes	Vertical resolution: Pixels/meter
	Colors Used	4 bytes	Number of actually used colors
	Important Colors	4 bytes	Number of important colors
Bitmap raw data (size= Width* Height* Bits Per Pixel)			

The objective of this experiment is to horizontally flip, to change the resolution, and to perform uniform scaling (resizing) on the following input images (Fig 1), and finally save the results as BMP format files.



(a) (b)

Fig 1. Input BMP images. (a) size : 640*940*(8*3). (b) size : 640*800*(8*4).

1.2 Horizontal flip

In this section, the main objective is to horizontally flip an image and output it in a BMP format. The approach in this experiment is to place each pixel's data of the image in its corresponding position along the horizontal symmetry axis. The following images (Fig 2) are the results of horizontally flipping the input images.

Fig 2. The results of horizontally flipping the input images.

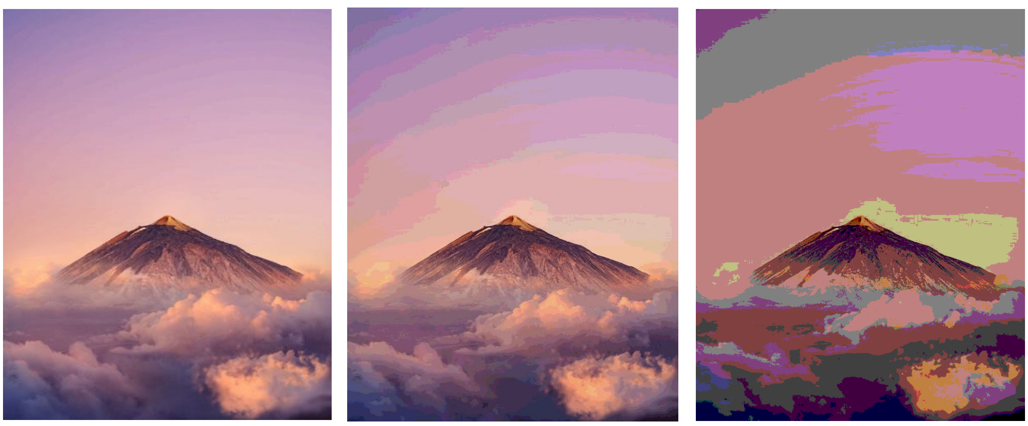
2 Resolution

In this section, the primary objective is to convert the original 8 bits per pixel input images into images with 6, 4, and 2 bits per pixel and save them as BMP files. The approach in this experiment involves using "shift operations," which means first shifting the data of each pixel to the right by a certain number of bits and then shifting it back. The specific mathematical formula for this process is detailed in Equation 1. The following images show the results of converting the two input images into images with 6, 4, and 2 bits per pixel, respectively (Fig 3 and Fig 4).

$$PixelData_{Qantization} = \left(PixelData_{origin} \gg Shift\ level\right) \ll Shift\ level \quad \text{(eq1).}$$

(a) (b) (c)

Fig 3. The results of converting the image input1.bmp into images with 6 (a) , 4 (b) , and 2 (c) bits per pixel.



(a) (b) (c)

Fig 4. The results of converting the image input2.bmp into images with 6 (a) , 4 (b) , and 2 (c) bits per pixel.

3 Scaling

In this section, the main purpose is to perform a 1.5x scaling (either upscaling or downscaling) on two input images using Bilinear Interpolation. The mathematical expression for Bilinear Interpolation is described in the following equations. Bilinear interpolation involves interpolating the data of each pixel by considering the data from the four nearest pixels, and the following images compare the original images and images with up-scaling or down-scaling by Bilinear Interpolation with rate 1.5. (Fig 5 and Fig 6.).

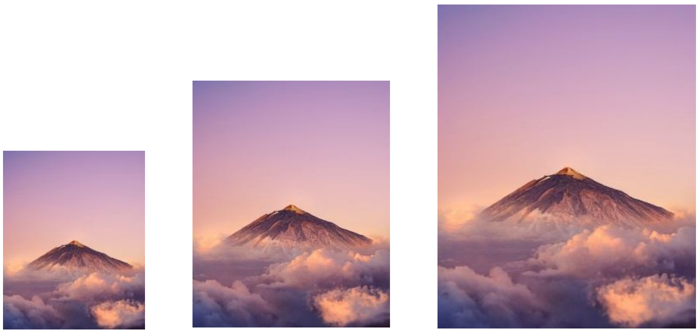
$$\mathrm{x_l} = floor(ratio \times x),\ y_l = floor(ratio \times y), x_h = ceil(ratio \times x), y_h = ceil(ratio \times y),$$

$$\mathrm{x_{weight}} = (ratio \times x) - x_l,\ y_{weight} = (ratio \times y) - y_l,$$

$$\begin{aligned} \mathrm{PixelData_{Bilinear\ Interpolation}}(x, y) \\ &= \mathrm{PixelData_{origin}}(x_l, y_l) \times (1 - \mathrm{x_{weight}}) \times (1 - y_{weight}) \\ &+ \mathrm{PixelData_{origin}}(x_h, y_l) \times (\mathrm{x_{weight}}) \times (1 - y_{weight}) \\ &+ \mathrm{PixelData_{origin}}(x_l, y_h) \times (1 - \mathrm{x_{weight}}) \times (y_{weight}) \\ &+ \mathrm{PixelData_{origin}}(x_h, y_h) \times (\mathrm{x_{weight}}) \times (y_{weight}). \end{aligned}$$

(a) (b) (c)

Fig 5. Comparison between the input1.bmp and input1.bmp with up-scaling or down-scaling by Bilinear Interpolation with rate 1.5.



(a) (b) (c)

Fig 6. Comparison between the input2.bmp and input2.bmp with up-scaling or down-scaling by Bilinear Interpolation with rate 1.5.