CENTRO *UNIVERSITÁRIO* DE BARRA MANSA
ACADEMIC PRO-RECTORY

COMPUTER ENGINEERING COURSE

INFLUENCE OF TONAL AND SPATIAL RESOLUTION ON THE IMAGE FILE SIZE

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Wellington Magalhães Leite

Barra Mansa
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Paper presented to the Computer Engineering course at Centro Universitário de Barra Mansa, as a partial requisite to the obtention of the first grade pertaining the Computer Graphics discipline, under prof. Ronaldo Dias Corrêa supervision.

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ABSTRACT

It is interesting to notice how the three variables (bits per pixel, number of colors and image file size) discussed in this paper are extremely related.

More and more we express ourselves through the use of images, which consequently need a place to be stored and this has to do with their usage in digital mediums as is the case of the Internet. Take the Flickr service as an example. The storage is made in a digital form, that is, in bits.

It is known that: the better the image quality, the bigger will be the number of bits per pixel that are used to compose the image, what make us capable of visualizing a great number of colors (tonal resolution), for the number of colors is coupled up to the quantity of bits per pixel. If we increase the number of pixels (spatial resolution) of the image, the generated file size will be bigger, in other words, more bits will be consumed to compose the image and depending on this value, the distribution or visualization of the image can be inadequate in certain conditions.

So, we can perceive the necessity of a case by case study, looking for a suitable value to the three variables, what will provide us with an ideal image file for each type of job.

Keywords: computer graphics, tonal resolution, spatial resolution, bits per pixel, number of colors, image file size

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1 INTRODUCTION

1.1 Objective

Our objective is to investigate the relation between these three variables: the number of bits, the number of colors and the size of an image file.

1.2 Definition

A bit is the smaller measure unit used in computers. Each bit indicates one of two different states, on (represented by 1) or off (represented by 0). A single bit doesn't carry much information, but it's possible to create a sequence of bits through the binary code to represent numbers, words, images, or whatever type of computation data. In fact, all the data is codified in binary numbers and appears as a series of 0s and 1s.

0010101110010010010111011011010100000011011110100110101 0

For a digital photo, the bit depth or color depth [1] (or simply quantity of bits per pixel) can be considered as the number of colors that can be shown in an image. Given the fact that the bits can only indicate 1 of 2 possible states (0 or 1), the number of colors must be an exponent of 2. Some examples of bits per pixel for image files are: 2-bit (2 ^ 2 = 4 colors), 4-bit (2 ^ 4 = 16 colors), 8-bit (2 ^ 8 = 256 colors), 16-bit (2 ^ 16 = 65.536 colors), e 24-bit (2 ^ 24 = 16,777,216 colors).

Each color of pixel in a digital image is created through some combination of three primary colors: red, green and blue (RGB) [2]. Each primary color is commonly referenced as a color channel and can have any intensity level of values specified by its bit depth. The bit depth for each primary color is designated "bits per channel". The "bits per pixel" (bpp) reference the sum of all bits in all the three color channels and represent the total of colors available in each pixel.

The bigger the bpp, the bigger will be the quantity of colors that can be used in an image. The smaller the bpp, the smaller will be the quantity of colors that can be used in an image. Knowing that the number of colors in an image is proportional to the amount of information that the same stores we can conclude that the image size will also increase. So, the image's bpp is directly related to the size of the file and to the number of colors.

In this experiment we'll modify the number of colors of a digital image and measure he resultant effect through the file's size, bpp and download time. Will the file's size and download time always increase if the bpp increase? How changing the bpp of an image we

can alter the number of possible colors? This is a linear relation? These are some of the questions that we seek to clarify.

1.3 Tonal resolution

Is the number of bits used to represent a digital image. The intensity and color of each pixel are represented by an integer value or a set of integer values.

1.4 Spatial resolution

Is the term used to reference the number of pixel used to construct digital images. Images that have a big spatial resolution are composed by much more pixels than those that have a low spatial resolution. We can considerate it as the number horizontal and vertical pixels of an image.

2 DEVELOPMENT

2.1 Image edition

2.1.1 Creating the work directory

We created a folder called “Compugraph" in the root directory C:\.

2.1.2 Obtaining the data “bits” for the experiment

Using the keyboard Print Screen key, we copied the content of the window that shows an image [3] from Flickr.

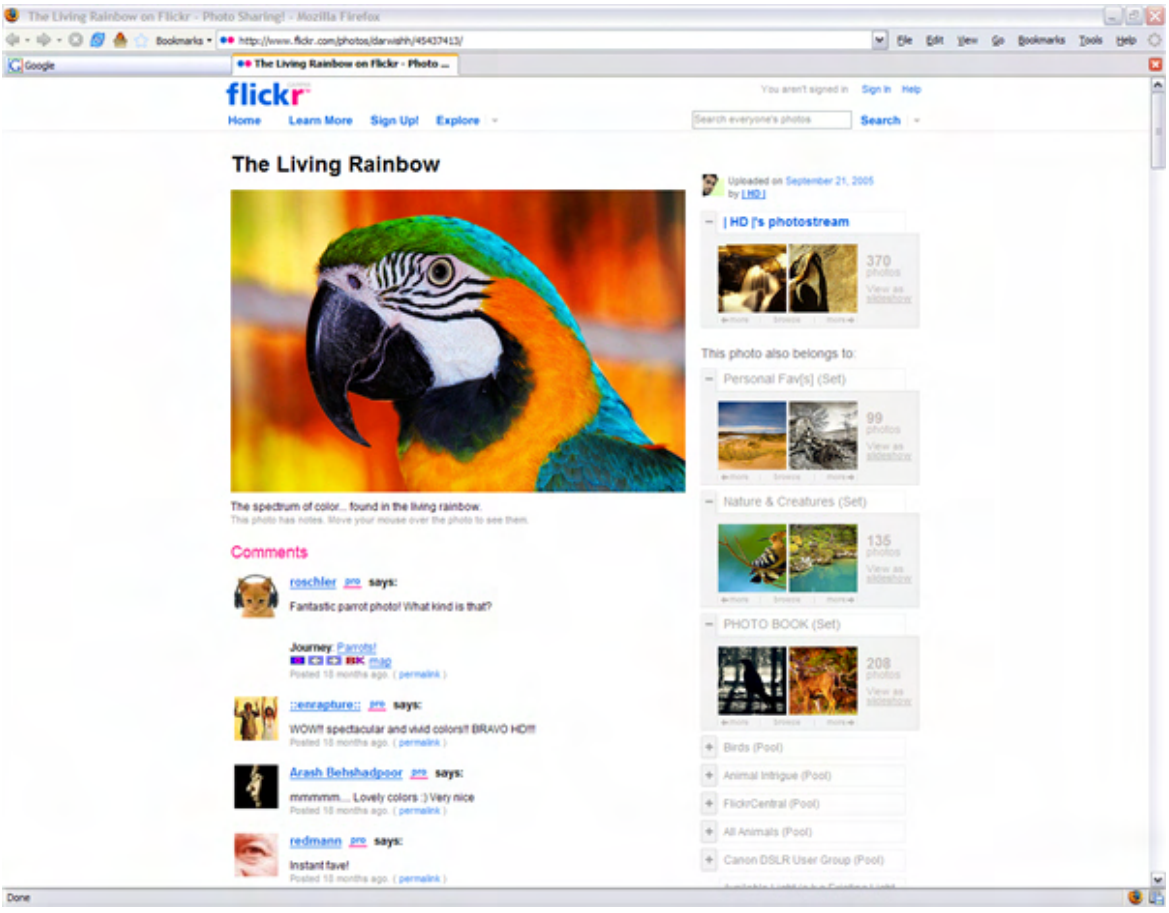

Figure 1 - Original image screenshot

2.1.3 Selecting only the image of interest

With the aid of the Windows Paint [4] program, we selected only the parrot image and saved the same in a file called parrotoriginal.bmp. We put this file inside the “Compugraph” folder.

The chosen image has vivid, brilliant colors so that we can visualize in a more accurate form the influence of the realized tests.

It's also important to note that the image file format chosen (BMP) [5] does not compress the image, what make us capable of acquiring the real file size that can be calculated according to the following formula:

$$\text{BMP file size} \approx (\text{Resolution}^2 \times \text{Width} \times \text{Height} \times \text{bpp}) / 8.192$$

Where:

BMP file size = KB | Resolution = pixels/inch | Width = inches Height = inches | bpp = bits per pixel

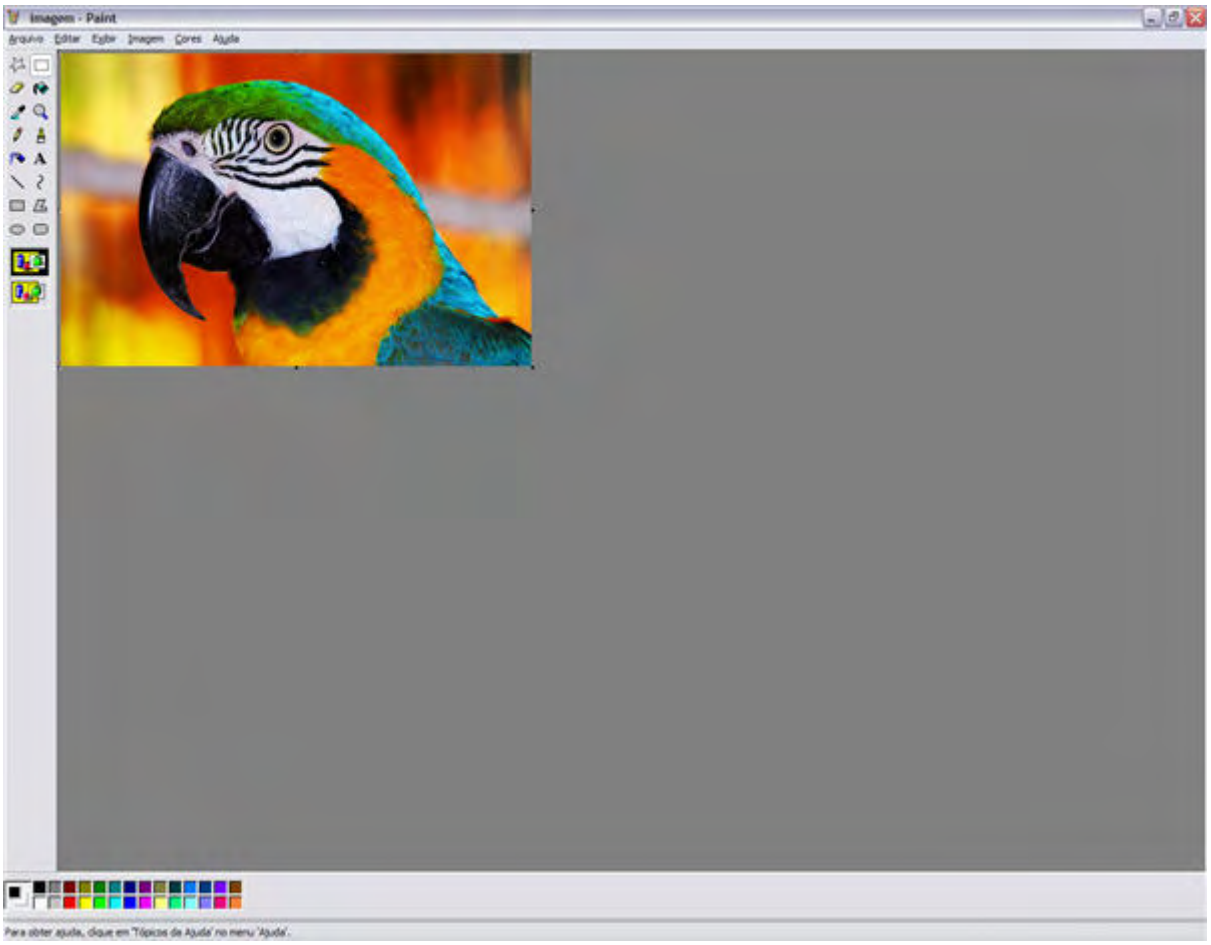

Figure 2 - Editing the screenshot on Windows Paint

2.1.4 Opening the test file with Photoshop

We then opened the file parrotoriginal.bmp with Adobe® Photoshop® CS2 [6] version 9.0.

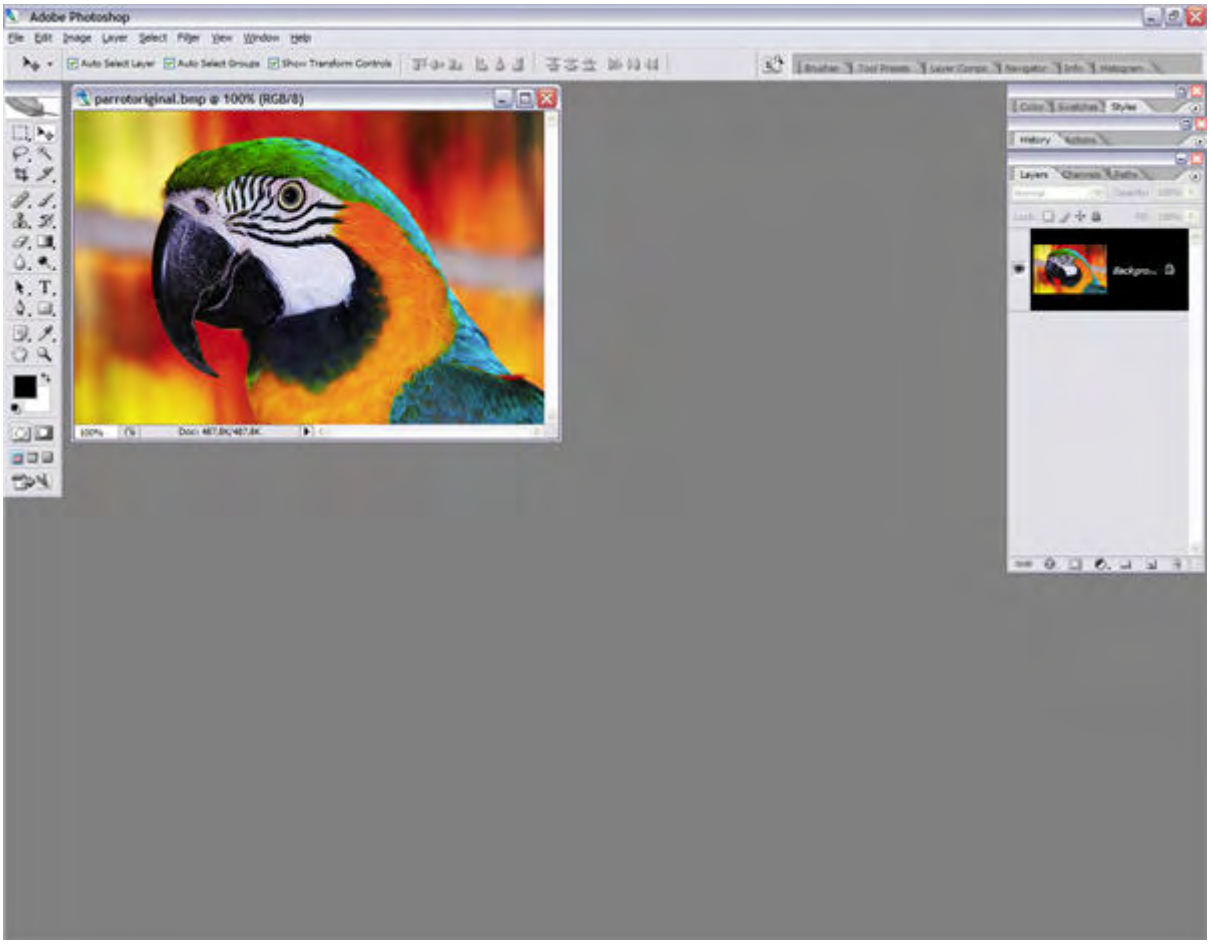

Figure 3 - Test file on Photoshop

2.1.5 Visualizing the image size properties

In the menu “Image” inside Photoshop, we selected “Image Size...” obtaining the following dialog window:

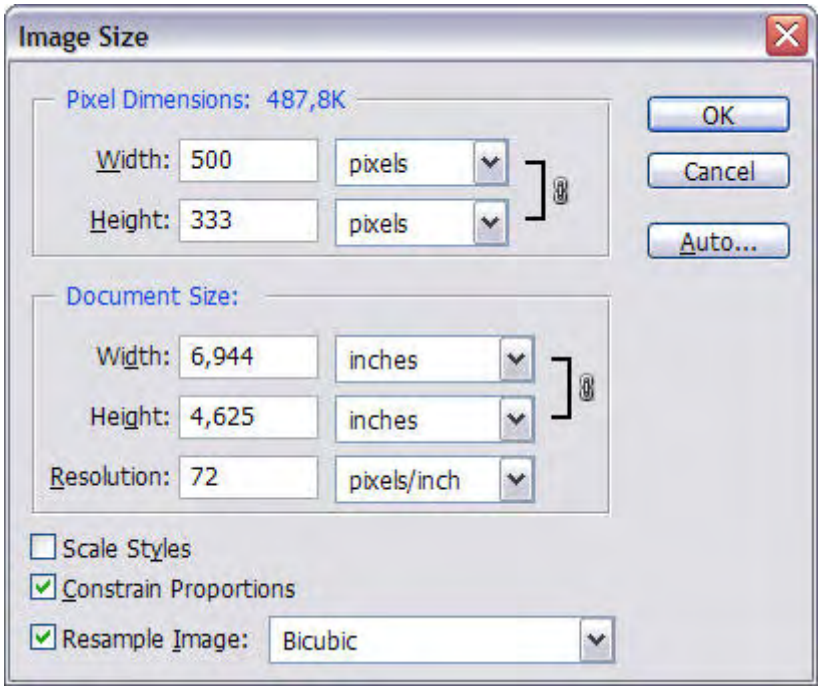

Figure 4 - Image size properties

2.1.6 Redefining the image size

On “Pixel Dimensions” from the previous dialog window, we changed the values to 1600 in “Width” and 1200 in “Height”.

Note: we unchecked the option “Constrain Proportions” so that we could specify a new value for width and height according to our necessity.

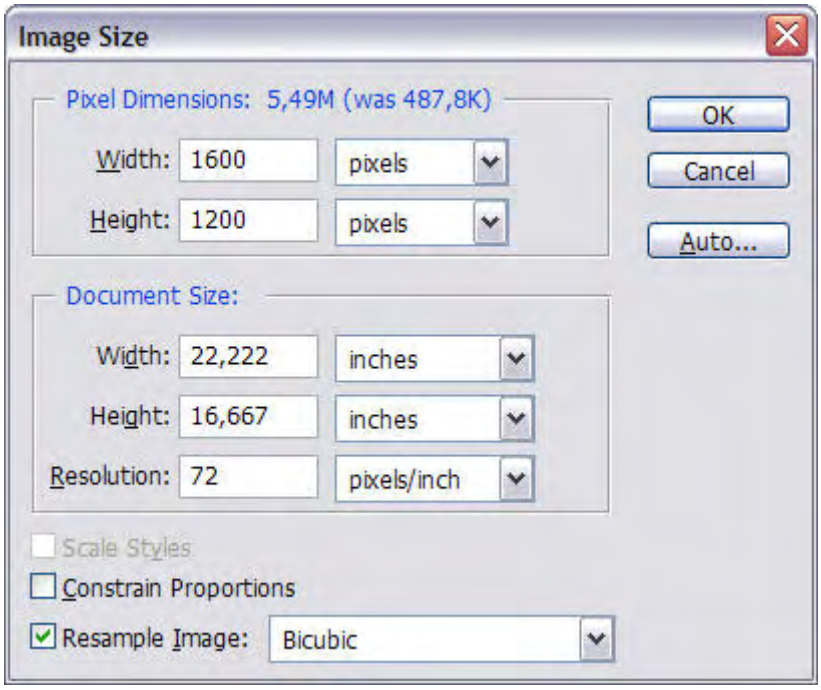

Figure 5 - Changing the image size (spatial resolution)

2.1.7 Saving the modified image

In the menu “File” we clicked on “Save As...”. We selected the BMP format as the output format. We called the file the name parrot-1600x1200pixels-24bit.bmp saving it in a new folder called parrot-1600x1200pixels, which was created inside the folder “Compugraph”.

On the dialog window “BMP Options” we selected 24 Bit.

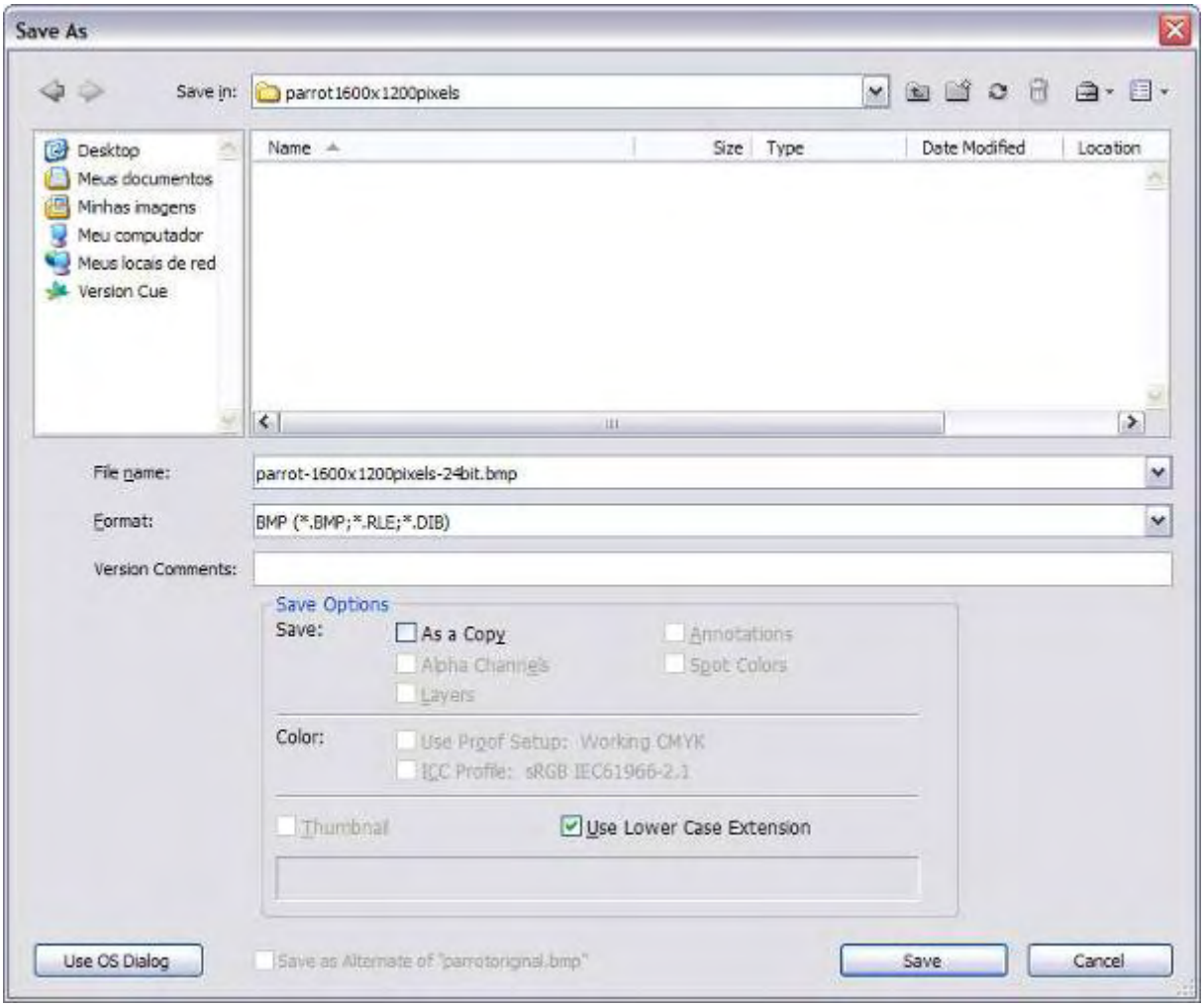

Figure 6 - Dialog window "Save As"

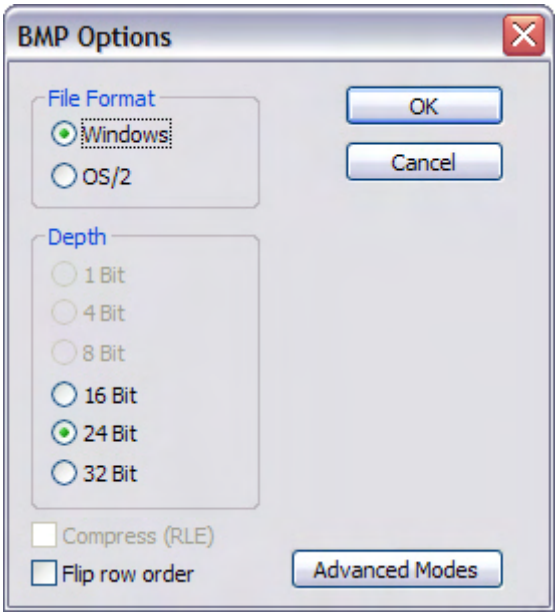

Figure 7 - Selecting 24 bits per pixel

2.1.8 Producing images with different spatial resolutions

We repeated the process starting at 2.1.4 until 2.1.7 for more three times to get images with different dimensions. The other three images have the following dimension in pixels: 1280 x 1024, 1024 x 768 e 800 x 600. We kept the same naming scheme adopted for the file names, that is, the images' name are respectively: parrot-1280x1024pixels-24bit.bmp, parrot-1024x768pixels-24bit.bmp e parrot-800x600pixels-24bit.bmp.

2.1.9 Altering the tonal resolution

Still working with the image parrot-1600x1200-pixels-24bit.bmp opened in Photo-shop, we clicked in the menu "File" and after that in "Save As…". We selected the BMP file format as the output format. We named it parrot-1600x1200pixels-16bit.bmp saving it inside the folder parrot-1600x1200pixels. On the "BMP Options" dialog window, in "Depth", we selected "16 Bit".

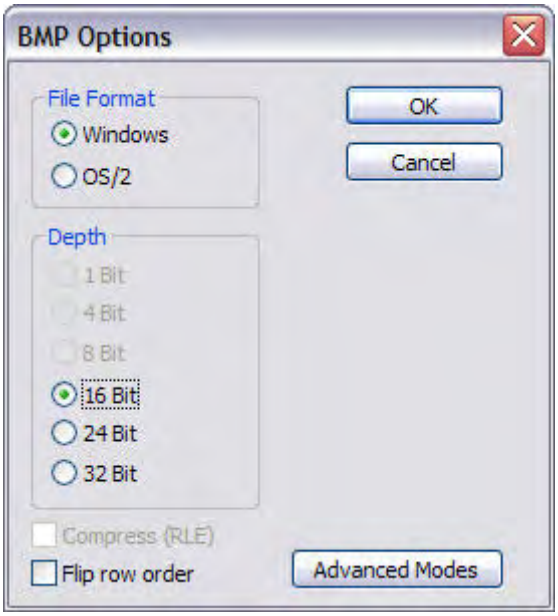

Figure 8 - Selecting 16 bits per pixel

2.1.10 Returning to Windows Paint

The Windows Paint program is capable of generating BMP images with tonal resolutions of 1, 4 and 8 bits.

Working with the image parrot-1600x1200pixels-24bit opened inside Paint, we clicked on the menu “File” and after that on “Save as...”. In the option “Save as type” of the dialog window, we selected “Monochromatic Bitmap” and renamed the file to parrot-1600x1200-1bit.

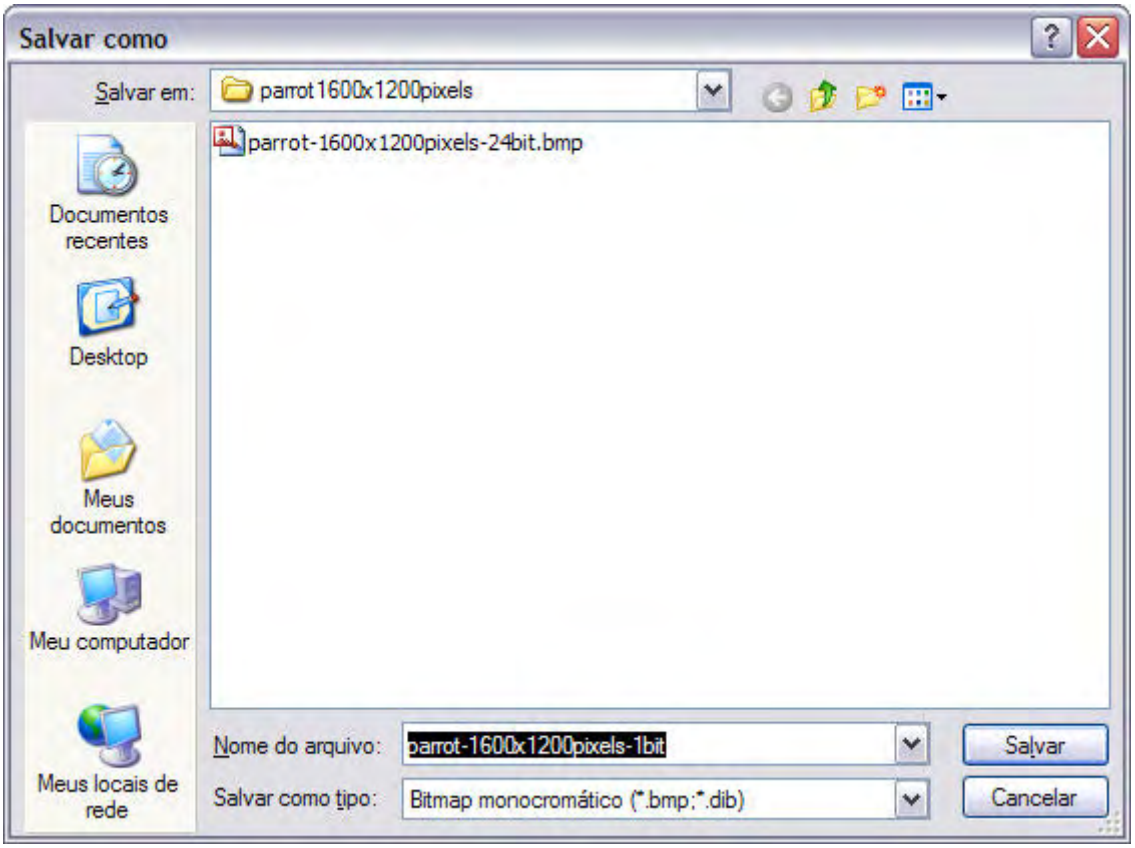

Figure 9 - Selecting 1 bit per pixel

We repeated this step twice more to acquire the images with different tonalities. The other two images have 16 and 256 colors respectively. We kept the naming scheme, that is, the images' names are respectively: parrot-1600x1200pixels-4bit.bmp and parrot-1600x1200pixels-8bit.bmp.

2.1.11 Producing images with different tonal resolutions

We repeated the process 2.1.10 for more three times to get images with different tonal resolutions for the other spatial resolutions: 1280 x 1024, 1024 x 768 e 800 x 600 and kept the naming scheme adopted for the file names.

3 APPLICATION

3.1 24, 16, 8, 4 and 1 bit tonal resolutions

The relation between the different tonal resolutions can be perceived in the following five images.

Figure 10 - 24 bits tonal resolution file

Figure 11 - 16 bits tonal resoultion file

Figure 12 - 8 bits tonal resolution file

Figure 13 - 4 bits tonal resolution file

Figure 14 - 1 bit tonal resolution file

3.2 Tonal resolution vs. Spatial resolution vs. Image size

The relation between the three variables studied in this paper can be better comprehended through the following chart, which gathers the data obtained during the tests. The data is in an external spreadsheet called Influence of Tonal and Spatial Resolution on the Image File Size.xlsx. This spreadsheet is part of this paper. Both, the paper and the spreadsheet can be downloaded at: http://lenielmacaferi.blogspot.com/2008/04/tonal-x-spatial-resolution-x-file-size.html.

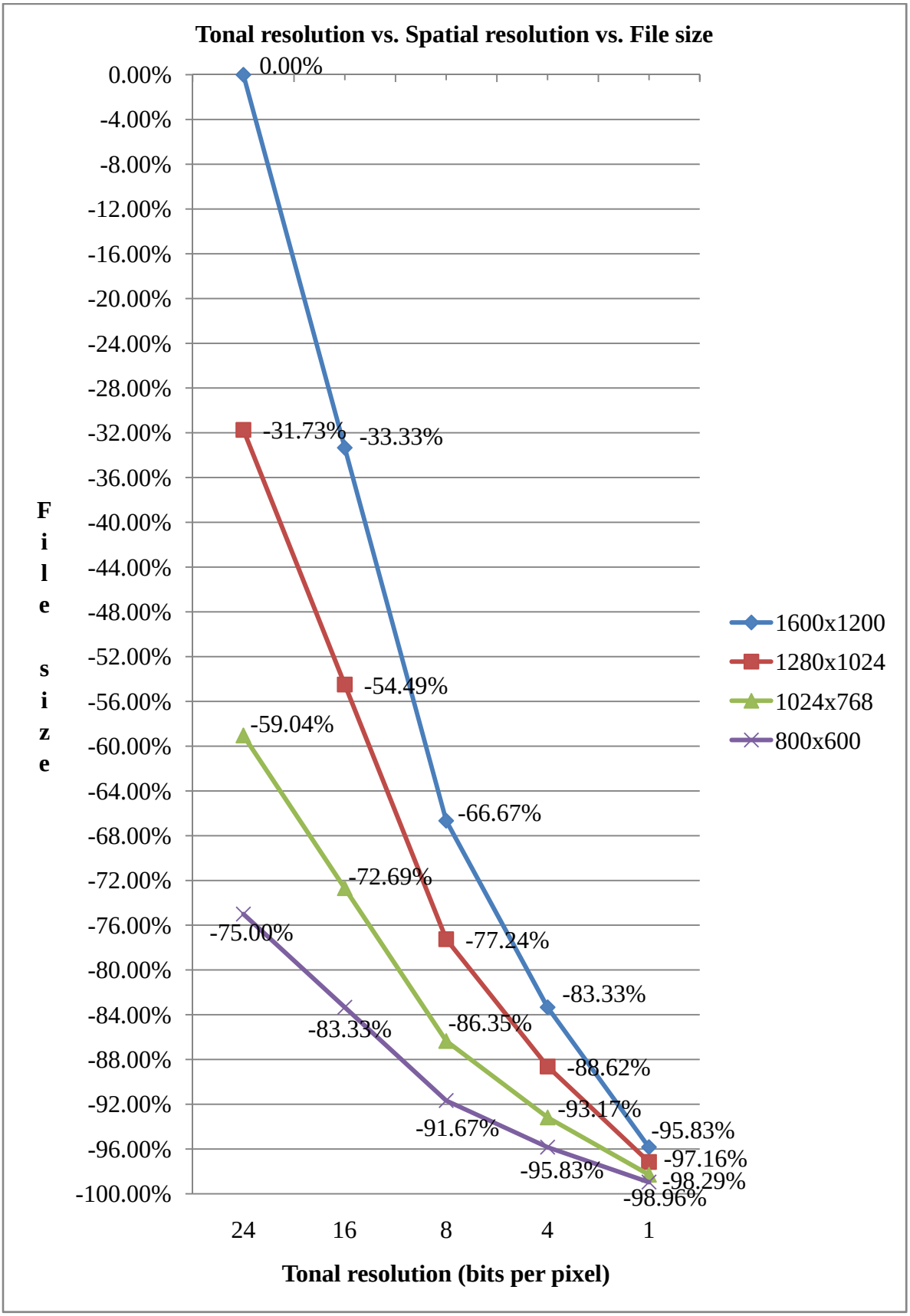

Figure 15 - Tonal resolution vs. spatial resolution vs. file size chart

4 CONCLUSION

During the development of this paper we had the opportunity of acquiring skills related to terms and concepts concerning the theme, what makes us capable to respond questions of the type: what is color depth (tonal resolution)? What is spatial resolution? How many bits are necessary to produce a good image quality and how the number of bits changes the number of colors and the size of the image?

With the technological advance it’s momentousness that we master such concepts, given the fact that the employment of images is vast in the computer arena. The internet is here, so present and is the most concrete proof of the above words. Let’s get for example, the Google Earth software product; the database is formed by terabytes of image data collected by satellites. For sure, the Google engineers implemented the concepts described in this paper so that they could obtain the ideal ratio for the available image quality and the better utilization of disk space. This is because the current computer network technology is limited (throughput) and storage costs stacks of money!

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