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Activity 3- Image types and formats

Objectives

- o To familiarize ourselves about the different image types and to know how to handle image manipulation techniques without destroying the quality of the image.
- o To learn what file formats are the most efficient ones to use when trying to limit the file size of a certain project.

Basic image types

Binary image

Figure 1. Binary image of a fingerprint.[1]

File size (kB)	203
Dimensions	732 x 1023
Width (pixels)	732
Height (pixels)	1023
Horizontal resolution (dpi)	96
Vertical resolution (dpi)	96
Bit depth	24

Grayscale image

Figure 2. Scanned x-ray of the skull.[2]

File size (kB)	26.3
Dimensions	537 x 553
Width (pixels)	537

Height (pixels)	553
Horizontal resolution (dpi)	300
Vertical resolution (dpi)	300
Bit depth	24

True-color images

Figure 3. True-color image of a scenery.[3]

File size (kB)	121
Dimensions	563 x 844
Width (pixels)	563
Height (pixels)	844
Horizontal resolution (dpi)	72
Vertical resolution (dpi)	72
Bit depth	24

Indexed images

Figure 4. Indexed image of a yellow flower.[4]

File size (kB)	15.1
Dimensions	1045 x 697
Width (pixels)	1045
Height (pixels)	697
Horizontal resolution (dpi)	-
Vertical resolution (dpi)	-
Bit depth	8

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In summary, the image properties of the basic digitize image types are listed in Table 1.

Table 1. Image properties of the different basic image types.

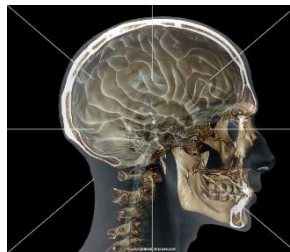| Image type	File size (kB)	Dimensions	Width (pixels)	Height (pixels)	Horizontal resolution (dpi)	Vertical resolution (dpi)	Bit depth
Binary	203	732 x 1023	732	1023	96	96	24
Grayscale	26.3	537 x 553	537	553	300	300	24
True-color	121	563 x 844	563	844	72	72	24
Indexed	15.1	1045 x 697	1045	697	-	-	8

The binary and grayscale images are both black and white, while the other two are composed of RGB colors. An indexed image, however, is of a smaller file size because of its indexed color image (a pixel has an index referring to a specific color), compared to the true-color image which has an RGB color value (much larger).[5]

Advanced image types

High dynamic range (HDR) image

Figure 5. HDR picture taken in New Zealand. [6]

File size (kB)	770
Dimensions	1467 x 2000
Width (pixels)	1467
Height (pixels)	2000
Horizontal resolution (dpi)	96
Vertical resolution (dpi)	96
Bit depth	24

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Multi or hyperspectral image

Figure 5. HDR picture taken in New Zealand. [7]

File size (kB)	415
Dimensions	510 x 306
Width (pixels)	510
Height (pixels)	306
Horizontal resolution (dpi)	-
Vertical resolution (dpi)	-
Bit depth	24

3D image

Figure 5. HDR picture taken in New Zealand. [8]

File size (kB)	82.2
Dimensions	900 x 773
Width (pixels)	900
Height (pixels)	773
Horizontal resolution (dpi)	300
Vertical resolution (dpi)	300
Bit depth	24

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Temporal image

Figure 6. HDR picture taken in New Zealand. [9]

File size (kB)	80
Dimensions	310 x 469
Width (pixels)	310
Height (pixels)	469
Horizontal resolution (dpi)	96
Vertical resolution (dpi)	96
Bit depth	24

In summary, the examples of advanced images shown above have the following image properties:

Table 2. Image properties of the different advanced image types.

Image type	File size (kB)	Dimensions	Width (pixels)	Height (pixels)	Horizontal resolution (dpi)	Vertical resolution (dpi)	Bit depth
HDR	770	1467 x 2000	1467	2000	96	96	24
Multi/Hyper-spectral	415	510 x 306	510	306	-	-	24
3D	82.2	900 x 773	900	773	300	300	24
Temporal	80	310 x 469	310	469	96	96	24

The 3D image has the highest resolution in DPI. This is because the standard image resolution when publishing in journals should be around 300 dpi. Medical images need to be zoomed in from time to time to get a closer look upon medical observations. The high resolution of medical images ensures that when zoomed in, the quality of the image does not decrease. HDR images generally have large file sizes because of its enhanced image features.

Conversion of true-color images to grayscale and indexed
To observe the change upon conversion, the histogram and the image properties (file size, dimensions, resolution in *ppi*) were taken into account. A histogram shows the intensity distributions in a given image.[10]

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The original image used is a true-color image and has the following histogram:


Upon conversion to binary,

It can be easily mistaken that the histogram since it lacks readability. This makes sense since we know that binary images only contain 0 or 1 values. Thus, peaks on the histogram are only present on the left-most and right most parts, which indicate the black and white colors in the image, respectively.

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When the same true-color image is converted into grayscale, the following histogram is obtained.
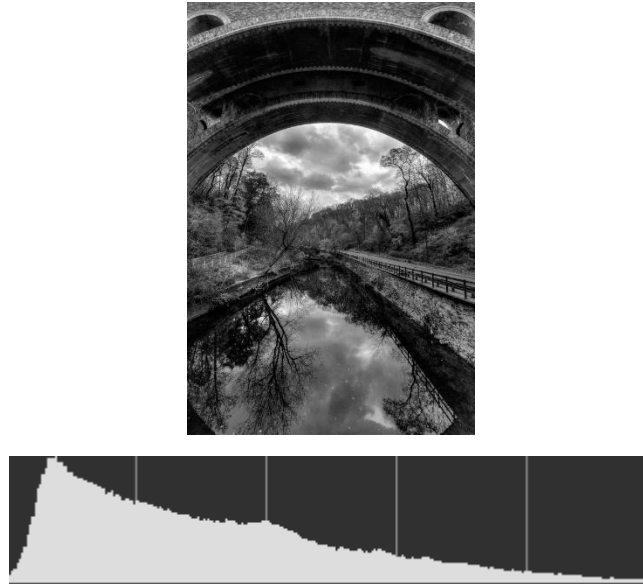
Theoretically, histograms of grayscale images are supposed to concentrate on the middle since we see mostly gray colors, which is located in the middle of the histogram chart. However, in this histogram, the entire intensity range is covered, mostly on the left side. Looking at the converted image, black is the most dominant color, thus explaining the heavier weight on the left side of the histogram.

Lastly, when the true-color image is converted into an indexed image, the histogram below is obtained.
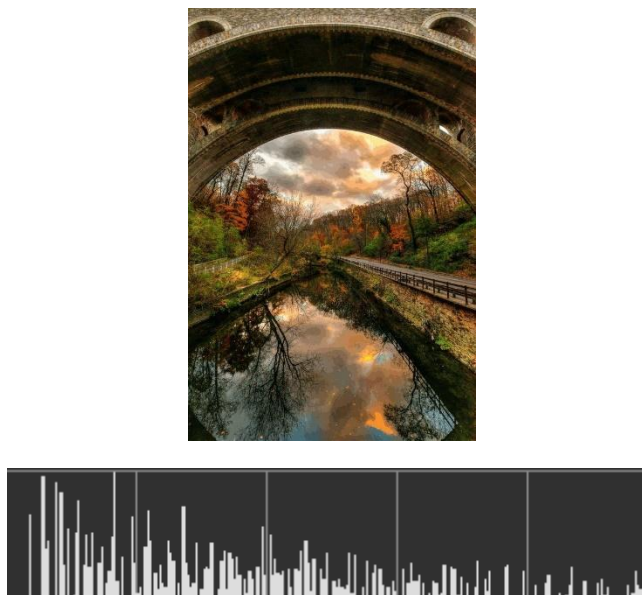
An indexed image is a colored image wherein the colors are represented by numbers which denote the index of the colors in a color map.[11] The separate peaks or sticks on the histogram

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represent a corresponding cumulative sum of pixel. Again, the histogram is in the entire intensity range and displays the number of pixels for each color level.

The summary of the image properties of the original true-color (highlighted in yellow) and its conversions to grayscale and indexed images are shown in the table below.

Table 3. Image properties of the converted images compared to the original RGB image.

Image type	File size (kB)	Dimensions	Resolution (ppi)
RGB	121	563 x 844	72 x 72
Binary	143	563 x 844	72 x 72
Grayscale	84	563 x 844	72 x 72
Indexed	81.4	563 x 844	72 x 72

From the table, we can infer that only the file size of the converted images changed. The reason for this is that even though the true-color image is converted into different color spaces, it still came from the same image source—thus, the dimensions and the resolution of the images are all the same. In terms of file sizes, only the conversion to a binary image increased its file size. Converting to grayscale and indexed images reduced the file sizes of the original true-color image. Indexed image conversions are expected to reduce its file size due to more discrete pixel values.

Different file formats

Compression is applied to images to reduce its size while maintaining its high quality. In this part, a temporal image is used to explore the properties of different file formats. Such formats are necessary to be considered for image compression and thus, for size reduction. Image compression is either a lossy compression or a lossless compression. A lossless image compression ensures that every bit of data remains in the file after being uncompressed. It is used in images where every pixel and every bit of information/detail is important. On the other hand, a lossy compression is when only a part of the original information remains after being uncompressed.[12]

Shown in the table below are the different file formats and their image compression types.

Table 4. Different file formats and their image compression types.

File format	Image compression
Joint photographic expert group (.jpeg)	Commonly used in photographs; has a **lossy** compression
Bitmap (.bmp)	Generally uncompressed or compressed with a **lossless** image compression
Tagged image format (.tif)	**Lossless** image compression
Portable network graphics (.png)	**Lossless** image compression

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This temporal image is exported to different file formats and the file sizes thereafter are compared in the table below:

Table 5. The corresponding file sizes of a similar image exported in different formats.

File format	File size (kB)
Joint photographic expert group (.jpeg)	80
Bitmap (.bmp)	427
Tagged image format (.tif)	554
Portable network graphics (.png)	282

As seen on the table, the Joint photographic expert group (.jpeg) file format has the least file size, which is expected since only a certain portion of the image was preserved after being uncompressed.

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References

[1] https://danielmiessler.com/blog/real-world-testing-of-the-iphone-5s-fingerprint-sensor/?fbclid=IwAR07P1IFP3bW2hhv-LaocsRp3wHHVj8yDZ_5A4f-lcUvAP1qYy48iLYyNRA

[2] http://www.ablesw.com/3d-doctor/imgproc.html?fbclid=IwAR0rIo2_gWFznPfSali7quIl669-LT5dZrN9lZxzz3aAlDr-9cyvvD2Yly8

[3] http://pinterest.com

[4] https://teition.com/3-or-more-colored-images-indexed-color/?fbclid=IwAR23YL9FGjUjeMHG8CZvg8cwhi_KQ09XJfWJKJ3ZkeKTbbRlTiMZbBBQ3GA

[5] http://www.drububu.com/tutorial/image-types.html

[6] https://viajes.nationalgeographic.com.es/a/corazon-maori-isla-norte-neozelandesa_8793/3

[7] https://www.spiedigitallibrary.org/journals/journal-of-applied-remote-sensing/volume-8/issue-01/085098/New-hyperspectral-difference-water-index-for-the-extraction-of-urban/10.1117/1.JRS.8.085098.full?SSO=1&fbclid=IwAR3KygArZSZDk139YWm3TcXS6ZYToSeyDec4kLS5hEMTixWZkz9W-JOIKy0

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[9] https://www.picturecorrect.com/tips/high-speed-photography/?fbclid=IwAR0xchwLTnaHtvgBV9DFKUy4oulCL21xMDd4fgQvqM_8eWzk6Rcqq3ZODS4

[10] https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_histograms/py_histogram_begins/py_histogram_begins.html

[11] https://www.mathworks.com/company/newsletters/articles/how-matlab-represents-pixel-colors.html

[12] https://whatis.techtarget.com/definition/lossless-and-lossy-compression

Self evaluation

The activity required more than the lecture and lab hours to be finished. Although a lot of things had to be done, every step of it was essential in understanding the whole activity. Overall, I have learned a lot of new things in this activity.

Technical correctness	5
Quality of presentation	4
Initiative	1
Total	**10**