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2015-07420
Activity 3: IMAGE TYPES AND FORMATS
August 14, 2019

OBJECTIVES:

- Explore various digitalized image types.
- Determine key differences between varying image types.
- Explore the effect of converting one type of an image to another.

I. Basic Image File Types and their Basic Properties

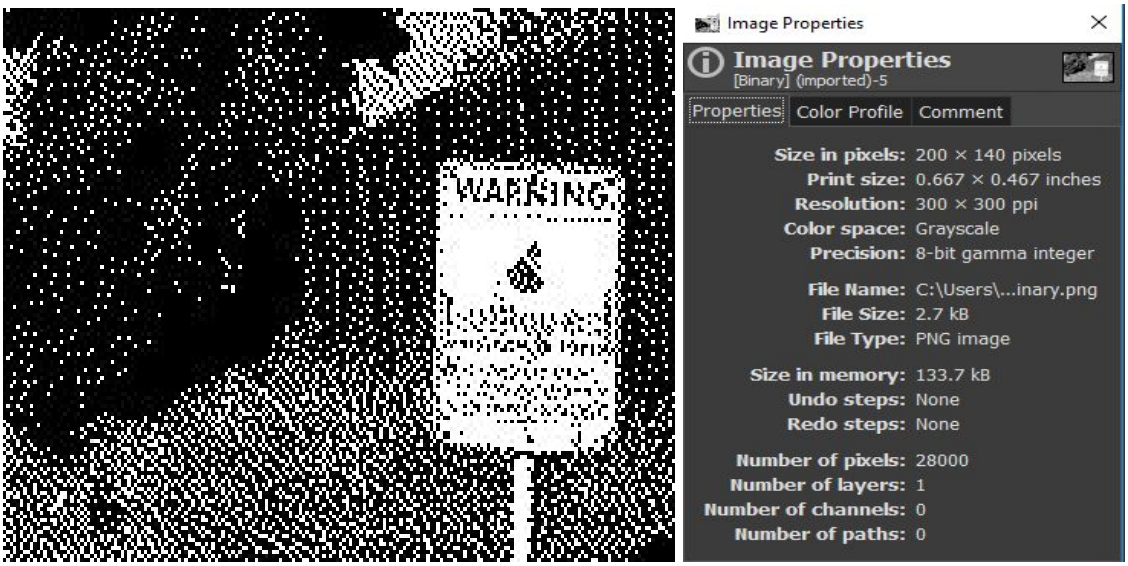

Figure 1.0 Binary image retrieved from [1] . The image is composed of pixels with values limited to only 0 or 1, whereas, this would determine whether a specific pixel would hold a black (0) or white (1) color. The image was relatively small in size (2.7kB) due to the small amount of storage required to append binary values of each pixel. The image on the right presents a more detailed overview of the properties of the image when loaded onto GIMP. It presents additional info such as the resolution in terms of ppi (pixels per inch). However, one may notice that some of the formatting was lost in the process, whereas, the initially 2-bit image was converted into an 8-bit gamma integer image with a color space suggesting grayscale – which we know is far from the truth.

File Size	2.7 kB
Dimension	200 px x 140 px
Bit-depth	1

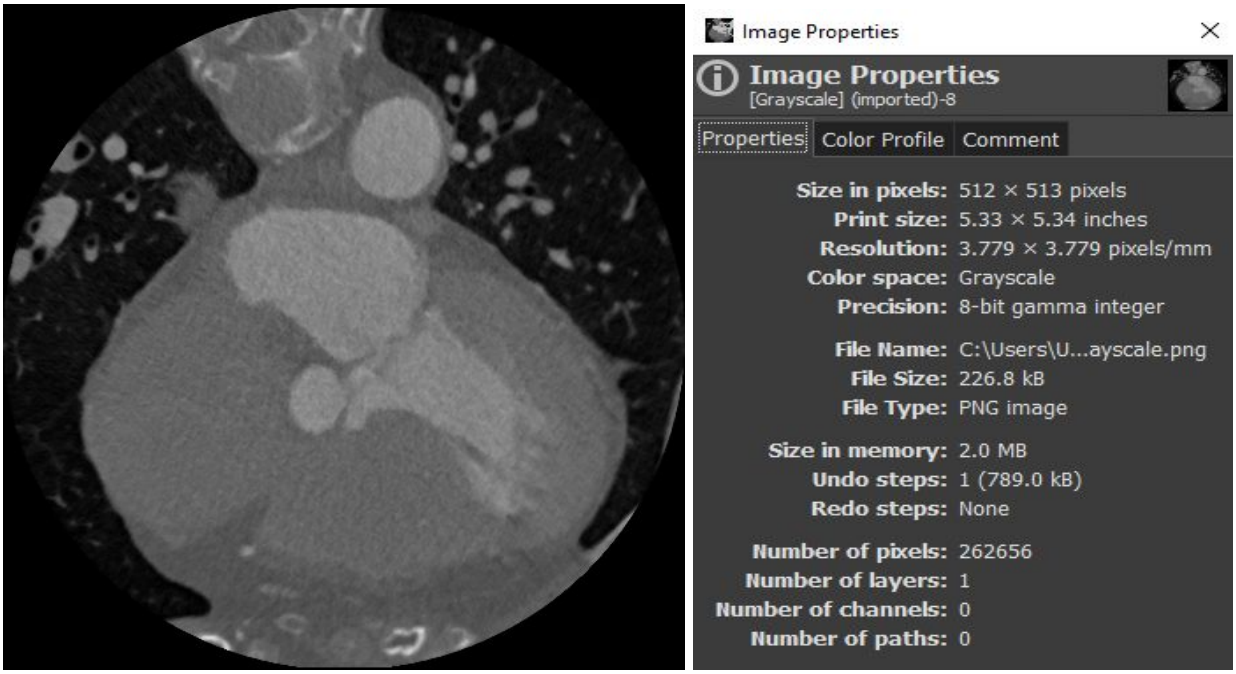

Figure 2.0 A grayscale image of a single slice of a heart CT scan retrieved from [2]. Each pixel possess a value which range from 0 (black) to 255 (white).Values between these extremes would convert to an equivalent shade of gray (from dark gray to light gray).

In comparison with the binary image, the grayscale image poses a higher storage consumption as it is not limited to two values per pixel but is limited from 0 to 255. As such, a proportional increase in size is expected.The image on the right presents a more detailed overview of the properties of the image when loaded onto GIMP. In contrast to Figure 1.0, the resolution of this image is described in pixels per mm, which is mainly a factor on the formatting of the image inputted into GIMP.

File Size	226.8 kB
Dimension	512 px x 513 px
Bit-depth	24

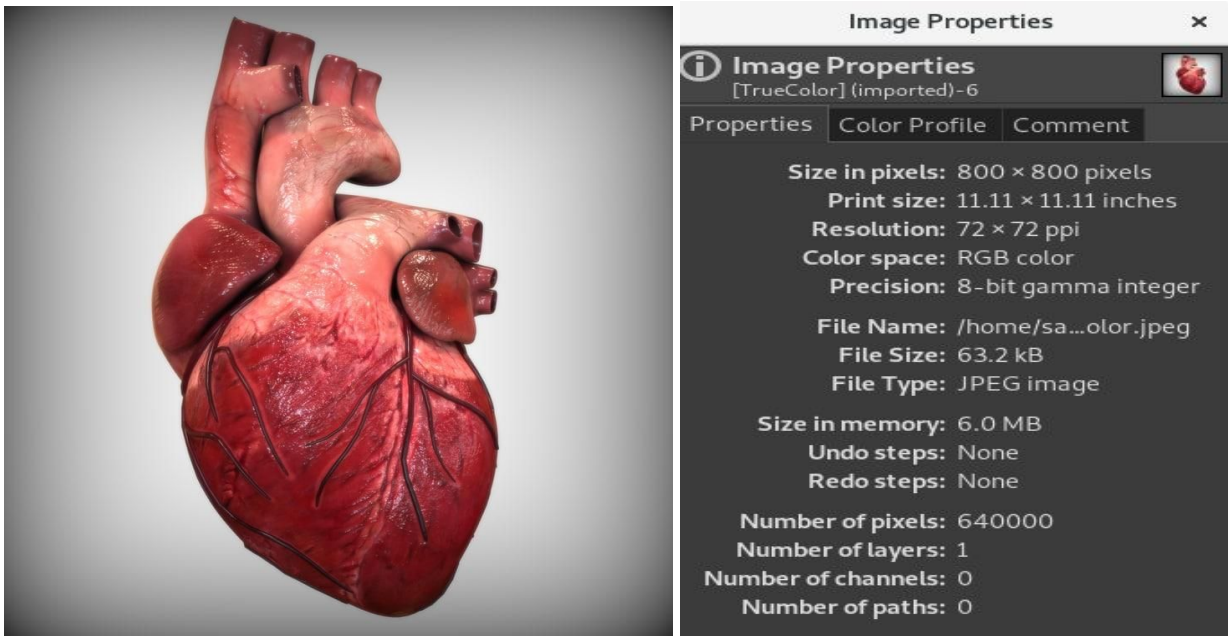

Figure 3.0 A truecolor image of a Human Heart model retrieved from [3]. The image is composed of three channels: red, green, and blue. The overlaid intensities of each channel forms the final image seen above. The image has a resolution of 72 dots per inch which specifies the amount of magnification possible for the image. The image on the right presents a more detailed overview of the properties of the image when loaded onto GIMP.

As seen from the Image properties, it differs in the color space whereas it contains RGB color: red, green, and blue channels. It was also observed that although the image has a larger pixel size and print size in contrast to Figure 2, it still has a much smaller file size – which should be the opposite in theory. However, one should also account for the format used in each of the images, whereas, the grayscale image was saved in a lossless image compression (.png) while this image was saved via lossy image compression (.jpeg) where some details may have been loss in compression. However if one were to compare their weight on the memory (uncompressed) , we can see that the truecolor image behaves as expected .

File Size	63.2 kB
Dimension	800 px x 800 px
Bit-depth	24
Vertical Resolution	72 dpi
Horizontal Resolution	72 dpi

II. Advance Image File Types and Properties

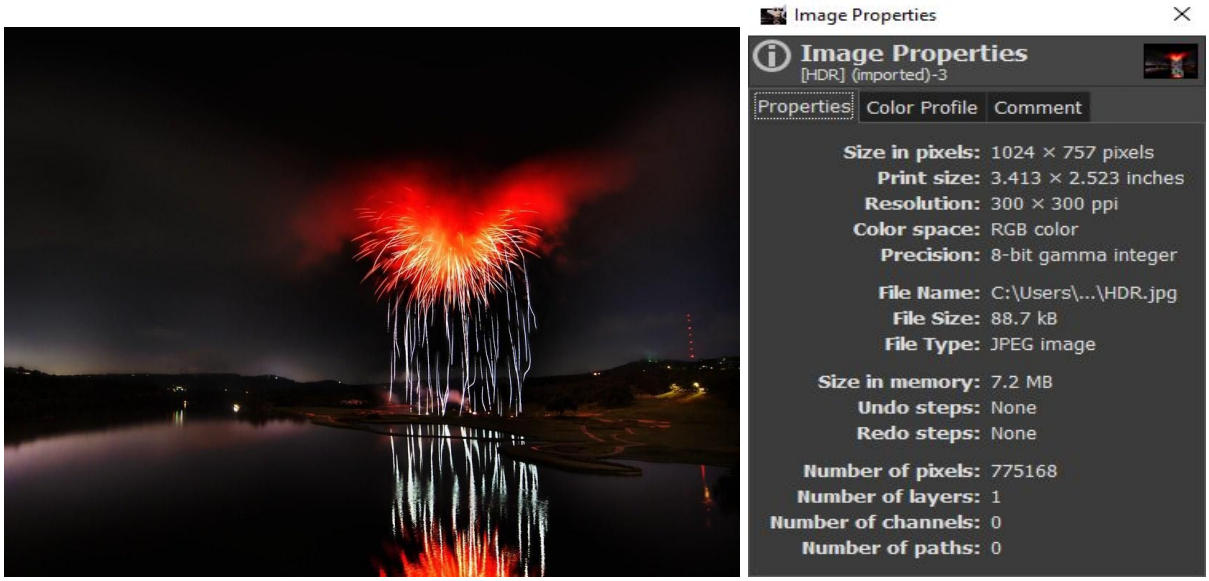

Figure 4.0 A high dynamic range (HDR) image of a scenery captured using a camera. [4]

The image captures a high amount of detail specifically in cases of extreme brightness or large contrasts between dark and light areas. However, due to the limitations of the hardware(monitor and graphics card) used, the precision can only reach a maximum of 8-bits in contrast to a minimum of 10-bits required to appreciate an HDR image. Key characteristics regarding HDRs are their use of specialized/high-powered cameras and capturing devices that are capable of capturing large amounts of information to be able to create a "closer to life" digital imitation of a scene.

File Size	88.7 kB
Dimension	1024 px x 757 px
Bit-depth	24
Vertical Resolution	72 dpi
Horizontal Resolution	72 dpi
Resolution Unit	2
Color Representation	Uncalibrated

	Camera Model	**Exposure Time**	**ISO Speed**	**Exposure Bias**	**Focal Length**	**Flash Mode**	**Metering Mode**
HDR	NIKON D2Xs	2	ISO-100	-1 step	17mm	No Flash	Pattern
	Contrast	**Light Source**	**Exposure Program**	**Saturation**	**Sharpness**	**White balance**	**Digital Zoom**
	Soft	Unknown	Normal	Normal	Normal	Auto	1

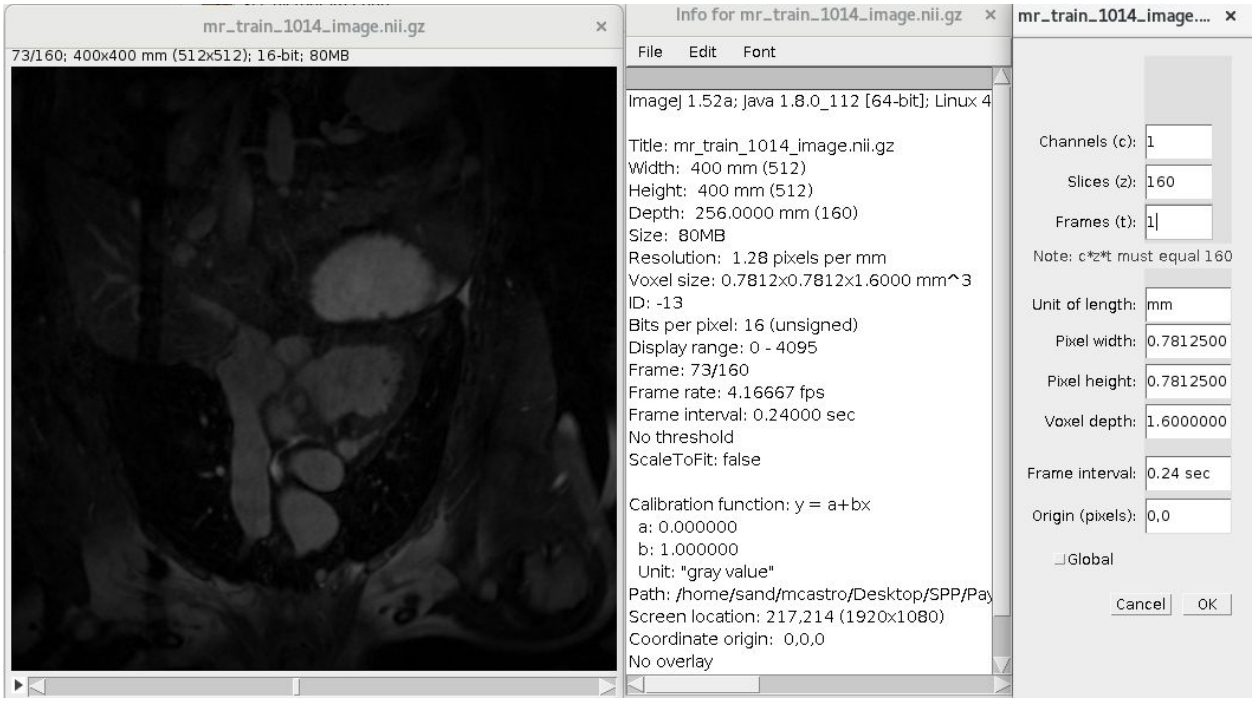

Figure 5.0 An example of a 3D Image from [2]. The image in question is an axial view of an MRI scan of the cardiac area, typically used in diagnosing cardiac diseases.This image is composed of several stacks of 2D images with intervals of 0.24 seconds between each 2D image.

File Size	64 MB
File Format	.nii (NiFTi)
Dimensions	400 mm x 400 mm x 256mm 512 tangential slices and 160 axial slices
Resolution	1.28 pixel per mm
Voxel Size	0.7812 mm x 0.7812 mm x 1.6 mm
Bits per pixel	16
Frame Interval	0.24177 sec

III. Exploring Image Processing Tools within GIMP

As I was interested in further exploring the effects of using different image types and image processing tools in GIMP, I had done the following:

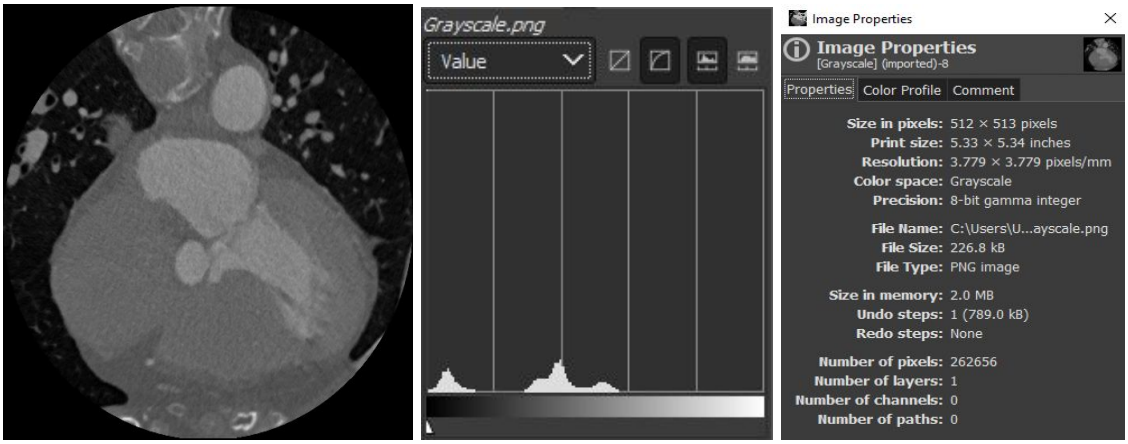

Figure 6.0 Using the grayscale mentioned earlier in this report, I determined its corresponding histogram, seen in the middle image, and saw that it had peaked at some portions of the gray and black portions of the color bar.

I then tried to crap the image such that only a portion of the image was left, whereas,

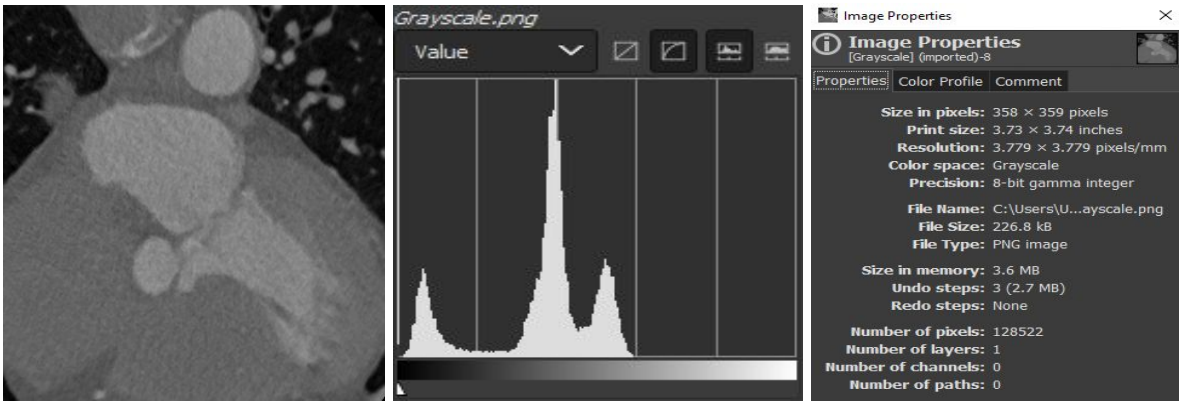

Figure 7.0 Cropped image exhibited larger peaks as the distribution of color was now smaller. Increased detail in peaks can now be observed on the histogram.

As I had discovered that by limiting the range of the image, I was able to generate a more detailed and more appealing histogram of the image. I then took my curiosity a step higher by exporting the image into a binary file as to limit the image into white and black. Such that,

Figure 8.0 Binary image conversion of the cropped grayscale image. The disappearance of dark-gray portions of the image is observed as it had limited the resulting image into the extremes of each end of the color bar, whereas, only the lighter portions of the image remain – converting everything else to a black color. This can be better visualized in the histogram (center image) whereas the only peaks present within the image are those that are at the borders of white and black.

IV. Exploring The Differences Between Various Image Types

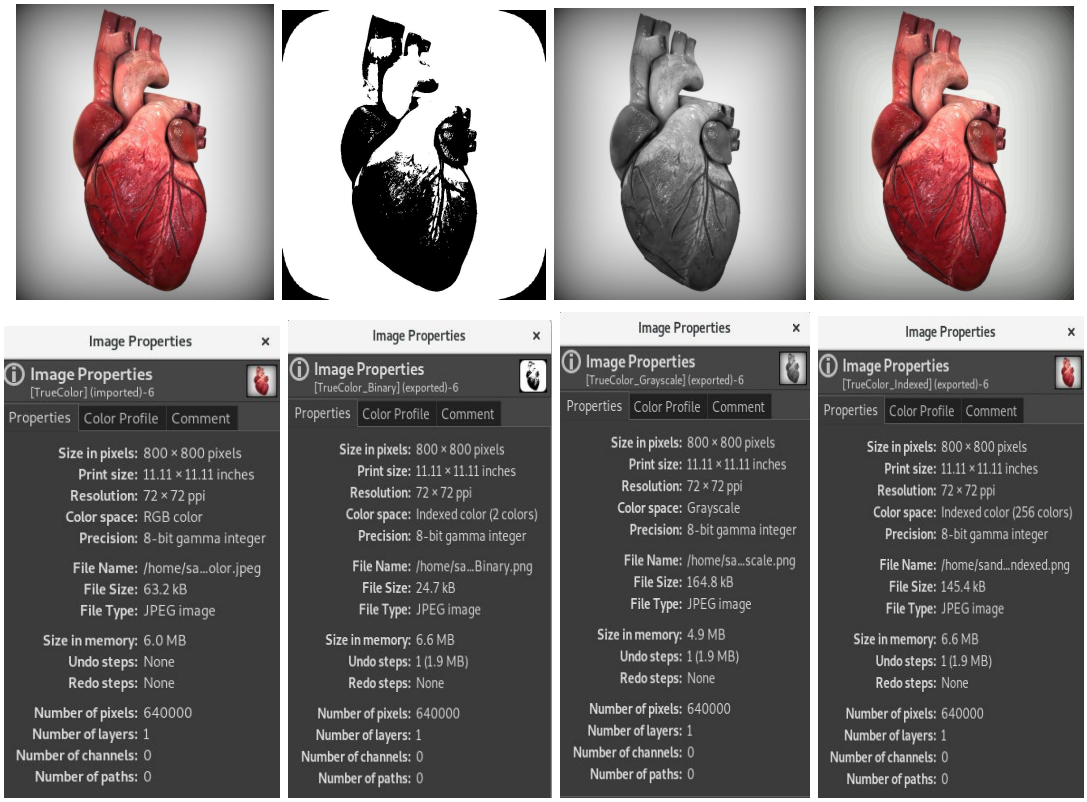

Figure 9.0 A side-by-side comparison of various image types of a human heart (L to R: truecolor, binary, grayscale, indexed). From varying image types of a human heart, various differences can be observed between any pair of images.

Comparing the true color image and the binary image, an obvious effect between the parsing of light and dark portion can be observed, whereas for this image, the darker portions of red and lighter portions of red were set as the extreme values and all shades in between were then converted into either black (if the shade is of a dark hue) or white (if the shade is a light hue). Another interesting portion of this comparison is its effect to the outer gradient of the image, whereas, the transition from black to white was simplified into a simple circular cut on the corners of the image. Comparison between the grayscale and binary is more-or-less similar. Comparison of the truecolor and the greyscale on the other hand acted a bit differently ,whereas, the dominant color of red mapped its various shades of red to values of 0 to 255 as to result into a grayscale image – this is slightly different and slightly slower when converting it to 0s and 1s. Another difference can be observed when one looks at the file size of each type whereas the largest file was observed to be the indexed image, then the truecolor image, afterwards would be grayscale image and the smallest file would be for the binary image – which is theoretically wrong as the true color image should have the larger memory allocation. However, upon taking into account that the original true color image was a lossy image format (jpeg) and the indexed image is a lossless image format (png), the result was within our expectations as images of the .png file extension generally take up more space compared to .jpeg images.

Another method for exploring differences between each type is by using histograms, whereas,

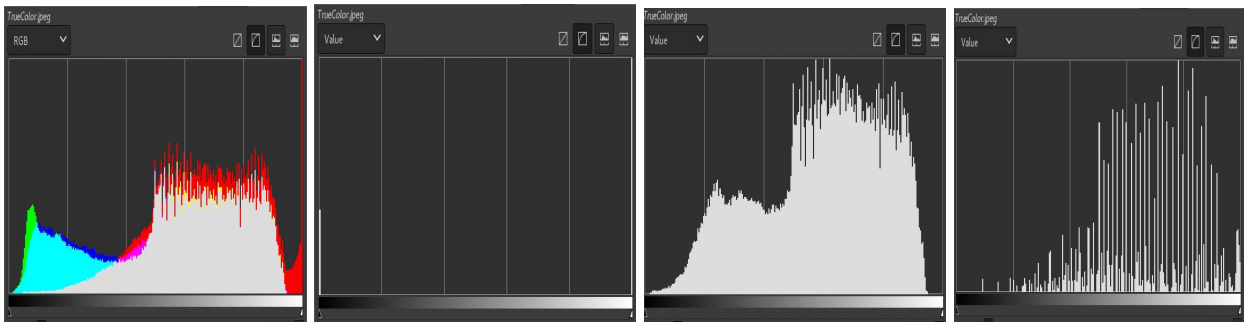

Figure 10.0 A side-by-side comparison of the histograms of various image types of a human heart (L to R: truecolor, binary, grayscale, indexed).

Comparing each of these histograms, certain differences may be observed. The first difference one may observe is that upon observing the histogram for a truecolor image, we are able to see that it separated into three major portions; red, green, and blue – the color channels. As we convert it to a binary image, we limit the first histogram into only the extreme values of white and black as to accommodate the conversion of each pixel to specific values of 0s and 1s. Whereas as for the grayscale histogram, we can observe that there are 3 dominant frequencies observed;black, dark gray, and light gray. As we had converted the shades of red,green, and blue into a single channel of grayscale, minor differences in shade are mitigated and only distinct differences in shades are observed- one may look at the images again to observe that some details of coloring have not been included in the grayscale image. As for the indexed image, it simply utilizes a different method for saving the colors of an image. The indexed image uses direct mapping of the frequency of each

index in the colormap. This is typically used for image processing as it is computationally easier to access and to utilize. As such, indexed images typically differ to grayscale and true color images when it comes to transitioning between colors as they are generally better at highlighting borders between colors but perform slightly worse in color gradients as they emphasize the transition of one color to another. This is in addition to less memory being used up by the indexed image.

V. The History of Image Formats Used

A) JPEG

Contrary to popular belief, JPEG which stands for Joint Photographic Expert Group is not a file type, but rather, is a type of image compression. It was simply a method to save a digital image into a computer without actually using the memory of the whole computer. This was before the age of Facebook, Twitter, or Emails - it was mainly for helping professional photographers store their images back in 1986 [5]. Simply, it takes in an image and utilizes an averaging function to minimize the amount of memory it has and compress the image into something of the same dimension but with less precision - causing some portions of the images, commonly the edges, to become blurry. Although it is not that obvious for the first few conversions, but through time it becomes more and more obvious.

This file extension was created for easier transfer and sharing of images, as such, it is important in any situation when it's important to have a small file - such as sending images through email, drafts, web images, or even as an alternative image to view for those who have slow internet. [7]

B) PNG

In the digital age, there comes a time when developers, programmers, and scientists begin demanding something in return for their contribution. By the end of 1994, Bob Berry and his lackeys demanded money for their work as "royalties" from authors of GIF-supporting software [6]. As money was scarce and programmers have yet to become millionaires and billionaires they are today, the internet crowd was frenzied by this sudden demand. This is where an informal Internet working group led by Thomas Boutell came in to save the day. Portable Network Graphics or PNG was developed as a remedy to this problem- better, smaller, more extensible, and most importantly, FREE!

Aside from being a lossless image format. whereas it retains all of the data contained in the file, it also supports transparency within the image. As such it is ideal to use for images that require transparency of an image such as when designing logos or when overlaying images over another. In addition, it is also preferred when an image is still in the middle of editing/processing as no discrepancies regarding the data is loss along the process. Whereas the use of lossy images would result to the exponential propagation of such a loss in detail.

VI. Score

Technical Correctness	Quality of Presentation	Initiative
5/5	5/5	2/2

REFERENCES AND SOURCES:

[1] https://en.wikipedia.org/wiki/File:Neighborhood_watch_bw.png
[2] X Zhuang, et al.: Multiatlas whole heart segmentation of *CT* data using conditional entropy for atlas ranking and selection. Medical physics 42 (7), 3822-3833.
[3]https://www.google.com/url?sa=i&source=images&cd=&ved=2ahUKEwif09-y2oPkAhXb62EKHeOND1UQjRx6BAgBEAQ&url=http%3A%2F%2Fwww.aljanh.net%2Fheart-wallpapers%2F3085128125.html&psig=AOvVaw3bL2CxUQKGKPe7ZwzbBT15&ust=1565918233989183
[4]https://www.smashingmagazine.com/2008/03/35-fantastic-hdr-pictures/
[5]https://mashable.com/2012/09/28/jpeg/
[6]http://www.libpng.org/pub/png/pnghist.html
[7]https://www.techsmith.com/blog/jpg-vs-png/